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2018 XIV International Engineering Congress (CONIIN)

Universidad Autónoma de Querétaro, Santiago de Querétaro, México

From 2018-05-14 to 2018-05-19

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Fiber Optic Sensors as an Alternative to Structural Health Monitoring in Concrete Structural Beams

Explanation and Development of a System Capable to Monitor in Real Live – Time Displacements, Temperature, and Strains in Structural Beams

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Seismic activity causes catastrophic effects all over the world. This is due to the bad standardization in the present normative in the construction of hospitals in order to prevent a disaster. The bad quality in construction, the low-cost materials and the poor manufacturing in the process affects, in an earthquake, way more than a bad design in the structure itself. This investigation reaches and creates a system capable of measuring in real live – time the variations of displacements, temperature, and strains created before, during, and after the catastrophe. Hospitals are very important to the people; we cannot ignore the fact that if such building collapses during an earthquake, many people lives will perish, and way more will be in danger if fallen debris harmed them in any matter. Fiber Bragg Grating optic sensors are capable to measure these variations. They deflect light that passes through them and rebounds some of it, causing an effect that can be related to changes in its initial position.

Keywords—Wavelength, Strain, Deformation, Fiber Optic Sensors, Strains, Embedded Optic Sensors

I. INTRODUCTION

Continuous monitoring is very important in order to prevent structural damages. Using fiber optic sensors we are able to measure the magnitude of the phenomenon that can affect buildings, such as hospitals. A high resistance mesh and fiber optic sensors becomes necessary along the entire internal body of the structural beams. [10] Providing a continuous and real-time diagnosis of the internal forces that were modified due to the seismic activity is the main purpose of this research.

Important and significant buildings, such as hospitals, libraries, airports and colleges should meet with a strict security system against contingencies, this because in an emergency they should work as shelter or safe house in order to protect citizens [8]

The techniques and methods to find a real result are very centralized. Since obsolete technologies are used to only distinguish the effects of the forces in a single point of the structural element. The optical fiber, when transmitted by light becomes faster, granting in real-time what it is in effect happening throughout the element. Becoming an efficient technology in the study of structural health monitoring. [3]

Our approach goes directly to the study of longitudinal structural elements, such as beams, and columns. The proposed mesh consists of high strength wiring with fiber optic sensors and a rigid transverse body that holds the mesh in place, thus providing sufficient stability so that it does not move once placed inside the structure. Once the fiber optic system has been built along all the main structural elements, they are connected to a single central console. [4] Programmed only to be able to register these changes continuously, to alert in time some variation or sudden re-arrangement in the elements analyzed, as well as make a file of these studies for a later analysis if it is required.

The analyzed elements will be selected in order to be able to generalize the behavior of this structure. Since, if the system were place in each of the elements, the system would be loaded with information and lose the ability to store information quickly. As well as hindering the study considerably. [12]

External forces are the most related factors to deformation, although they are the most significant, they are not the only causes to create them all the way across the sections in the entire structure. The proper weight of the elements affect the behavior of the building, also the shrinkage of concrete elements due to the loss of water, as well as the creep, were dead loads deform the sections were they are grounded through

time. This consideration can be analyze in the early behavior of the construction itself, in the case of shrinkage of concrete elements. [3]

II. THEORETIC CONSIDERATIONS

A. Fiber Bragg Grating Sensor Considerations

In 1978 Ken Hill, demonstrated that through the interference pattern of ultraviolet laser light and the Fresnel reflection, light did not reach entirely the final point of an optic interface [7]. This because part of the light that went through reflected and some other refracted [2]. He demonstrated and related this behavior to the Bragg wavelength:

$$\lambda_B = 2n_e \Lambda \tag{1}$$

Were n_e is the effective refractive index of the fiber core and Λ stands for the grating period.
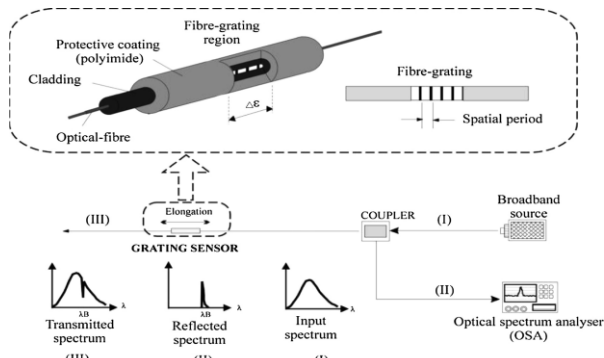

Fig 1 Main function of a Fiber Bragg grating core, reflected and refracted light – systemic strain measure [2]

A property of the Fiber Bragg gratings is that they perform as wavelength filters, this due to the reflection of light all over the incident broadband. [1] Transmitting only in his first wavelength range, producing the same spectrum as when it was initially induced, with the only difference of a clear depression in its spectrum, in which can be inferred the refracted light.

Other factors affect Fiber Bragg gratings, such as temperature. Strain ($\Delta\varepsilon$) and temperature (ΔT) variations might change lectures in the core if not read properly [5]. The shift in Bragg wavelength is given by:

$$\Delta\lambda_B = (1 - P_e)\lambda_B \Delta \in +(\alpha + \xi)\lambda_B \Delta T \tag{2}$$

Where P_e represents the effective photo-elastic coefficient, approximately, rounded to 0.22, expressed in the next equation:

$$P_e = \frac{n^2}{2}[P_{12} - v(P_{12} + P_{11})] \tag{3}$$

Where P_{ij} is the known Pockels coefficient of the strain-optic sensor and v is the Poisson ratio. [6]

When a strain is affecting a Fiber Bragg grating sensor, the elasto-optic effect vary the lectures in the effective refractive index, n_e , using equation (3) and assuming that the grating period Λ in equation (1), we can join (1), (2) and (3) in the following expression:

$$\mu\varepsilon = \frac{\Delta\lambda_B}{\lambda_B} = \left\{1 - \frac{n_e^2[P_{12} - v(P_{11} + P_{12})]}{2}\right\}\varepsilon \tag{4}$$

This relation expresses the Bragg wavelength relative changes due to the effects of any strain focused in the optic sensor applied.

If pressure from the environment is another factor to consider. Considering the atmospheric pressure or other features involving pressure, the Bragg wavelength changes can be expressed by: [9]

$$\frac{\Delta\lambda_B}{\lambda_B} = \frac{1 - 2v}{E}\left[\frac{n^2}{2}(2P_{12} + P_{11}) - 1\right]\Delta P \tag{5}$$

B. Concrete Structures Considerations

Concrete is known to be an alkaline substance; this factor obligates the optic sensor to be capable to handle well with corrosion. In addition, civil engineering requires maintaining quality in its structure, regardless of which structure is being built, its durability as well as its reliability is the key factor to creating and developing a sensor capable of reaching and surpassing these standards.

An athermal packaged FBG can be useful to measure sensible changes in temperature. The working temperature frame for this type of sensor varies across the 0°C to 75°C.

Fig 2 T&S model Athermal type FBG Sensor – Grupo COFITEL

An integrated deformation Fiber Bragg Grating (IDFBG) [11] sensor is the most common sensor for embedded structures. With a central wavelength of 1500 nm, the IDFBG is capable of measuring strains with a typical sensitivity of $1.5 \, pm/\mu\varepsilon$. Reinforced with a high-resistance steel capable of resisting the contraction of concrete in its first 24 hours after being emptied. [10]

The IDFBG sensors uses the high sensibility from other sensors to measure deformations, displacements or vibrations in a real-time analysis. Its typical deformation range goes to 5000 $\mu\varepsilon$ with a precision of 10 $\mu\varepsilon$.

The effect of the temperature on the sensor and on the base material is represented by the next equation: [13]

$$\sigma = xS - 7.32\Delta T - cte_{structure}\Delta T \qquad (7)$$

Fig 3 Concrete cylinder, f'c = 250 kg/cm², and a FBG sensor attached to the body of the cylinder for its further analysis.

III. METHODOLOGY

a) Designing the Concrete Cylinders:

The cylinders were designed to reach an f'c = 250 kg/cm^2 to its full resistance in 28 days. Giving us the next design:

Element	Concrete Design		
	Amount Needed for One Cylinder	*Quantity*	*Unit*
Water	Water needed	0.30074	lts
Cement	Cement needed	0.57752	Kg
Gravel	Gravel needed	1.42099	Kg
Sand	Sand needed	1.34790	Kg

Fig 4 Concrete design for an f'c = 250 kg/cm^2 used to build the concrete probes

For the test, they were needed steel cylinder molds with a section area of 0.15 m and 0.30 m high, respecting the relation 2 – 1 that the normative implements.

In order to prove if the concrete design for a 250 kg/cm^2 was correct, an axial force test was needed in two cylinders, and the media of both tests would launch our real compressive resistance of our design.
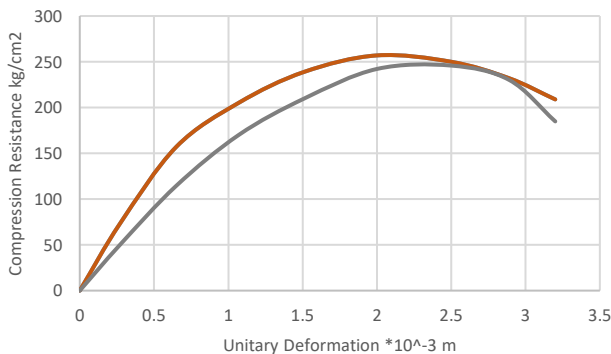

Graph 1 Axial Compressive Force of Tested Concrete Cylinders

The graphic show the maximum compressive force of 256 kg/cm^2 and 245 kg/cm^2. With our desired f'c = 250 kg/cm^2 and concrete design proved, we concluded the designing and modeling of the concrete cylinders

b) Running the Analysis:

Three concrete cylinders had the system implemented, the average of all specimens results, was the total wavelength movement. The length of all three grades of concrete were of 30.05 cm.

Once the probes were correct and calculated, they were left out of the consolidation room and waited nine hours to its full cool-down. Once in room temperature, the strains were measured in order to see the variations in the Bragg wavelength of the sensors. It is important to clear out that the peaks created in the spectra are due to a non-uniform distribution of compressive forces and strains surrounding the grating area.
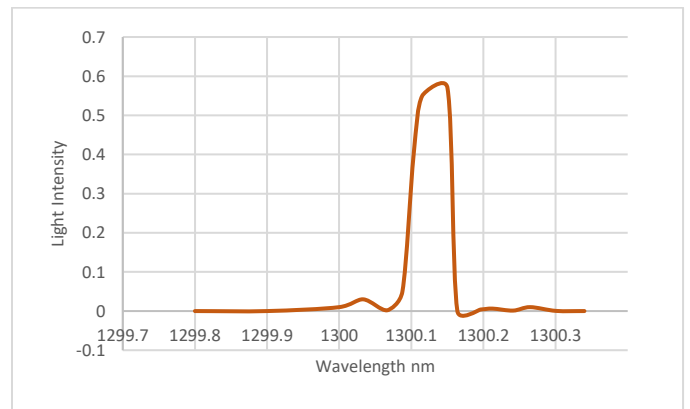
Graph 2 FBG Readings before embedding in concrete
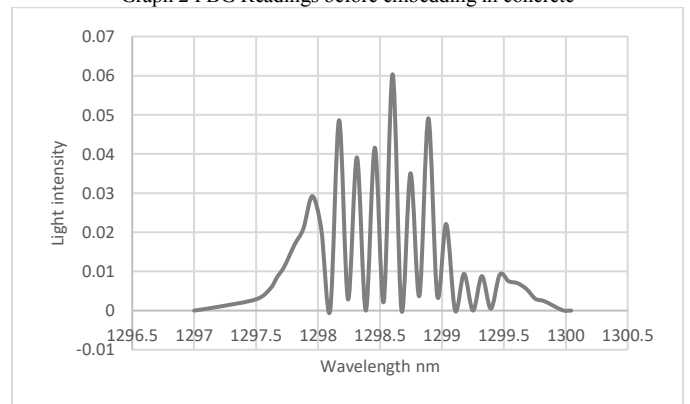
Graph 3 FBG Readings after embedding in concrete

The readings stabilized after a time, making the sudden peaks with a certain tendency to cero.

Graph 4 Sensor´s Bragg Wavelength location before embedded in concrete

Graph 5 Sensor´s Bragg Wavelength location after embedded in concrete

IV. SUMMARY AND CONCLUSIONS

According to the results shown as well as the research made, it is has been proven that fiber optic sensors, have a great usage and the bene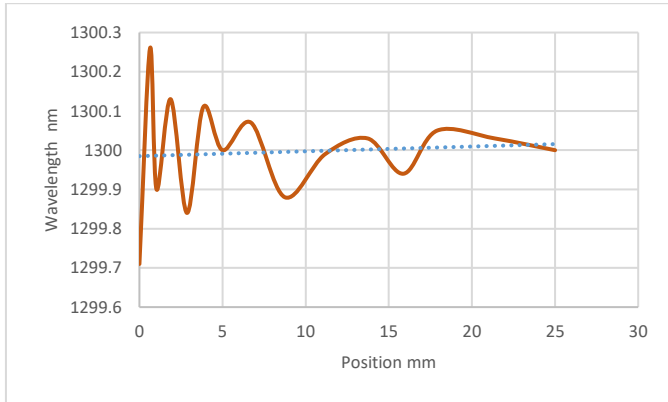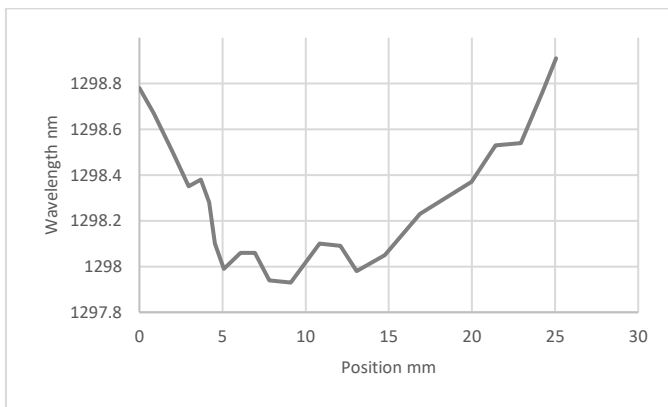fits in a vast field of opportunities, starting from telecommunications all the way to real – time analysis in the structural health monitoring field. [16

Results show that Bragg grating based sensors can be reliable and cast trustworthy data with a minimum range of error. According to the NOM-233-SSA1-2003 normative, hospitals should work as shelters if a catastrophe happens. This system functions and reaches information no other SHM system have reached.

Due to strains and constant deformations across the sections of the entire body of the structure, the system puts itself in danger if the considerations and factors in the designing process are not well estimated; this system not only shows and guides the construction field into the creation of well-built edifications. However, straightens our vision towards the future, light cannot be modified or tergiversated to the benefit of some. Light will show the incompetence with which our industry has been built, and clear out the right path and knowledge in which construction companies should and must work by. [17]

The fiber Bragg sensor applied in the system, not only reduces consistently the wiring across the walls and concrete elements, but also works as an elastic element inside a rigid frame, reducing drastically sudden cracks that may appear due to plastic contraction in the first 24 hours of emptied the concrete. [18]

The system itself can also be interpolated between fiber Bragg grating sensors granting unlimited points for analysis. Granting a correct diagnosis when a decision has to be done. [9] This is why fiber optic sensors across concrete elements are viable and reliable trustworthy systems. Leaving behind strain gages in which not only requires singularity in its connections, conditioning to a plenty of electrical wiring, but also leaving the criteria to a single-point analysis.

V. ACKNOWLEDGMENT

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Non-invasive System for the Identification and Classification of Melanomas

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Abstract— **This paper presents research performed at the Universidad Autónoma de Querétaro, Facultad de Ingeniería. Melanoma is the most severe type of skin cancer. Also, according to the World Health Organization (OMS) it is the leading cause of skin cancer death at the world. The first sign of a melanoma is a change in size, shape, color or texture of a mole. The objective of the project was to implement a portable, non-invasive system for the classification of benign and malignant melanomas, using image processing. The system was implemented on a *Raspberry-pi3* card using Python programming as the main programming language. The system is trained to evaluate the four main characteristics of melanomas, which are: size, shade dispersion, symmetry, and shape relation. Once the device was available, a database was taken to evaluate its functions; it was tested with each of the pictures and the results obtained were verified, compared and analyzed. The main features of the device are the following: it is portable, non-invasive, low energy consumption, flexible and has a friendly interface with the user.**

Keywords— *Malignant and benign melanoma; Raspberry-pi3; Python; image processing.*

I. INTRODUCTION

The digital processing of images has been significant progress for the technology since this set of techniques is applied to digital images with the aim of improving the quality of the image and facilitating the search for information.

The objective of this work was to improve the quality of the images received for their study and, in turn, through various techniques and programming algorithms, to obtain sufficient information to distinguish between malignant tumors and benign tumors of melanomas. This work will be part of a first stage for the prevention, detection, and treatment of one of the most severe skin diseases, since according to the World Health Organization (OMS) it is the leading cause of skin cancer death at the world [3], [6-8].

The International Labor Organization (OIT) reports that 56 percent of the world's rural population does not have health coverage, compared to 22 percent who live in urban areas. Also, it establishes that there are inequalities in health coverage in most countries, whether rich or poor, although the highest rural/urban gap is found in developing countries. The device designed during this research is oriented to rural areas because, being an easy-to-use device, accessible transportation and use, and not an invasive treatment, it can be used in rural areas of difficult access where they do not have this type of studies and that there are no specialists in dermatology.

The Raspberry-pi3 is an embedded system used with high frequency for the processing of images due to its technical characteristics such as speed and processing power, memory capacity and its possibility of wireless connection using Bluetooth or a Wi-Fi network. On the other hand, Python is a platform-independent and object-oriented scripting language. Some of the main features of Python are the following: Free software, general-purpose language, multiplatform, object-oriented, among others. The combination of these two elements allows us to develop high-performance applications in a short time and even low cost [1], [2], [5].

II. MATERIALS AND METHODS

The research was done in the facilities of the Universidad Autónoma de Querétaro at the Facultad de Ingeniería, since last year. The primary elements were the following: A Raspberry-pi3, a minor sd class 10 of 32GB, an HP computer (Intel Celeron N3050 processor, 4GB memory, and 8GB hard drive), and a camera for Rasberry-pi3.

The methodology was divided into three parts; the first part was the bibliographic search that allowed us to know the state of the art of the systems applied to the detection of melanomas. The second stage was the implementation of programming algorithms for the conditioning of images and obtaining characteristics, which allowed us to measure and evaluate the parameters that characterize malignant and benign melanomas. The third stage consisted in the evaluation of the device for which a database was taken in which cases of both types of melanomas were contained, and the results of each image were verified.

As mentioned above, four characteristics were evaluated for the identification of melanomas, and for each of them the device was trained, and an algorithm was designed to identify and assess the parameter.
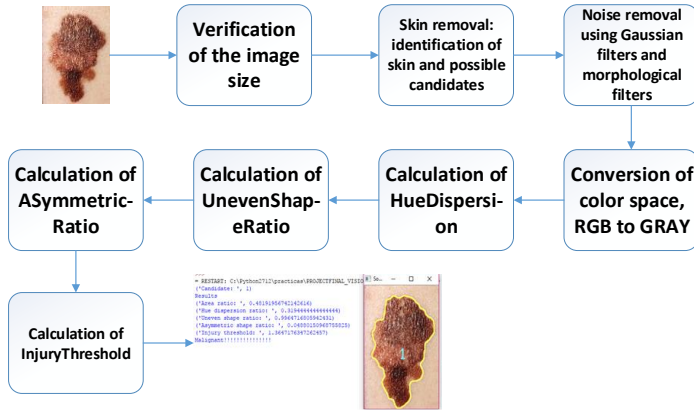
Fig. 1. Operation of the programming algorithm for melanoma detection.

Fig.1 shows a flowchart of the operation of the programming algorithm for melanoma detection. The image is entered in an RBG color space; the Gaussian noise is eliminated, the skin is removed, generating a mask in the HSV color space showing the skin in black and melanoma candidates in white. Table I shows some of the samples taken for the identification of the HSV range.

TABLE I.   IDENTIFICATION OF COLOR RANGES FOR MALIGNANT MELANOMA IN THE HSV SPACE

Imagen	M1	M2	M3
H:0-28 S:69-112 V:67-112			
H:0-28 S:69-112 V:67-255			
H:0-8 S:50-111 V:57-218			
	H:0-28 S: 0-114 V: 0-255	H:0-13 S:69-112 V:95-112	H:0-15 S:70-166 V:67-155

To identify the skin color, a sample of the corners of the image is recursively taken, and with the information obtained, the maximum and minimum level for each channel is identified in the space of HSV colors for the removal of the skin. A series of morphological filters (erosion followed by a dilation) are applied to eliminate noise generated from the previous step. Subsequently, the number of melanoma candidates is counted, and the image of the color space from HSV to GRAY is converted. With each of the candidates, the four parameters are verified, and a value is assigned according to the training weight of the system. The first parameter to evaluate is the size by identifying the contour and calculating the area. The color dispersion is then evaluated by calculating the histogram of each of each color. To calculate the symmetry, the image is divided into four semi-planes, and each one compares semi-planes, identifying their midpoints and concavities. To verify the shape, the detected contour of the candidate melanoma is compared with that of an ellipse and a level of similarity is established. Once each parameter has been evaluated, global weighting is done, and it determines if the melanoma is malignant or benign.

Fig. 2 shows one of the results obtained to verify each method of the algorithm and Fig. 3 shows an example of verification of symmetry.
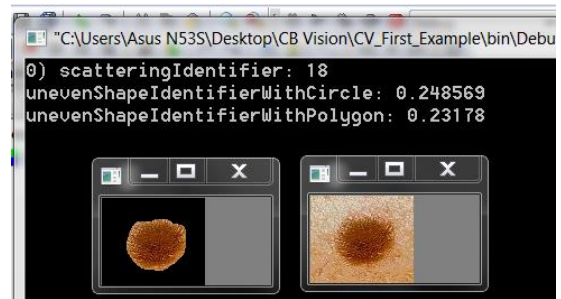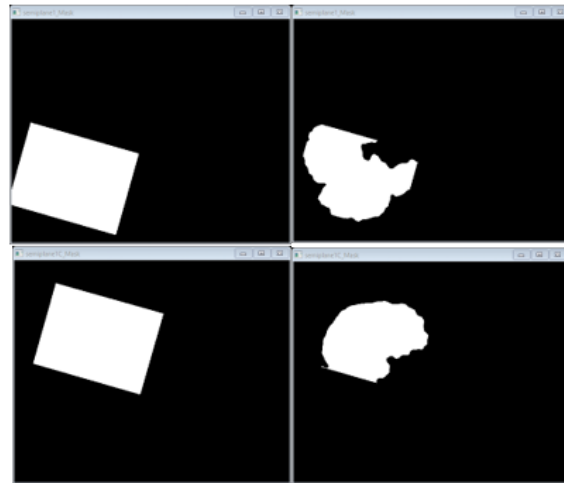

Fig. 2. Concavities identification test.

Fig. 3. Identification test of symmetry and shape.

To weight each parameter, we had the previous training of the system that consisted in the identification of the range of values according to a database taken from medical results in which cases of positive melanoma and negative cases were presented. That is, there were two databases in total, one to train the system and another to verify the operation.

III. RESULTS AND DISCUSSION

The primary purpose of this research was to achieve a non-invasive method for the detection of malignant melanomas, using image processing and as the primary language of Python programming. Several tests were performed to verify and validate the device, the first tests were on each of the methods used, and the following were about the diagnosis and percentage of melanoma identification. The system evaluates five parameters, and from these, a decision is made to define the type of melanoma, the settings are the following: Area ratio, hue dispersion ratio, uneven shape ratio, asymmetric shape ratio and injury threshold. Fig. 4 is shown some results of the second tests.
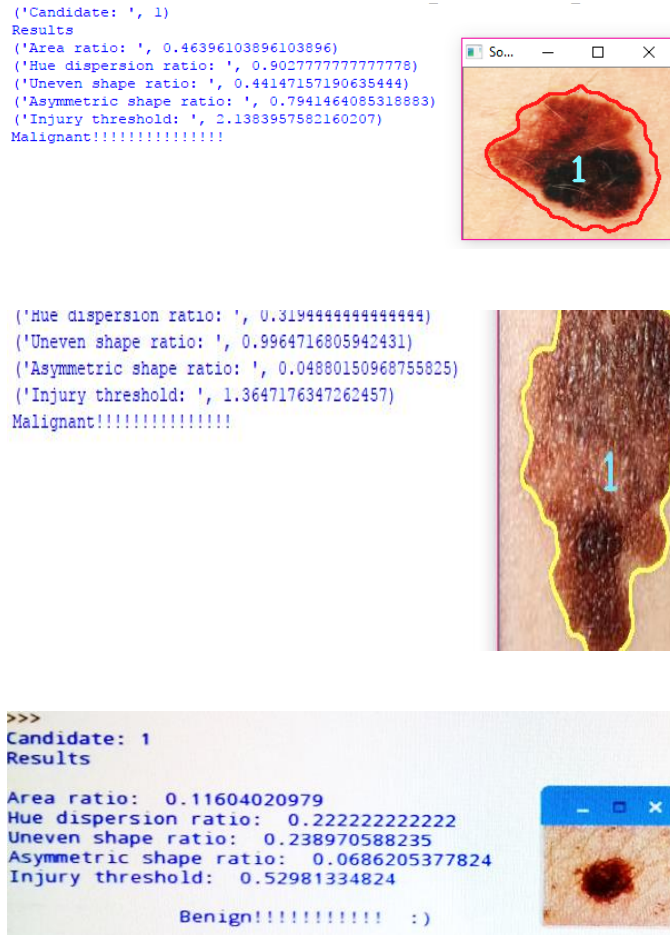

Fig. 4. Test results without using raspberry.

The system shows the result of the evaluation of each parameter, the type of melanoma according to the analysis of the results and the level in which it is located (this according to the color with which it marks the contour). For the calibration of the device a database with information on malignant and benign melanomas taken from a medical research center was used. To evaluate the device several photographs were made, and some others were taken from databases of research centers.

According to the results obtained in the research, it can be concluded that it is possible to identify melanomas with a non-invasive and portable system that uses image processing for the detection and classification of melanoma. Also, based on the sensitivity and specificity tests carried out, it can be affirmed that the system had an effectiveness of 98% of the total sample. The sensitivity tests allowed us to identify the ability of our device to give as positive cases the really sick cases, that is, the proportion of patients correctly classified. On the other hand, the specificity tests allowed us to determine the capacity of our device to give the healthy cases as negative cases.

IV. CONCLUSIONS

According to the results obtained, the functioning of the system was demonstrated and validated, which allowed us to fulfill the objective of the research project. The development of new techniques and algorithms for the detection of melanomas is significant as this contributes to the development of more efficient, user-friendly and easily accessible systems. Also, the development of new technologies for the early identification of malignant melanomas is encouraged.

According to the analysis of the results, it is concluded that the expected results were obtained and the hypothesis was met at the beginning of the project, because with the help of the Raspberry-pi3, images can be obtained with the camera that has integrated and make their corresponding processing to determine if the study area contains a melanoma, what type of melanoma and if malignant determines the severity. Also, the equipment can be installed anywhere that has an electrical outlet, which would be the only requirement to take rural communities with difficult access.

IMPLICATIONS OR IMPACT

This work constitutes a significant contribution for the development of algorithms applied to the detection of melanomas and the implementation of algorithms for image processing.

ACKNOWLEDGMENT

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Polymer concrete for paving using polyethylene terephthalate resins

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In the following document, the feasibility of developing a hydraulic concrete modified with polymers is analyzed so that it is implemented as a rigid pavement. The alternatives are reviewed when there is a need to use a material so that it works as pavement on high specification roads and a comparison is made with the polymeric concrete to see the attributes that it could provide.

keywords—polymer, pavement, hydraulic concrete, flexural strength, mechanical properties, durability.

I. INTRODUCTION

Hydraulic concrete is the most used construction material in the world. Its low cost, its workability and the resistance to simple compression it provides are the main qualities for it to be widely accepted [1]. Despite all this, it has important disadvantages, such as low resistance to bending and tension, high porosity and susceptibility to acid environments [2].

A point that requires special care when considering the construction of a rigid pavement is that the resistance to bending is the main parameter to perform the design [3], a deficiency that hydraulic concrete presents [2]. There are several investigations in which it was sought to improve the resistance to flexion obtaining favorable results.

By adding recycled PET fibers in 4 different proportions to 4 hydraulic concrete mixtures with the same dosage, it was possible to verify that the PET fibers increased the flexural strength of concrete by 19.2% in the optimum proportion. It was concluded that the resistance to bending increases proportionally to the increase of the fibers in the mixture. [4]

In a similar investigation, by means of the addition of urban solid waste (PET) fibers to hydraulic concrete in 66 specimens, which were differentiated by the length and quantity of fibers that each specimen contained, it was possible to conclude that there is an increase in tensile strength by 22% with the addition of fibers at 0.06% and with lengths greater than 24 mm [5].

On the other hand, it has been sought to develop a polymer concrete for a repair use in high specification pavements by adding liquid type silicone rubber or residual dust from tire to concrete. This investigation allows us to suppose that the highest amounts of tire dust induce to obtain higher deflections, having a higher area in the tension-deformation curve [6].

In a similar way, an experimental investigation was developed on a stretch of the "Quadrilatero-Marche Umbria" road in Italy, in which a concrete with polypropylene fibers was applied in a monitored test section and imposed on real traffic loads for 6 months. Very low deformation levels were obtained, located practically in the initial pre-service condition. A beneficial effect of tension relaxation dominated the recorded readings [7].With this, it can be said that it is no coincidence that hydraulic concrete with polymers of various types acquires superior mechanical properties, which can be used in the field of highway engineering, for the implementation of a material for paving that can be competitive with the materials currently used.

In general, based on various investigations, it is concluded that polymer concrete has greater durability and resistance than a common hydraulic concrete [8]. The improvement of the addition of the polymer is obtained by the interaction of the particles of this and the hydrates of the cement involved in the

formation of a film, positively affecting the microstructure of the material and with it the performance and durability [9].

Nowadays, the existing paving materials are flexible pavement, made of asphalt concrete or a rigid pavement, made of hydraulic concrete. The development of both materials has negative impacts on the environment. The cement industry was responsible for 38.5% of Co2 emissions in Europe, in 2009 [10]. Likewise, working with asphalt in high temperatures produces considerable amounts of greenhouse gases, as well as other chemical pollutants that affect air quality [11]. In this sense, it is inferred that for both materials modifications in its composition can be made, with the aim of reducing the polluting agents that arise from its production.

In general, the use of hydraulic concrete as pavement has been growing in recent decades as these provide greater durability and longer structural life than a flexible pavement [12]. This material is superior in terms of performance and durability, but it has the disadvantage of having a higher cost in terms of development and construction. However, through various methodologies, such as the addition of polymers, it is possible to make their production more economical using recycled materials [13]. With this it is inferred that a polymeric concrete has the capacity to be a competitive material both in the functional sense as in the economic one in the field of pavements.

II. METHODOLOGY

Initially it will be necessary to carry out the characterization of the aggregates. The coarse aggregates correspond between 40 - 50% of the total volume of the mixture [14], so special care must be taken in their selection to produce a hydraulic concrete of good quality. To develop a material that is useful to function as a rigid pavement it will be necessary to use the guide for the design and proportion of concrete mixtures for pavements of the ACI [15], of which the granulometries to be used are specified, as well as the parameters of quality of concrete aggregates.

The evaluation of the quality of the hydraulic concrete is done through various tests. In this case, it will be appropriate to evaluate the resistance to bending, since it is the parameter that needs to be improved. This will be obtained by means of the rupture module which is governed by the conditions of ASTM C 78 [16]. The modulus of elasticity is linked to the modulus of rupture, which will be obtained by means of the expression:

$$Ec = 26454Mr^{0.77} \qquad (1)$$

Where Ec is the modulus of elasticity and Mr is the modulus of rupture obtained from the previously performed assays. After this, a revision of the compressive strength must be made, which, although it is high in a conventional hydraulic concrete, it is necessary to make sure that the addition of the polymer did not have negative effects on said mechanical property. Therefore, what is described in the ASTM C39 standard [17] should be followed. Considering that it is necessary to obtain a material so that it works as a pavement, then it is essential that it has a workability according to the task it will perform. To measure this property, slump is used, which measures the fluidity that concrete gives in its fresh state. The regulations governing the review of this procedure is ASTM C 143 [18].

Having defined the mechanical properties to be improved, we will proceed to design the hydraulic concrete base mix, with a flexural strength of 682.7 psi, a value recommended by the AASHTO for high specification highways [19]. This mixture will be taken as the main indicator to make the comparison with the concrete modified with polymers. The polymer will be obtained from the condensation polymerization [20] applied to the polyethylene terephthalate, product of the waste of plastic bottles. This will make an addition in proportions of 6%, 8%, 10% and 12% of the total volume of the specimens to be tested. Through a set of 5 tests of each test by percentage of volume, a comparison of the results will be made by means of an analysis of variance, which will determine what percentage of polymers is the optimum of the 4 mixtures made with the different proportions described.

III. EXPECTED RESULTS AND CONCLUSIONS

According to what has been described in the investigations, it is expected that the polymer will benefit the microstructure of the mixture and thereby obtain a greater flexural strength than the obtained in the common hydraulic concrete. If such resistance is obtained it may be possible to carry out additional experimentation in which the quantities of cement or coarse and fine aggregates are reduced from the base design mixture of the polymeric concrete, to such an extent that it is possible to obtain the minimum resistance required for the concrete works as a high specification pavement (682.7 psi), bringing positive impacts on the environment by reducing the amount of cement in the material, without sacrificing its performance as pavement.

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Email classification using lemmatization and noun pattern recognition.

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Abstract— **The enormous amount of information sent via email is becoming almost unmanageable. Currently, thousands of emails are sent and received everyday by millions of users. Every email has by itself structure and meaning. However, all emails represent unstructured data. Perhaps, the ability to separate useful information from the rest has become a hard task. Nevertheless, processing text is an arduous task, it may result in a long-time activity. Hence, the importance of using a technique that involves the minimum quantity of variables to analyze but at the same time they must be significant.**

In this work lemmatization is used to determinate the lemma of a word based on its intentional meaning. Thus, using the lemma of a word in text classification may help the performance in the search by allowing to use only that part of the word instead of the entire term.

Keywords— *lemmatization, e-mail classification, NLTK, pattern recognition, data mining.*

I. INTRODUCTION

Data on the internet is growing in a way that it's becoming almost uncontrollable and unstructured, due to millions of users around the world with several devices. And a part of this data comes in form of an email.

More challenges are created for dealing with the amount of information on the web, while it continues growing quickly, and so do the inexperienced users. [6]

Email has become a crucial tool in many schools or companies and one of the most economical and quickest forms of communication. People are drowning in information contained in emails. They have to dedicate a significant part of their time to read all that it's received. Moreover, they have to separate it in categories like spam (a representation of misuse of this tool) and what it's significant. Subsequently, inside the category of significant, they must create subcategories to assign criteria of what it's more urgent to get reviewed or what represents important information to store. This is time consuming and human dependent. It tends to be "completely manual and somewhat haphazard" [4], this is hard to maintain and subjective.

Another common problem is phishing [2]. A variation on the word fishing, as bait is thrown out with the intention that a user "bites" it; phishing is unsolicited, fraudulent and potentially harmful email, especially threatening for ecommerce. [2]

Text meaningful classification represents a big challenge, due to the fact that it exists a large amount of data and several number of features embedded, and it gets difficult whether to read an e-mail. "Key phrases have shown to improve system efficiency and accuracy". [12]

In this specific case, in an email only a low percentage of all features may be useful for classifying text. Furthermore, using all the features maybe counterproductive since it can affect the performance.

In this paper, we discuss which feature selection process will be formulated for identifying the most relevant words influencing the content of the information in the text of an email. Only text will be analyzed, leaving features like tables or images out of the scope of this paper.

II. RELATED WORK

Different approaches have already classified information. In [1] four classifiers are compared: Neural Network, SVM, Naïve Bayesian and J48, they were tested to filter spam from a dataset of emails, where results concluded that Neural Network and SVM didn't show good results compared with J48 or Naïve Bayesian classifier, because these algorithms were not appropriate to make binary decision. And J48, a simple C4.5 decision tree for classification, gives a binary decision tree, providing a better result for classification or spam filtering.

The Feature Extraction *approach* uses the original feature and the converts it to a more compact new one. Hence, all the original features are converted and reduced, containing meaningful information. [2]

In [3] a domain knowledge is used to extract keywords. The results showed that domain knowledge utilization improves the performance and accuracy of keywords. [3] It uses TextRank, inspired by PageRank launched by Google, it's an unsupervised ranking algorithm and graph-based. It makes a network of words from a text, and every edge linking two elements references a relationship between those words. The rank of a word is determined by the importance of its neighbors.

Thus, improving the performance of keyword extraction takes advantage of the domain knowledge, since every word is semantically related with each other. Meaning that if a candidate word never appears in the domain, it will be discarded. Their results showed that domain knowledge improves the keyword extraction, but it is not perfect, especially in areas such as petroleum and mathematics. In their opinion, the advantage of domain knowledge relies on coverage and quality of known keywords.

Maybe one of the most important projects is found in [6], the founders of Google created PageRank. It is based in the measure of its citation, as they said that it corresponds with the subjective people's idea of importance. Another subjective consideration was that a page's PageRank could be even higher if many pages considered important were pointing at it.

When PageRank was launched (1998), a total of 26 million web pages could be computed in a few hours in a medium size computer. Today, it is considerably faster.

In [7] experimented with speech recognition and used the term frequency, inverse document frequency (TFIDF) algorithm to analyze the information and it also made an insertion of POS (part of speech) material to improve the exactitude of their results.

They concluded that a simple unsupervised TFIDF executes reasonably well, and that adding information from POS helped to extract more precise keywords. One observation they had about the things that may influence the precision of the analysis was the difference between the consideration of the actual speech and the human transcriptions.

People were included as part of giving they own classification. Users rejected a between 2% and 5% more the computer-made categories. But even so, the acceptance in general was good. [7]

In [8] they found out that startup companies needed to manage a large number of daily emails, as it was the principal via of communication of their employees and customers.

Sometimes employees wanted to consult specific data and the number of emails increased with time. The owners needed applications to manage this situation, and software for such task was available but the cost was high and not affordable for a startup company.

So, in [7] employees were asked to define the main classifications for them, such as: Sales, agent, Shipping, Customs, Billing, Packing and Moving and Insurance. After this step, 12,465 were selected randomly and 1260 used as training data. Separating the words and eliminating those with no meaningful impact, like 'not', 'thanks' or 'regards'.

According to [7], its approach had a good level of accuracy, showing some problems to consider like: some emails could not be categorized because of the acceptable criteria and some words may represent more than one category.

Next, in [11] worked on a binary text classification project, they tried to categorize spam and ham or phishing and spam. In other words, malicious emails from others.

The basic objective of [11] was to reduce the dimensions of the original space so it'd be easier to examine but also conserve the most significant part of the data. In this work, the authors compared several feature selection methods with content-based statistical feature extraction for e-mail classification. Techniques such as PCA (Principal Component Analysis), BDA (biased discriminant analysis) and ANMM (Average Neighborhood Margin Maximization). They were proven useful to classify e-mail. The results showed good binary classification, and above all BDA, which showed better results, under the ROC (Receiving Operating Characteristic) area.

Finally in [12] presented a procedure for extracting keyphrases automatically from documents named B&C. This system scores the keyphrases according to their frequency and length to determine their importance in the text.

The rest of this paper is organized as follows: In section 3, the algorithm is presented and described, while section 4 contains the results and finally section 5 the conclusions.

III. THE ALGORITHM

III. 1 ALGORITHM DESCRIPTION

Keywords, consisting of one single word or several words, may encapsulate topics and ideas of an e-mail. Furthermore, keywords help us find information from a massif amount of data.

TFIDF weighting is used to obtain the keywords. Finding the words that appear more repeatedly in an e-mail, but not necessarily in all the inbox files. Effectiveness of TFIDF is been proven before [7].

Regardless of the enormous growth of the web, its content has become commercial. Hence, its value is considered extraordinary and the separation of wanted and unwanted information becomes harder and harder.

Usually, an e-mail has two main sections: the header and the body. The header covers general information about the subject of the message in the body, data about the sender and receiver. And the body gets the message.

The original words are transformed into new reduced but meaningful ones and becoming a smaller representative term. Like this, the input data is converted into a reduced representation of the word.

The data set is obtained from a Gmail account with approximately 30 emails with text on them. Then the e-mails are categorized with the words from the feature selection. Using only the top 5 found categories, since the users "are still only willing to look at the first few tens of results." [6]. So, more accurate tools are needed to retrieve the most relevant information in the top results of a search.

Table 1 shows the analysis of each email individually:

word	Notification	Account	Operation	Credit	Card
Repetition number	4	2	2	2	2

Table 1 Analysis of individual email

The type of e-mails considered for this paper, the body contains plain text. In this work a separation between header and body is not pondered. All the information is taken as a whole.

The extracted words are obtained by using lemmatization and parsing. The parsing process is in charge of getting the features from the e-mail and the lemmatization. This stage reduces inflected (or derived) words. The words with no meaningful importance are removed, in fact, only nouns are

considered for the classifier. Selecting from keyword candidates is contemplated as a ranking problem.

The goal of this classifier, as an alternative, is to have data in a shorter and more representative way. Reducing the complexity of handling many variables in the classification process originating in an increase of the process speed.

The hypothesis of this paper is that nouns are more likely to be meaningful. So, the search of words and their frequency is limited to nouns and their lemmas. Considering that the lemmas represent words that are similar in terms of semantic value. For example, taking the words Notification and notification, when lemmatizing stage is over, only the word Notification is chosen to represent both words, so no time and effort is expend in both when it can be appreciated that the email intention is to notify something.

When a text is short, the term frequency may not be as highly reliable. However, the unsupervised approach is much simpler than other methods and does not require any sophisticated modeling to get significant results.

In this project, the Natural Language Toolkit (NLTK) was used. It is a Python tool with a GPL open source license. Recently, it has become a popular instrument in research. [5]

The University of Pennsylvania developed NLTK in 2001, with three purposes in mind: demonstrations, assignments and projects. [5]

The flow of the algorithm is explained in the figure 1.
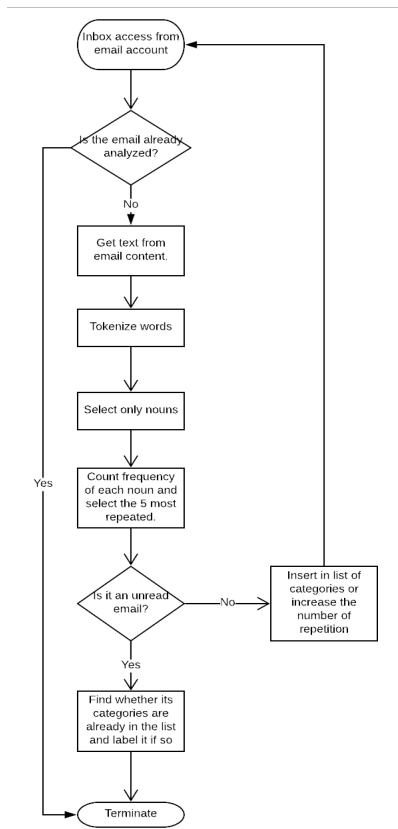
Figure 1: Flow chart of the proposed algorithm

III.2 Algorithm implementation

Python was chosen because of its syntax and its good string-handling functionality.

A. These are the steps followed by the classifier algorithm.

- Tokenization: Used to label words according to their lexical function such as: Nouns or verbs. Using NLTK library. For a multi-word search, the situation is more complicated and the inaccuracies are more visible.
  The main module used to achieve this task was *nltk. tokenizer* to split the text into its fundamental parts.

- The words with no meaningful impact to the classifier are removed. In this case, only nouns are considered.

- Lemmatization is implemented to remove flexional endings from the nouns selected in the previous step.

- Finally, a matrix is created where a row is an e-mail and each column represents a term in the document, and each cell represents the number of appearances in all the top 5 categories of all the collection of documents.

IV. RESULTS

The results of the final analysis are shown in table 2:

Table 2 Final results

word	http	Notification	Account	Help	email
Repetition number	106	65	61	53	46

After analyzing all the emails, these were the top 5 categories selected by the classifier. Considering only the top 5 words selected by each email.

Each email contributed with its 5 most-repeated lemmas, and then the the sum of them all.

When a new email is received, it goes through the same process of lemmatizing and counting, but to tag it into the correct category, the software goes throughout the categories found in the training stage to find a match between its categories and the general categories.
The process is shown in figure 2:

Figure 2: Process to classify

While working in the project, many points to consider were found.

First, not necessarily the most relevant, in the step of tokenization, several inaccuracies were found. Some belong to the linguistic complexity of the natural language, in this

particular case: English. Phenomena such as verbs becoming noun or adjectives provoked mistakes, for example:

Helping others is great.
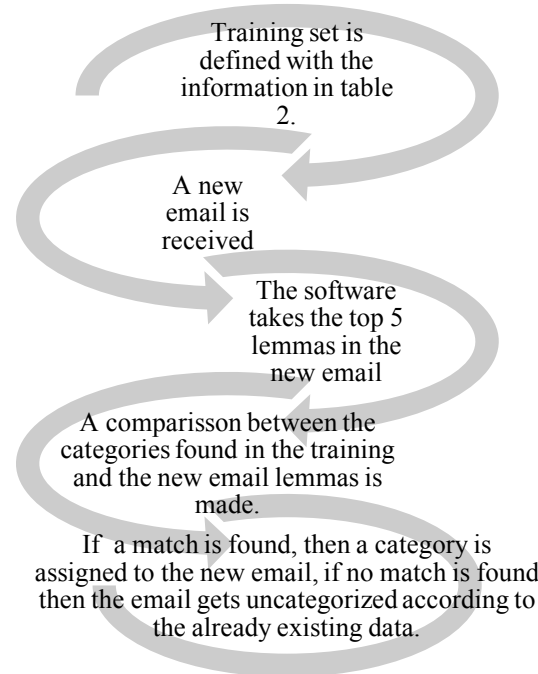
She is **helping** others.

In the example, the word *helping* is working as a noun while in the latter it's a verb conjugated in present continuous tense.

Another observation worth making is the composed nouns like *Credit Card*. Shown in table 1, the words credit and card were evaluated as separated entities while they belong to just one. That is a problem due to all the complex words found in the English language and the inaccuracy that this may cause.

Interpreting the final results, the word *http* is the most repeated one in the whole examination. It seems odd, but manually reading some of the emails to find a possible answer: chain messages were found, where a URL started with *http* was in it several times and also it appeared in the signature of some enterprises.

Particularly, this represents an issue because the word *http* does not give the clarity of what the emails are about, and the purpose of the classification gets lost, since the category doesn't really represent something clear to the user.

Another thing to consider is that the process is completely attached to the completeness of the *NLTK,* meaning that it depends on its content and how it is structured. While the algorithm should work universally, another set of tools or corpora may perform better or worse results.

Nonetheless, the project was developed simple but expressive, trying to innovate the linguistic elements considered to verify that it can improve classification methods in the field of Natural Language Processing (NLP).

V. CONCLUSIONS

When evaluating the results, it is observed that this technique gives a good label for each classification using the minimum of information. While others may give more accurate and detailed results but they also need more features to evaluate. It denotes an advantage because analyzing a big data set may take a lot of time if more features are considered.

The method doesn't have the sophistication of others, it's rather simple. Nevertheless, it proposes the use of lemmatization which is a feature not used before in these classification techniques and it may offer a new option to consider when selecting the features to analyze.

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Comparison of urban expansion models

An analysis of the methodologies created to predict the expansion of a city

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Abstract— **This research compares the different methodologies that have been developed to model the expansion of a city, evaluating first the variables that sustain the models. Other factors to take into account are the combination of different models and theories to form a final model, the modeling software and the results obtained by each methodology. A comparative table of the different methodologies was carried out and a more complete methodology was proposed in the form of a conclusion that contemplates variables that are intimately linked to the phenomenon of urban growth, specifically those related to a city of medium size and rapid growth in Mexico.**

Keywords—urban expansion; GIS; urbanization; cellular automata; land usage; dynamic simulation analysis; models

I. Introduction

The world population increasingly lives in urban areas; in Mexico it is not the exception, where the migration from the countryside to the city or from small cities to larger cities has caused the growth of large cities, reaching some, enormous proportions that exceed the limits of municipal and state political division [8].

The uncontrolled growth that almost always occurs, involves challenges in terms of provision of services such as public transport, housing, employment and care for the environment. This has led to the study of urban growth in the discipline of modeling. Most methodologies simulate land use change and urban expansion over time, to predict a pattern of change and be part of basic urban development planning systems for the future [7][11][18].

The majority of models aim to understand the continuity of the historical development of an urban agglomeration, predict its future evolution, simulate its condition of expansion and find its advantages and disadvantages. However, there are differences among them, mainly in the variables that interact directly as factors of urban growth, in addition, in most of the methodologies, explanatory variables are not taken into account that by their use could be estimated more realistic results.

The results obtained by some researchers regarding urban growth models are shown below, which compares the different methodologies created to predict urban expansion, as well as other studies that have been conducted to model the expansion of urban development. Subsequently, a comparative conclusion is created to evaluate the similarities and differences between the methodologies and indicate which would be the best to use in a specific case in Mexico; also, suggest explanatory variables that help improve the selected methodology.

II. State of the Art

According to the reference [3], the study of urban growth finds new challenges every day due to the environmental, social, economic and cultural impacts that the urbanization processes comprise. The simulation of future urban spatial patterns can provide knowledge of how our cities develop under multiple social, economic and environmental conditions [4]. Different models have been used to simulate different types of urban and development forms, as well as to investigate the evolution of the urban spatial structure over time.

From the table I, it is possible to indicate that the models made to simulate the growth of a city involve precision techniques and use geographic information systems (GIS) to work the models and show the results. Regarding the methods used, the main ones are the Cellular Automata and Dynamic Simulation, each author makes use of them in a unitary way or mixes them with some other tools or methods. Regarding the variables, which are commonly used is land use and historical data on urban growth, depending on the study approach, other variables are used. The results always show a tendency to the growth of the urban sprawl and predict the potential for growth.

TABLE I. RECENT STUDIES ON URBAN EXPANSION MODELING

Reference	Description of the study
[1]	They developed a model based on a binomial logistic framework to predict urban growth in terms of land use change.
[13]	They investigated the application of urban growth models based on cellular automata in urban areas of developing countries. They used Clarke UGM software and its variables were historical growth, transportation, digital elevation model and protection areas.
[12]	He developed the weighted scenario method using the analytical hierarchical process method to simulate urban expansion using distributed cellular automata models, which generated maps of urbanization potential.
[16]	They used global and local logistic regressions to model urban expansion with variables of land use and historical growth.
[20]	Using a cellular automata approach, they created a model of urban development, based on the theory of urban growth and integrates logistic regression and MoonLoop to obtain quantities. They used local sensitivity analysis to evaluate the performance of the model.
[2]	In their study they mixed cellular automaton with geographic information systems to generate simulations and realistic predictions of informal settlements in the context of unplanned areas.
[15]	They proposed a model of urban expansion called simulation model of urban growth patterns. They used the cellular automaton model and the discrete selection model, in addition to the Monte Carlo method.
[21]	It proposes the dynamic analysis of simulation based on the theories and methods relevant to the spatial analysis of urban agglomerations. It used geographic information systems to dynamically simulate urban expansion.
[9]	They created a model to predict the future expansion of an urban area for target years through a simulation using geographic information systems, automaton cell and Markov chain. Its main variable was the change in land use.
[19]	They proposed a model of urban expansion to capture the relation of the evolutionary process between the propagation of the population and the development of roads. They used the cellular automaton model with the road network variables and the random exploration factor.
[5]	They implemented a spatial distribution model based on the cellular automaton, focusing on the relationship between the economic performance of commercial corridors and the expected urban growth.
[6]	Using an integrated modeling approach based on the Markov chain, logistic regression and cellular automata, they studied the dynamic changes in land use. Its variables were the use of land and the demand for public transport.
[10]	They created an urban growth model with the help of SLEUTH software and using the cellular automaton model. Their data were satellite images covering 21 years of information and the results were compared with other methods using the type of land use.
[14]	They used the model of cellular automaton with the help of heuristic rules and data by pixel to model the urban expansion, its main variable was the density of urbanization.
[17]	They linked a model of a cellular automaton with a flood modeling tool called openLISEM to generate scenarios of changes in land cover and generate ordering policies. Its response variable was the percentage of urbanized area.

The models commonly used to model urban growth are Cellular Automata and Dynamic Simulation. The first one is essentially a rule of temporal evolution on a discrete set, where given a point of this set, a rule that associates another point of the set is presented. The second is a process in which we work with the dynamics, agents and central processes of the system necessary for the construction of the model, which is fed with data and factors, making each parameter clearly sustainable, which allows us to make a qualified and concrete weighting of the variables and factors.

The use of Cellular Automata coupled with a geographic information system creates great adaptability to various situations of urban growth. In particular, it is possible to realistically represent the spatial complexity and dynamics of urban growth change by adapting the configurations of the basic elements of the models.

The dynamic simulation analysis aims to understand the continuity of the historical development of an urban agglomeration, predict its future evolution, simulate its condition of expansion and find its advantages and disadvantages. This method can include current and historical development situations, as well as anticipate future development trends and simulate degrees of expansion in various directions of the urban agglomeration.

The most widely used variables are the use of land, density of urbanization, influence of roads and historical growth data.

III. CONCLUSIONS

About models, the one that could best explain the urban growth of a city in Mexico is Dynamic Simulation, because its main function is to model in time and in the directions that are requested, in addition to admitting a greater number of variables and does not need auxiliary methods. Moreover, it is easier to model with the help of a Geographic Information System (GIS).

Cellular automaton is a more austere and conservative method, in addition to its complexity to handle it. It also makes necessary the use of other theories and models to reinforce it.

The variables that should be included in a model that explains urban growth in Mexico should be those that directly interact in the phenomenon and that studies already conducted in other parts of the world have not been taken into account. Some of the ideal variables to use together are the use of land, modes of transport, distance to work centers, transport modes, topography, population, roads, and other factors.

The dynamic simulation model can be used as a tool in spatial plans and development strategies, as well as in policies

for the reform of urban agglomerations in developing countries, especially in Mexico, where most of its cities show disorderly growth. On the other hand, the dynamic simulation analysis can provide methodological support for the study of the metropolitan area. The model, data and methods described can be useful references for the investigation of urban agglomerations in Mexico and Latin America.

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From process to user-centered desing

A development perspective.

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Abstract. - Often the product developers experience difficulties to identify and understand the sensitive factors; Therefore, this paper exposes the relationship between the design process and the user experience which has its origin in the execution of the design tools, starting from the analysis that shows the behavior of the developer immersed in the process, based on in-depth interviews with professionals in design and innovation. Also arguing the need for the creation of tools that serve as support in the development of projects which have as a starting point qualitative variables of an emotional nature.

Key Words: user, experience, process, developer, design.

I. INTRODUCTION

The traditional methods lead the designer to obtain a list of requirements (non-formal linguistic), but do not provide a clear path to formal synthesis. [1]. The lack of tools to analyze the emotional factors of the experience on the interaction between user and product, give subjective validations and little support. These factors influence the perception of the user on the added value of the product, service or process; causing that the products derived from the design processes do not completely match the aspirations and expectations of the user, leading to the development of experience without emotional sense, which has an impact on the user.

As the degree of human collaboration required in the development of a project increases, also increase the need to formulate working methods that will facilitate such collaboration as much as possible and help to interpret into a single language the data and proposals that come from the different areas of design [2].

For being a synthesis of multiple factors, this process must be flexible and holistic, [3] referring to the latter as a design vision focused not only on the consideration of human aspects and their needs but also on the environmental and technological aspects that surround the user [4], derived from this is "User-centered design". The general term used to describe the design in which the user influences the final result, being at the same time, a philosophy and a process; This philosophy, has a strategic orientation, which places the person at the centre with the intention of developing a product adapted to their needs and requirements.

II. LITERATURE REVIEW

The importance of the method consists in the fact that it is endowed with cognitive properties that allow for an orderly approach to a part of reality and that it depends on the cognitive subject how useful it can be in achieving what, through research work, it is possible to clarify what was previously unknown. The application of the method does not depend on itself, but on the subject, who, in his or her opinion, chooses the object of study, selects the system of concepts to be worked on and structures the way in which the research is to be carried out. [5].

A key element in the user experience is to consider the affective and emotional aspects, i.e. taking into account the emotions that users experience when using a system, and getting systems to recognize, understand and express opinions. [6]. User experience can take advantage of emotions to improve design [7].

The theory of Emotional Design proposed by Donald Norman [7], is where emotions support a user's decision making

allowing for greater learning and problem solving about objects as well as interaction with different mental processes in relation to consciousness and work [8].Within the processes of interaction, users will experience three psychological levels, visceral, behavioral and reflective.

- Visceral: appearance, an automatic layer of genetically determined dispositional systems, is the ability to react.

- Behavioral: pleasure and effectiveness of use, the part that contains the cerebral processes that control daily behavior.

- Reflective: self-image, memories, personal satisfaction, the contemplative part of the brain, being the home of reflection [7].

The experience culminates or is consummated when the individual finds a meaning to the situation lived if it is induced or accidental. At that moment, at the end or consummation of one experience, another one begins immediately, thus weaving continuous chains of tiny experiences. [9].

A clear example of the design tools created under the statutes of User-Centered Design is the "Human Centered Design" proposed by IDEO It establishes a practical and repeatable approach to innovative solutions; A step-by-step guide to unleashing creativity, putting people at the centre of the design process to arrive at new answers to difficult problems, is divided into three main parts Listen, Create and Deliver.

- Listen: During the Listen stage, the design team will collect stories, anecdotes and elements of inspiration. They will need to prepare for the research and guidance of the fieldwork [10].

- Create: the team will work on an exercise whose purpose will be to compile what has been observed in people to put it in theoretical frameworks, opportunities, solutions and prototypes. During this phase they will move from concrete thinking to more abstract thinking in identifying issues and opportunities, and then back to concrete through solutions and prototypes. [10].

- Deliver: The stage in which they will begin to realize solutions through a financial model of revenues and costs, capacity assessment and implementation planning. This will help to launch new solutions in the world [10].

Emotional interaction in product design focuses on personal experiences and puts emotional elements into products, endowing products with the ability to communicate with people [11]. Obviously, more ecological insight is needed on the narratives between designers and clients as well as more

broadly on all types of projects, e.g. using case studies, in order to provide UCD practitioners with established strategies [12].

III. CONSIDERATIONS

Therefore, it was determined that the most appropriate way to develop projects on user experience is divided into three points. The first one (Fig 1) refers to the area where the problem is located, i.e. where the user intercepts the product; The user being the one who interacts with a set of elements, endowed with specific characteristics, as well as the execution of actions on the whole. It mentions that the product is a combination of tangible and intangible aspects with the capacity to be exchanged.

The second one (Fig.2) refers to the levels that the process of experience follows to induce an emotion. It begins with an impact on the user and that through interaction the user is exposed to developing an experience with respect to the product itself that is endowed with an awareness of sensitive events that, by bringing an impulse, establish the affective and sensitive faces.
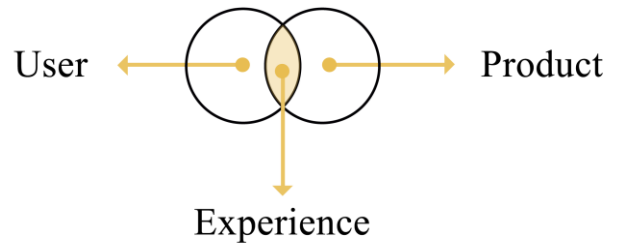

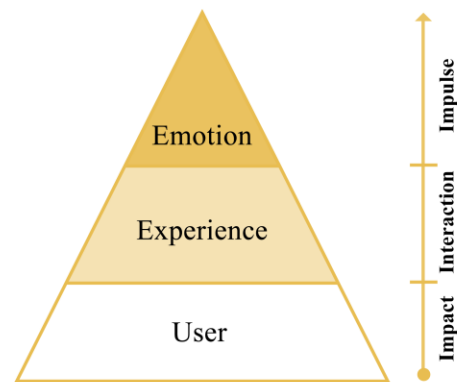Fig 1. User experience location diagram, source: self-created.

Fig.2. Levels of evolution for the user experience, source: own elaboration.

Finally, point three, according to the observation of the user experience process, refers to the creation of a proposal as a design tool for the analysis and study of the consumer experience regarding a product, with the objective of providing to developers with an efficient and simple way to validate their products from a holistic point of view, which allows for a quantitative evaluation of those parameters. This method must comply with established quality requirements and critiques.

However, it is necessary first to understand the needs and expectations of developers with respect to design processes, in order to generate value propositions that allow them to meet the proposed objectives. According to the above, an approach to the user (developer) was made, with the intention of detecting the difficulties presented in the implementation of design tools for the development of projects, as well as the analysis of the developer's behavior in the execution of projects.

IV. METHODOLOGY

As a guide for the project, it was considered pertinent to make use of the HCD which allows a greater approach to the problem. The "Human Centered Design" methodology provokes a real approach to the user, putting him/her in the center of the research, enough to know the aspirations and needs, this methodology gives the developer an intuitive and replicable process for the application in different types of projects.

For the analysis of the experimental subject in this stage, the "Focus Group" technique was used, which serves as a guide for "Card sorting" activities for the collection and analysis of information within the research topic. This activity was developed using cards (post-it) placed according to the criteria of each developer; each card contained steps from different methodologies such as the scientific method, double diamond, human-centered design. In order to understand the process of analysis and deduction of the developer to provide a solution to a design problem, which consists of 3 main stages, it was necessary to identify the critical points that generate conflict at the time of carrying out a process. Once the focus group was concluded and based on the observations made, the "Journey Map" [10] graphically identify the user's behavior with respect to the design processes.

The focus group was carried out with a sample of men and women between 25 and 60 years of age, gender indistinct, corresponding to teachers and professionals within the Faculty of Engineering of the "Universidad Autónoma de Querétaro" involved in the different areas of design. This analysis was conducted in a semi-informal environment in a classroom, at a neutral time, weather conditions are irrelevant in the application of the study.

Also, a format was developed that served as a guide for the development of the activity, for the correct application of the same.

Parts descriptions:

- Participants: 1 Moderator, 1 Analyst, 6 participants (men and women aged 25 to 60).

- Main subject: Knowledge of the designer's analysis and deduction process to provide a solution to a specific problem, which consists of 3 main stages. It will be necessary to identify the critical points that generate conflict when carrying out a process.

- Moderator Profile: It must remain neutral in the face of the contributions of the participants, able to direct and coordinate the corresponding activities in a fluid manner, as well as the control of time between each activity.

- Analyst's profile: Capacity for synthesis and abstraction of concepts, observer of details and with the capacity to recover information.

- Activities: three activities and one conclusion by the focus group.

Activity 1 (knowledge of the designer's analysis and deduction process) 20 minutes.

Objective: to know how they carry out the process to solve a specific problem, which consists of 3 main stages: 1st Stage, 2nd Stage, 3rd Stage

Description: to propose the actions to follow within the creative process for the solution of a problem.

Instructions: on the established space the necessary actions (post it) should be ordered to reach an objective and assertive result. The group should agree to give the order, once sorted the options (post it green) may add steps that they think necessary (colored post it).

Activity 2 (knowledge of the designer's analysis and deduction process) 15 min.

Objective: to observe the capacity of synthesis of professionals within the creative processes.

Instructions: according to the order proposed by the group, a synthesis of the steps will be made in two stages, at each stage 5 steps will be removed that the group considers not very relevant.

Activity 3 (knowledge of the designer's analysis and deduction process) 15 min.

Objective: is to identify the critical or conflicting points when carrying out a problem-solving process.

Instructions: write down (colored post it) those critical points or difficulties you experience when carrying out a design process.

V.   RESULTS

It was necessary to know first-hand the implementation of design processes by the developers, as well as their behavior, which are described below in three main activities:

Activity 1

Objective: to know how they carry out the process to solve a specific problem, which consists of 3 main stages: 1st Stage, 2nd Stage, 3rd Stage

Activity 2

Objective: to observe the capacity of synthesis of professionals within the creative processes.

Activity 3

Objective: is to identify the critical or conflicting points when carrying out a problem-solving process.

Knowledge of the analysis and deduction process	Stages of the Process			
	Stage 1	Stage 2	Link	Stage 3
Order of elements in a design process.	Problem Define problem Research Collection of data Define user Emotions	Data Analysis Measure Research Methods Understand Synthesis Hypothesis Ideas Emotions	Materials Technology Experiment Prototypes Define	Interaction Doing Emotions Implementation Validate Delivery Accept Improvement

Table 1. The proposal made by participants of focus group, source: own realization.

Knowledge of the analysis and deduction process	Stages of the Process (First simplification process)			
	Stage 1	Stage 2	Link	Stage 3
Order of elements in a design process.	Problem Research Collection of data Define User emotion	Data analysis Research Methods Synthesis Hypothesis Ideas	Materials Technology Experiment Prototypes Define	Interaction Implementation Validate Delivery Accept Improvement

Table 2. The outcome of the group for the first simplification process

Knowledge of the analysis and deduction process	Stages of the Process (First simplification process)			
	Stage 1	Stage 2	Link	Stage 3
Order of elements in a design process.	Problem Collection of data User Name	Data analysis Research Methods Ideas	Experiment Prototyping	Implementation Delivery

Table 3. Group result for the second simplification process.

Difficulties during the process	Stages of the Process			
	Stage 1	Stage 2	Link	Stage 3
Elements of the stages of the creative process.	Define problem Define the scope Coordinate	Coordinate Time Resources Method selection	Empathy Emotion	Metrics and instruments

Table 4. Difficulties in the analysis of the processes detected by the focus group.

Journey Map

The present tool used a Likert slave from 1 to 5 being 1 as bad and 5 as excellent. It can be observed that the behavior of the screwdriver starts with a "good" behavior at the beginning of the project development, (ZMOT). However it decreases in the first moment of truth (FMOT) at the moment of arriving at the prototyping stage where its behavior becomes "regular" due to the complexity that represents the stage, the behaviour continues to decrease in the second moment of truth (SMOT) when the validation process is reached with a "bad" scale due to the problems of carrying out a qualitative or quantitative validation that allows us to determine the reliability or success of the design to be implemented. (Fig 3).
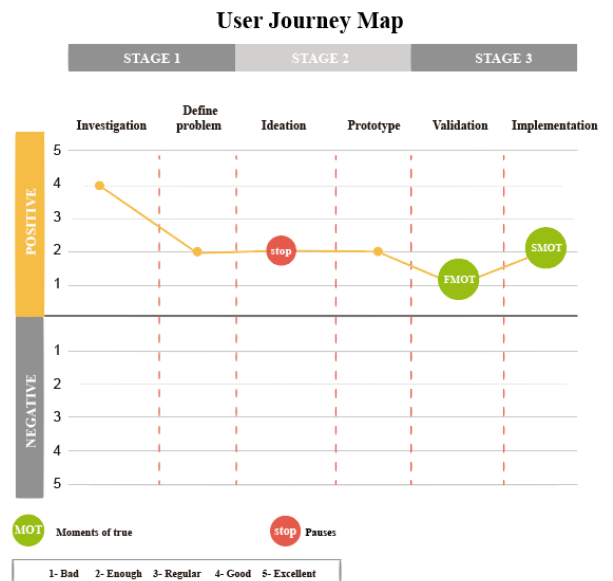

Fig. 3. Journey User Map, source: self-created.

VI. DISCUSSION

Within the insights, the group experiences problems in the selection of methods according to the information. While two common characteristics were detected, the first one refers to the difficulties in the application of measurement instruments concerning qualitative variables, the second characteristic defines that an efficient process is divided into three main stages of development with links between each part.

VII. CONCLUSION

The results obtained promotes that the efficiency of a process includes concrete tools with a reduced number of steps; It incorporates them into their creative processes according to the needs of the project; This allows the knowledge of the process of analysis and deduction of the designer to give solution to a specific problem, emphasizing that the developer has also become the user, a user of the processes; This will have an impact on the generation of proposals that match the needs and aspirations of the final user, which in turn may be able to generate a satisfactory user experience. So it is imperative to consider the development of new tools that have as their main objective not only the solution of problems but also to have the main characteristic of being an effective support for their implementation.

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Image processing algorithm for detection of aquatic macroinvertebrates

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Abstract— **Pollution in aquatic ecosystems has significant impact on the ecology and on the health of people living in the surrounding areas. Detection of aquatic macroinvertebrates is useful to determine the water quality, depending on the species found in the study area. This article presents a methodology for the detection of aquatic macroinvertebrates using an image processing algorithm. The algorithm was programmed in Matlab software, no toolboxes where used. The results show a percentage of success of 97.8% when detecting an insect sample. The images were taken with a Dino-Lite camera and the samples were taken from lakes and rivers from the province of Michoacán.**

Keywords—Insect; Recognition; Identification; Moments of Hu; Images; Euclidean distance; Processing.

I. INTRODUCTION

Rivers represent an essential component of our natural and cultural heritage. But, they have suffered an important ecological deterioration since the middle of the last century, mainly due to the regulation of the flows, the channeling of rivers, the occupation of the riverbanks, agriculture, industry and urbanization. As a result of this deterioration, 80% of the world population is currently affected by the degradation of rivers [1].

Polluting waste alters the ecological status of rivers, lakes, aquifers and seas. The contamination of drinking water sources and aquatic ecosystems is a problem that today greatly harms all ecosystems. These contaminants can be physical, chemical or biological. Alterations in ecosystems are reflected in damage to the condition and functioning of their biotic communities (a set of species of plants, animals and other organisms that occupy a certain area) [2]. For this reason, this problem has been studied since the twentieth century, reaching the conclusion that aquatic biota changes their functioning by modifying the environmental conditions of their natural habitats.

So, it is possible to use some characteristics or structural and functional properties of the different levels of biological organization to evaluate in a comparative way the state of the aquatic biota, whose condition is a reflection of the ecological state of the water body. These evaluation characteristics are known by the generic name of bioindicators [3].

Bioindicators are a good method to assess the quality of the environment of these systems and to determine other types of impacts. These indicators use family or gender as an identification level, so they are low cost, efficient and easy to use. Aquatic macroinvertebrates are those aquatic invertebrates with a size greater than 500μm. Aquatic macroinvertebrates are ideal for use as a bioindicator due to the following characteristics [4]:

- They are abundant, widely distributed and easy to collect.

- Relatively easy to identify visually.
- Chemicals are not required to be detected.
- They are sedentary mostly and reflect local conditions.
- They have long life cycles.
- They can be grown in laboratories.
- They respond quickly to environmental tensors.

Knowing this information about the bioindicators and the aquatic macroinvertebrates, it is planned to use the digital image processing for the detection of these insects, since their wide utility in the detection and classification of objects has been demonstrated. This detection is possible because certain characteristics of insects can be known, such as their shape and size. By detecting and classifying the insects, this information can be used for a method of quantifying biotic integrity and with which the conditions of the ecological state of the water in which the samples are found can be determined.

The identification of these macroinvertebrates will be done using the image processing, because this method speeds up the identification and classification times, in addition to allowing the processing of large amounts of images in minutes. This is done because there are several programs and tools for the processing of digital images and it is a widely used programming language.

The purpose of the system that is created is to identify and classify macroinvertebrate species that can be used as bioindicators and thus use this information for its use in the biotic integrity index.

II. MATERIALS AND METHODS

2.1 MATERIALS

2.1.1 Experimental insects.

The insects used for these experiments were provided from the School of Biology of the Universidad Michoacana de San Nicolás de Hidalgo. These insects are native to the river and lake areas of Michoacán.

We used 3 different species of insects, which are: *Dixella*, *Gyrinus* and *Rhagovelia*.

Fig. 1. Gyrinus.
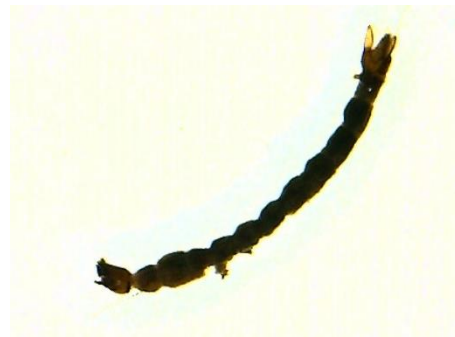

Fig. 2. Rhagovelia.

Fig. 3. Dixella.

2.1.2 Image acquisition equipment.

For the capture of images, a Digital Microscope Dino-Lite litter was used, it has a 10x-200x cabling, 8 LED lighting, 640x480 JPEG / BMP image captures and it is

compatible with Windows systems and iOS systems [5].

Fig. 4. Camera Dino-Lite AM-311ST.

2.1.3 Digitals Images.

An image can be defined as a function, $f(x, y)$, where x and y are spatial coordinates (plane), and the amplitude of any coordinate pair (x, y) is called the intensity or gray level of the image at that point. When x, y and the amplitude values of f are all finite, discrete quantities, the image is called as a digital image. A digital image is composed of a finite number of elements, each of which has a particular location and value. These elements are referred to as pixels and image elements [6].

2.2 METHODS

2.2.1 Image Processing.

The image processing aims to improve the appearance of the images and make more evident in them certain details that you want to be noticed. For this, there are several tools or techniques that allow to obtain certain information of the pixels that the image contains.
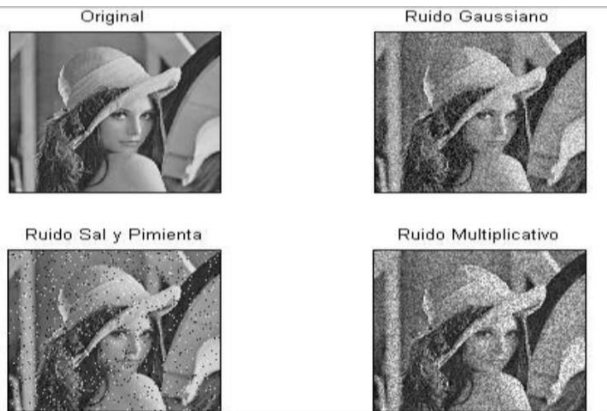
Fig. 5. Image with different types of noise.

As shown in Fig. 5, you can have different types of noise that prevents you from having detailed information about the image, because if the image is not better, the information obtained would be incorrect.

2.2.2 Image Filtering.

Filtering is a technique to improve an image, this filter can highlight or attenuate certain characteristics [7]. Because noise is an undesired characteristic, and since this is a variation on the levels of the image, it corresponds to high frequencies. Since noise is a signal that is added to the original signal (image), the gray level of a pixel can be defined as the sum of the ideal gray level ($f1$) and noise (r):

$$f(x, y) = f1(x, y) + r(x, y) \qquad (1)$$

2.2.3 Image binarization.

The binarization of an image consists of comparing the gray levels present in the image with a predetermined value (threshold). If the level of gray in the image is smaller than the value of the predetermined threshold, the value of 0 (black) is assigned to the pixel of the binarized image; and if it is greater it is assigned the value of 1 (white).In this way a black and white image is obtained, which in general, most image recognition techniques are worked with binarized images.

Fig. 6. Binarized image.

2.2.4 Object recognitions.

This step is fundamental for the processing of images, mainly because this is the strongest part of the programming and which will help us obtaining information useful to recognize and classify objects.

For this the characteristics of an object (circular, spherical, square) can be quantified by moments, which

describe the way in which the pixels of an object are distributed on the plane of an image.

2.2.5 Moments of Hu.

The moments must be invariant (similar values for objects of the same type) to the geometrical transformations (translation, rotation and scaling) to which the objects are subjected when analyzed. These values with fundamentals to recognize objects more easily, since they can be compared with the moments of Hu of another object, with this data it can be known by the difference between the values of the moments of Hu if an object is similar or very different from another object. [8].

The moments of Hu are invariants before the aforementioned transformations and are defined in the following relations; in this case the 7 standard moments of the method were used so that the system was more precise when identifying an object and making comparisons with the moments obtained from another object [9]:

$$\emptyset_1 = \mu_{20} + \mu_{02} \tag{2}$$

$$\emptyset_2 = (\mu_{20} - \mu_{02})^2 + 4\mu_{11} \tag{3}$$

$$\emptyset_3 = (\mu_{30} - 3\mu_{12})^2 + (3\mu_{21} - \mu_{03})^2 \tag{4}$$

$$\emptyset_4 = (\mu_{30} + \mu_{12})^2 + (\mu_{21} + \mu_{03})^2 \tag{5}$$

$$\emptyset_5 = (\mu_{30} - 3\mu_{12})(\mu_{30} - \mu_{12})[(\mu_{30} + \mu_{12})^2 - 3(\mu_{12} + \mu_{03})^2] + (3\mu_{21} - \mu_{03})(\mu_{21} + \mu_{03})[3(\mu_{30} - 3\mu_{12})^2 - (\mu_{12} + \mu_{03})^2] \tag{6}$$

$$\emptyset_6 = (\mu_{20} - \mu_{02})[(\mu_{30} + \mu_{12})^2 - (\mu_{21} + \mu_{03})^2] + 4\mu_{11}(\mu_{30} + \mu_{12})(\mu_{21} + \mu_{03}) \tag{7}$$

$$\emptyset_7 = (3\mu_{21} - \mu_{03})(\mu_{30} + \mu_{12})[(\mu_{30} + \mu_{12})^2 - 3(\mu_{12} + \mu_{03})^2] + (3\mu_{12} - \mu_{03})(\mu_{21} + \mu_{03})[3(\mu_{30} - \mu_{12})^2 - (\mu_{12} + \mu_{03})^2] \tag{8}$$

2.2.6 Sphericity.

Sphericity is a descriptor of form, or morphology, which describes the deviation of a non-spherical particle from a spherical, because all these factors must be in a range of 0 to 1, with 1 being the value assigned to particles completely spherical; in this way it is possible to obtain the percentage of sphericity of a particle through the analysis of 2D images, the equation to calculate the sphericity is the following [10]:

$$S = \frac{4\pi A}{P^2} \tag{9}$$

2.2.7 Classification of objects.

The method of Euclidean distance for the separation of classes is useful when we have different classes of objects, and they must be differentiated from one another. This method tells us that the information of an image is stored in a plane and the classification is based on the fact that the analyzed object is compared with already established information of an object. So, the identification of the object would depend on the smaller distance that is obtained in comparison of the values of the object and of the standard values.
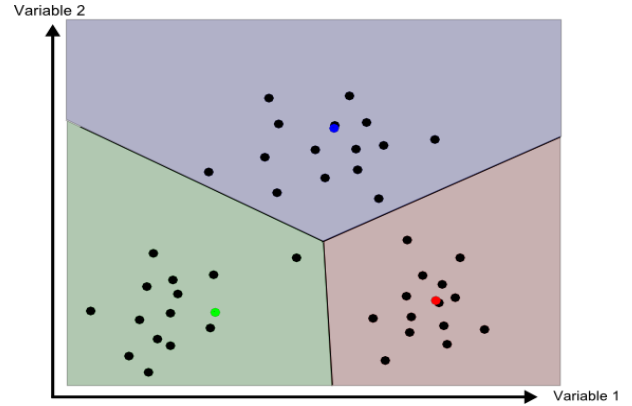
Fig. 7. Method of classification by Euclidean distance.

The equation to determine this distance is shown below:

$$d_{i,j} = \sqrt{\sum_{v=1}^{n}(x_{vi} - x_{vj})^2} \tag{10}$$

2.3 METHODOLOGY

1.- The database was created taking several images to the insects that were used to perform the tests. In the case of the insect *Gyrinus* 20 images were taken because the 3 insects are very similar, from the insect *Rhagovelia* 33 images were taken because each insect is different from each other and finally from the insect *Dixella* 17 images were taken since only one is counted with a single sample of that species.

2.- All the images were submitted to the pre-processing to ensure that there is no noise in the image and affects the results, this pre-processing is the filtering of the image, and the binarization of the image.

3.- By having the binarized image, the methods of the moments of Hu and the sphericity are used in each of the images. These values are stored in a matrix.

4.- Having this data, the Euclidean distance method is used to classify each image with a species of insect from the database, this procedure is done to detect a single insect.

5.- The previous steps are repeated but now with images where they contain more than one insect sample of the same species to train the system in the recognition and classification of an insect species.

6.- Finally the steps are repeated but now with the three samples of insects in a single image.

III. RESULTS

The aim of this article is to be able to identify the 3 species of insects using a programming algorithm in Matlab software. In these tests the first step is to have the database of different photographs of each of the species. Being a total of 70 images for training the system in which each species of insect was identified separately.

Then 10 images were taken with 3 insects of the species Gyrinus and another 10 images with 3 insects of the species Rhagovelia to make tests in the recognition of a single species of insect. Finally, another 10 images were taken with the 7 insects of the 3 different species for the final tests.

3.1 Pre-processing of images.

Once that we have the database of all the images, we start with the image pre-processing. It consists in applying a filter to the image to eliminate noise that affects the image and then binarize it and continue with the recognition of objects. This pre-processing must be done in each image that is in the database to ensure that they have noise when binarizing the image.

Fig. 9. Binarized Rhagovelia image.
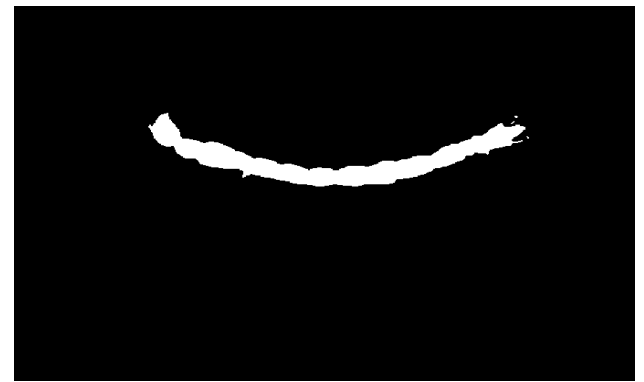
Fig. 10. Binarized Dixella image.

When we have all the binarized images, we are ready to use the moments of Hu and sphericity to get the average values of all the values. In Table 1 all the average values of the moments of Hu and sphericity of the images of each species are shown. These values are used to identify each of the species, as shown in Fig. 11 and Fig. 12. The samples are classified with the method of the Euclidean distance with the name of the insect species to which it belongs.

Fig. 8. Binarized Gyrinus image.

Insect	Table 1. Moments of Hu							
	∑ Hu1	∑ Hu2	∑ Hu3	∑ Hu4	∑ Hu5	∑ Hu6	∑ Hu7	∑ Sphericity
Gyrinus	0.1939	0.0112	5.653 e-5	5.5174e-6	1.7318e-10	5.7106e-6	7.3311e-6	0.4358
Rhagovelia	0.3247	0.0118	0.0017	2.418e-4	1.1164e-7	1.7327e-5	3.0271e-4	0.0456
Dixella	1.2798	1.4388	0.3244	0.0453	-0.0038	-0.0376	0.0379	0.1782
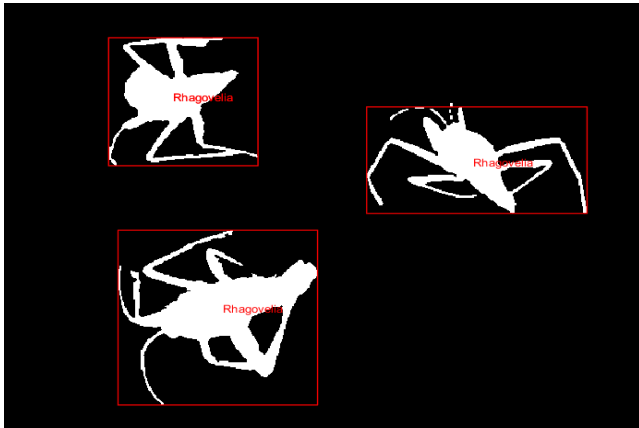
Fig. 11. Identification of Rhagovelia.

Fig. 13. Identification of species.

When verifying that the system works by identifying 2 species, detection and classification tests were carried out with all the samples of the 3 species (7 insects) with which the tests were carried out. As shown in Fig. 14 with green color, the species *Gyrinus* is identified and labeled, in the same way with the red color the species *Rhagovelia* is identified and with blue color the species *Dixella*.

Fig. 12. Identification of objects of the same species.
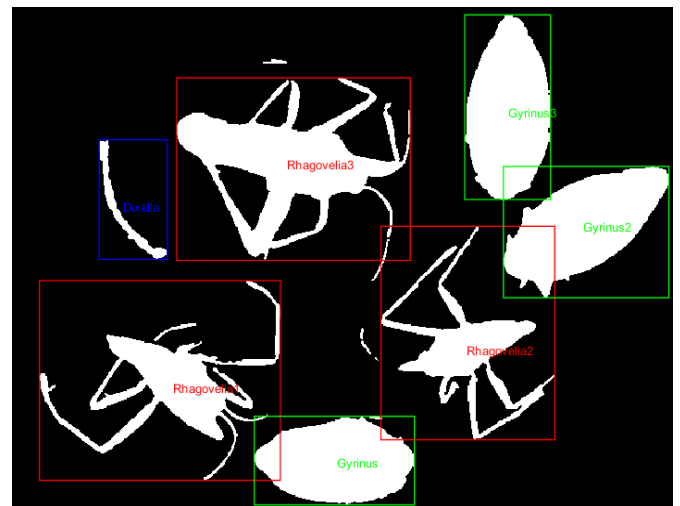
Fig. 14. Identification of the 3 species.

The tests to identify the species *Gyrinus* was 20 tests, 17 tests for *Dixella* and 33 tests for *Rhagovelia*, these tests were made by the number of images that were taken of each species of insect. The percentages of hits by species individually are shown in Fig. 15.

After having trained the system to recognize each of the species, we tried to identify in a single image each of the insects that are in the image. As shown in Fig. 13 with the moments of Hu and the Euclidean distance classification, it was possible to identify and classify 2 species in one image.

Fig. 15. Percentage of hits by species.

In the tests carried out, it was found that in the *Gyrinus* species I detected the 3 samples as in the *Dixella* species, whereas in the *Rhagovelia* species, an error of 3.04% was observed because the 3 samples were very different from each other, which it did not happen in the other species.

Finally, for the last test where the 3 different species are identified, 10 photographs were taken. As shown in Fig. 16, the system showed 92.85% success when identifying the 3 insects and 96.22% when identifying between 2 different species. This error is caused by the error that occurs when identifying the species *Rhagovelia*, where some cases cannot identify a sample because they are different.
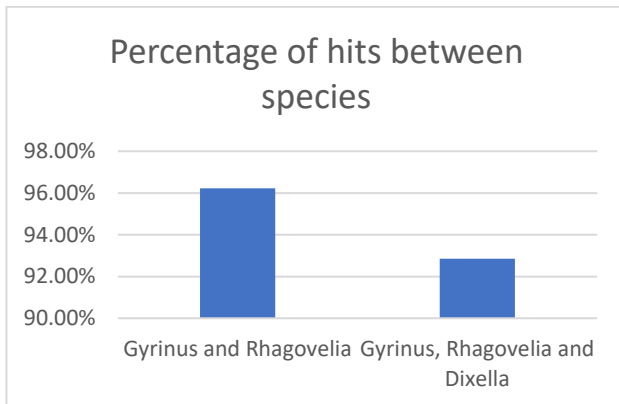
Fig. 16. Percentage of hits between species.

IV. CONCLUSIONS.

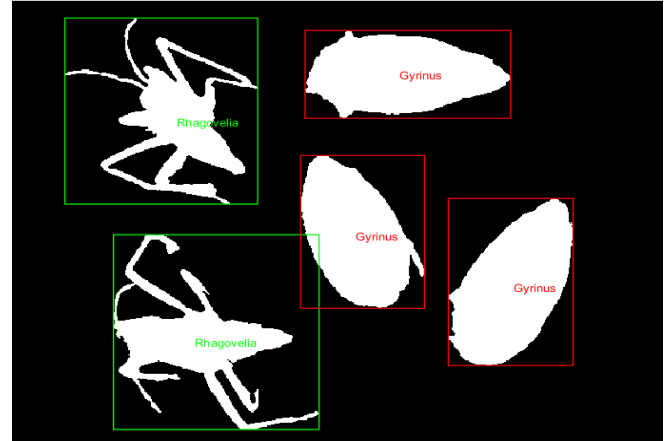This article presents a methodology that successfully detects aquatic macroinvertebrates using an image processing algorithm. The algorithm was programmed in Matlab software, no toolboxes where used. This article reports results with 3 different species. These results have high levels of certainty (91.6% for three different species and 95.3% for two different species) are. This confirms that the moments of Hu, as well as the classification method are useful tools for detecting insects. The error obtained may be due to having more than one object in the same image, what maybe alters the values of the moments of Hu; however it is still a useful method.

Future work will be done with an approximately 10 different species. Moments of Hu will be used again, but it would be necessary to add another descriptor to improve the recognition of objects. It might be necessary to use another method of classification of objects because, if there are insects of the same dimensions or characteristics, the Euclidean distance method can fail to find very similar distances between these species. In general, the data obtained indicates that it is still necessary to tune details, as well as to use other methods of recognition to improve the efficiency of the classification.

V. ACKNOWLEDGMENT

VI. REFERENCES.

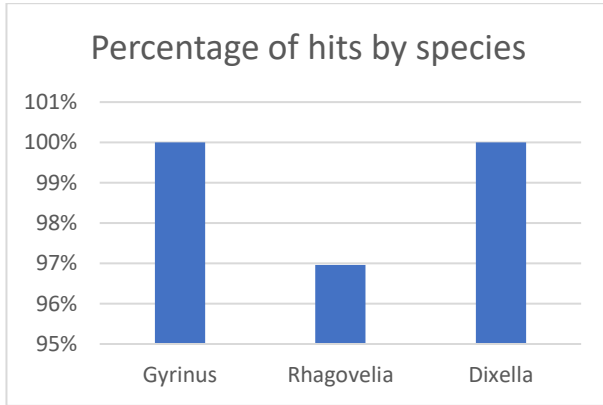[1] Ladrera, R., Rieradevall, M., & Prat, N. (2013). Macroinvertebrados acuáticos como indicadores biológicos: una herramienta didáctica. Ikastorratza. E-Revista de Didáctica I, 1-18.

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Modeling of humidity in clothes drying machines by means of a pattern detection algorithm.

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Abstract— **This article presents a novel methodology to describe relative humidity in clothes drying machines (CDM). This methodology is carried out by implementing a pattern detection algorithm, with this it is possible to predict humidity levels in ranges where a conventional sensor is not able to give a reliable measurement. By obtaining reliable humidity levels, it is possible to reduce the drying cycles and thus obtain an energy saving as well as making a more efficient drying, avoiding damaging the clothes by over drying them, or leaving them still wet. It is necessary to obtain a relation between the relative humidity (which is the one found in the environment) as well as the humidity that is found in the tissue of the clothes (that is, the amount of water impregnated clothes have) to obtain more favorable results in drying. This relationship is important since the variable that really matters is monitoring the humidity that is in the clothes and not in the environment. This last one is the one usually measured by the sensors. Finally, materials, tools and platforms used for the development of the algorithm are presented, as well as simulated tests where the efficiency of the algorithm for the prediction of humidity in the dryers is demonstrated.**

Keywords— Clothes care, Energy saving, Mathematical models, Relative Humidity, Relative Humidity in Clothes.

I. INTRODUCTION

The increase in the use of clothes dryer's machines (CDM) in homes has increased in recent years, resulting also in an increasing of the development of new methods and technologies to make CDM more efficient. Generally, an RH sensor is not able to measure or interpret humidity correctly in low ranges, this is where mathematical tools help to correct these problems. The implementation of complex mathematical models (based on thermodynamics) or models that require different types of variables to make the description and modeling of humidity. These models depending on the application or the implementation that is required can be moderately viable [1]. You can also implement simpler models that are easier to implement and require less computer work, especially when you plan to implement these models in microcontrollers.

This article focuses on describing and modeling the behavior and tendency of moisture in CDM. To achieve this, it is necessary to understand what humidity is and that there are diverse types of humidity based on where you want to measure it. Humidity can be defined, according to the Royal Spanish Academy (RAE) [2], as: "The amount of water, water vapor or any other liquid that is present on the surface, or inside a body, or in the air". Starting from the previous definition different terms are derived, for example: absolute humidity or relative humidity, to say some. The relative humidity (RH) on which this article focuses, is defined according to the RAE [2] as: "A percentage expression on the amount of water vapor present in

the air with respect to the maximum possible of the amount of water vapor present in the air with respect to the maximum possible for given conditions of pressure and temperature". However, RH is not the objective humidity to be controlled. There is another type of relative humidity called relative humidity in clothes or RMC (it is called RMC by its abbreviations in English Relative Moisture Clothes). The RMC humidity represents the amount of water that really wants to be controlled, as this is the amount of moisture that the clothes contain within their tissues. However, the conventional, or more typically used sensors, do not measure RMC but rather the RH. Therefore, from here the importance of obtaining a relationship, based on the measurements of RH, that allows forecasting at what time RMC has reached suitable levels for a good drying of clothes [3].

In the CDM, generally, two types of humidity are measured, RMC and RH. The mathematical equations to determine the amount of moisture RMC and RH are (1)[3] and (2)[4].

$$RMC = \left(\frac{Current\ Weight\ of\ Clothes\ (Kg)}{Weight\ of\ Dry\ Clothes\ (Kg)} - 1\right) * 100 \quad (1)$$

$$RH = \frac{Water\ Vapor\ Present}{Saturated\ Water\ Vapor} * 100 \quad (2)$$

Although these equations are easy to calculate, the tools that are needed for measure the input variables are not viable to be applied in domestic CDM, at least not in a practical way. It is not feasible to implement or equip a CDM with a weighing system that will present calibration problems over time, or damage the weight measuring cells due to the vibrations generated by the CDM.

A. Patterm Detection Method

The recognition of patterns is the science that deals with the processes on engineering, computing and mathematics related to physical or abstract objects, with the purpose of extracting information that allows establishing properties between sets of said objects. Pattern recognition consists of identification of signals. The patterns are obtained from the processes of segmentation; extraction of characteristics; and description, where each object is represented by a collection of descriptors. The recognition system must assign to each object its category or class (set of entities that share some characteristics that differentiates them from the rest). To recognize the patterns, the following processes are followed:

- Data acquisition.

- Feature extraction

- Decision making.

The essential point of pattern recognition is classification: you want to classify a signal depending on its characteristics. The

signs, characteristics and classes can be represented in diverse ways [5].

B. Patterns Clasification.

There are two general classification techniques, supervised and unsupervised. A supervised classification is presented when the user defines the decision rules for each class directly or provide a data training (prototype classes) for each class with the aim of guiding the classification process. An unsupervised classification process is presented if no prior training is required and if the user needs to specify the number of classes [3].

C. General Procedure in the Classification of Patterns.

- Establish a classification scheme. Determine the classes in which the pattern will be labeled. The characteristics must be appropriate according to the type of objects to be classified and include background classes that can be confused with the target classes.

- Select the characteristics that will be used in the classification. Redundant or ineffective data is eliminated.

- Determine the parameters required for the classifier. Use the training data to estimate the parameters required by the classification algorithm.

- Execute the classification. Evaluate the discriminant functions and label the patterns according to the decision rules, to subsequently make the necessary adjustment determined by the training algorithm of the classifier. Evaluate the results. Use test data to evaluate the accuracy of the classification [6].

II. MATERIALS AND METHODS

This section presents all the methodology to be followed as well as the materials used during the development of the algorithm, all based on the pattern recognition methodology that was previously explained. In order to generate the algorithm, it was necessary to make a relation, or some indicative, that would allow relating the values of the RH with respect to the RMC. To achieve this, the RMC trend information was obtained and adjusted versus the RH trend (all this information was obtained based on data previously obtained from CDM). Finally, the reported relationship was achieved through mathematical equations as characteristic polynomials generated with their trend lines.

A. Materials.

The materials used for the development of this methodology in terms of hardware were:

- An Arduino Due Card.

- A computer.

The Arduino Due card, it has a microcontroller with a 32 bits architecture that is the same architecture that the CMD normally contain. for the development of this work did not need the use of a sensor since the data that was analyzed and with which it worked had already been previously obtained. This article does not focus on the characterization or control of the sensor used because it is not listed in the materials used or sensor characteristics are mentioned. Regarding the obtaining of humidity RMC was obtained by means of the use of a scale, but it is necessary to clarify that these data of the humidity RMC already had been previously obtained along with the RH for that reason in this article it does not deepen in this area. The used software was:

- Microsoft Office Excel.
- MATLAB.
- Arduino IDE.

The data, as well as the graphs, were analyzed and observed in Excel, while the mathematical polynomials and some digital filtering were carried out in MATLAB. Finally, the algorithm that was tested was implements by using the Arduino IDE.

B. Methodology.

The steps that were followed during the development of the project are:.

1) According to the data that had been previously acquired from the CMD, the most relevant data were taken for their study and exported to Microsoft Excel for analysis. These data are: Time, RH and RMC.

2) Once the RH data of the 2, 7 and 12 lbs. Loads of clothes were exported to Microsoft Excel, they were plotted, as well as their respective RMC, in order to analyze if there was a relationship between the RH and the RMC.

3) With the information obtained when processing all the information and analyzing the graphs of the behavior of the RH and RMC in Microsoft Excel, the relevant information of the RH and RMC was extracted and exported to MATLAB.

4) In MATLAB the information was processed to generate the mathematical models, this stage was one of the most important because here the adjustment was made so that the crossing point between the RH generated by the mathematical model and the CMR obtained from the CMD coincided in the range between 3.7% to 3.3% of both humidities. That is, when the RMC is between 3.7% to 3.3% the RH described by the model is between 3.7% to 3.3% and to the contrary. This point is explained in more detail in the results section.

5) With the models obtained from MATLAB they were transferred to Microsoft Excel where they were re-plotted and it was compared that the points of intersection between the modeled RH and the CMR of the CMD were the same within the range of 3.7% to 3.3%.

6) Once verified that the models were correct in the Arduino IDE, these models were programmed based on the pattern detection methodology.

7) The pattern detection algorithm was programmed based on the literature discussed in the introduction section, based on a supervised pattern classification.

8) Finally, the code was tested by performing two types of simulations.

9) The first simulations were done manually, that means that the data that had been acquired from the sensor were entered randomly along with the manual sampling time.

10) Subsequently, a simulation was carried out. This is closer to the real application. A real time base was programmed, and the sensor data was randomly entered. The procedure that was established to carry out the simulations were as follows: take 50 samples of the sensor during the first 5 minutes after these samplings, the system will determinate the load of clothes and determine now the required humidity levels have been reached 3.7% to 3.3% on average. The last is determined by the models obtained from the general equation (3). These models help to determine the RH in acceptable ranges in terms of the RMC.

III. RESULTS

The tests carried out were for diverse types of clothing loads of 2, 7 and 12 pounds with 9 repetitions each, analyzing a total of 27 loads. The data describing the behavior of the RH were previously acquired by a RH sensor. These data were isolated and plotted to observe the behavior of RH. Fig. 1 shows the RH average behavior obtained and the RMC average by the sensor and bascule in drying cycles for loads of 2 pounds clothes.

Fig. 1. Trend of RH average and RMC average during drying cycles for loads of 2 lb.

Looking at Fig. 1, we can see that the humidity measurement tends to stabilize at around 30% RH, even though the drying cycle has ended. This tendency cannot be taken as valid because at the end of the cycle the RMC is in acceptable ranges where it can be considered the clothes are dry (between 3.7% to 3.4%), and not in 30% as the RH sensor indicated.
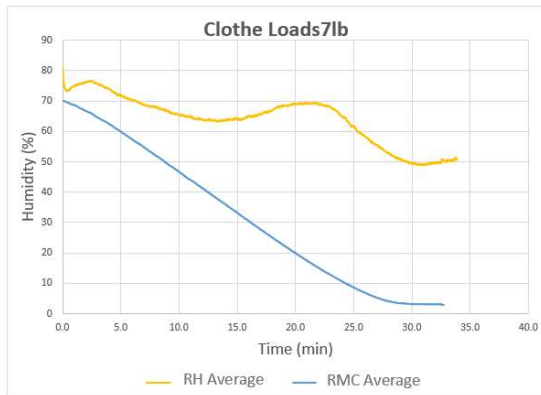
Fig. 2. Trend of Humidity RH Average and RMC average during a drying cycle for a load of 7 lb.

The humidity RH behavior in Fig. 2 again shows tendencies to be stable in the end and fluctuates very little during de drying cycle. We can observe how it remains in a range between 50% to 80% of RH. Is not throws us relevant information to be able to determine at what moment the clothes are in RMC levels, where the clothes can be considered as dry (ranges between 3.7% to 3.4%). In Fig. 3 we can notice that even though the moisture decreases, at the end of the cycle the humidity is still very high compared to the humidity RMC.

Fig. 3. Trend of Humidity RH average and RMC average during a drying cycle for a load of 12 lb.

Table 1. presents concentrated information of the most relevant data such as the average RH and RMC, and the average drying times for each type of load when the cycle was end.

Table. 1. Humidity percentages RH and RMC as well as the time of the drying cycle for the different loads of clothes.

Load clothes	RH average	RMC average	Time average
2 pounds	30%	3.1%	28 min.
7 pounds	50%	2.9%	33 min.
12 pounds	35%	2.3%	83 min.

From table 1. We summarize that more clothes to dry imply longer drying times. The RMC is always very similar and low, so it can be said that the clothes are dry in those levels. However, the RH does not present a tendency or characteristic for each type o load, and besides, it always present high values that do not seem to be related with RMC.

With the information obtained, based on the analysis of the graphical data and the information in table 1, it is found that an adjustment must be made in the RH so that it decreases and adjusts to the actual drying cycles times and to the RMC tendency. In order to obtain this adjustment, equations of the type shown in equation (3), generated in MATLAB, were drawn from the real trend of the RH obtained from the sensor. The polynomial form of equation (3) [7] is shown in a very general way, but this type of model allows using the information. But first, the trend of the information must be adjusted with MATLAB.

$$P(x) = a_n x^n + a_{n-1} x^{n-1} + \ldots + a_2 x^2 + a_1 x^1 \qquad (3)$$

In order to be able to make the adjustments of the humidity tendency by means of the model, it was necessary to truncate

In Fig. 4 we can see the result of the RH trend obtained by means of the model. We can see that the RH humidity level is 0% at 25 minutes. At this time, you have RMC of 3.7% average. At this percentage we can consider that the clothes are dry. By comparing the drying time of 25 minutes versus the 28 minutes for the 2 pounds loads, there is a difference of 3 minutes. With this it can be concluded that a reduction of the drying cycle of 3 minutes would be obtained.

Next, the graphs in Fig. 4, Fig. 5 and Fig. 6 show the trend of modeled RH humidity. Recall that in the methodology section in point 4 spoke of adjusting the humidity RH with respect to moisture RMC. It is in this section that the adjustment of the modeled RH and the RMC can be seen with greater clarity so that both humidities coincide in a range between 3.7% and 3.4% humidity.
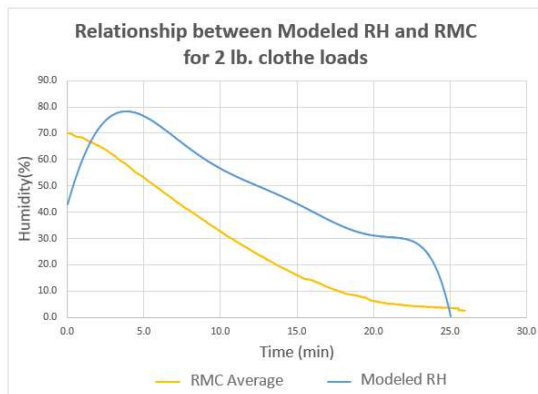
Fig. 4. Relationship between modeled RH and RMC 2 lb. loads.

Fig. 5. Relationship between modeled RH and RMC 7 lb. loads.
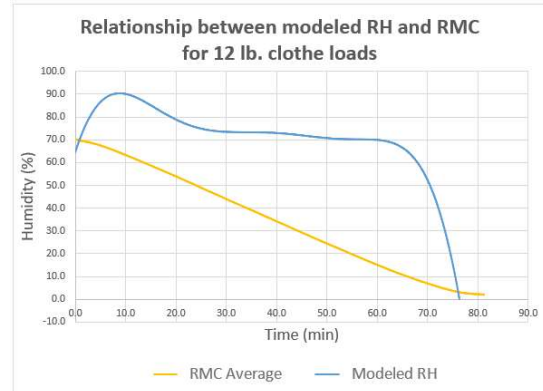
Fig. 6. Relationship between modeled RH and RMC 12 lb. loads.

Fig. 5 and Fig. 6 show the moderated RH trends for the 7 and 12 pounds load, respectively. When the RH ranges reach percentages of 3.5% the drying cycle times are 27 and 76 minutes respectively. Having again reference to table 1 for these loads, there were 33 and 83 minutes times where the RMC was 2.9% and 2,3%. Whit this information we can say that there are reductions in the drying cycles of between 5 minutes for the 7 pounds load, and 7 minutes for the 12 pounds load. The way in which it can be verified that the humidity of 3.5% RH is equal and very similar to the RMC was by graphing both humidities and verifying the point where both humidities crossed. Such crossing point occurs in an average range of 3.7 to 3.3% RMC.

Once we had everything to begin the implementation of the algorithm, the models that were generated could be defined as the process of extraction of characteristics which will serve as reference to be able to recognize and classify the signal from the sensor.

With the above information and the models generated, the algorithm was programmed in the Arduino IDE based on the methodology of pattern detection with a supervised data classification. The results are shown below in the following images. As mentioned, two different simulation tests were done, the manual simulations section is shown below.

```
Carga de Ropa Detectada:
2 lb
Numero de muestra:
50.00
Descriptores 2.7.12 lb:
16
5
3
```

Fig. 7. Results of the first manual simulations for the 2 lb. load.

In Fig. 7 can see the results of the first simulations which have the detection of dynamic ranges. In Fig. 7 the interface of the serial monitor that integrates the IDE of Arduino is presented. Fig. 7 shows which load of clothes is detected. It was established a total of 50 samples for the recognition

process. Fig shows the result of the descriptors, and it can be appreciated that several descriptors obtained coincidences, however, the algorithm managed to correctly identify the load of clothes.

Another corroboration is shown in Fig. 8. Here data was entered from a different repetition of the same type of 2 pounds load. it is expected to determine the same load since the model is based on the average of all the repetitions that belong to the load of 2 pounds We can see that the proper load of clothing was re-sighted. Looking at the descriptors we can see that there are two that showed 10 matches and one of 12 matches. Despite of the near possible error, the system detected the load of clothes.

In Fig. 9 and Fig. 10, the results of the test made with data from two different drying cycles of the same 7 pounds laundry loads are shown. The results that were obtained were the expected algorithm achievement to properly interpret the data and correctly determine the loads of clothing. Regarding the descriptors, they were very varied because for a test there were 39 matches (Fig. 9) while de second test only 17 (Fig.10) matches were obtained. Likewise, not only was there this difference in the second test (Fig. 10) but also that, apart from the fact that the coincidences were less, other descriptors also showed similarities being close to each other.

```
Carga de Ropa Detectada:
2 lb
Numero de muestra:
50.00
Descriptores 2.7.12 lb:
12
10
10
```

Fig. 8. Results entering data from a different repetition for a load of 2 lb. laundry.

```
Carga de Ropa Detectada:
7 lb
Numero de muestra:
50.00
Descriptores 2.7.12 lb:
17
39
10
```

Fig. 9. Simulation results for a 7 lb. load of laundry.

```
Carga de Ropa Detectada:
7 lb
Numero de muestra:
50.00
Descriptores 2.7.12 lb:
11
17
10
```

Fig. 10. Simulated results from a different repetition for the same 7 lb. laundry load.

Fig 11 and Fig. 12 show the results of the simulation of two different drying cycles of the same laundry load of 12 pounds. The descriptors in this case are strong, that is, no other descriptor showed any coincidence in; however, if we compare, Fig. 11 shows 21 matches while Fig. 12 shows 17 matches. This difference is due to the fact that they are different repetitions and the sensor data is logical that they are not the same and vary and this is where this difference in the descriptors is reflected, even if it is the same load of clothes because it is a different repetition. Moisture behavior is not exactly the same and is reflected in the descriptor. This difference is considered to be within expected by the fluctuations of the sensor when measuring.

```
Carga de Ropa Detectada:
12 lb
Numero de muestra:
50.00
Descriptores 2.7.12 lb:
0
0
21
```

Fig. 11. Results for the simulation for a 12 lb. load of clothing.

```
Carga de Ropa Detectada:
12 lb
Numero de muestra:
50.00
Descriptores 2.7.12 lb:
0
0
17
```

Fig. 12. Results for the simulation of a different repetition for a 12 lb. load of clothes.

Finally, the results of the second type of simulation are shown, where the database was integrated into the program and more closely linked to reality. Fig. 13 represents the results of the simulation; observe that the interface is subtly different from the rest of the other simulations. A counter was added indicating how much time elapsed in the cycle. You can see that in minute 5 it detects the load. In this case the simulated data corresponded to a load of clothes of 12 pounds. From minute 5 the model starts to represent the humidity tendency when the system detects the humidity levels RH of the model marks the end of the cycle shows the percentage of

3.5% and finally tells us in what time the drying cycle would end in this case it was 76 minutes remembering Fig. 6, The RH model predicted that humidity within the range of 3.7% to 3.4% on average would be reached in 76 minutes, this was an estimate. With the simulation we can see that actually the cycle was completed in 76 minutes with this making comparisons of drying cycles duration in table 1, 5 minutes are saved in the cycle so it can be said that by reducing the cycle 5 minutes by inherencies one obtains an energy saving and when stopping the cycle within the suitable rank it is avoided to dry of plus the clothes and with this to damage it therefore it is also obtained a care of the clothes.

```
Numero de muestra
49.00
Tiempo (min) es:
4.90
Descriptores:
4
10
17
Carga de Ropa Detectada:
12 lb
Tiempo transcurrido (min):
5.10
Fin del ciclo Humedad RMC promedio del 3.5%
Ciclo terminado en:
76.00
Minutos
```

So, the results obtained demonstrate that the pattern detection method works properly to detect the loads of clothes that are drying. To determine how long the load cycle will take, it can be predicted from the model that describes the clothing.

IV. CONCLUSIONS

This article presents a novel methodology to describe relative humidity in clothes drying machines (CDM). This methodology is carried out by implementing a pattern detection algorithm; with this it is possible to predict humidity levels in ranges where a conventional sensor is not able to give a reliable measurement. Based on the results we can conclude that the applied methodology works properly during the total tests made (29 simulations in total). The system presented an average error of 9% at the time of detecting the laundry load. The error that the algorithm showed is not significant enough to conclude that the method is not viable. It was demonstrated, in the simulations, that the system can detect de clothes load in a lapse of 5 minutes on average. This time can be thought to be too long, but it is relatively low in comparison of the average time that the drying cycles last, more than 15 minutes. On the other hand, other advantages of using this methodology were, as we saw in Fig. 1. Fig. 2 and Fig. 3, that the behavior of RH does not offer us significant information to be able to determinate at what moment the laundry is considered dry.

With this algorithm we can determined at what time the laundry is in percentages that are dry, this is thanks to the implemented models that describe a moisture tendency based on the RMC. Finally, we can say, based on the results obtained, that the drying cycles are reduced on average 5 minutes. This time may seem small, but if we approach it from a broader long-term point of view, these 5 minutes become a considerable time. For example, if a household uses CDM 3 times a week doing 4 cycles for each time it uses CDM; it gives us a total of 12 cycles per week. If you save 5 minutes per week in each cycle you will save 60 minutes. a year, 624 cycles would be carried out on average, multiplying the 12 weekly cycles for the 52 weeks of the year. This year reflects a saving in time of 3120 minutes per year taking into account only one home. If we multiply it by hundreds of homes, the reflected energy savings take on significance. Therefore we can say that with this methodology we can save energy.

A. Future work

The results shown so far have been simulated; short-term future work includes taking these tests to a next step and making them experimental. That implies performing the drying cycles directly in a CDM and obtaining experimental results. Another work that remains to be done is the improvement of detection ranges and gives a deeper learning to the algorithm in order to make it more robust. It is expected to obtain an average error lower than 9%.

V. ACKNOWLEDGMENTS

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FUSION SURFACING

VARIABLES EFFECTS OVER CRACKING ON AEROSPACE NICKEL-BASE COMPONENTS

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Abstract—**Low pressure turbine blades suffer from wear and corrosion caused by the nature of the components function, as well as their interaction with some elements such as friction, pressure, temperature and environment.**

To prevent such wear, low pressure turbine blades are provided with coatings that help against several wear causes during engine functioning. In order to provide tribological properties to these components, a hardfacing process is used to add a friction resistant alloy to the blades' contact points. The most widely used process for this purpose in the aerospace industry is fusion surfacing by gas tungsten arc welding (GTAW).

One of the main production problems linked to this hardfacing method is hot cracking. Throughout this work, the variables voltage, welding current, gas flux and welding arc time are proposed for a design of experiments with the objective of finding the best combination of variable levels to reduce the metal cracking due to this hardfacing process.

Keywords—hardfacing; welding; blades; surfacing; GTAW

I. INTRODUCTION

Materials in aerospace components are essentially linked to several demands depending on the engine phase they are meant to be fabricated. On the other hand, fuel economy has also led aircraft manufacturers to search for materials and components that would help improve the engines performance [1].

Under this principle, the main elements that make up an aircraft engine are distributed as shown in figure 1. Being the titanium the main element used for fan and low pressure compressor structures; nickel for combustion chamber and low pressure turbine as well as aluminum and composite materials for external elements and the engine vessel.

Given the nature of the function of the low pressure turbine blades, a complex wear phenomenon is present and influenced by several factors such as environment, interaction between other components, temperature, friction and pressure among others. Turbine blades are subject to constant contact and friction between other blades, this is also known as tribosystem [2].
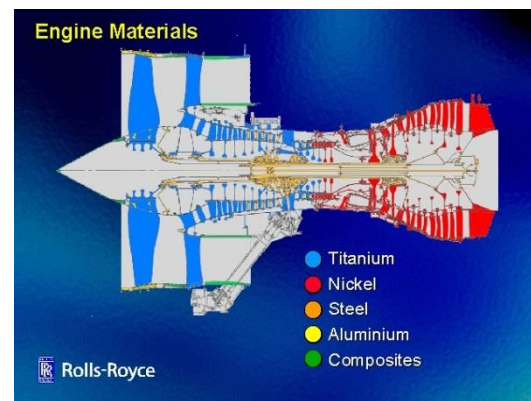
Fig. 1 Main elements in an aircraft engine [3].

In order to provide this blades with tribological properties as well as corrosion resistance, a welding hardfacing process is used (also known as 'fusion hardfacing'). This procedure is widely used in the aerospace industry due to its low cost compared to other hardfacing techniques such as thermal spraying [4].

There are different welding processes for hardfacing application like: Shielded Metal Arc Welding (SMAW), Gas Tungsten Arc Welding (GTAW), Oxyacetylene Welding (OAW), Plasma Transferred Arc Welding (PTAW) and Submerged Arc Welding (SAW). However, among this several methods of hardfacing application, it is Gas Tungsten Arc Welding (GTAW) and Plasma Transferred Arc Welding (PTAW) the ones that mainly fill the manufacturing of aerospace engine components [5]. GTAW has been extensively used for over half a century in the semiautomatic welding industry and later on the automatic welding of several alloys and metals of industrial application [6].

Cobalt based elements are the ones used the most for fusion hardfacing. This is due to their chemical intrinsic properties which turns them wear-resistant. Nonetheless, one of the main problems linked to this hardfacing methods is the cracking apparition, since as a result of welding contraction, the ductility of the hardfacing coating decreases and allows cracking growth [7].

The present paper is based on the determination of the variables that influence the most over the welding process as well as the levels that help the reduction of crack apparition on low pressure turbine blades.

II. PROJECT PLAN

Design of experiments is a statistical tool to help model a plan of trials based on the variables and value levels determined significant for the process under scope. Then, valid statistical analysis are carried out to resolve the variables and levels that best fit the hypothesis presented at the beginning of the experiment.

The present paper proposes an experimental design based on the literature of research within the field hereby developed, as well as the expected results. In order to perform the series of experiments, the next steps will be followed and later on be developed and explained:

A. Determine the process variables and levels to be considered for the experiments.

B. Define the materials and equipment to be used during the experimentation.

C. Define the research hypothesis.

D. Development of a design matrix.

A. Determine the process variables and levels

GTAW process has several factors that can be identified in most of the aerospace industry applications. Table 1 lists the main ones and shows their characteristics:

TABLE 1 GTAW MOST COMMON PARAMETERS.

Parameters	Comments
Electrode diameter	From 1.6mm to 3.2mm[a]
Protection gas	Inert gas (Argon and Helium most frequently used)
Welding current	Continuous variable, unit: Amperes
Electrode sharpening	Discrete variable, from 30° to 90° at 10° intervals
Pulsation frequency	Continuous variable, unit: Hertz
Welding velocity	Continuous variable, unit: mm/sec.
Protection gas flow	Continuous variable, unit: l/sec.

[a] Depending on the pistol specifications.

Previous to this experiment proposition, in 2014, Tsai *et al.* [7] used the GTAW technique to perform an experiment in order to demonstrate that a hammer peening process over the welding bead should help mitigate cracking propagation due to the welding procedure. For this experiment, they settled the process at a current of 140A and an advancement speed of 10 cm/min.

Later, in 2017, Saha and Mondal [8] stablished the parameters and levels shown in Table 2 for a Manual Metal Arc Welding (MMAW) procedure looking forward to optimize the technique by measuring the critical-to-quality factors: Bead width, weld reinforcement and bead hardness.

The next year, Venkatesh *et al.* [4] in the research of an improvement on the properties of cobalt-based hardfacing coatings against solid particles erosion, decided to perform an

experiment evaluating the influence of the GTAW process conditions by fixing as variables: Voltage, welding current, welding speed and protection gas flow as well as their respective value levels shown in Table 3.

TABLE 2 WELDING FACTORS AND LEVELS USED FOR MMAW CHARACTERISTICS OPTIMIZATION.

Factor	Low level	High level
Welding currant (A)	140	160
Arc voltage (V)	17	25
Welding speed (mm/min.)	20	60

TABLE 3 PARAMETERS AND EXPERIMENTAL LEVELS FOR PROPERTIES IMPROVEMENT AGAINST SOLID PARTICLES EROSION.

Factor	Values
Welding current (A)	70, 80 & 90
Arc voltage (V)	440
Welding speed (mm/sec.)	2.25, 2.75 & 3.00
Protecting gas (Argon) pressure (Kg/cm^2)	10

Using the previous experiments, it can be inferred that given the contribution of this experiences, the most important factors to take into account for this paper's work are: Welding current, arc voltage, welding speed and protection gas flow. Also, we have decided to add the factor "electrode sharpening angle" as it may have an important influence during the first fusion arc. The factors' levels were stablished based on the experience from an existing aerospace field industry. The factors and levels are shown in Table 4.

TABLE 4 EXPERIMENTAL FACTORS AND LEVELS.

Parameters	Level 1	Level 2
Welding current	20A	30A
Pulse frequency	100Hz	300Hz
Electrode sharpening angle	20°	60°
Protection gas flow	8 l/m	12 l/m
Time (sec.)	Low (<10sec)	High (>20sec)

B. Define the materials and equipment

The equipment and materials to be used for this experimentation process are defined as follows:

1) Gas Tungsten Arc Welding process: TransTIG 2200 Job by Fronius International.

   a) Protection gas: 99.9% purity Argon.

   b) Electrode material: Tungsten 2% Cerium.

2) Fluorescent Penetrant Inspection line: PROCECO 504.

   a) Penetrant liquid: RC65 Sensibility 3, Sherwin Williams.

   b) Hydrophilic emulsifier: ER83A, Sherwin Williams.

   c) Revealing powder: Dry powder D-90G, Sherwin Williams.

C. Research hypothesis

Nowadays, aerospace engine components manufacturers deal with high costs linked to process flaws that unfortunately cannot, in most cases, be detected before tests are performed. This is the case of turbine blades cracking due to fusion hardfacing processes. Turbine blades have to be weld, machined and passed through a thermal treatment before they can be inspected under UV light at the FPI control area to look for surface discontinuities and cracks. This path adds considerable value to the parts and when cracks are detected, in most cases, the part is rejected, causing a high cost loss in manufacturing facilities.

Given this facts, the project hypothesis can be developed as follows:

"By reducing and adjusting the variables welding current, pulse frequency, electrode sharpening angle and welding speed, the rejection rate due to welding cracking can be reduced to up to a 50% on low pressure turbine blades manufacturing".

D. Design of experiments matrix

A full factorial design was chosen to develop the experimental trials matrix so it includes all the variables and levels considered for this papers' work. Therefore, the experimental matrix is developed as shown in Table 5.

TABLE 5 FULL FACTORIAL EXPERIMENT DESIGN MATRIX

Trial	Current	Frequency	Angle	Flow	Time
1	20	100	20	8	Low
2	30	100	20	8	Low
3	20	300	20	8	Low
4	30	300	20	8	Low
5	20	100	60	8	Low
6	30	100	60	8	Low
7	20	300	60	8	Low
8	30	300	60	8	Low
9	20	100	20	12	Low
10	30	100	20	12	Low
11	20	300	20	12	Low
12	30	300	20	12	Low
13	20	100	60	12	Low
14	30	100	60	12	Low
15	20	300	60	12	Low
16	30	300	60	12	Low
17	20	100	20	8	High
18	30	100	20	8	High
19	20	300	20	8	High
20	30	300	20	8	High
21	20	100	60	8	High
22	30	100	60	8	High
23	20	300	60	8	High
24	30	300	60	8	High
25	20	100	20	12	High
26	30	100	20	12	High
27	20	300	20	12	High
28	30	300	20	12	High
29	20	100	60	12	High
30	30	100	60	12	High
31	20	300	60	12	High
32	30	300	60	12	High

3) Degreasing line: ELMA.

   a) Degreaser: ARDROX 6333A.

   b) Rising liquid: Deionized water.

III. EXPECTED RESULTS

After performing the experiments and the statistical analysis, it is expected to find that all parameters involved are significant so that a combination of levels can be proposed in order to achieve the objective presented within the research hypothesis. Also, as a complementary result, a mathematical model should be obtained expecting it to be significant enough so it can be considered as predictive. These results shall be applied in other aerospace manufacturing facilities managing GTAW processes.

ACKNOWLEDGMENT

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Synthesis of Micro and Nano-Sized Hydroxyapatite Fibers Through the Microwave Assisted Hydrothermal Method

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The synthesis of hydroxyapatite (HAp) fibers was performed using a microwave assisted hydrother- mal methodology. The actual reaction mixture was placed in a Teflon tube inside a microwave oven at 170 C and 80 bar. Polycrystalline hydroxyapatite nanofibers were obtained under these operat- ing conditions. The control on heating and cooling rates inside the reactor was critical as well as the use glutamic acid to guide the crystal growth. According to the results, the nanofibers showed a preferential crystalline orientation in the [300] but they grew in the [001] with high crystallinity and good purity. These nanofibers were closed packed inside hexagonal microfibers with a singular arrangement. Additionally, structural studies were done using X-ray diffraction by powders along with the chemical composition supported by infrared spectroscopy (FTIR) analyses. The morphol- ogy and microstructure characterization as well as crystalline features of the HAp nanocrystals were done through Scanning Electron Microscopy and High Resolution Electron Microscopy.

Keywords: Nanofibers, Hydroxyapatite, Biomaterials.

1. INTRODUCTION

The production of synthetic hydroxyapatite (HAp) ($Ca_{10}(PO_4)_6(OH)_2$) has become a classic for several research groups since it is considered as bioactive mate- rial. This compound has a chemical composition and struc- ture similar to that of the inorganic constituent of natural bone tissues.[1] Actually, the natural HAp is the main min- eral constituent of hard human tissues such as bones and teeth. The synthetic one, on the other hand, has excellent biocompatibility and bioactivity properties. Consequently, synthetic HAp has been extensively used in health-related fields as an implant material in the restoration of dam- aged bones or teeth.[2] Current additional uses of synthetic HAp are: piezoelectric material,[3–5] catalyst,[6–8] in water treatment[9–11] and others. All these applications make the Hap quite an interesting material.

Sol–gel methods of HAp synthesis recently published, in which the precursors are blended in solution (wet chemistry) and the chemical reaction takes place at room temperature for several days.[12–14] Other methods car- ried out HAp synthesis through solid state reactions.[15 16] Although these papers are important due to the reported experimental procedure for the HAp synthesis, most of these works make no emphasis on the control of morphol- ogy, size and structural parameters of the HAp aggregates.

Remarkable methods of HAp synthesis used different chemical substances as surfactants agents, amino acids or halogen salts to control structural nucleation and crys- tal growth that led to featured morphology of HAp assemblies.[17–20] Some of these methods use a hydrother- mal process in the synthesis reaction. The hydrothermal process has proved to be

effective for the HAp synthesis, the controlled heat supply in an aqueous solution produce steam which increases the pressure within the reactor and

as a consequence, the reaction rate can be increased. The use of this method has been improved due to low cost and simplicity to synthesize HAp in a large scale and high purity.[21–24]

The conventional hydrothermal method underwent a sig- nificant development when a microwave oven was used in the synthesis reaction of inorganic compounds. The microwaves provided the energy necessary to initiate the chemical reaction and they could be focused into the reac- tor in order to optimize the energy used. Nowadays, this method allows the obtaining of different materials with an excellent morphology control, size and preferential crys- tal orientation. Microwave-assisted hydrothermal method- ology has been successfully applied in synthesis of HAp nanostructures which present well-defined morphologies, high crystallinity and purity.[25–31] The structures more often obtained by this method are nanoparticles, nano-rods and nanofibers.

In this work, a microwave-assisted hydrothermal method was used to prepare micro and nano-sized hydroxyapatite fibers with a high crystallinity and good purity. Gradient- less operation conditions concerning pressure, tempera- ture and composition allowed to obtain controlled heating and cooling rates to produce micro and nanofibers with a preferential crystallographic orientation in the [300]. The arrangement of nanofibers closely packed inside the microfibers which have a well-defined hexagonal cross section area, is a particular morphology not reported

before in the literature. The careful control in the thermodynamic variables during the synthesis reaction along with the use of the glutamic acid to guide and control the crystal growth of HAp were the main factors to obtain such singular nano- fibers packets.

2. EXPERIMENTAL PROCEDURE

2.1. Synthesis of HAp Structures

The procedure currently used for the HAp fibers synthesis was similar to that reported elsewhere.[28] Initially, reactants are dissolved in tri-distilled water at 60 C with magnetic stirring for 2 hours in order to obtain two independent solutions; one containing glutamic acid $[C_5H_9NO_4 \cdot H_2O]$ and calcium nitrate $[Ca(NO_3)_2 \cdot 4H_2O]$ and the other con- taining monobasic potassium phosphate $[KH_2PO_4]$ mixed with potassium hydroxide $[KOH]$. Afterward, both solu- tions were mixed and a reacting mixture was made. The chemical composition in the reacting mixture was kept constant in order to obtain only fiber at the end of the chemical reaction. According to the commercial reagent composition and making a rough mass balance of the solu- tions, the amount of each component of the reaction mix- ture has been estimated and it is summarized on Table I.

The experimental set-up and actual reactor for the HAp synthesis were 8 plastic tubes (Teflon) placed within a microwave oven (Synthos 3000 by Anton Paar). The react- ing mixture was placed inside the plastic tube and almost

Table I. Calculated formulation of reacting mixtures. Reacting compounds in (g)

G	Ca	P	OH

2.178	0.858	0.729	0 .552
Notes: G = glutamic acid; Ca = Calcium Nitrate; P = Potassium phosphate and OH = potassium hydroxide.			

immediately the microwave oven was turned on which was considered as the initial reaction time. The power used in the oven was 1000 W. The heating rate was 7.5 C/min until 170 C which is considered being the actual reaction temperature. The final operating pressure reached 80 kPa and the reaction was kept for another 45 minutes for each experiment. It is important to consider that the heating and cooling rate were determined on the final morphology of the HAp nanostructures. Since there was no stirring, only diffusional and thermodynamic effects were the driv- ing forces for the HAp formation having the glutamic acid to guide the crystal growth. The white crystalline solid obtained from the reacting mixture was filtered and washed with cold 1:1 ethanol-water mixture and dried at 50 C in an oven with a slight vacuum.

2.2. Characterization of HAp Nanofibers

2.2.1. X-ray Diffraction (XRD)

In order to identify the crystalline components contained in the final product, XRD by powders was performed in all the samples obtained from the synthesis reactions. A diffractometer D8 Advance made by Bruker was used for the analyses and the operation conditions in the equip- ment were 35 kV of accelerating voltage and a current of 15 mA. The CuK radiation (wavelength of = 1 5406 Å) was used. All diffraction experiments were made from 10 through 90 on a 2 scale with a step size of 0.05 . Sample preparation was no required, all the samples were put inside the sample holder and no milling process was done. The last was made to determine pos- sible preferential crystallographic orientation in the HAp nanostructures.

2.2.2. Fourier Transform Infrared (FTIR)

All the experimental products were analyzed by FTIR to assure the presence of hydroxyapatite and to determine the existence of other mineral components. The samples were taken after the washing, filtration and drying processes, and then they were mixed separately with potassium bro- mide at a 1:10 ratio volume respectively. The analyses were carried out by using a Bruker Vector 33 spectropho- tometer with a 4 cm^{-1} resolution frequency.

2.2.3. Scanning Electron Microscopy

Observations of the morphology and microstructure of all samples were made using a Scanning Electron Microscope (SEM) JEOL JSM-6390 LV. The accelerating voltage used in the microscope was 20 kV and all the images were formed from secondary electrons. The sample was col- lected when the dried process was over. A small portion of the filtered solid was put on a sample holder and glued by a carbon painting. Moreover, some HAp samples were observed by means of a Field Emission Scanning Electron Microscope (FESEM) Hitachi model SU8200 also using secondary electrons to obtain a detailed information of sample morphology.

Additionally the Ca/P ratio was determined by using an Energy Dispersive X-ray Spectrometer (EDS) Quantax EDS by Bruker attached to the SEM. The samples were compacted applying a slight pressure to obtain flat surfaces which were used to the elemental analyses.

2.2.4. High Resolution Electron Microscopy (HREM)

With the aim of analyze at detail the morphology and crystal structure of HAp nanostructures, observation of all samples was done with a JEOL F2100 electron micro- scope. The accelerating voltage was set at 200 kV for the observations and high resolution images were recorded. A selected area electron diffraction was tried, but sam- ple deterioration took place rapidly, and as a consequence, the high resolution images recorded were analyzed by the Digital Micrograph software provided by Gatan. Interpla- nar distances were determined and Fast Fourier transforms were generated.

3. RESULTS AND DISCUSSION

3.1. Infrared Analyses

Analyses made by FTIR determined the obtaining of HAp. On Figure 1 a typical spectrum of the Hap, synthesized in this work is shown. All the bands seem well-defined with large intensities. The signal at 3570 cm^{-1} is related to

structural –OH groups, those bands at 1101 and 1025 cm^{-1} corresponds to the deformation of PO^{3-} ions and the band 4 at 960 cm^{-1} was produced by the stretching of PO$^{3-}_4$ group. Additionally, the signals at 605 and 565 cm^{-1} were also related to the deformation of PO^{3-} ions, and finally, 4 the band at 635 cm^{-1} is associated to the –OH groups. No other organic or inorganic compounds were detected by the FTIR, yet a small amount of moisture, which is repre- sented by the wide band at 3420 cm^{-1}, could be observed; the low intensity of this band indicates the low content of water. The well-defined and narrow bands in the FTIR spectrum were an indication of a good purity.

3.2. Scanning Electron Microscopy

An observation made by using the SEM allowed determin- ing the morphology in the HAp samples, and the micro- scope revealed the obtaining of microfibers as can be observed on Figure 2. The average diameter of the fibres is 4.67 m and their lengths were in the range of hun- dreds of micrometres. The microfiber surfaces appeared

Figure1. Representative FTIR spectrum of HAp obtained by microwave assisted method in this work.
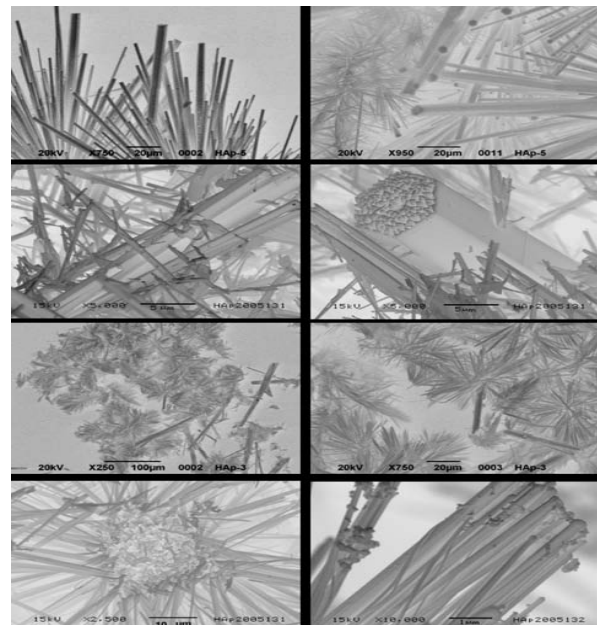
Figure 2. SEM Micrographs of HAp microfibers which have a mor- phology of hexagonal packets with a smooth surface that contain several nanofibers (a to d). When the microfibers shell broke, the inside nano- fibers were dispersed and their morphology could be observed (f to h).

quite smooth all of which possess a hexagonal transversal section area (Figs. 2(b and d)). The facets and edges that form the microfiber body look well-defined, and this is evi- dence of a good-quality crystal growth. All the microfibers appeared rather rigid as a group of pencils (2(a)).

A closer observation on the transversal section area (Fig. 2(d)) allows seeing that the microfibers looked as if they were packets filled with smaller pointed-end struc- tures, covered with a hexagonal husk or shell.

A thermal treatment was applied to the microfibers with the intention to break the shell. The fibers were dispersed in water and heated from room temperature up to 160 C inside a Teflon vessel in the microwave oven. This temperature was kept constant for 30 min and then, it was decreased quickly up to room temperature. At the end, the hexagonal shells were broken and their content was revealed. Several nanofibers were contained within the microfibers. On Figure 2(e) a lot of nano- fibers can be observed, they appear randomly dispersed after the thermal treatment. Figure 2(f) allows observ- ing some broken microfiber shells which look like empty containers. When some microfibers were broken as shown on Figure 2(g), the nanofibers inside became disseminated around lined and attached in the hexagonal shape as shown on Figure 2(d). Other microfiber shells were broken, and the nanofibers inside kept their arrangement similar to a spaghetti packet (see 2(h)). The exposed nanofibers have a uniform diameter (with an

average value of 97.5 nm) and similar length, most of them show a rather smooth surface.

Those nanofibers were observed through the FESEM for the morphology analysis. On Figure 3(a) a microfiber is displayed along with a nanofiber which is located in the right bottom corner in the image. Similar to the microfibers, the nanofibers also show a hexagonal cross section, well-defined facets and a smooth surface. Figure 3(b) allows seeing some nanofibers with morphol- ogy similar to a pencil. The nanofibers located around the bottom left corner in the micrograph have a tip ending and their diameter seem to decrease gradually. The nanofibers at the centre of the image, where broken possibly by the sample preparation process, and show their cross sections which do not appear hexagonal due to the irregular cut. The nanofibers appeared as if they were a smaller version of the microfibers.

SEM observations to the microfiber-shell fragments were also performed. A close up was done to those shell fragments produced by the thermal treatment in the microwave oven, and an interesting morphology was found. The microfiber-shell looked as if it were made of several nanofibers which became fused possibly by the microwave energy. This union of nanofibers is much more evident in the microfiber surface, where the nanofibers pro- duced a smooth surface. The SEM micrograph displayed on Figure 3(c), there are some lines on the microfiber sur- face indicated by the white arrows. These lines revealed some nanofibers not well integrated to the external shell

wall or they could be nanofibers that were separated from the wall by effect of the energy in the microwaves. On Figure 3(d), other microfibers were damaged and their sur- face

were broken in several sites. In the fragment borders there are several nanofibers exposed as it is indicated by the black arrows on Figure 3(d). On this image it is more evident how the external shell wall is made by the union of several nanofibers.

4. CONCLUSIONS

The obtaining of Hydroxyapatite micro and nanofibers through the hydrothermal assisted method was successful. All nanofibers are polycrystalline with a high purity and crystallinity which have hexagonal cross sections. Several nanofibers join to build microfibers which also have hexag- onal cross section. The union and organization of these nanofibers to form the microfibers is rather particular, such result is reported for a very first time in this work. The morphology and assembly of these nanofibers are quite interesting. The morphology of fibres with hexagonal cross sections is a crystal habit, it is a magnification of the crys- tal unit cell of the HAp. The morphology of fibers had an influence in the XRD results. A preferential crystal orientation in the [300] direc- tion was found and it was a consequence of the fibers orientation during XRD experiments. The fibers grew in the [001] direction.

The crystallographic analysis done in this work, made evident the influence of controlling synthesis reaction con- ditions (pressure, temperature and reaction time) on the morphology and preferential crystal orientation; besides, the use of a chemical substance as the glutamic acid to guide the crystalline growth had a remarkable effect.

Taking into consideration the morphology and dimen- sions of nanofibers synthesized in this work, they could be useful to obtain nano-

biomaterials which could be applied as implant materials in bone tissue, among other potential applications.

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Elicitation with Nanomaterials in the Early Stages of Plants

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Abstract — **In recent years, nanotechnology has been introduced to agriculture around the world. The initial work applied in this new field of nanoagriculture, began with the application of nanomaterials (NMs) in seed germination and seedling growth, due to the importance of the initial stages of the plants, the great variety of NMs and the need to have a quick response to guide investigations. The researches have shown interesting results with NMs, where is observed for example, that the speed of germination increases in the same way as the biomass and as elicitors activating the defense system of the plants [1, 7].**

Keywords — Nanomaterials, NMs, NPs, Seed, Seedling, Elicitor

I. INTRODUCTION

The agriculture demand for more food production with better characteristics, to supply the world population and industry [2].
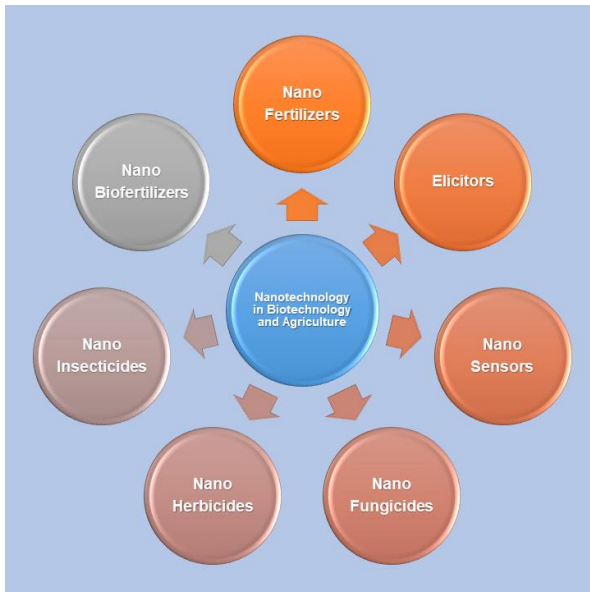
Fig. 1. Applications of nanotechnology in biotechnology and agriculture

Actually, there is a new tool to get that, the nanotechnology. Thanks to the fact that in recent years the agriculture and biotechnology opened the door to nanomaterials (NMs) with properties and advantages different to the same materials in a bigger scale, now there is the possibility of replace or enhance the current inputs. In most of cases, the NMs are use as nanosensors for speedy detection of diseases, as elicitors when activate and stimulate the defense system of the plants, and as vehicles containing fertilizers, insecticides and herbicides facilitating the precise release of nutrients and agrochemicals (Figure 1) [3].

In plants, the seed germination and seedling growth, is an essential fact in modern agriculture because the correct handling of these stages, guarantee its survival [4]. That´s why the studies that evaluate the seed germination are very important, due to this phase is critical for plants growth and development [5]. Therefore, it is significant to understand their relation to NPs. For example, some research show that the effects of the NPs in plants, depends of the concentrations applied [6].

In this review was analyzed, the most recent research that has been achieved on the application of NMs in the initial stages of plants, focused on the stimulation of seedling germination and growth (first roots and leaves). As well as its elicitor effect, by activating the response of the plant defense system.

II. EFECTS OF NANOMATERIALS IN THE EARLY STAGES OF PLANTS

The applications in agriculture are actually of great importance, because the positive effects, could significate a decrease on the production cost of food.

Most recent research that demonstrate good responses to NMs, are reported in plants as tomato (*Solanum lycopersicum*) when was treated with nanoparticles (NPs) of SiO_2 where the study reveal an improved percent of seed germination, mean germination time, seed germination index, seed vigour index, seedling fresh weight and dry weight [6].

Among silver, copper and gold metal NPs applied in Arugula (*Eruca sativa*), silver NPs showed maximum positive response and seed germination frequency was recorded as 73% [7].

Is studied that Fe_2O_3 nanocubes, Fe_2O_3 short nanorods, Fe_2O_3 long nanorods, Multi Walled CNTs, TiO_2 NPs on rice (*Oryza sativa*), stimulated roots elongation and promoted shoots growth at most concentrations. Some effects were different according of the shape of the NMs [8].

For blackberry (*Rubus adenotrichos*), the carbon nanotubes treatments were beneficial for plant growth and rooting. The treatment at a 4 μg/ml concentration presented the shortest average time for root emergence and the plants also had the greatest stem growth. Furthermore, the TEM analysis evidenced an enhancement in cell metabolism with the stem tissue of plants under the 4 μg/ml carbon nanotubes treatment [9].

Some tomato seeds, in cotton-cushioned glass bottles were exposure to 40 mg/L of graphene. Their germination rate at 2, 4 and 6 days was increased by 26.6, 43.4 and 13.5%, respectively, when compared to untreated controls. Positive impacts can be attributed to the fact that graphene was able to penetrate seed husks and the penetration might break the husks to facilitate water uptake [10].

Investigations with multi walled CNTs at low concentrations benefit the growth of maize (*Zea mays*) seedlings by enhancing water/nutrient transport and biomass. These findings suggest a potential for the utilization of CNTs for optimizing water transport in arid-zone agriculture and of improving crop biomass yields [11].

A test conducted with carbon nanotubes (CNTs) made significant contributions few years ago, when was reported that some people managed to improve the elongation of the root on onion and cucumber. They also observed that the effects were clearer after exposure to CNTs at 24 h than at 48 h. In addition, both, CNTs and the functionalized CNTs, formed sheets of nanotubes on the root surfaces of the cucumber; however, no form of CNTs entered the roots. The seed germination test was able to detect significant differences in germination of the seeds caused by the nanotubes, despite the considerable variability between replicated petri dishes [12].

Recently other investigations have seen that carbon nanotubes (of single-wall and multi-wall) in many cases can penetrate the seed coat and plant cell wall which depends on their size, concentration and solubility. The size of carbon nanotubes alone is of great significance in agriculture and biotechnology. The penetration of carbon nanotubes into the plant system can bring changes in metabolic functions leading to an increase in biomass and fruit/grain yield. And their concentration may be controlled within the permissible limit to prevent any damage by phitotoxicity [13].

The nanoparticles of manganese oxide (MnOx) and iron oxide (FeOx) significantly improved the elongation of the root of lettuce (*Lactuca sativa*) seedlings, demonstrating these NPs could be used as a fertilizer or vegetable growth enhancer, thus improving agronomic production. In addition, the NPs had little or no phytotoxicity at concentrations of <50 ppm (MnOx) or 5-20 ppm (FeOx) [14].

Other natural NPs as chitosan and oligochitosan have had an influence on growth and development, defense system and other effects. The best response was with oligochitosan in a concentration of 0.0625% when wheat (*Triticum aestivum* L.) seeds were pre-soaked [15].

In tomato, the seeds reacted significantly to the Cu–chitosan NPs developed (0.08, 0.10 and 0.12%), where were registered higher values of seed germination percentage, seedling length, fresh and dry weight and seedling vigour index as compared to all other treatments. Results of the study clearly show the growth promotory effect of Cu–chitosan NPs on tomato seedlings [16].

III. ELICITATION AND DEFENSE SYSTEM BY NANOMATERIALS IN THE EARLY STAGES OF PLANTS

Because of their small size, the NMs easily penetrate the seed and activate genes responsible of replies to environmental stress, regulating the water channels proteins that participate in the germination and growth of the plants, in addition offering many advantages due to its high surface area, which in precision agriculture helps to the exact delivery of substances [17].

Recent information about activation of plant defense system by NMs has revealed that they can alleviate the damage caused by abiotic stress. This possible association is related to the increase of reactive oxygen species (ROS), although it cannot be consistently concluded about the mechanism of action of NMs. However, available research may indicate that they mimic signalling molecules in the cytosol and are detected by specific proteins, inducing genetic expression that leads to stress
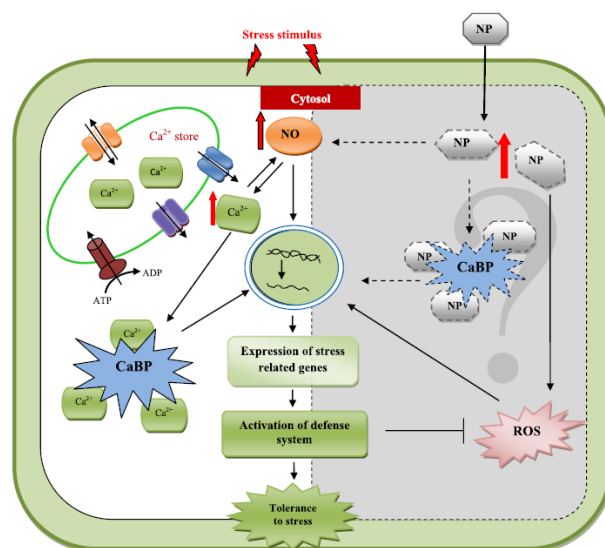

Fig. 2. Defense mechanism in plants under environmental stress and proposed action of the NMs in the mechanism [18].

resistance, but further research is still needed to ensure that NMs are inhibitors or stress inductors (Figure 2) [18].

Some investigations have been observed that the exposure of ajowan (*Carum copticum*) seeds to chitosan (0.2%) could improve its germination and growth. In the same way, some treatments can reduce the harmful effect of salinity during growth. Chitosan tolerance to salt stress may be related to the influence on water content [19].

Currently, there is enough information to indicate that the application of chitosan to plants can improve tolerance to a large number of pathogenic microorganisms, adverse climatic conditions and stimulate growth, indicating that the use of natural elicitors such as chitosan could help achieve sustainable agriculture [20].

Nanoparticles of zinc oxide improved germination and caused a better tolerance to drought. Under these conditions, all germination characteristics decreased, except dry and fresh weight. That is why, the application of 1 g/L of nano zinc oxide can be positive to increase and improve the germination of soybean (*Glycine max*) seeds under stress drought [21].

The effect of the application of analcite nanoparticles to soil (at 0, 500, 1000 and 1500 mg/L) on the drought resistance of wheat and corn seedlings was studied. The positive effect has been established for all the doses: seed germination, seedling growth criteria and photosynthetic pigments content increased. The application of analcite caused acute accumulation of protective antioxidants (flavonoids, carotenoids) and activation of catalase (in corn) under soil drought [22].

Some results with nanoparticles of silicon showed great effects to reduce damage by salinity. But the behaviour in certain doses (high) of the treatments that have been evaluated, still do not make clear the behaviour with these NMs [23].

A research carried out on lentils (*Lens culinaris*) shows that the application of nanoparticles of silicon oxide can have positive effects, especially in plants stressed by the effect of salinity. The pre-planting of seeds treated with some NMs such as nanoparticles of silicon oxide, nano fertilizers, seeds covered with nanomaterials or nano-absorbing water can result in the improvement of seed germination and an increase in vigour in seedlings [24].

Pumpkin (*Cucurbita sp.*) seedlings treated with NaCl and nanoparticles of silicon dioxide showed significant changes in growth and physiological characteristics. When the seedlings were exposed to salt stress, the germination percentage, vigor, growth and physiobiochemical characteristics of the seed decreased. However, silicon nano dioxide significantly reduced the adverse effects of salinity by mitigating cellular oxidative damage. The effect of nanoparticles of silicon dioxide was dose dependent [25].

One study reveals that the stress caused by salinity resulted in a considerable decrease in seed germination, vegetative growth and yield of faba bean (*Vicia faba*). The results highlight the role of nanosilicon in the regulation of salinity responses, since it could protect bean plants from the effect of salinity [26].

The applications of NMs can stimulate the anticipated germination of the plant, interrupt the dormancy of the seed and improve the production of the plant. Significantly increase seed germination, mean germination time, germination rate, seedling weight and vigor index. It has been proposed that the application of SiO_2 nanoparticles together with pre-cooling could be used as a new alternative potential for the breaking of seed dormancy in high wheat grass [27].

In *Eruca sativa* the applied copper nanoparticles were more stress inducing than silver and gold nanoparticles because of the fact that copper at bulk level is also more toxic than silver and gold [7]. But in pea (*Pisum sativum*) seedlings showed an increase in oxidative stress and alter the antioxidant defense system when exposed to silver NPs [28].

Because the first response to the influence of stress on plants, is the decrease in growth, carbon nanotubes (CNTs) can not be considered as a tensor material, because it has a positive effect on the growth of *Satureja rechingeri* calluses. But it was found that they can act as an elicitor by enhancing the production of rosmaniric acid, this by increasing the primary metabolites such as the amino acids tyrosine and phenylalanine. Now the production process of secondary metabolites must be studied thoroughly and reach a molecular level. And the security when using CNTs continues in debate. But at this time its use is safe for the production of secondary metabolites [29].

In tomato, the graphene penetration of vacuole and its deposition in root tips were two causing factors for reduced biomass production in tomato. Furthermore, that stems and roots were longer than those of the control. May be related to elevated gibberellic acid biosynthesis in graphene-treated seedlings, but further studies at cellular and molecular levels are needed understanding of underlying mechanisms [10].

A variety of metal oxide nanoparticles (CeO2, ZnO, CuO, TiO2, Fe3O4 and Al2O3, etc.) have been examined in seed germination, shoot/root growth, biomass production and physiological and biochemical activities. Demonstrating both, beneficial and adverse effects, on the system and production of plants. Most studies in the early stages of plant development, but that requires a long-term study to achieve results. It is expected that some of the nanomaterials will minimize the use of toxic chemicals and fertilizers in the near future [30].

IV. CONCLUSION AND FUTURE PROSPECTS

After review the current information around the world, about the application of NMs in early stages of interest plants, the general conclusion is that NMs have an effect on plants, because of their properties at this scale and there are enough information to demonstrate it, but is not concise yet.

In seed germination, the response to the activity is relate with aquaporins or water channels. In seedling growth, the NMs activate the defense system, but is missing more information to clarify the action mode and define if the NMs inhibit or induce the abiotic stress.

The necessity to research in this critical stage of plants continue, but is time to start the investigations in advance phases of growth and development to have a wide vision of the effect of the effect of NMs and guide the investigations in the productive stage.

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Hydrophobic concrete resistant to sulfates as a protection mechanism against the presence of seawater

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Summary- Exposing a concrete structure to seawater becomes more vulnerable than that which is not exposed to it, because some substances such as chlorides and sulphates attack low permeability structures that are more exposed to corrosion. The Institute of Cement, Concrete and Aggregates of Australia (CCAA) and Portland Cement Association (PCA) have found through reasearch that due to the aforementioned it is proposed to generate a concrete capable of resisting the effects of corrosion through a sulphate resistant cement and a hydrophobic coating which will give us a guarantee that the structures made in this way will have an excellent performance before this problem and to make sure of this the tests are made based on the ASTM (filtration speed test and unit weight test and empty content).

Keywords-concrete; corrosion; permeability; hydrophobic.

I. INTRODUCTION

To obtain a sustainable construction [1] or a conscious use of the natural resources that are available for construction and a design or constructive process that considerably reduces the environmental impacts, a huge change of mentality in the construction industry is needed . In this same sense, the technology of concrete responds with the characteristics of sustainability that enhance the material in a new market, improve environmental conditions and save resources; This vision includes both energy, water and materials, as well as systems or strategies that affect the global concept of quality.

It treats will give him solution to this problematic through a cement resistant to the sulfates and complementing with a hydrophobic coating that is a step different from which it has done in Spain where has worked with the addition of slag and volatile ashes [2] with which they have shown that low calcium fly ash is an effective mineral addition to improve sulfate resistance of normal portland cement [3].

The materials that are going to be used are:

Portland Cement: Industrial portland cement resistant to sulphates has been used.

Additions
The additions that will be used will be a granulated blast furnace slag, a fly ash and a ground siliceous sand to be used as a control [4].
a) Slag
b) Fly ash
c) Arena
To manufacture 1 x mortar test tubes (1: 3)
1 X 6 cm natural sand has been used, with a SiOg content greater than 99%. The grain size is between 1 and 1.5 mm. On the other hand, this sand has been used as an addition to the cement, once ground until it has passed through a sieve of 88 ^ m [5].
d) Hydrophobic coating

ASTM TESTS

Tests will be conducted based on the ASTM standards to know the behavior of the concrete after having been created with the materials discussed above, the tests will be those of:
a) unit weight and content of voids
b) infiltration rate
c) compressive strength

UNIT WEIGHT AND VACUUM CONTENT

To perform the test requires a cylindrical metal mold of 7 liters capacity, similar to that used in the test of air content for conventional concrete
(ASTM C231) [6], a compaction hammer such as that used in the soil compaction test of the Proctor Standard, weighing 2.5 kg (ASTM 0698) [6], and a

Rectangular metal plate 6 mm thick and with a length and width of at least 50 mm greater than the diameter of the cylindrical mold [7].

The test consists of obtaining a concrete sample, in accordance with ASTM C172 [8]. Previously, the mold is moistened, and then filled with concrete mix in two layers of approximately equal depth. Each layer is compacted by applying 20 strokes with the Proctor hammer, which is dropped from a height of 300 mm, taking care to compact over the entire surface. Finally, the surface is flush with the rectangular plate. The unit weight and empty contents are calculated with expressions 1 to 3.

$$PU = \frac{P_{(m+c)} - P_{(m)}}{V_{(m)}} \quad (1)$$

$$\%V = \frac{P_{(theoric)} - PU}{P_{(teórico)}} \quad (2)$$

$$PU_{(theoric)} = \frac{P_{(t)}}{V_{(t)}} \quad (3)$$

INFILTRATION SPEED

Test Method for the Field Infiltration Rate of the Porous Concrete (ASTM C1701 Standard Test Method for Infiltration Rate of In Place Pervious Concrete), [9]. The method is applicable to detect the possible reduction of the infiltration rate in the test zone. It does not measure the influence of the possible obstruction and / or plugging of the voids in the infiltration velocity, for which it is necessary to extract a core from the section of the test zone. To determine the infiltration velocity of a pavement, multiple measurements must be made at several points, maintaining a distance of one meter between measuring points and calculating the average [10].

For the test, a rigid and cylindrical metal ring of 300 mm diameter and 50 mm diameter is required.

mm height The inner surface of the ring is marked with two lines at a distance of 10 and 15 mm from the bottom of the ring.

The test consists of moistening the test area, placing the ring sealing the contact area with the concrete surface [11]. A known volume of water is poured into the ring and the time it takes the pavement to absorb the water is recorded. The infiltration rate is calculated with the expression 4.

material	Infiltration rate
concrete	0.1ml/min

$$I = \frac{kP}{D^2 t} \quad (4)$$

In the expression, I (in mm / h) is the infiltration rate of the porous concrete, k (in mm³ * s) / (kq * h) a constant, P (in kg), the weight of the infiltrated water, D (in mm) the diameter of the ring and t (in s) the infiltration time of the water in the test area. The constant k is 4583666000 for the International System of Units.

COMPRESSION RESISTANCE

The type of test must be evaluated in addition to the compaction technique, the pitch material and the appropriate cylinder size. The relationship between compression resistance obtained in cylinders and cores is also studied [13].

RESISTANCE TO FLEXION

The Working Group believes that the new proposal should be very similar to the one used for conventional concrete. However, two test versions are contemplated, one of single section for porous concrete without reinforcement and another of more complex section for fiber reinforced porous concrete [14].

TESTS

When performing the infiltration test we observed how quickly the water penetrated into concrete.

Figure 1.preparation for the infiltration test

Figure 2. infiltration test

RESULTS

Table 1. infiltration rate

It can be seen that an infiltration rate of 0.1ml / min is generated for the concrete created.

CONCLUSION

BY MEANS OF THE TESTS CARRIED OUT WE CAN ASSURE THAT THE SULPHATE RESISTANT CONCRETE AND WITH A HYDROPHOBIC COATING IS TOO FEASIBLE SINCE IT HAS GOOD RESULTS THAT GENERATE GREAT RESISTANCE TO THE STRUCTURES EXPOSED TO THE SEA WATER SINCE THE RESULTS OBTAINED IN THE TEST OF INFILTRATION TELL US THAT OUR STRUCTURES WOULD BE HYDROPHOBIC AS WELL AS RESISTANT TO SULFATES.

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Estimation of origin-destination matrices in a urban road network through RFID technology.

Case Study of the Querétaro Metropolitan Area

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Abstract— **In recent years the problem related to traffic control in large cities has been increasing, due to the exponential growth of vehicles that circulate in its road network. This growth in the number of vehicles causes the information, necessary to perform a traffic analysis, to be more complex to obtain. However, thanks to the application of recent technologies, different methodologies have been investigated to obtain passive traffic information. These investigations have obtained favorable results; for instance, origin-destination matrices, these can be used to feed the intelligent transport systems. But, it must not be forgotten that the estimated matrices must be reliable, since any serious transport analysis must be based on high quality origin-destination matrices. It has been found thanks to previous studies that the quality of an origin-destination matrix depends mainly on two factors; the precision of the input data and the location of the points where these data is collected, being the last one sometimes forgotten.**

Keywords— *origin-destination matrix; RFID; high quality on matrices; mobility; traffic; intelligent transport systems; Querétaro Metropolitan Area.*

I. INTRODUCTION

Mobility in cities contributes to their development and strengthening, by creating a system that seeks to improve the conditions for productive activities of the population, therefore it is necessary that there is a correct traffic control that allows a stable planning enough for said system to operate without problems. Nevertheless, given the growth of cities such control has become more complex to achieve, since when the city grows there is also an increase in the demand for transport, which in turn is related to the number of vehicles that drive around the city. This behavior causes traffic analysis to be more complicated to carry out, which is why the need to apply recent technologies to control and analyze the traffic is vital; an example of these are real-time intelligent transport systems (*ITS*) and dynamic traffic management systems (*DTMS*). However, this type of intelligent systems need real-time information about the behavior of the transport network. The main source of this behavior are origin-destination matrices; the origin-destination (*O-D*) matrices represent the spatial distribution of travels between traffic analysis zones in a transport network, i.e., they illustrate how many trips are made from a place A to a place B within a certain time frame.

II. REVIEW OF THE LITERATURE

A revision on the topics related to the ideal location of the RFID reading sites is presented, to serve as a background of the methods and procedures that have been carried out before. These starts talking about the traffic phenomenon; continues with an explanation of the need to estimate high quality *O-D* matrices; and its ended with a discussion of the recent technologies for obtaining data of the traffic behavior.

A. Traffic Phenomenon

In their studies, [1] and [2] agree that since the 90s the increase in transport demand has induced, especially in large cities, an increase in the congestion, delay times, accidents and environmental problems. In this context, [3] mentions that vehicular traffic is a complex dynamic behavior, since each vehicle behaves differently from the rest; such behavior occurs in a specific space and time, so if we want to understand the behavior of traffic it is necessary to understand these spatio-temporal characteristics. It is further explained that when traffic density is high enough, a congestion regime is generated; which is normally defined as a state of traffic resulting from a traffic jam in a road, as an inevitable consequence of an upstream flow that exceeds the capacity downstream of the traffic jam.

On the one hand, [4] propose a method of measurement for congestion composed of two traditional measurements, the speed and delays in the travels; on the other hand, [5] mentions that the base measures for congestion are the travel time and delays, moreover, [5] also points out that there are other variables capable of measuring the congestion of a city or road system. These variables are identified in [6], among which are:

- Duration: This variable is defined as the total time in which the congestion affects the trips in the system.
- Level: It is calculated by estimating the number of people or vehicles affected by congestion, and by the geographical distribution of congestion.
- Intensity: It is defined as the severity of the congestion that affects the displacements. It is used regularly to differentiate between levels of congestion.
- Reliability: It is the key component of the estimation of congestion, and is described as the variation between the three previous elements.

Another measurement approach for congestion is the economic one, which is suggested by [7], which examines how urban traffic congestion imposes economic costs within metropolitan areas. Considering that the various producers of goods and services are sensitive to congestion through their impacts on business costs, productivity and production levels.

B. Importance of the Quality on O-D Matrices

A problem that has occurred in recent years in cities where there is a socio-economic growth, is the incessant increase in displacements demand that takes place within modern cities and their metropolitan areas; which according to [8] has generated an increase in the use of vehicles thus producing problems of vehicular congestion. In this same sense, [9] considers that this increase within and between large metropolitan areas has caused an increase in the complexity of travel patterns. To understand this complexity, simulation tools are used for real-time intelligent transport systems (*ITS*) and dynamic traffic management systems (*DTMS*), which have the ability to estimate the behavior of the network and predict their evolution in the short term (*REF*).

According to [10], [11] and [12]; the most important source of information for the planning and management of transport networks are the origin-destination (*O-D*) matrices. In this sense [13] state that questionnaires are traditionally used in households, on the road or by telephone to obtain information and to estimate *O-D* matrices. However, this type of traditional methods of estimating *O-D* matrices presents some problems such as the long time from data collection for the analysis of these. Due to the above, recently methodologies have been developed for the estimation of *O-D* matrices in "real time".

As mentioned by [11], the estimation of high quality *O-D* matrices is a fundamental requirement for any serious analysis of the transport system. The quality of the *O-D* matrices estimated through traffic counts depends on two aspects of vital importance, the first, is the reliability and precision of the input data; while the second refers to the number and location of the counting points. Although several investigations have been carried out regarding the input data and several methodologies have been proposed for its analysis, the second point concerning the location and number of counting points has received very limited attention. One of the first studies on the subject was carried out by [14], where they proposed some heuristic procedures to identify the order in which links should be selected to estimate *O-D* matrices. Another contribution of interest is

those of [15] and [16], they agree in the analysis of the concept of maximum possible relative error (*MPRE*) with respect to the number and location of the counting points in the network. For their part, [15] mention that not all the links of text counts include the same amount of information, some of them do not include any information to the *O-D* matrices. Through the *MPRE* theory they establish four location rules for traffic counts, these rules are the *O-D* coverage rule, the maximum flow fraction rule, the maximum flow intercept rule, and the link independence rule.

Another approach is that of [17], they develop strategies to select additional traffic counts to improve the estimation of *O-D* matrices. These strategies are generated based on a screen line of traditional traffic count location models (*TLC*), which are expressed as whole programming formulations.

In recent years, the need has arisen to apply the aforementioned theories to the new data collection technologies for the generation of dynamic O-D matrices. Two examples of this are [18] and [19], while [18] conducted an investigation for license plate recognition devices (LPR), [19] conducted the study for *bluetooth* sensors. However, both agreed on the need to reduce installation costs while at the same time maximizing data collection.

C. Technologies for obtaining dynamic data

For [20] the new methodologies for estimates of *O-D* matrices in "real time" are based on the incorporation of Automated Vehicle Identification Systems (*AVI*). For its part, [21] states that *AVI* technologies which are being developed and implemented will increase the ease of acquiring and analyzing large volumes of detailed data on vehicle flow, which will be a primary source of information for the dynamic estimation of *O-D* matrices. As stated by [22], *AVI* systems can be categorized according to two key characteristics; the first refers to whether the cooperation of the user of the vehicle is necessary, the second is the scope, that is, if the *AVI* system is capable of covering the entire network. So, some of the most used *AVI* systems are GPS-based systems, Cell Phone Tracking, Transponders, License Plate Recognition, Bluetooth, among others.

For instance, [23] conducted studies of dynamic estimates of O-D matrices based on Bluetooth Traffic Monitoring; in their investigation by means of a computational simulation in which the Kalman filter was applied, an O-D matrix was generated thanks to the tracking of *bluetooth* device. In their results they found that in cases where the analysis intervals are very long, the accuracy of the estimation of the *O-D* matrix can vary. In contrast, [24] conducted a study for the estimation of *O-D* matrices through the analysis of Data from the Cellular Network; the results of this study were satisfactory, since valuable *O-D* matrices could be obtained. In the results was noted that a factor of great importance is the time in which the cell receives and/or sends data, since it is at this moment when the location of the vehicle is obtained.

III. Conclusions

It is observed, thanks to the previous information, that at present it is of great importance that a city has an adequate traffic control system, in order to reduce the delays caused by congestion, which may even affect economic aspects. That is why, there is a need to continue investigating methods that allow the estimation of high quality *O-D* matrices. However, future researches must take into account the observations made by each author, so that these investigations are closer to an optimal solution to the problem. Consequently, we intend to carry out a research in which the use of *RFID* technology was considered as a basis for obtaining information. Where this information will later be used to estimate an *O-D* matrix, which allows obtaining patterns of movement in an urban network with high precision. This precision will be obtained by taking into account the most suitable locations for installation of the *RFID* system, in such a way that the error in the matrix, the installation cost of the system, and the invasion of users' privacy are reduced. For the verification of the investigation, a case study will be made in the Querétaro Metropolitan Area. In this way it will be possible to verify that the elements that will be considered during the investigation generate the expected result. Therefore, this result is the determination of an algorithm that allows locating *RFID* readers in an urban road infrastructure network, which in turn supply the input data for *O-D* matrix estimation with 80% accuracy.

ACKNOWLEDGMENT

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Modeling greenhouses microclimates by system dynamics

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Abstract— **Two important tools that provide the ability to predict crop yields and to control the microclimate of greenhouses are modeling and simulation. However, the greenhouse as a system, is in interaction with many variables that need to be considered. That´s why, in this work, the dynamics of systems is presented like a viable methodology for modeling the microclimate of the greenhouses.**

Keywords— dynamic modeling; system dynamics; microclimate control; greenhouse; methodology

I. INTRODUCTION

The main direction in the activity of greenhouse production is to replenish the market by fresh vegetables and greens during the whole year. As practice has shown, this production is expensive, power consuming, and requires compliance with the technology of growing vegetables. Climate maintenance in greenhouses is one of the priority problems since even despite good genetic properties of crops, the quality of fertilizers and soil, incorrect maintenance of temperature humidity mode of the greenhouse and poor dosing by the carbon dioxide may result in a considerable drop in productivity up to the loss of crops and, consequently to million strong losses [1].

The dynamic behavior of microclimate is a combination of physical processes involving energy transfer (radiation and heat) and mass balance (water vapor fluxes and CO_2 concentration). These processes depend on the outside environmental conditions, structure of the greenhouse, type and state of the crop and on the effect of the control actuators (typically ventilation and heating to modify inside temperature and humidity conditions, shading and artificial light to change internal radiation, CO_2 injection to influence photosynthesis and fogging/cooling for humidity enrichment) [2].

Modeling and simulation offer a powerful option for planning and decision-making that influence cost reduction and increase crop yield in greenhouses. The microclimate control models allow the development of the agroclimatic conditions of a greenhouse considering the elements that take part in the growth of a specific crop [3].

System dynamics have been applied in several areas. In turn, this methodology is based on a systemic approach, which is a process of thinking about systems, that is, emphasizes the relationships between the parts of the system. It is also a modeling tool due to its rigorous approach in capturing interrelations between variables and handling dynamic aspects of system behavior [4]. It is for this reason that the methodology under which the modeling of microclimate control of a greenhouse is proposed to revolve around the systems dynamics, methodology proposed by [5].

II. MODELING GREENHOUSES MICROCLIMATES

Greenhouse presents two problems that limit the expansion of this cultivation method, first the primary climate variables include temperature, humidity, CO_2 concentration, and light intensity at the plant level [6]. Second, the excessive energy cost mainly due to the use of various controlled actuators such as ventilation system, heating system, humidification system, and cooling system which make the greenhouse a large consumer of energy and imply the increase of the cost of production [7].

The actuators for greenhouse climate control are usually controlled by the greenhouse process control computer. Those control systems are developed rather detached from general building control and are a domain on their own. Most of control rules in the process control computer are heuristic rules based on the experience of the growers and suppliers [6]. Dynamic simulation models use systems analysis techniques for model development. Systems analysis is a procedure for the planning, design, evaluation, study or management of large-scale systems. Systems analysis integrates the methods of synthesis and analysis used by various engineering disciplines and incorporates them into a procedure. Dynamic modeling is a crucial element for the development and elaboration of modeling greenhouses microclimate, as well as for the modeling of crop growth [3].

III. SYSTEM DYNAMICS

Systems analysis is a procedure for the planning, design, evaluation, study or management of large-scale systems. Systems analysis integrates the methods of synthesis and analysis used by various engineering disciplines and incorporates them into a procedure. In many cases, computers oversee integrating these elements. The integration of the elements is itself the modeling process Therefore; a model is a map of a system. Models can be static or dynamic. A static model is one whose output keeps with time or where time is not a variable. However, a dynamic model is one whose output varies over time and in which processes are characterized. The system dynamics facilitate the learning of complex systems through formal models and simulation methods. The difference, with other methods, is the study of feedback systems. A model based on the system dynamics can be said to be structured by policies in interaction, being understood by politics the representation of the causes of an action, since the very nature of the dynamical feedback structure of the systems tends to lead erroneously to actions that are ineffective and even counterproductive to the efficient functioning of the system [8]. The interaction of dynamic modeling with experimental research in agriculture allows for a large expansion of a scientific view of complex biological systems and guides experimental research in fruitful areas with great benefits. Dynamic simulation models use systems analysis techniques for model development. The characterization of the processes in a dynamic model consists in knowing and defining the state variables. The state variables are those necessary to define the state of the system at a point in time [9].

IV. SYSTEM DYNAMIC IN MODELING GREENHOUSE MICROCLIMATES

The greenhouse system is complex and can be divided into three main components that interact in a strong way: the internal atmosphere, the crop and the soil. The behavior of the whole system depends of these interactions, but also of the external climate and the actions that are exerted on the components of the system through the climate control. The main objective of the climate control problem is to maintain the variables that define the interior environment of the greenhouse within suitable ranges. The difficulty lies in the complexity of the phenomena that condition the ideal environment, the greenhouse system is considered as non-linear, multivariate, non-stationary and open to the external environment, that is, it is dynamic [7].

For the initial phase of dynamic model generation, is necessary to identify all of parameters that affect climate, such as temperature and humidity conditions, shading and artificial light to change internal radiation, CO2 injection to influence photosynthesis and fogging/cooling for humidity enrichment.

In addition, in this phase the limits of the study system are identified and established, as well as the different subsystems that interact in it, indicating the elements that belong to it and which are excluding it, that is, what is the scope and area of influence of the system and what elements are necessary to represent the situation or problem under study.

The next step for the modeling of greenhouses, is the conceptualization, in which the graphic representation of the problem to be solved is made (influence maps), which allows identifying the facts of the phenomenon and linking them to each other through influence, representing each event through a set of interconnected variables, thus allowing to generate behavioral relationships.

A behavioral relationship is the narration of the effect of one variable on another variable, as well as the result of that influence. In this step, the limits of the model should be fine-tuned using causal diagrams and graphs of behavior variables over time. Next, the representation or formulation of the model must be carried out, which consists in generating the dynamic model since for this point a structured model has been conceptualized, as well as its representation through an influences map also called cause-effect diagram. Following this, the representation is made of the causal diagram in a simulation model that can be interpreted by some programming language, generally the interpretation of the cause-effect diagram goes to a Forrester diagram.

Finally, to conclude the dynamic modeling, the units and the mathematical relationships that represent each of the variables in the Forrester diagram will be identified.

It is fundamental to consider that a variable that affects another variable can only be related to each other provided that the unit that represents it is coherent with each other; if it does not deal with this aspect, the behavior of the variables in the dynamic model will not simulate the reality of the problem. For each of the variables of the Forrester diagram in the simulation, equations, percentages and arithmetic units will be supplied.

Before the simulation, an evaluation of the model will be carried out, which consists of conducting sensitivity tests and evaluating the model by simulating the mathematical model using programming software.

The results obtained from the evaluation of the dynamic model allow refining and analyzing the variables and their behavior in the simulation when compared with the real historical data of the problem being analyzed. This to generate the scenario that will allow the analysis of validation and verification of the dynamic model. In addition, it is expected that the dynamic model is ready to be tested with the formulation of scenarios for decision making.

Once the dynamic model offers consistent results of the problem under study, it will be possible to visualize scenarios through the definition or redefinition of policies that affect the behavior of the variables in the system.

The modeling process is showed in Fid, 1. This process is presented in two dimensions. First dimension can be called "conceptual", which integrates the three primary phases of the project, while the second dimension, "technique", is the part that integrates the modeling tools and the simulation of the dynamic model.

Fig.1 Stages of the system dynamics methodology

In this way, the research will be carried out at the Universidad Autónoma de Querétaro, Faculty of Engineering campus Amazcala, located on the highway to Chichimequillas S / N km. 1, Amazcala, El Marqués, Querétaro.

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Arsenic adsorption using iron oxide nanoparticles supported on a mesoporous SBA-15 matrix

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Abstract— The influence of the incorporation of iron oxide Fe_2O_3 nanoparticles in the Santa Barbara Amorphous-15 SBA-15 mesoporous on the arsenic (III) and (V) adsorption in aqueous solution will be studied. The SBA-15 material will be synthesized by sol-gel process using tetraethyl orthosilicate (TEOS) as the silica precursor and Pluronic P123 surfactant as the mesostructure shape-directing agent. The incorporation of Fe_2O_3 nanoparticles into the internal surface from the SBA-15 pores will be made through the pore-filling impregnation method, using iron (III) nitrate as Fe_2O_3 source. In order to find the optimal concentration of Fe_2O_3, it will be incorporated in different concentrations (wt%). The adsorbents will be characterized using N_2 77 K adsorption-desorption isotherms, X-ray diffraction (XRD), ultraviolet-visible spectroscopy (UV-Vis), micro-Raman spectroscopy and scanning and transmission electron microscopy (SEM and TEM). A proper characterization of these materials will help in the understanding of the kind of interaction between the iron oxide nanoparticles (active adsorption centers) from the mesoporous Fe_2O_3/SBA-15 material and the arsenic ions during de adsorption process to propose an adsorption model.

Keywords—SBA-15; mesoporous; arsenic; adsorption; iron oxide

I. INTRODUCTION

Arsenic is a widely distributed metalloid throughout the world. This element can exist naturally in soils and groundwater, but anthropogenic sources have raised its concentration in water bodies, severely affecting human health. Inorganic species make it highly contaminant, mainly with its trivalent As (III) and pentavalent As (V) forms [1]. Multiple countries around the world, including México, face severe health problems related to high amounts of arsenic on drinking-water. Therefore, the World Health Organization has stablished 0.01 mg/L as the maximum concentration limit for arsenic in water bodies. Despite this, México adjusted its limit since 2005 only to 0.025 mg/L [2]. Exposure to arsenic can cause skin problems, neuronal damage and to promote different kinds of cancer [3]. There are several techniques for arsenic removal from water, such as oxidative processes, coagulation-precipitation, filtration and adsorption [4–7]. However, the adsorption method using nanostructured materials became a good alternative due to its efficiency and low cost [8]. Likewise, the convenient textural properties, high surface areas and ideal pore volumes and sizes of porous materials are a suitable choice for heavy metals ions removal from wastewaters through the adsorption technique [9,10]. By choosing a proper functional group, nanoparticles can be incorporated into the porous materials to achieve the adsorption. In this proposal, iron oxide Fe_2O_3 nanoparticles are going to be scattered throughout the internal surface of the SBA-15 mesopores to reach a high adsorption capacity.

II. EXPERIMENTAL

A. Mesoporous silica synthesis

The material is prepared by a sol-gel process according to [11] as shown in Fig. 1. First, a solution is made dissolving the surfactant Pluronic P123 as a template with a 4 M hydrochloric acid aqueous solution HCl, Then, tetraethyl orthosilicate TEOS is added dropwise as the silica precursor and the mixture is stirred at room temperature until a clear solution is obtained. The solution was kept at 35°C with stirring for 24 hours and then transferred to an oven at 80°C for 24 hours to let it age. The product is filtered, washed and dried at 110°C for 18 h and then calcined at 550°C for 4 hours.

B. Iron oxide Fe_2O_3 incorporation

A pore-filling impregnation method will be used to incorporate iron oxide nanoparticles into the SBA-15 support material. The source of the iron oxide solutions will be iron (III) chloride hexahydrate $FeCl_3 \cdot 6H_2O$. The Fe_2O_3 loadings will vary in a weight percentage. Then, the impregnated samples will let dry at 110°C for 18 h and calcine at 500°C for 4 h.

C. Characterization of the mesoporous support material

In order to determine the SBA-15 textural properties nitrogen physisorption studies will be performed at 77 K BET using a Quantachrome Autosorb-IQ2 surface area analyzer. These studies will give information about the pore size and volume and the surface area of the material. The morphology will be analyzed through Scanning Electron Microscopy SEM and Transmission Electron Microscopy TEM with a JEOL HRTEM with the support of the Catalysis and Petrochemisty Institute from the Superior Counseling for Scientific Investigations from Madrid, Spain.

D. Characterization of the adsorbent

Micro-Raman spectra will be acquired to detect the iron oxide presence on the mesoporous silica SBA-15 with a Labram-Dior device. The electronic transitions from de Fe_2O_3 will be analyzed through Ultraviolet-Visible spectroscopy UV-Vis with a Cary 5000 instrument. X-Ray Diffraction XRD patterns will be recorded to learn about the adsorbent crystallinity with a D8 Advance Bruker instrument. Finally, X-ray Photoelectron Spectroscopy XPS will be carried out to identify the elemental composition and the chemical species on the support material with a VG ESCALAB 200R from the ICP.

E. Arsenic adsorption

In order to estimate the adsorption capacity for the material, 100 ppm arsenic aqueous solutions will be prepared. Different amounts of adsorbent will be added to the mentioned solutions under stirring at room temperature to monitor the contact time for the arsenic adsorption.
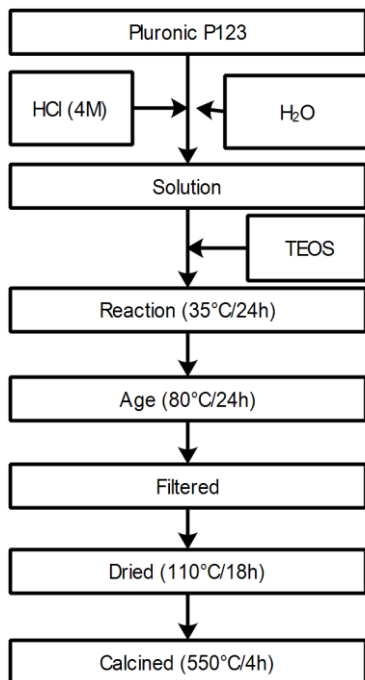
III. EXPECTED RESULTS

It is expected to obtain a mesoporous material SBA-15 in a short particle size functionalized with iron oxide nanoparticles. Once the SBA-15 material is obtained, its textural, thermal and structural properties will be analyzed to compare them with the iron oxide functionalized SBA-15 correspondent properties. A proper characterization of these materials will help in the understanding of the kind of interaction between the iron oxide nanoparticles (active adsorption centers) from the mesoporous Fe_2O_3/SBA-15 material and the arsenic ions during de adsorption process to propose an adsorption model.

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Figura 1. Synthesis procedure for the SBA-15 support

GROUND RUBBER IN ASPHALT MIXES

ADVANTAGES OF ITS USE AS MODIFIER OF ASPHALT MIXTURES

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Abstract- Conventional asphalt mixtures have suitable mechanical properties for certain traffic and temperature conditions, however, the increase in traffic volumes and the susceptibility of asphalt to temperature changes, cause that its performance became insufficient in relation to viscosity and fragility of the pavement, from there the need to modify asphalts, with the purpose of achieving a better performance of the mixtures.

Research carried out affirm that through the addition of ground rubber from tires out of use, a change in the performance of the asphalt is achieved, making it more stable and less deformable; also improving the fatigue behavior of the mixtures and thus increase the useful life of the pavements.

Keywords-ground rubber; modified asphalt; fatigue.

I. INTRODUCTION

The repeated action of traffic loads causes structural damage to the pavements reflected in the form of cracking due to fatigue and permanent deformation. In addition to the passage of traffic, temperature and humidity are factors that also affect the behavior of the pavement.

The phenomenon of fatigue and thermal cracking is caused, for example, by climatic changes. When microcracks appear in the surface layer, they can not be repaired by themselves, but, on the contrary, they propagate forming the so-called crocodile skin. The damage process can be accelerated if there is detachment of aggregate or asphalt from the surface of the pavement as a result of the friction generated by the passage of vehicles. Added to the above, the penetration of water in the cracks would lead to irreversible failure of the layer.

The wear and tear of pavements is often due to the gradual increase in traffic volumes observed in the roads and the magnitude of vehicle loads, so the fundamental objective for public administration is to improve performance and increase the useful life of the tracks. Although one way to achieve this is to use high quality raw materials, an alternative to improve the performance of an asphalt mix is the implementation of ground rubber from tires out of use tires (NFU, by its initials in Spanish).

The incorporation of ground rubber to asphalt, modifies its rheological properties and improves its performance as road material [1]; improves the mechanical and functional properties of asphalt mixtures under loads derived from traffic. The modification of the asphalt with ground rubber gives resistance to climatic changes and also manages to reduce the fatigue fracturing of the mixture.

Besides the properties that the rubber gives to the asphalt mixtures, its use has been a viable alternative to reduce the environmental problems caused by the deposits of used tires. The asphalt industry can use NFUs that can not be recycled as tires, but used as a tire dust for the modification of asphalts.

The extent to which the improvements in the characteristics provided by the rubber to the mixture are achieved will depend on the incorporation technique used for the rubber, the type of mixture and its situation on the pavement.

II. STATE OF ART

A bibliographic review is presented about topics related to the modification of asphalt with ground rubber coming from NFU and the characteristics that it contributes to the mixtures used in paving. The above works as a reference for the methods exposed in this investigation.

It begins with the properties and procedures of incorporation of rubber, the fatigue phenomenon and the advantages of the use of rubber in asphalt mixtures.

III. INCORPORATION OF THE RUBBER TO THE ASPHALT MIXTURE

There are two traditional ways of adding rubber to a mixture, these are: wet and dry.

The first one refers to the addition of rubber to the asphalt in a previous way, while, in the dry way, the rubber dust is incorporated as if it were a stone aggregate.

A. Wet way

Reference [2] states that the process for the manufacture of wet asphalt mixtures is normally carried out in mobile units, consisting of a rubber feed hopper and two tanks that have the function of storing and carrying out the mixing process.

In the first instance, the rubber powder is mixed with the asphalt in a first tank after being weighed. In this step it is important to keep the asphalt in agitation to conserve the dispersed rubber dust, otherwise it will decant in the tank.

Subsequently, the mixture matures, that is, the process in which the rubber absorbs the lightest fractions of the asphalt and swells. The maturation time will depend on the system, composition and proportion of the tire powder.

After the ripening time, the modified asphalt is pumped from a mobile unit to the central mixer of the asphalt mix. The modification of the asphalt should be done just before its use, or otherwise, keep it under agitation and at elevated temperatures.

B. Dry way

The elaboration of rubber mixtures by dry way consists of incorporating the rubber to the stone aggregates and then the asphalt is added. In this procedure the mixing times are longer, as is the manufacturing temperature.

According to [3], rubber is considered a fraction of the aggregate, or even used as a replacement for the fine part of the stone.

The rubber incorporation method is a determining factor for the final properties of the modified asphalt mix. The author [4] points out that the dry process demands a greater quantity of asphalt, requires a special procedure for the addition of rubber and a longer compaction time on site; on the other hand, the conditions of the wet process require new equipment in the plant as a unit for mixing and storing the ground rubber, as well as additional energy to heat the mixture at higher temperatures.

Nonetheless, asphalt mixtures modified with wet ground rubber have shown better characteristics because when mixing rubber with asphalt cement, it attracts light components to produce a particle that is bonded inside the asphalt matrix, generating a blanket more resistant to cracking. For this reason, the research focuses on the advantages offered by wet ground rubber added.

IV. FATIGUE

[5] recommends that it is basic to understand the fatigue performance of the asphalt mix to achieve a good calibration of the structural design methods. That is why research reported in [6] and that coincides with [7], state that the characterization of fatigue tests is fundamental, and that they focus on related long-term load bearing capacity in a mixture.

The phenomenon of fatigue of a material is characterized by its rupture after repeated application of a large number of stresses, where the amplitude of the stress is less than the instantaneous rupture load of the specimen [8]. In the case of asphalt mixtures, these are subjected to short-term stresses when the axles of the vehicle pass, which causes fatigue cracking [9].

In a study carried out by the Asphalt Institute [10], the fatigue performance and performance grade of rubber-modified asphalt mixtures are determined and compared with polymer-modified mixtures, by means of laboratory tests. In this paper it was found that the rubber modified mixture showed an improvement in groove deformation resistance as compared to the polymer modified blend; the mixture with rubber exceeded the mixture with polymer fatigue by bending from 4 to 18 times depending on the strain of the test, which indicates that the rubber-modified mixture from NFU fractures less than a mixture with polymer and this at the same time shows that there should be a cost saving in the mixture with rubber, since by increasing its useful life, the need for maintenance is reduced.

The following table shows the results obtained from the research mentioned:

TABLE I. Fatigue life through the repeated Flexion Fatigue Test.

Test Description	Gmm	Sample Description	Air Voids, %	Actual Avg Strain, μ	Cycles to Failure, Nf		Flexural Modulus, MPa
					Cycles*Modulus	50% of Initial Stiffness	@50cycles, MPa
I-40 PM Mix (sampled 10-28-2008)	2.485	5822-A	7.4	800	9,540	na	3,707
		5800-A	6.4	600	28,767	89,805	4,944
		5822-1	6.2	500	125,852	173,975	4,045
I-40 TR Mix (sampled 10-22-2008)	2.482	5800-A	6.7	800	109,836	130,020	3,014
		5800-B	7.0	600	544,319	762,309	2,680
		5870-A	6.9	500	544,072	852,452	3,062

PM Mix refers to the modified asphalt mix with polymer.
TR Mix refers to the modified asphalt mix with rubber.
Reference [10].

As seen in the results of Table 1, the modified rubber mixture supports a greater number of load cycles compared to the mixture in which polymer is incorporated.

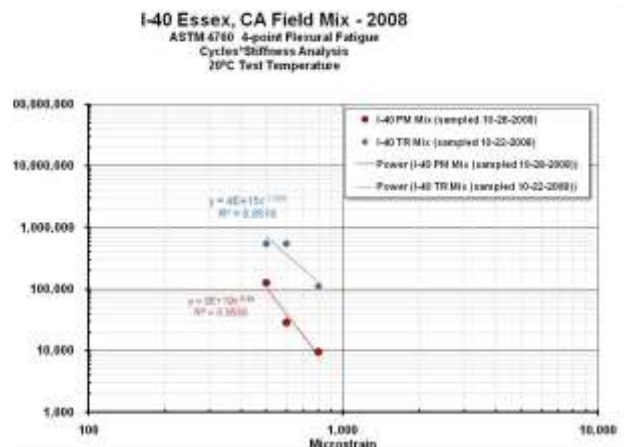In Fig. 1, the results obtained by the Asphalt Institute are presented graphically.

Fig.1. Fatigue beam results graph by repeated bending test.
Reference [10].

Although it would be convenient to add specimens tested in this study to improve the accuracy of the test, a clear adaptation of the data is shown for the samples tested, with which it is possible to conclude that the mixture containing rubber is more flexible and less brittle than the one to which polymer is added.

It is essential to continue with studies of the behavior of ground rubber in asphalt mixtures, because despite knowing the contributions that it can give, there is not much reference to its use with Mexican asphalts. In this sense, it is necessary to continue with investigations that justify the investment of incorporating rubber in the best way and demonstrate its operation with products of the country and through fatigue tests that allow us to quantify the possible increase in the useful life of the pavements.

V. CONCLUSIONS

It has been demonstrated that the incorporation of rubber to asphalt improves the thermal susceptibility and its rheological characteristics, providing an asphalt cement not at high temperatures nor at fragile at low temperatures.

The binders modified with rubber tire outperform the conventional products, however, a record of their behavior through laboratory tests is limited to fully justify this trend; that is why it is necessary to extend its analysis to studies that demonstrate its performance to be applied in the field and to determine with greater precision the benefit that the incorporation of rubber contributes in the design of asphalt mixtures for flexible pavements.

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Current trends in alternative feed sources for fish culture

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Abstract— The global aquaculture production has drastically increased, and this trend suggests that this will continue in the future. This growth causes an increase in the demand of aquaculture feeds, and currently, problems in formulation, a decline in catches of wild fish and the price increase of fishmeal and fish oil result in an increase of feed prices. Because these represent 40–70% of the cost of the fish production the search for sustainable alternatives for aquaculture feeds is needed and must meet the necessary requirements: have a lower price and similar nutritional qualities. This article reviews the published results of experiments using alternative feed sources for fish. Microalgae and black soldier fly larvae are proposed to be included in tilapia diets in order to obtain a balanced aquaculture feed.

Keywords—aquaculture, alternative feeds, microalgae, black soldier fly larvae.

I. INTRODUCTION

In the last five decades, an increase in world fish production has been reported, whereas in 1974 aquaculture provided only 7% for human consumption, by 2004 it had already increased to 39% [1]. This growth also causes an increase in the demand of aquaculture feeds. Problems in formulation, a decline in catches of wild fish and the price increase of fishmeal (FM) and fish oil (FO) result in an increase of feed prices [2]. Because these represent 40–70% of the cost of the fish production [3,4] the search for sustainable alternatives for aquaculture feeds is needed and must meet the necessary requirements: have a lower price and similar nutritional qualities [2].

Protein is one of the principal components of animal tissues and therefore, it is an essential nutrient for animals. Fish need it for maintenance and growth, principally for generating new tissue; since they are limited to synthetize proteins from carbon skeletons, the implementation in the diet becomes vital [5].

The nutritive needs of fish, include a high quality and quantity of protein in their diet and it has been reported that the average dietary requirement for fish is between 30-60% [5]. To achieve a balanced nutrition, protein sources must have a high-protein content, an adequate amino acid profile (arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine), high digestibility, good palatability and no anti-nutritional factors [6,7].

Aquaculture feeds are principally made of fishmeal and soy meal. Fishmeal (from whole fish) is a high-quality protein source, it is a rich source of energy, minerals and is highly digestible and palatable to most fish [5]. Because its rising demand, it has been produced from fish by-products (wastes from fish processing) that were previously discarded. This affects the composition and quality of the fishmeal, giving it a lower protein percentage and has to be used carefully since it has more ashes that can produce mineral imbalances. About 35% of world fishmeal production was obtained from fish residues in 2012 [2].

Soybean meal has a high digestibility, high quality and quantity of protein, also has one of the best amino acid profiles of all protein-rich plant feedstuffs for meeting most of the essential amino acid requirements of fish. However, vegetable sources should be used partially due to low palatability, high portion of fiber and deficiency in certain amino acids, also their cultivation compete directly with human alimentation [8].

In addition to these limitations, there are some environmental issues. Soy cultivation causes the deforestation, high water consumption and use of pesticides. Fishmeal depends on the catch, and this affects the production, making it variable and continuously increasing its price [9].

The present article aims to review the published results of experiments using alternative feed sources for fish.

II. ALTERNATIVE SOURCES

a. *Cassia fistula*

Legume, ornamental and medicinal plant, it is also a shade tree, there is no current production of the seed, but the trees are often found on the streets of warm countries [10]. Its main composition is Nitrogen Free Extract (505.32 ± 66.73 g kg^{-1} dry matter) and crude protein (257.05 ± 5.73 g kg^{-1} dry matter) giving this source profitable characteristics [11].

- Inclusion in aquaculture.

Cassia fistula seed meal (CFSM) was included in the diets of *Oreochromis niloticus* fingerlings. To obtain the CFSM the seeds were roasted in order to reduce moisture and reduce anti-nutrients, then milled and blended with other ingredients. Five diets were formulated with different quantities of the meal (0, 170, 340, 509 and 670 g kg^{-1}). This study showed a growth depression as the portion of the seed inclusion increased in the

diet, which was attributed to high fiber content and the reduced digestibility [11].

There are reports that *Cassia fistula* seed contains anti-nutritional factors, like hemagglutinin and phytin that when digested, a part of them bounds to other diet proteins making them difficult to digest [12, 13]. Therefore, this experiment suggests different pretreatments, other than roasting as an option to eliminate this hazards [11].

b. Cocoa husk

Cocoa (*Theobroma cacao*) husk is an agricultural waste available in cocoa plantations and its main composition is Nitrogen Free Extract (353 g kg^{-1} dry matter) and crude fiber (334 g kg^{-1} dry matter) [14].

- Inclusion in aquaculture.

This study evaluated the feed consumption, digestibility and growth of *Oreochromis niloticus* fingerlings fed with diets containing cocoa husk at two inclusion levels (100 and 200 g kg^{-1}). The husk was milled and mixed with other ingredients. They found that cocoa husk in the diet is acceptable, however, there is a need to improve the low digestibility and poor feed conversion ratios [14].

c. Cereals: maize, wheat and rice

Cereals are great and cheap sources of carbohydrates. In Kenya, the most common among these by-products include maize, wheat and rice brans (MB, WB and RB) [15].

- Inclusion in aquaculture.

There have been some trials using cereals as sources of carbohydrates, however this study, focuses in semi-intensive production. In this experiment, it was found that fish that were fed maize and wheat grew faster than those who were fed with rice brans, also, fish fed with maize grew significantly better than the ones fed with wheat. It was concluded that fish grow better with decreased levels of fiber, regardless the level of dietary protein [15].

Wheat resulted in the source with more profitability and if not available, maize could replace it with higher costs. Another approach would be application of staged feeding strategy [16].

d. Waste date meal (WDM; low-quality date palm, *Phoenix dactylifera* L.)

Dates grow around the world and when processed, a substantial amount of total production results inedible. The waste has low quality and usually is rejected and poorly valorized. Its main composition is Nitrogen Free Extract (853.2 g kg^{-1} dry matter) [17].

- Inclusion in aquaculture.

Four diets including WDM at different proportions were evaluated (0, 100, 200 and 300 g kg^{-1} dry matter) in Nile tilapia. In this study, they found that final body weight and specific growth rate were statistically not significantly different and that WDM could be a substitute for SBM up to 300 g kg^{-1} in practical Nile tilapia diets without compromising growth [17].

e. Poultry by-product meal-pet food grade and porcine meal

Animal by-products such as meat and bone meal (MBM) and poultry by-product meal (PBM), have considerable potential as feed ingredients. Their main composition of this sources are Protein (548.0 and 649.0 g kg^{-1} dry matter respectively), Ash (244.4 and 127 g kg^{-1} dry matter respectively), and Fat (101.1 and 121.1 g kg^{-1} dry matter respectively) [18].

- Inclusion in aquaculture.

Two diets were tested, including 70% of the base diet and 30% of each ingredient. A highest nutrient digestibility for PBM-PG in comparison with PM was reported and it could be related to bioavailability of amino acids, its higher protein content and that was similar to Fishmeal. It suggests that PBM-PG could replace FM protein in diets for fingerling Nile tilapia without affecting growth performance. However, it is important to mention that in order to achieve comparable growth performance with fishmeal diets, an amino acids supplementation should be made [18].

f. Okara meal

Okara meal (OM) is a residue left from soybean after extraction of the water extractable fraction used to produce soymilk and tofu [19]. About 1.1 kg of fresh OM is produced from every kilogram of soybean processed for soymilk [20]. Since the processing of soybean leaves huge amounts of wastes it could use as feed. Is primarily composed of Protein (349 g kg^{-1} dry matter), Fiber (206g kg^{-1} dry matter), and Nitrogen Free Extract (222 g kg^{-1} dry matter) [21].

- Inclusion in aquaculture.

In this study, five diets with different percent replacement with okara meal were tested (0% - control diet, 25%, 50%, 75% and 100%). Fishmeal protein (18% of the diet) was used as source protein in the control diet. Results revealed that the fish fed diets 0, 25, 50 and 75% had significantly the best average body weight, weight gain, specific growth rate and feed intake compared with diet with 100% substitution, which had the lowest values. Also, it was reported that incorporation of OM in the diets increased significantly whole body fat content, this could be due to an apparent increase in digestibility These findings suggest that up to 75% of FM protein can be replaced by OM protein [21].

g. Rice wine residual

Rice wine is an alcoholic beverage that is widely produced in most Asian countries. Because its development, rice wine

brewing industries have been improving, having consistent availability and nutrition value [22, 23]. Unlike wine, rice wine goes through a process of multiple, parallel fermentations. First, Rice starch is converted to sugar by fungi and at the same time, this sugar is converted to alcohol by yeasts. After separating the liquid, the rice wine residual (RWS) is disposed as waste. This waste contains many nutritious substances, and is primarily composed of Protein (381.2 g kg^{-1} dry matter), so it can be especially utilized as a protein source [24].

- Inclusion in aquaculture.

To evaluate the inclusion of RWS seven diets were formulated to incorporate 0, 75, 150, 225, 300, 375 or 450 g kg^{-1}. It was found that growth did not differ significantly. Among all the data and taken together, RWS (at 225 g kg^{-1}) could be used in juvenile Nile tilapia diet without negative effects [24].

h. Protein hydrolysates

As mentioned before, when processing fishes, there are wastes generated that cause environmental pollution [25]. Hydrolysis is a process that has been developed to convert fish wastes into more acceptable forms [26].

- Inclusion in aquaculture.

Fish protein hydrolysate is an ingredient that has already been used in fish feed [27]. In this study, four experimental diets were fed to turbot these diets were made with fish hydrolysate and ultra-filtered fish hydrolysate on growth performance. The hydrolysates of different sizes were produced by enzymatic treatment and size fractionated using ultra-filtration to replace fish meal protein. Fish meal was used in the control diet. Results indicate that a diet containing higher dose of the small molecular weight compounds in fish hydrolysate show the best growth and feed utilization [28].

Other study was made in juvenile red seabream. A basal diet was used as control and three other diets were made using krill hydrolysate concentrate, shrimp hydrolysate powder or tilapia hydrolysate powder. It was reported that growth performance and feed utilization were significantly higher in the krill and shrimp diets. Also, that supplementation of the hydrolysates at approximately 5%, replacing fish meal by 10%, can improve the growth performance of juvenile red seabream [29].

i. Dry olive cake

Olive pomace is a product that remains after oil is extracted from the olive, it is available thanks to the great tonnages it reaches. This waste has fragments of skin, pulp pieces of kernel and some oil, its main composition is Fiber (231 g kg^{-1} dry matter) and protein (117.8 g kg^{-1} dry matter) [30].

- Inclusion in aquaculture.

Olive pomace is already used as an alternative source for animal feed [31]. There are studies on the use of olive pomace and pomace oil as an oil source for aquaculture feeds [32, 33, 34]. In this study, dry olive cake was included in the diets for juvenile hybrid tilapia (*Oreochromis niloticus* x *Oreochromis aereus*). Four diets were prepared including OC at levels of 0, 120, 240 and 360 g kg^{-1}. It was observed that growth performance, digestibility, feed conversion rate and protein efficiency rate decreased with the increase of dietary Olive cake levels. This residue can be incorporated to diets of juvenile hybrid tilapia up to 120 g kg^{-1} without adverse effects [30].

j. Rubber seed

Rubber seed is a by-product of natural rubber plantation (*Hevea brasiliensis*). China produces an estimated average of more than 1.13 million tons rubber seeds annually. This quantity is largely wasted [35] and could be used as animal feed due to its composition, which consists primarily of fat (685 g kg^{-1}) and protein (174 g kg^{-1}) [36].

- Inclusion in aquaculture.

A feeding trial was made to evaluate the effects of replacing plant proteins with rubber seed meal (RSM) on juvenile tilapia (*Oreochromis niloticus* x *Oreochromis aereus*). Five experimental diets were formulated with 0, 65, 130, 195 and 260 g kg^{-1} RSM levels. The results indicate that dietary RSM inclusion level up to 195 g kg^{-1} did not affect the growth and health status of tilapia. Also, inclusion of RSM might result in reduced feed digestibility [37].

k. Corn protein concentrate

Corn protein concentrate (CPC) is a newly manufactured corn protein prepared by enzymatically removing the non-protein components of the corn. This by product consists primarily of 752 g kg^{-1} crude protein and 41 g kg^{-1} crude fat [38]. It has more protein than common corn gluten meal (600 g kg^{-1}). CPC has also a strong yellow color as it is made from yellow corn [39].

- Inclusion in aquaculture.

Four diets containing 0, 50, 100 and 190 g kg^{-1} corn protein concentrate (CPC) as replacement for dietary fish meal were fed to Nile tilapia *Oreochromis niloticus* fingerlings. The obtained results show that it is possible to replace up to 534 g kg^{-1} of dietary fish meal using 100 g kg^{-1} of CPC without any negative effect on fish [39].

l. Freshwater shrimp (*Caridina nilotica*) and mung bean (*Vigna radiata*) meals

Mung beans (*Vigna radiata*) are popular for human consumption, however in Uganda there is a limited consumption even though it grows well in the area. Freshwater shrimp *Caridina nilotica* may be a suitable protein source since it is a natural prey of Nile tilapia [40].

- Inclusion of mug beans in animal feed.

Mung beans (*Vigna radiata*) have been successfully used in diets for broiler chicken [41] and Asian sea bass [42]. Results from a study suggest that *V. radiata* can partly replace fishmeal in the diets of juvenile Nile tilapia [43].

- Inclusion shrimp in aquaculture.

A study suggests that *C. nilotica* can be used to partially replace fishmeal in feed for Nile tilapia. The growth of the tilapia was best when *C. nilotica* replaced partially the FM and better than when FM was the only protein source [44].

- Inclusion shrimp and beans in aquaculture.

This study examined the potential of shrimp *Caridina nilotica* (CNM), and mung beans, *Vigna radiata* (VRM), to replace fishmeal (RAF) in fish feeds in East Africa. Six diets were tested on Nile tilapia. The growth performance was best in groups fed diets containing either fishmeal or *C. nilotica* or a combination of the two. There was poor feed conversion ratio when the diet was a combination of *C. nilotica* and *V. radiata*. *Caridina nilotica* is a good candidate to substitute fishmeal in practical diets for Nile tilapia [40].

m. Microalgae

Microalgae trade is successful because they can be used in several ways: for the production of food supplements, antioxidants, natural colors and polyunsaturated fatty acids. The most important applications in aquaculture are in nutrition as a single component or as an additive in food [45].

The most used species are: *Chlorella, Tetraselmis, Isochrysis, Pavlova, Phaeodactylum, Chaetoceros, Nannochloropsis, Skeletonema* and *Thalassiosira*. To be used, they must meet certain requirements such as easy to grow, have no toxicity and have a high nutritional value [46]. It is also important that they contain polyunsaturated fatty acids; such as eicosapentaenoic acid (EPA), α-linolenic acid (ALA) and arachidonic acid (AA), are essential for several fish since they serve as precursors in the regulation of development and physiology. Most microalgae have moderate to high levels of EPA, *Nannochloropsis* and diatoms have the highest levels of AA (0-4%). Chlorophytes such as *Dunaliella* and *Chlorella* are deficient in polyunsaturated fatty acids (C20 and C22), therefore, they have low nutritional value and are not suitable for a diet [47].

- Inclusion in aquaculture – *Spirulina*

In this study, *Sprirulina maxima* was used as protein source for tilapia (*Oreochromis mossambicus*) fry. Five diets were made, with animal protein replaced with algae at ratios of 20%, 40%, 60%, 80% and 100% and a diet control with fishmeal as animal protein. Growth rate showed no significant difference between control, 20% diet and 40% diet. None of the diets showed adverse effects on carcass composition. They concluded that *Spirulina* can replace up to 40% of fish meal [48].

In other study, in order to develop a food chain (phytoplankton–fish) in a recirculating aquaculture system, *Spirulina platensis* was fed to tilapia *Oreochromis niloticus* with a commercial diet as the control treatment. Fish grew efficiently and showed a high survival rate (95%), the ones fed with *Spirulina* had a higher protein content, a higher polar lipid content and a lower ash content than fish fed the commercial diet. The results suggest that it is feasible to use *Spirulina* to feed tilapia [49].

- Inclusion in aquaculture – *Chlorella* spp and *Scenedesmus* spp

In this study, the effect of partial replacement of fish meal with dried microalgae (*Chlorella* spp and *Scenedesmus* spp) in Nile tilapia (*Oreochromis niloticus*) diets on fish growth performance, feed efficiency and body composition was researched. Diets were formulated with *Chlorella* and *Scenedesmus* as fish meal replacers (10, 25, 50 and 75%) and a control. Results indicated that dried *Chlorella* spp and *Scenedesmus* can replace fish meal up to 50% in Nile tilapia diets without having any adverse effects [50].

- Inclusion in aquaculture – *Spirulina platensis*, *Euglena gracilis* and *Chlorella vulgaris*

Three species of freshwater algae (Spirulina platensis, Euglena gracilis and Chlorella vulgaris) were fed to larval tilapia (*Oreochromis niloticus*) to assess their acceptability. For all three algae, it was found that assimilation efficiency improved when larval sized increased. *Spirulina* was better assimilated (61.4–80%) than *Euglena* and *Chlorella* [51].

- Inclusion in aquaculture – Algal mix

Three diets containing 0 %, 35% and 100% algal supplementation were used in combination with other conventional fish feed ingredients to fed tilapia (*Oreochromis mossambicus*). The algal genera used were *Phormidium valderianum*, *Spirulina subsalsa*, *Navicula minima*, *Chlorococcum infusionum* and *Rhizoclonium riparium*. The results suggested that 35 % supplementation with composite algal mix can be used in Mozambique tilapia diet [52].

- Inclusion in aquaculture – Freshwater (*Spirulina*, *Chlorella*) and marine (*Schizochytrium*) microalgae

The digestibility coefficients of macronutrients, amino acids and fatty acids for freshwater (*Spirulina*, SPI; *Chlorella*, CHL) and marine (*Schizochytrium*, SCI) micro algal ingredients in Nile tilapia via four diets were determined. The results showed higher coefficients in *Spirulina*, determining that this microalgae is a good alternative protein for tilapia diets [53].

- Inclusion in aquaculture – *Schizochytrium* sp.

This study determined the optimum level of fish-oil substitution with microalgae for maximum growth of Nile tilapia. When fully replaced, they found higher weight gain compared to control. Results also show that replacing fish oil with DHA-rich marine Sc improves the deposition of PUFA levels in tilapia fillet. *Schizochytrium* sp. proved to be a high quality candidate for complete substitution of fish oil in juvenile Nile tilapia feeds [54].

n. Insects

Since ancient times, insects have been one alternative protein source to humans for compensating the scarcity of other sources. The most existing studies have focused on the insects that have played an important role in human nutrition in Africa, Asia, and Latin America [55]. Insects could be an interesting source of protein for animal feeding. Mass rearing could ensure a constant production in quantity, quality and stability of supply and price. Rearing does not compete with feed resources or land use. Use of insects could be a high-quality animal protein source making use of environmentally sustainable technology [56].

To use insects for fish feeding, it is necessary to determine the nutritive characteristics of these insects. In this study, 16 different species of the orders Coleoptera, Diptera and Orthoptera were examined. The analyzed insects have a higher proportion of fat and less protein than fish meal. The amino acid profile is similar to fish meal with the exceptions of histidine, threonine and lysine, Diptera was the most similar. However, insects have higher ratios of omega 6 and monounsaturated fat, composition of fish meal has lower ratios, so this must be taken in care when inclusion in diets [57].

- Inclusion in aquaculture – *Tenebrio molitor*

Tenebrio molitor (Coleoptera: Tenebrionidae) is primarily composed of Protein (584.2 g kg^{-1} dry matter) and Fat (300.9 g kg^{-1} dry matter), which shows this could be a promising protein and fat source for feeds. In this work, the inclusion of Tenebrio molitor meal (TM) to replace fishmeal in *Oreochromis niloticus* diet was studied. The results indicated that an inclusion up to 500 g kg^{-1} of TM in the diet did not affect the fish [56].

- Inclusion in aquaculture – *Musca domestica*

The house fly *Musca domestica* Linnaeus (Diptera) is one of the most known and studied. A trial using housefly (*Musca domestica*) maggot meal (MM) in diets for Nile tilapia (*Oreochromis niloticus*) was conducted to assess the growth performance. Five diets where fishmeal (FM) was substituted by MM at the level of 0, 90, 180, 270 and 360 g kg^{-1} were fed to tilapia. No significant difference was showed in feed intake and apparent digestibility coefficient between the treatments. Replacing up to 270 g kg-1 FM did not show an impact on the growth performance and ingredient utilization, completely replacing of FM caused a lower survival rate, weight gain, specific growth rate and higher feed conversion rate [58].

- Inclusion in aquaculture – *Black Soldier Fly*

The black soldier fly larvae (BSFL), *Hermetia illucens*, has become a popular bio-recycling that breeds in various substances [59]. Due to this, BSFL are used to compost wastes (manure, and animal and vegetable food wastes). Mature larvae and prepupae grown can be used to supplement diets [60]. This meal contains >400 g kg^{-1} of protein and >350 g kg^{-1} of lipids [61, 63].

Catfish and tilapia

Black soldier fly larvae *(Hermetia illucens* L.) were fed to catfish and tilapia, alone, and in combination with

high-(45%) and low-(30%) protein commercial diets. The commercial diets were also fed as controls. Similar effects of the six diets were reported. Taste tests were also made with no adverse effects [59].

Rainbow trout (*Oncorhynchus mykiss*)

Two of the test diets included the black soldier fly, Hermetia illucens, prepupae. The total protein from black soldier fly prepupae (BSFPP) in the two test diets was 15 and 34%, respectively. Results show that a diet where fly prepupae constitute 15% of the total protein has no adverse effect. However, fish fed with BSFPP showed reduced levels of omega-3 fatty acids in their muscle fillets [61]. Other study used the Black soldier fly larvae in different levels of fishmeal replacement (0, 50, and 70%) and found negative trends when increasing its inclusion, however they concluded that it can substitute fish meal up to 50% in trout feds [62].

Other study included a partially defatted Hermetia illucens (HI) larvae meal as potential feed ingredient in rainbow trout (*Oncorhynchus mykiss* Walbaum) diets. The inclusion levels were 0% (HI0, control diet), 25% (HI25) and 50% (HI50). Results showed that this larvae meal can be used as feed ingredient in trout diets up to 40% of inclusion level without impacting survival and growth performance [66].

Turbot (*Psetta maxima*)

Six diets were formulated to replace fish meal protein subsequently by Hermetia meal (HM) protein, they contained 0%, 17%, 33%, 49%, 64%, and 76% of HM. Feed intake was affected, it decreased when increasing HM incorporation due to low palatability. Growth performance was high, but also affected, protein retention and decreased when increasing HM. This study shows that the incorporation of HM protein in fish diets is possible, but limited [63].

Tilapia (*Oreochromis niloticus*)

This study evaluated the effects on the performance, feed utilization efficiency and body composition of an inclusion of Black Soldier Fly larvae meal (MM) in a commercially formulated diet for advance nursing Nile tilapia (*Oreochromis niloticus*). Three test diets were made with inclusions of MM

(0, 30, 50 and 80 g/kg) and poultry by-product meal substituting fish meal, fish oil and soybean meal. Growth performance, feed utilization efficiency indices and feed intake were not significantly different between treatments [64].

Atlantic salmon (*Salmo salar*)

Two insect meal of BSFL (different due to different nutrient isolation and processing techniques) (IM) were tested in diets for Atlantic salmon. The control diet contained 200 g kg^{-1} fish meal (FM), which was replaced by insect meal A and B with 25%, 50% or 100% levels of inclusion. A25, A50 and A100 performed equally well as the FM100 diet. Only Insect Meal A was suitable to replace up to 100% of dietary fish meal [65].

Jian carp (*Cyprinus carpio* var. Jian)

To investigate the effects of Black soldier fly inclusion in juvenile Jian carp (Cyprinus carpio var. Jian), five experimental diets were formulated by substitution of 0%, 25%, 50%, 75% and 100% soybean oil (SO) with BSO. Fatty acid composition and lipid deposition was determined, and the results showed that growth and nutritive utilization were not different. These results suggest that the growth of Jian carp is not affected by dietary BSO, while it decreased lipid deposition in the intraperitoneal fat tissue [67].

Other study was carried out to estimate the effects of fish meal replacement by defatted black soldier fly larvae meal (DBSFLM) in Jian carp (*Cyprinus carpio* var. Jian) juveniles. Five diets were formulated by replacing 0%, 25%, 50%, 75%, 100% fish meal (FM). The results showed that the growth performance and nutrients utilization of fish in five groups were not different. These results suggest that the growth of Jian carp is not affected by dietary DBSFLM. The study also proves that it is viable to replace up to 50% of dietary fish meal [68].

III. CONCLUSIONS AND FUTURE CONSIDERATIONS

By not having a sufficient supply of aquaculture feeds and the existence of a constant variation in prices, the search for alternative supplies is essential. Different alternatives for protein and fat parts have been researched, obtaining good results. However, these results show that the inclusion of them until now is partially due to the low palatability and digestibility that they have when ingested by the fish. It is necessary to develop foods that improve tilapia composition, as well as increase their effectiveness when consumed. Innovative foods, environmentally and socially sustainable are needed. Still more studies should be done with these sources to reduce feed costs as much as possible. After reviewing and observing both its performance and composition, it was observed that two of the most promising supplies to be used for balanced feeds are microalgae and black soldier fly larvae. There is still a lack of results with mixes in tilapia, so both are proposed to develop an innovative feed. Under this statement, a balanced feed for tilapia with different proportions of these supplies and commercial diet was developed in the Laboratorio de Bioingeniería and are ready to be evaluated and try to attack the presented problem.

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Use of Polyethylene Terephthalate (PET) as aggregate in concrete mixes.

Mechanical strength of the concrete added with Polyethylene Terephthalate (PET).

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Keywords—PET; Concrete; Resistance; Environment.

I. ABSTRACT.

The following experimental work aims to observe the behavior of concrete mixtures added with polyethylene terephthalate (PET) as aggregate. The foregoing, due to the disproportionate consumption that is currently given to PET, and to find an alternative that can be used in Civil Engineering, as it is needed options to reduce the impact on the environment such material.

A simple concrete pattern mixture was made, to which it was added PET in proportions of 5%, 10% and 15%, to the previous designs were replaced sand by the PET. To carry out the tests of mechanical resistance, a universal machine was used and the specimens of 15x30 cm. were subjected with an age of 28 days to axial compression.

All the designs showed similar behaviors, but the most suitable to be considered in Civil Engineering uses is the one that was added with 5% of PET, because as it increased the percentage used of PET, the resistance to compression of Concrete specimens decreased.

With this we can say that the use of PET as an aggregate in the concrete is possible, however, in need to continue investigating the impact that produces these mixtures in order to reach the proportionality that allows its implementation in Civil works.

II. INTRODUCTION.

Environmental impact of PET.

Basically the elaboration of the PET is based on large quantities of oil, in addition to its production it is necessary to use toxic substances, heavy metals, chemicals and pigments that remain in the environment and pollute it considerably.

PET also has characteristics that make its demand increase, and as a result its production. Some of them are economic, light and waterproof. However, the problem that arises from the above is that the PET slows to degrade about 700 years and if it is not reused for other purposes, the only thing that is causing is to store in the environment all the plastic produced. It is estimated that 25 million tons of plastics accumulate in the environment each year and can remain unchanged for a period of between 100 and 500 years. [1]

We can say that the PET currently pollutes both in its production, as well as after its useful life.

History of the use of polyethylene terephthalate (PET) as construction material.

Research around the use of PET as a construction material has become important in recent years due to the problems it poses. These investigations are of a varied nature, to mention some of the uses is the one proposed by the School of Civil and Environmental Engineering, from the Concrete Structural Engineering Laboratory, in South Korea [2], which is to use recycled PET fibers to reinforce concrete.

Similar investigations have been carried out in the Department of Civil Engineering, at the University of Salermo, in Italy [3], since by the same principle of the implementation of recycled PET fibers in the concrete, the thermo-mechanic properties that this material can provide have been analyzed.

To mention initiatives in Latin America, it has to the Centro Experimental de Vivienda Económica (CEVE) of Argentina, has made bricks with PET, whose greatest benefits is that they are light bricks of about a kilo of weight.

Examples such as the above, make the implementation of PET in the construction will be a reality in the present, as well as an alternative to solve the environmental problem that the plastics represent.

III. ELABORATION OF CONCRETE MIXTURES ADDED WITH POLYETHYLENE TEREPHTHALATE (PET).

The designs were made from a mixture of simple concrete pattern calculated to have a resistance of 200 kg/cm^2, from it was carried out the optimal dosage of the others, once calculated the first proceeded to calculate the percentage of PET of each of the

others and the content in kg. was disaggregated to the total of sand for each one of the proposals.

In this sense, four mixes were made, as mentioned above, the mixture pattern, the mixture with 5% of PET, the mixture with 10% of PET, and finally the one that had 15% of PET.

The PET used, was crushed in a commercial way and not carried out particle size, however, it is estimated that the material varied in dimensions of 1/8" to 1/2".

Three specimens were produced for each of the mixtures. The specimens that were of the type cylinder with dimensions of 15 x 30 cm. as marked by the standard ASTM C 31 "Standard practice for the preparation and curing of concrete test specimen in the work".

The quantities of each component of the mixtures are presented in Table 1.

Material.	Mix Types.			
	A	B	C	D
PET (kg)	0	0.8875	1.775	2.6625
Cement (kg)	3.75	3.75	3.75	3.75
Sand (kg)	17.75	16.8625	15.975	15.0875
Stone (kg)	17.75	17.75	17.75	17.75
Water (l)	4.3	4.3	4.3	4.3

Table 1 | Mixing supply.

Where:

Mix A: Concrete pattern mix.

Mix B: Concrete with 5% Polyethylene Terephthalate.

Mix C: Concrete with 10% Polyethylene Terephthalate.

Mix D: Concrete with 15% Polyethylene Terephthalate.

Once the specimens were left in the moulds for 24 hours, after this period, the specimens were taken out of the moulds and cured in a curing chamber to avoid loss of moisture that will cause fissures in the tubes and modify the results of the investigation.

IV. Tests of concrete specimens added with Polyethylene Terephthalate (PET).

The nomenclature used to name each of the specimens was as follows, the letter means the type of sample and the number the order in which they were made.

The test to which the specimens were subjected was to axial compression, using a universal machine. The essays were carried out at 28 days and basically the procedure was the following.

Before the test, all specimens were nodded with Sulphur mortar as indicated in ASTM C 617 "Normative practice for the nod of cylindrical concrete specimens", this in order to ensure that the load was applied perpendicularly to the specimens. After that, the cylinders were tested and the results are shown Table 2.

Cylinder.	Table Column Head		
	Max. Load (kg)	Max. Stress (kg/cm^2)	Avg (kg/cm^2)
A-1	35900	203.15	
A-2	38000	215.04	208.7
A-3	36740	207.91	
B-1	35100	198.62	
B-2	34700	196.36	199.0
B-3	35700	202.02	
C-1	34500	195.23	
C-2	33900	191.83	194.47
C-3	34700	196.36	
D-1	32650	184.76	
D-2	32100	181.65	186.77
D-3	32500	183.91	

Table 2 | Results of the axial compression test.

In addition, it was possible to identify the type of failure that prevailed in the cylinders tested. The fault was due to adherence, which means that the interphase between the components of the mixtures was not formed, causing fissures within the specimens themselves that caused the cylinder failure at the time of loading them.

V. Results and Discussion.

The results obtained during the experimentation lead us to analyze different factors that cause as the percentage of PET increases, the resistance of the mixture is affected. The main one is that by increasing this percentage and reducing the fine aggregates for obvious reasons the adhesion of the particles of the mixture will be less, factor that caused that the majority of the specimens failed by adhesion.

In relation to the above, by decreasing the amount of sand and replacing it with PET, the water in the hydration reaction of the concrete behaved in a different way, and possibly also modified the results.

The foregoing suggests that PET is a possible alternative, however, the methodology that will be carried out will have a significant impact on the mixtures. Therefore, it is advisable to continue experimenting to obtain a relationship of addition of the studied material that allows it to be employed in work, perhaps not in structural elements, but in masonry elements as in bricks or in similar applications.

VI. CONCLUSION.

Throughout the experimentation, we could observe a number of factors that make the addition of PET in concrete mixes an alternative to try to solve one of the biggest environmental problems of the last decades, and to contribute of this way to the final disposal process of polluting plastic waste.

As could be seen in the results, to extent that varies the percentage of PET and reduces the amount of fine aggregate, in this case sand, the resistance to the compression varies with visible relationship, to greater PET contains the mixture, the lower its resistance. And this may be due to different factors, but the most notable ones are that there is no adhesion in the mixture due to the addition of the plastic, besides that the irregular shape and with pronounced vertices of the particles of the PET can cause the elements to fail.

The main benefit is that reduces the amount of PET in the environment, however, it cannot be used in items involving large loads as it does not respond in the way it would be expected, on the other hand, it can be an alternative to be used in bricks or masonry blocks.

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Study of the profitability of a polyculture in a greenhouse ventilated naturally with CO_2 injection

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In recent years agriculture has faced a shortage in world production, a measure that has been taken is the production in greenhouses, within this there is the technique of carbon fertilization, presenting multiple benefits in the crop, mainly the increase in production in the mass of the fruit; In this article, an analysis was made of the carbon enrichment technique and the costs involved in this. This article begins with agriculture and its current state, then deals with how CO_2 is involved in the process of photosynthesis and what carbonic fertilization consists of, after which the works that have been presented with respect to the subject are mentioned. Finally, the profitability analysis and the costs involved in this work are explained in more detail

Keywords—: analysis of rentability, Carbon dioxide, carbonic fertilization, CO_2 management, greenhouse, increase of cultivation

I. INTRODUCTION

1.1 Agriculture today

Agriculture today faces more and more challenges, it has to produce more food in order to give food to a population that is increasing, this leads us to the need to adopt more efficient and sustainable production methods. Studies show that to feed a world population that is estimated to reach 9 100 million people in 2050, it will be necessary to increase food production by 70% between 2005/07 and 2050. Within this increase, it is estimated that around 80 % of the increase will be due to the intensification of crops and the rest to the increase of the cultivable area (FAO, 2009).

A way to intensify crops that has been gaining strength over the years is the protected agriculture, this consists of the use of greenhouses for the development of the crop; As described by Serrano (2005), it is a construction that is protected by covers, the purpose of which is to defend the plants from the action of harmful external factors. This construction also has the function of controlling and providing the optimal conditions for development; the conditions or parameters that are controlled are usually temperature, relative humidity, concentration of CO_2 in the air, light intensity. By being able to control the aforementioned parameters we can have a large number of advantages such as increasing the quality, production and number of crops per year in the crop, as well as we can decrease the water consumption and the time of the crop cycle, in addition to to be able to cultivate in climatic zones and seasonal periods in which it is not possible in open field, also it offers protection against plagues, illnesses and adverse climates, finally it will allow us to work with greater comfort and security.

1.2 Carbonic fertilization in greenhouses

As we know the development of a crop is linked to its ability to perform the process of photosynthesis, a physical-chemical process by which plants and other organisms use the energy emitted by the sun in the form of light to synthesize organic compounds, the process involves the release of molecular oxygen and the use of atmospheric CO_2 (Pérez and Urria, 2009). Enoch (1990) and Lorenzo (2012) emphasize that the growth and development of crops is usually determined in large part by the photosynthetic assimilation of CO_2

The procedure in which the environmental level of CO_2 is increased in a greenhouse is known as carbonic enrichment or carbonic fertilization, this increase is usually between 700 and 800 ppm, this technique has been used for years in greenhouses in cold climates, however , in hot climates it becomes difficult to apply CO_2 because it is necessary to keep the windows open of the greenhouses to allow a correct natural ventilation that allows to reduce the high temperatures. (Antón et al., 2011).

1.3 Study of the profitability

As we know, starting a CO_2 injection system is an investment that must be analyzed in the long term to quantify the profitability of this type of project through the useful life of these systems; One way to analyze it is through a projection of money over time to do this. We must analyze the inflows and outflows of money that this type of systems will represent throughout the life of the project. The net present value is one of the most widely used economic methods in the evaluation of investment projects. It consists of determining the equivalence in time zero of the future cash flows generated by a project and comparing this equivalence with the initial outlay, when said equivalence is greater than the initial outlay it is recommendable that the project be accepted

II. Materials and methods

The project is being carried out in the town of Amazcala, municipality of El Marques, Queretaro within the facilities of the Autonomous University of Querétaro, Amazcala Campus. It worked with two crops, tomato *(Lycopersicon esculentum Mill.)* And cucumber *(Cucumis sativus L.)*, the selection of these crops was made due to its economic importance and its high demand in the market.

The first step developed in our experiment, was the habilitation of spaces, for this the conditions of the two greenhouses were reviewed (experimentation and control), it was checked that the plastics, meshes and irrigation system were in good condition, which already They were damaged and replaced by new ones.

A CO_2 injection system was installed in one of the greenhouses, consisting of a 25 Kg liquid CO_2 tank with a solenoid valve, manometer and the necessary connections to connect to a gas distribution network through the greenhouse, The distribution network was made by perforated pipes through the greenhouse.

We continued with the monitoring system of climatic conditions for this we relied on two CO_2 sensors model FYAD 00 CO2B10, two temperature and relative humidity sensors model FHAD462 as well as the measuring instrument with which the ALMEMO® 25904AS model sensors worked , all the equipment of the ALHBORN brand; With this equipment measurements were made and tests were done to see how the climatic conditions behaved inside the greenhouses.

III. Results and discussion

At the moment the crops have not reached their flowering stage in which it is recommended to begin with the carbonic fertilization, already beginning this stage it is expected to document the expenses that were carried out due to the liquefied CO_2, as well as those implied by the system distribution and CO_2 injection. Finally at the end of the harvest the difference in production of the two greenhouses can be quantified and an estimate of the net profits due to carbonic fertilization can be made and all these numbers can be taken to a net present value to observe the profitability of these systems

IV. Conclusions

It is expected to have an increase in crop yield close to 20% considering the current conditions of the greenhouse, therefore it is expected that this activity is profitable and that more knowledge about this type of systems is generated.

Acknowledgment

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DFT Calculations of AlAs and GaAs

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Abstract—**This paper contains the results obtained from ab-initio DFT calculations made for aluminum arsenide (AlAs) and gallium arsenide (GaAs) alloys. The unit cell for each alloy was modeled. The importance of the calculations rest in the fact that both compounds are classified as III-V semiconductors and by performing the DFT calculations we can theoretically determine its electrical properties. The results show that GaAs has a direct band gap, conversely AlAs has an indirect band gap. The difference in the band gap size can also be observed.**

Keywords—aluminum arsenide, gallium arsenide, convergence energy, band gap, face centered cubic.

I. INTRODUCTION

When analyzing any compound, compression of the material's structure at the atomic level plays a very important role. For these analyses ab-initio methods were used, these methods refer to the computations derived directly from theoretical principles (such as the Schrödinger equation), without including experimental information [1, 2]. The approximations used are commonly mathematical, such as using a simpler functional from of a function or obtaining an approximate solution to a differential equation. The ab-initio methods are characterized by the following: (1) They can be systematically improved to increase their accuracy, (2) It is not necessary to parameterize or calibrate according to the experiment, (3) It allows to describe geometries and properties (i.e. energy and reactivity), (4) They are computationally expensive, since they require computing time to perform their calculations [2]. These methods are very useful since they can simulate materials that scientists want to synthesize predicting beforehand whether or not they have the properties that are required.

Class III-V Alloys such as aluminum arsenide (AlAs) and gallium arsenide (GaAs) [3, 4], are semiconductors that have subjected to several experimental and theoretical studies, for they possess significant technological implications [5], e.g. one of its most important applications is in the creation of solar cells [6].

II. METHODOLOGY

Ab-initio calculations were carried out with Quantum-Espresso in Linux operating system, Quantum-Espresso code is based on the Density Functional Theory (DFT) [7]. Correlation is adjusted by the Perdew-Burke-Ernzerhof (PBE) generalized gradient approximation (GGA) [8].

XcrysDen Software was used to model the cubic structure of AlAs and GaAs.

III. RESULTS

A. AlAs and GaAs Structure

AlAs structure is a zinc-blende type face centered cubic (fcc) as shown in Figure (1) and has an indirect energy gap. The GaAs has a direct energy gap with a face centered cubic zinc-blende crystal structure (Figure 2). Both compounds were modeled using XcrysDen.
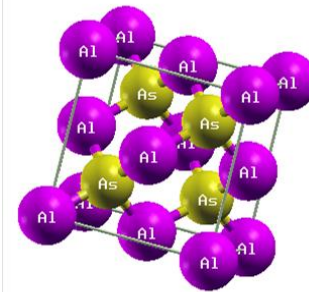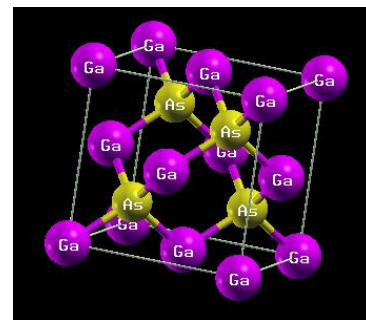

Figure 1. AlAs FCC structure.

Figure 2. GaAs FCC structure

B. Cut-Off Energy

Energy convergence for both alloys was determined by varying the cut-off energies. The energy convergence graph for AlAs is shown in figure (3), energy convergence is observed at cut-off energy of 55 Ry.
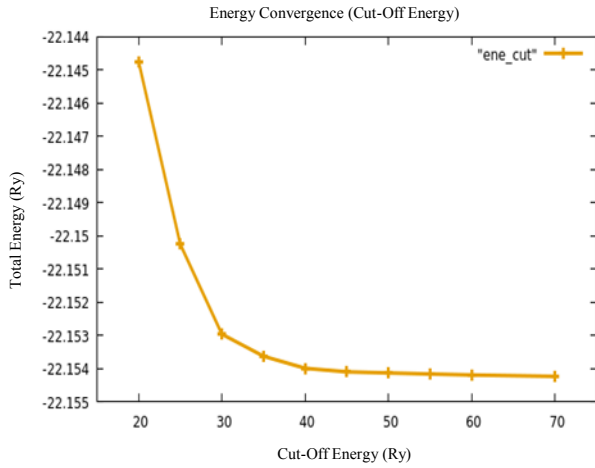
Figure 3. Energy Convergence (Cut-Off Energy) AlAs.

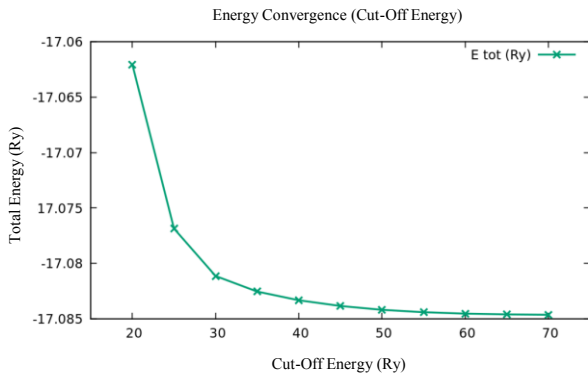For GaAs energy convergence is reached at a 65 Ry cut-off energy (Figure 4).

Figure 4. Energy Convergence (Cut-Off Energy) GaAs.
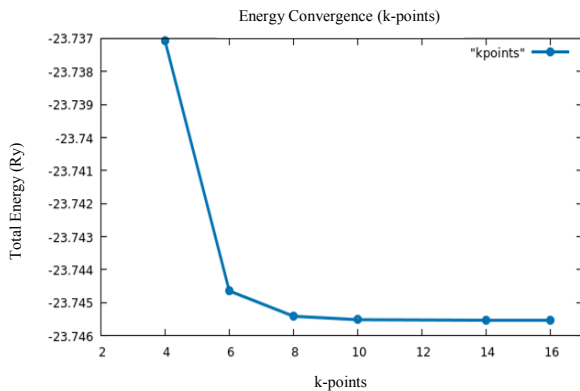
C. K-points

Figure 5. Energy Convergence (k-points) AlAs.

To determine the energy convergence point of the system for a sampling of the Brillouin zone (k-points), the k-points were varied from 4 to 16 for AlAs, and from 2 to 18 for GaAs. From the results in Figure (5) it can be concluded that for AlAs k-point

14 is where convergence is reached since starting from this point variations in the energy of the system are negligible. For GaAs, Figure (6) shows that the convergence is reached at k-point 14.
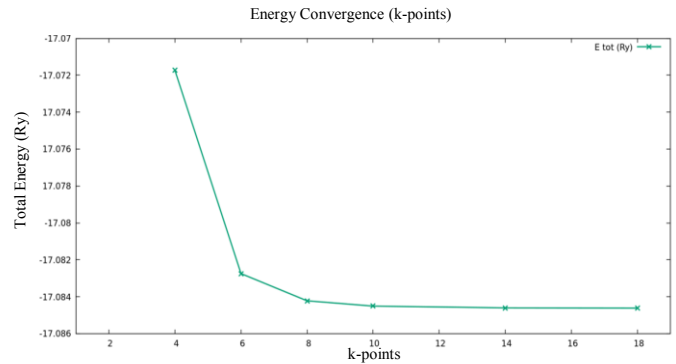

Figure 6. Energy Convergence (k-points) GaAs.
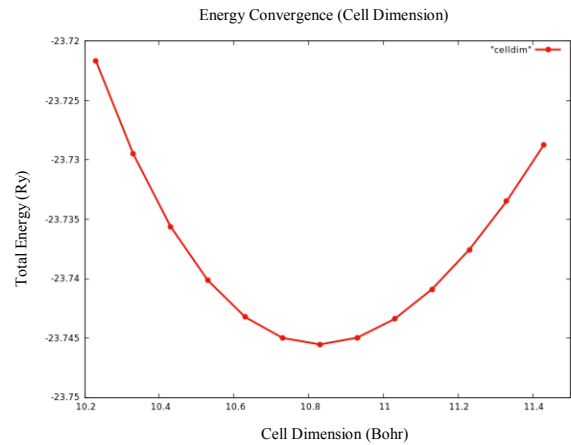
D. Lattice Parameter

Figure 7. Energy Convergence (Cell Dimension) AlAs.

With the convergence data obtained, it was possible to obtain the lattice parameters for both alloys. Total energies were calculated while the cell dimension was varied. When graphing the energy results, parabolic graphs were obtained whose lowest points indicate the lattice parameter for the alloys (see Figures 7, 8). However, at first glance it is not possible to determine which the lowest energy point is.
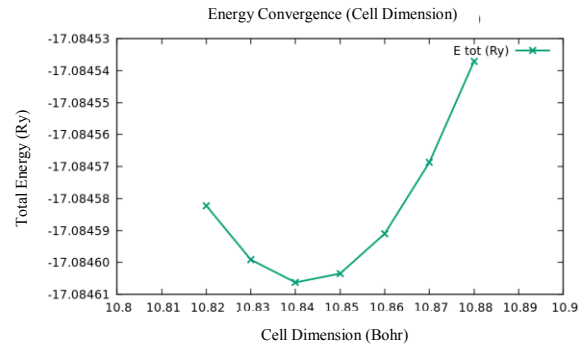

Figure 8. Energy Convergence (Cell Dimension) GaAs.

E. Minimum Energy

To obtain the minimum energy of the system, Birch's second-order equation was used. This equation allows to know the exact point where the energy is at its lowest. With the help of this equation and Quantum-Espresso the following data were obtained:

For AlAs the lattice parameter is 10.8273 bohr. or 5.72956 Å that corresponds to a minimum energy of -23.74554 Ry. For GaAs, the lattice parameter is 10.8421 bohr or, 5.73741 Å equivalent to a minimum energy of -17.08461 Ry. The energy convergence and lattice results ca be seen in Table (1).

Table 1. Results.

Results		
Variable	AlAs	GaAs
Cut-Off Energy	55	65
k-points	14	14
Lattice parameter	5.72956 Å	5.73741 Å

F. Band Structure

Figure (9) shows AlAs band structure where the indirect band gap can be observed, where the highest valence band value appears close to gamma and the lowest conduction band value is close to X, between X and W. The band structure of GaAs is depicted in Figure (10) where the direct band gap is located at the Gamma point.

As it can be observed, in the case of GaAs the band gap is almost imperceptible, this is caused by the type of pseudopotential used, which has trouble accurately representing the bad gap for GaAs.
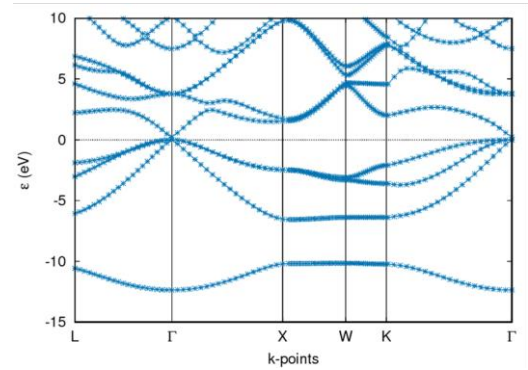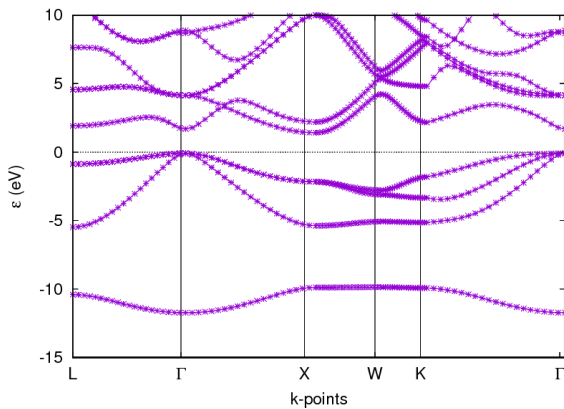

Figure 10. Band Structure of GaAs.

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Nanoencapsulation of Lauric Acid with Chitosan for Bacterial control.

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Abstract— **This work has studied the preparation of chitosan(CS) particles to nanoscale for loaded and released drugs which were synthesized by ionic gelation method, using in CS particles crosslinked with sodium tripolyphosphate (TPP). Different samples were prepared (CS) with different proportions of modifier agents: crosslinker (TPP) and lauric acid (LA) for bacterial control**

Keywords— Nanoparticles, chitosan, lauric acid, ionic gelation, encapsulation.

I. INTRODUCTION

In last decades, the implementation of new pharmaceutical forms of loaded and released drugs, have had great interest in representing a promising platform for the optimization of medical treatments. They are devices that provide better properties, such as stability, high ability to associate, bioadhesivity and reduction of adverse effects, improving the speed, time and place of drug release [1]. Currently, in the development of controlled release systems, a large number of polymers are used. Among them, there are two major groups: Natural polymers and Synthetic polymers [2].

Nowadays, the natural polymers are used as biomaterials. These are biodegradable, non-toxic and biocompatible. They are also abundant in nature and their extraction processes are inexpensive. From the various natural polymers, the chitosan has stood out for its characteristics and great potential. The chitosan is a linear cationic biopolymer obtained by the partial deacetylation of the chitin which is found in the shell of the shrimp, the second most abundant polysaccharide on earth [3]. Some of the functional properties of CS are biodegradability, biocompatibility, mucoadhesivity, absorption promoter, antimicrobial activity, anticholesterolemy and antioxidant. Chitosan has pharmaceutical applications as an extended drug release matrix and it has biomedical applications. From a physicochemical point of view, CS has the special quality of gelling upon contact with anions thus allowing the formation of beads under very mild conditions [4].

The ionotropic gelation method is commonly used to prepare nanoparticles of polysaccharides. This technique has attracted considerable attention due to the fact that this process is non-toxic, organic solvent free, convenient and controllable [5]. This method allows the cross-linking of polymer chains that are ordered in nanostructures by interactions that may be intermolecular of the covalent or non-covalent type, behaving as a metastable thermodynamic system which is highly sensitive to variations in ionic strength [6].

Antibiotic resistance is an emerging problem worldwide present in many bacteria[7]. Indiscriminate use of antibiotics and the environmental selective pressure made by antiseptics and disinfectants have generated a survival answer in the microorganisms, enabling them to efficiently evade the bactericidal action of some agents [8]. The increasing antibiotic resistance is due to the acquisition of different molecular mechanisms of resistance through point chromosomal mutations and /or horizontal transfer of genetic material between related or different species [7].

In the field of microbiology, are called negative microorganisms when they have a different reaction to the Gram stain in their wall cell compared to Gram positive, as there are stained dark blue or violet, pink color. [10] Infections caused by Gram negative bacteria are highly prevalent in hospitalized patients.[11] The cell wall of gram-positive bacteria is host to a wide variety of molecules and serves a multitude of functions, most of which are critical to the viability of the cell [12].

Surface epithelia constitute the first line of defense againstpathogens. This defense depends both on barrier function and on specific microbicidal effector molecules [13].

fatty acids have been shown to be the most potent molecules, possess antistaphylococcal activity[14].

New days are well know that essencial oils derived from plants and spices have antimicrobial affects. Early studies suggest that medium-chain fatty acids, commonly found in tropical oils such as coconut oil, are bactericidal for gram-positive bacteria, even more than gram-negative bacteria, fungi, protozoa, and viruses [10].

Lauric acid is a medium chain saturated fatty acid, present in lauric oils up to 50%. Its systematic name is dodecanoic acid. It doesn't induce any cytotoxicity to human sebocytes. It has a greater antiviral and antibacterial activity than other medium-chain triglycerides. The antibacterial activity mechanism of LA suggests that membrane lipids are solubilized as the LA fatty acids integrate into the membrane, causing lysis of bacteria [11].

II. MATERIALS AND METHODS

A. Materials

Chitosan medium molecular weight with a 75–85% degree of deacetylation came from Sigma–Aldrich, Sodium tripolyphosphate technical grade 85% , Glacial acetic acid, Acetone, Lauric acid ≥98% from Sigma–Aldrich, Inoculo of E. Coli and P. aeruginosa with 16hr growth, PBS/Tween 1%, Agar LB.

B. Chitosan–tripolyphosphate nanoparticle production

CS-TPP nanoparticles were produced using a modified ionic gelation method [12]. CS was disolved in acetic acid (the concentration was, 1.75 times higher than that of CS) aqueous solutions at various CS concentrations: 0.05%, 0.2% and 0.3% (w/v). Later, TPP was dissolved in purified water at the same concentration as CS. In 10 ml of the CS solution was added a variable volume of the TPP solution (2ml, 4ml and 6ml) under magnetic stirring, drop by drop with the aid of an insulin syringe.

	2ML	4ML	6ML
CS 0.05%	TPP 0.05%	TPP 0.05%	TPP 0.05%
CS 0.2%	TPP 0.2%	TPP 0.2%	TPP 0.2%
CS 0.3%	TPP 0.3%	TPP 0.3%	TPP 0.3%

Table 1 Preparation of solutions at different concentrations of chitosan and TPP.

C. Preparation of CS/TPP/LA-loaded nanoparticles

LA-loaded were formed spontaneously after the incorporation of TPP aqueous solution of 10 ml of the CS acidic solution, containing various concentrations of LA (0.2ml, 0.4ml, and 0.5ml), the LA was dissolved in acetone at the same concentration as CS, under magnetic stirring.

	2ML TPP	4ML TPP	6ML TPP
CS 0.2%	0ml LA	0ml LA	0ml LA
CS 0.2%	0.2ml LA	0.2ml LA	0.2ml LA
CS 0.2%	0.4ml LA	0.4ml LA	0.4ml LA
CS 0.2%	0.5ml LA	0.5ml LA	0.5ml LA

Table 2 Preparation of solutions at different concentrations of TPP and LA.
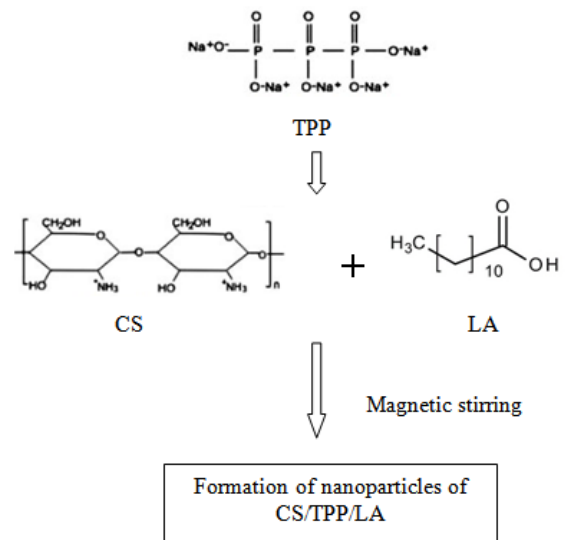

Figure 1 Preparation of nanoparticles. [6, 12, 13]

D. Preparation of QS/TPP/LA films.

Was placed 30 ml of the previously selected solution of Qs/TPP and Qs/TPP/LA on a Teflon surface of 10cm in diameter X 1cm, to avoid the adhesion of the film on any other surface, it continued with storage in a desiccator for evaporation and obtaining od the film required.

E. Preparation of working inoculum.

- Place 5 ml of LB / PBS solution in culture tube with 250 μl of bacteria suspension.
- Make a 1:10 dilution (500 ul of 10^8 + 4.5 ml of LB: PBS).
- Make a 1:02 dilution (2.5 ul of 10^7 + 2.5 ml of LB: PBS).

F. Antimicrobial evaluation of samples.

The first is the neutralization of films, take a small samples of 2cm diameter, and wash films with NaOH solution after wash films with distilled water until the pH of the solution reaches 7. Leave films in distilled water for 2 h for complete hydration. After sterilization of samples placing them in light UV during 30min.

Put 25 μl of the bacterial suspension on the surface of the films, put a coverslip on the sample with bacteria making sure that it is completely covered, incubate samples at 37º C, at different times. Wash films, take 100 ul of the washing solution and put them in an agar box. Incubate during 14hrs. Finally count the colonies to get the percentage of control of the bacteria.

III. RESULTS

The nanoparticle of CS/TPP was visually analyzed at different concentrations, and three main systems were identified: conglomerate, opalescent suspension and clear solution. Based on Table 1, a comparison graphic of the present systems was made. In Graphic 1 the three systems formed, according to the established concentrations, were observed. According to previous research [12], the sample of the opalescent suspension, which should correspond to a solution with very small particles, is illustrated (only visually) in figure 2 (b, c). These opalescent solutions are in the range of 1.5 to 3 mg / m as shown in Graphic 1.
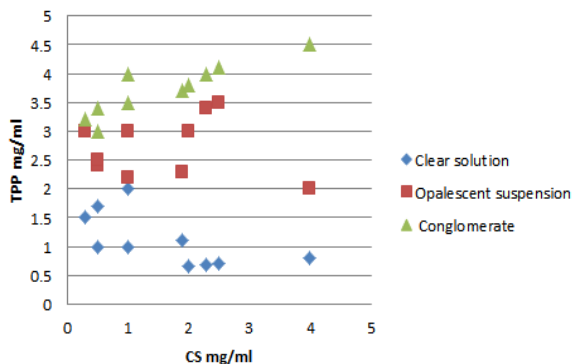
Graphic 1 Comparative analysis of chitosan particles in respect to their concentration.
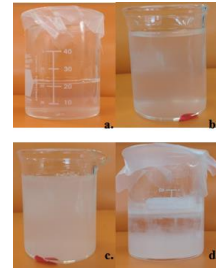
Figure 2 Solutions of nanoparticles with different concentrations of TPP, a) clear solution, b) and c) Opalescent suspension, d) Conglomerate.

The solution with concentration of 2 mg/ml was used to incorporate LA. More opaque solutions were obtained, without separation of phases or conglomerates as show in Figure 3 (a, b).

Figure 3 Solutions of nanoparticles of CS/TPP/LA, a). 0.2% CS/TPP 2ml LA, b) 0.2%CS/TPP 4ml LA.

Was obtained thin films with a coloration opaque translucent as shown in figure 4. In a) is a Qs/TPP film which is translucent with limited flexibility and without visible clusters, in b) is Qs/TPP/LA film which is more opaque than the previous film without flexibility apparent and with some visible clusters, this film also presents a slight odor to soap characteristic of LA deducting the presence and interaction with Qs.

a. **b.**
Figure 4 a). Qs/TPP film, b). Qs/TPP/LA film.

Swellimg capacity of films shows in figure 5 where there is a higher concentration of lauric acid there is better swelling

capacity with .008% of Lauric acid the biggest expansion of the film was obtained, where its original size almost tripled.
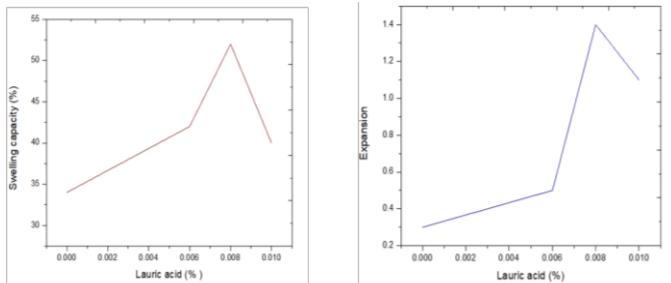

Figure 5. Swelling capacity of films of chitosan with different concentrations of lauric acid.

Chitosan colloidal particles were recognized as an opalescent suspension, which was used for the preparation of nanoparticles loaded with lauric acid (obtaining a stable solution) with this solution was obtained a film which has Nps with structure irregular as show in Figure 6, Transmission electron microscopy of a film with nanoparticles chitosan and lauric acid and nanoparticles of chitosan with size of 70 nm to 120 nm.
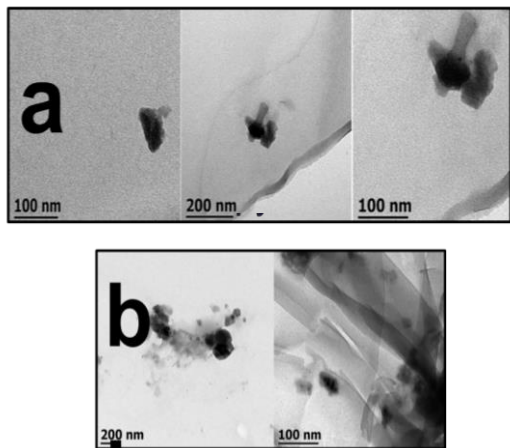
Figure 6. TEM of a) Nps of chitosan with Lauric acid and b)Nps of chitosan.

In Figure 7. b) Infrared Spectroscopy of Film of chitosan with lauric acid shown that there is an interaction in the characteristic amino groups of chitosan, un this system shows in 3500cm-1 and 3000cm-1 (correspond -OH, NH2) an interaction with lauric acid and Sodium tripolyphosphate

where cross-linking is taking place with the chitosan. Also shows in 1650 cm-1 and 1599 cm-1 (correspond O=C-NHR)
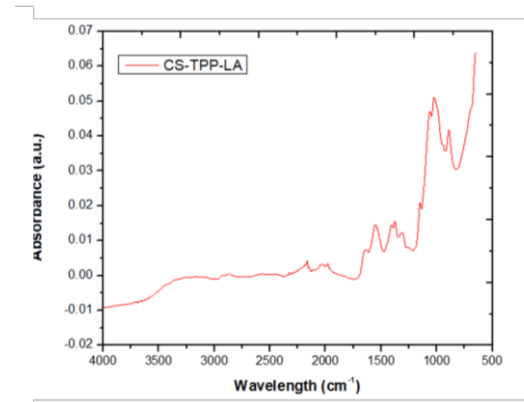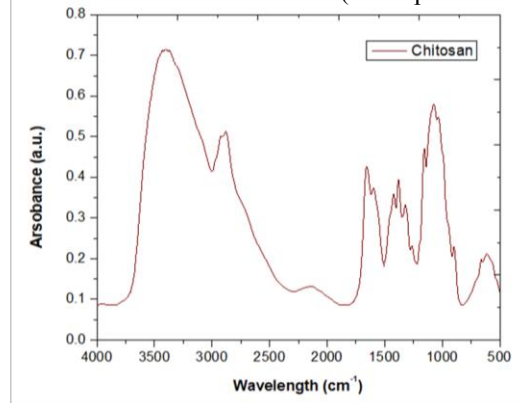
Figure 7. Infrared spectroscopy of a) film of chitosan and b) film of chitosan with lauric acid.

Thermogravimetric Analysis in Figure 8 the Chitosan with lauric acid system shows a slight displacement of 5 ° C of the temperature characteristic (point of degradation at 250 ° C) of chitosan degradation caused by the interaction with fatty acid.

Figure 8. Film of Chitosan (red) and Chitosan with lauric acid (black).

In the Figure 9. shows the Dynamic Light Scattering of chitosan nanoparticles loaded with lauric acid, shows two populations with an average size different from 70nm and 320nm (agglomeration may occur) respectively.

Figure 9.. DLS of Nanoparticles of chitosan with lauirc acid.

IV.CONCLUSIONS

Chitosan nanoparticles were synthesized with lauric acid by the proposed method.

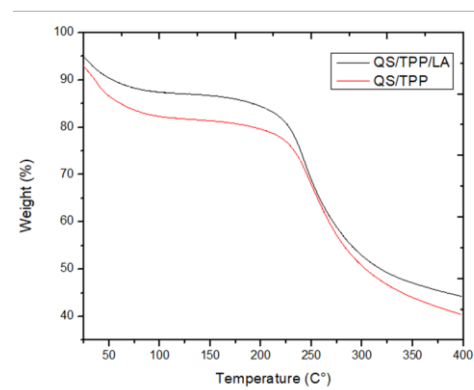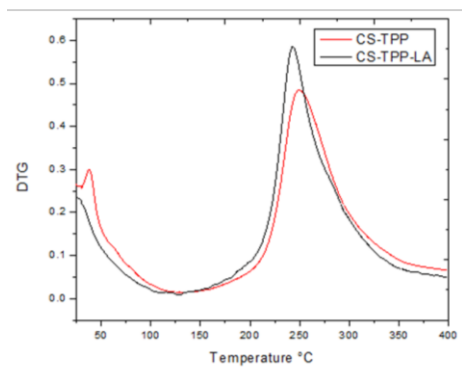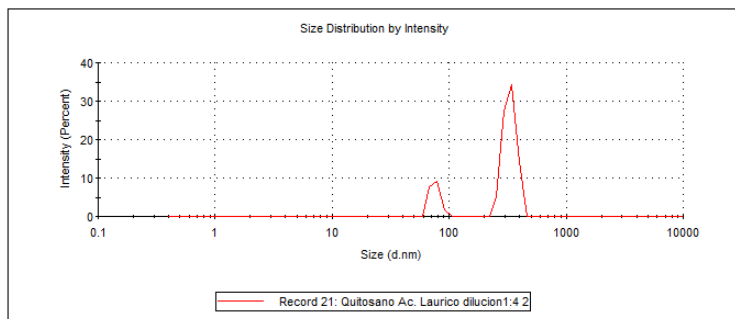Was obtained a film of the nanoparticle system of chitosan with lauric acid, increasing its properties of flexibility and swelling capacity by incorporating lauric acid.

The CS-LA Nps systems were characterized by TEM, TGA and IR to obtain information about their structural, physical and chemical properties as part of the component validation process.

the next step to follow, Ivitro tests are in process with gram-positive bacteria as well as gram-negative bacteria for the verification of their antimicrobial capacity.

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Modified asphalt mixtures with recycled materials to be used as a wearing course in long-lasting pavements

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Abstract— One of the strategies for the creation of long-lasting pavements is the inclusion of materials that, in addition to providing structural capacity to the asphalt mixture used, are friendly to the environment. The demand for resistance and mechanical properties of the pavement, implicit in the durability of it, suggests the use of recycled materials, which on the one hand improve the properties of the mixtures and on the other, there is the possibility of eliminating them from landfills that generate pollution.

Keywords—recycled materials; hot mix asphalt; sustainable roads.

I. INTRODUCTION

Since their origin, roads have been responsible for promoting the economic and social growth of a country, as they have the main function of communicating the territories. This communication through roads and highways facilitates the movement of people and merchandise, creating productive chains that promote trade and industrialization, resulting in more developed countries. Nevertheless, industrialization brings with it an increase in traffic intensity, especially of heavy vehicles that must be supported by pavements.

The application of criteria of sustainability in the pavements for roads of vanguard is promoting the study of new concepts in his design to prolong substantially the useful life of these, especially of the flexible pavements, so that structural damage does not appear, and maintenance is only focused on a periodic renewal of the surface wearing layer due to safety and comfort requirements [1]. The latter is a window of opportunity that material engineers from all over the world have taken advantage of to conduct research focused on manufacturing asphalt mixtures modified with recycled materials. The above, has given rise to works with common purposes, such as: take advantage of the enormous potential of reuse of recycled materials, obtain asphalt mixtures with mechanical properties high or equal to conventional ones, reduce pollution of ecosystems and environmental impact which involves the manufacture of hot mix asphalt, in addition, develop sustainable road infrastructure.

II. LONG TERM PERFORMANCE PAVEMENTS

The latent tendency to subject the pavements to higher traffic volumes, higher axle loads and extreme climatic conditions, positions mechanistic-empirical design methodologies as a sustainable alternative in the construction of roads with high traffic volumes. The implementation of the mechanistic-empirical methodology becomes relevant from several points of view; the engineering, the economic and the environmental. On the one hand, the structural designs are optimized by reducing the thicknesses of the different layers of the pavement without abate their bearing capacity, of course, with the decrease in costs associated with using a smaller amount of raw materials and, on the other hand, it is designed against specific deterioration that afflicts flexible pavements such as cracking due to fatigue in the asphaltic layers and permanent deformation both on the subgrade soil layer and on the wearing surface [2]. The previous deteriorations can be canceled or minimized if a series of asphalt mixtures superimposed with specific functions and applications are designed and built properly within the asphaltic package that forms the pavement structure. [3].

In this context, long-lasting pavements fit perfectly, which can be defined as an asphalt pavement designed and built to last more than 50 years without requiring major structural rehabilitation, where only is periodically needed the reconstruction of the wearing surface, because the deteriorations only occur in the upper part of the structure [4] or, as a type of pavement that will not show significant structural deterioration, either in the foundation or base layers, provided it is subjected to adequate surface maintenance [5].

Unlike a conventional asphalt pavement, this structure is characterized by being composed of a robust asphaltic mixture package divided into a waterproof, durable, and rut resistant surface layer, followed by an intermediate layer resistant to rutting, highly rigidity and considerable thickness, as well as a flexible bottom layer of high resistance to fatigue cracking supported on a stable foundation, such configuration is shown in Fig. 1.

37 to 50 mm of high quality
HMA or GGHMA

100 to 175 mm of high modulus,
rut-resistant HMA

75 to 100 mm of flexible,
fatigue-resistant HMA

Crushed aggregate subbase or
prepared subgrade

Fig. 1.   Typical structure of a long-lasting pavement
Reference [6].

While is true that these structures throughout their construction and useful life require a smaller amount of raw material compared to a conventional flexible pavement, it is worth mentioning that keeps needing crushed stone aggregates of the highest quality, as well as modified asphalts, which are product of quarrying and oil refining respectively. The previous situation, although to a lesser extent, generates a negative impact on the environment due to the non-renewable nature of aggregates and asphalt. Nonetheless, worldwide material engineers have not been indifferent to this problem and has focused part of their research on identifying which recycled materials can act as modifying agents of asphalt mixtures in substitution of a part of the asphalt cement (wet way) or of the stone aggregates (dry way).

III.   MODIFIED ASPHALT MIXES WITH RECYCLED MATERIALS

The asphalt paving industry is a leader in the use of recycled products [6]. The asphalt concrete pavement is the most recycled material in the world. In addition to the RAP, other recycled materials commonly used in hot asphalt mixtures are:

- Plastic waste
- Rubber tire
- Construction and demolition waste
- Blast furnace slag

The adequate incorporation of these recycled materials in the asphalt cement or in the stone aggregate has given place to asphalt mixtures with mechanical properties equal or even superior to the conventional ones, as indicated by the authors of Table 1.

TABLE I.   INVESTIGATIONS CARRIED OUT INCORPORATING RECYCLED MATERIALS INTO HOT MIX ASPHALT

Author	Modification method	Amount and type of recycled material incorporated	Improved property
Kamada and Yamada [7].	Dry way	10% Polypropylene	Permanent deformation
	Dry way	10% Polyethylene	Indirect tension Fatigue
Lastra and Indacoechea [8].	Dry way	1% Rubber tire	Fatigue Permanent deformation Dynamic modulus
Raposeiras, A, Movilla, D, Vargas, A, Bilbao, R, and Cifuentes, C [9].	Dry way	35% Slag 20% RAP	Indirect Tension Resilient modulus
José Luis García and Alexandra Ossa [10].	Dry way	30% -40% Waste from construction and demolition	Permanent deformation
Ayman M. Othman [11].	Wet way	4.5% Low Density Polyethylene	Indirect tensión Fracture Toughness

Other investigations, have successfully developed asphalt cements modified with recycled materials, mainly polymeric waste, giving asphalt mixtures greater strength and durability. Nevertheless, the modification of the asphalt cement by the wet way requires very low percentages of recycled materials, in addition, it demands a greater effort and quantity of energy in comparison with the modification of the asphalt mixture through the dry way, process where the recycled materials can be incorporated in greater amount and add directly into the mixer drum when is making the asphalt concrete.

On the other hand, asphalt mixtures modified with recycled materials require a complex analysis in the laboratory focused on obtaining their mechanical properties and resistance against the main deteriorations that afflict asphalt mixtures; permanent deformation and fatigue cracking, schematized in figure Fig. 2.

Permanent deformation   Fatigue cracking

Fig. 2.   Common distresses in asphalt pavements
Reference [12].

References [13] and [14] assert that nowadays it is possible to determine in the laboratory the susceptibility to present the previously indicated failures, this with the purpose of verifying if indeed its behavior will be adequate once it is part of a pavement in service. Performance tests such as dynamic modules, resilient modules, fatigue tests, indirect tensile tests and permanent deformation tests are the most commonly used

to characterize in terms of resistance to asphalt mixtures. The tests mentioned above are performed in equipment such as those shown in Fig. 3.

Fig. 3.   Simulation and performance equipment for asphalt mixtures. Reference [6].

In the case of long-lasting pavements where its design philosophy stipulates that there should be no damage to the underlays to the wearing surface, the engineering of pavements has developed modified asphalts with polymers (elastomers and plastomers mainly) of proven quality that endow the asphalt mixtures with high rigidity and flexibility for the intermediate layers of high module anti-deformation and the bottom layers absorbing tension respectively. In this sense, there is a very wide window of opportunity to use recycled materials in asphalt mixtures whose purpose is to serve as a surface layer, as a sustainable and durable alternative to existing wearing layers. The above, based on the greater ease involved in removing or replacing the surface layer of the pavement compared to the lower layers, if the road layer formed by asphalt mix and recycled materials does not behave or have the performance expected.

Evidently, the wearing course surface is the first element of contact between the structure of the pavement and the main destructive agents to which it is exposed during its useful life. The latter, represented by vehicular loads and environmental conditions, generate certain deteriorations that cannot be completely annulled by the asphaltic layer.

As it is known, none hot mix asphalt can by itself withstand deformation, fatigue or moisture damage all at once, since highly rigid asphalt mixtures with low susceptibility to permanent deformation are prone to cracking and fissuring, in the same way, asphalt mixtures rich in asphalt highly flexibles and with high resistance to fatigue are prone to deformation. However, the theoretical support and the positive results obtained in various investigations encourage to continue incorporating in the asphalt mixtures recycled materials that precisely transfer that elasticity or rigidity to the mix asphalt, even using two or more recycled materials in the same mixture in search of that duality or balance of mechanical properties that a wearing course demands when is looking for a prolonged durability.

IV.   CONCLUSIONS

From a perspective of environmental care, long-lasting pavements represent a great advance in the construction of sustainable roads and, even more if within their structure they are able to incorporate recycled materials that provides an increase in the useful life of their different asphalt layers, instead of being part of the pollutant landfills, thus restoring its economic value in a second life cycle, favoring a saving of energy and raw materials without prejudice to health, ecosystems or their elements.

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Comparison between PET based prefabricated sidewalks and simple concrete sidewalks

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Abstract

In the present paper the results of some tests performed on concrete reinforced with fibers made from waste polyethylene terephthalate (PET) bottles are reported. Investigation was carried out on two groups of mortar samples, one made with only sand aggregates and, second made with PET and sand aggregates together.

The cement mix for the two types of sidewalk was calculated with a water-cement proprotion of 0.8 and a strenght of 150 kgf/cm2. The fibers have been obtained by simply cutting the bottles, we got together 5.3 kg of plastic. The quantity for the mass of PET was calculated in function of the volume for the concrete mix needed.

The tests are to be considered as an approach to a more extensive investigation on the use of PET as a reinforcing material for concrete in the construction industry. The main tests applied to specimens were compression strength and absorption.

The results that have been obtained are very interesting, especially regarding the absorption in the mix between PET and concrete, the reduction in compressive strength as a result of PET waste inclusion obtained was expected. Is possible to use recycled PET in concrete considering the final use of the mixture and the strength required depending on the destination of the materials, in our case for sidewalks.

Keywords

PET, Sidewalk, Concrete, Mortars, Compression strength, Absorption.

I. Introduction

With the growing demand of sustainability and the boundless growth of population in cities, walking has been profiled as one of the principal means of transportation for people who travel short distances. As a consequence of this, it becomes necessary to connect all ways with sidewalks so people can make use of adequate and safe roads. (Maria V. C., 2016). Hence, it is recommended to include variables that can be associate with sidewalks, pedestrian activities and safety (Ahmed O., 2017). An example is the concrete, this represents one of the most important

factor because it's the main ingredient of the elaboration of a sidewalk, and makes possible to create a relationship between the pedestrian, trees, plants, ads and the environment. (A. North, W. D'Amato, & B. Russel, 2017). By other side, the cost-effectiveness has great impact sociable and economy, for this reason it is necessary to create a new cheaper method to do sidewalks. (Gunn, Lee, Geelhoed, Shiell, & Giles-Corti, 2014).

The PET (polyethylene terephthalate) particles possess a granulometry similar to that of the substituted sand. (A. North, W. D'Amato, & B. Russel, 2017). Several researches have been performed to determine the security and the kindness given to the environment, whereof it can be inferred that the life elongation of PET for its later integration in concrete is a real possibility and solution to urgent problems that have to be solved as pollution, making the clarification that those structures built with PET are designed to not hold exceeding loads (Sharma & Bansal, 2016). Is Known that the sidewalk doesn´t need too much compression strength. (Federal, G. d. (s.f.)., 2016).

On the other hand, cubes containing shorter fibers performed slightly better when compared to those containing longer fiber... from the flexural test show that the concretes containing fibers achieved a higher peak load that the control mix. (Borg, Baldacchino, & Ferrara, 2016).

The head findings in researches of the particle use of crushed plastic in concrete, indicate that workability, density (7 – 50%) and mechanical strength, such as compression strength (34 – 70%), traction strength, flection strength and the elasticity module; tend to decrease meaningfully with the increase of plastic content. (Alqahtani, Ghataora, Khan, & Dirar, 2017). Therefore, to overcome the negative effects…measures should be taken to accelerate early hydration. (Ghourchian, Wyrzykowski, Baquerizo, & Lura, 2018).

Finally, at a replacement ratio of 10% by volume, this has the potential to save 820 millions tonnes of sand every year from being used in concrete mixes. (Thorneycroft, Orr, Savikar, & Ball, 2018)

II. METHODOLOGY

A. Design of the Concrete Mixes

For the comparison between simple concrete and concrete with PET it was determined to design two equal small pieces of each type with the following measurements:
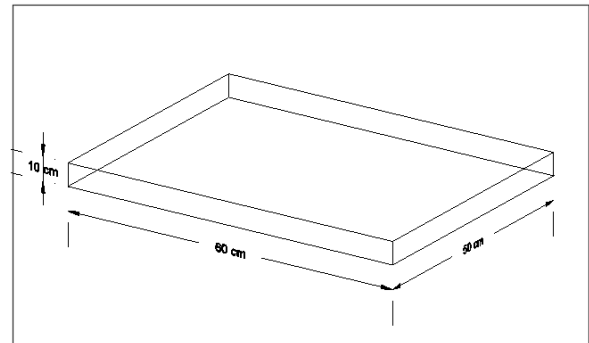
Fig. 1: Sidewalk Model.

The total volume for each type of sidewalks was 0.03 m3.

The cement mix for the two types of sidewalk was calculated with the ACI method for dosage (ACI 211 code desing) with a water-cement proprotion of 0.8 and a strenght of 150 kgf/cm2. The design of the concrete mix for the simple concrete sidewalks was in function of the desing tables with a fineness module of 2.6 (which was the value for the sand employed on the construction proces) and a volumetric weight of 1500 kgf/m3 for gravel (which was previously determined with instruments inside the laboratory). The quantities for water, cement, sand and gravel for the first two simple concrete sidewalks are shown on the next table:

Material	Mass (kg)
Water	12.3
Cement	15.3
Sand	62.3

Material	Mass (kg)
Gravel	28.8

Table 1: Base mix.

After that estimation for water, cement, sand and gravel, the quantity for the mass of PET was calculated in function of the volume for the concrete mix needed, keeping in mind that this quantity of PET was goint to replace the volume of sand. Finally, the quantities for the concrete with PET sidewalks are the next:

Material	Mass (kg)
Water	12.3
Cement	15.3
Sand	35
Gravel	28.8
PET	5

Table 2: Mix with PET.

B. Obtainment of sand and gravel

For the obtainment of sand and gravel, it was necessary to sieve both sand and gravel with the sieves number 4 for sand, and the sieves number 3/4 and 4 for gravel.

Fig. 2: Sieving of Gravel.

C. Obtainment of PET

For the trituration of PET, it was first required to collect as much plastic bottles as needed inside the engineering school. They were collected in all the trash cans inside the classrooms but mostly from a big PET collector at the center of the engineering school. Approximately, 160 plastic bottles were collected, the most of 600 ml and the rest of 1000 ml. Finally, we got together 5.3 kg of plastic.

After the collection, the bottles were removed from its caps and its commercial labels, so they could be easier to cut.

First, the bottles were smashed manually and then they were perpendicularly cut with shears across their horizontal axe, having the bottle normally standing.

Fig. 3: PET bottle cut horizontally.

The next step was to locate points every centimeter with a black marker at the top and the bottom of the bottle, and then to cut again the plastic rows obtained before to finish with small pieces, approximately squares of 1 cm per side.

Fig. 5: Plastic rows cut with shears.

Fig. 4: Squares of approximately 1cm2 from one bottle.

D. Formwork Elaboration

The formwork used was exactly made with the same measurements shown in the Fig. 1, employing common wood jointing every piece with screws and drill.

Fig. 5: Formworks.

E. Concrete Mixes

The first concrete mix made was for the simple concrete sidewalks, and three days after the PET based concrete mix was made. All mixes were on the ground, with the previous wetting of the working surface, and by shovels.

First the total sand was placed on the ground after the wetting, and then the total gravel was put over the sand, so we could mix with shovels that first phase of material.

Fig. 6: Mixing sand and gravel.

Next, the total mass of cement was included and again we keep mixing with shovels from the center and the bottom to the borders and from the borders to the center continuously until the complete mix looked uniformly gray in every little portion we took with the shovels.

Fig. 7: Mixing concrete.

After, half of water was measured and mixed for two or three minutes, and then the other half was put and perfectly mixed again.

With the formworks covered with oil on the inner surfaces and well located in the ground with sacks under each formwork, the concrete was placed inside the formworks, compacting with a dipstick and producing vibrations with constant hits by a rubber mallet on the outsides of the formworks.

F. Sidewalks Specimens

Four specimens were fabricated, two pieces of normal simple concrete (like usual sidewalks) with f'c of 150 kgf/cm2 (for the dosage was applied the ACI 211 design code) and two PET-Based specimens with dosage described in the previous point changing only a percent of sand for PET and same water-cement ratio to compare the difference between simple concrete and PET Based Concrete Sidewalks. Specimens were poured in the formwork designed for the prototype whose dimensions were described in a previous point. After 28 days curing (inside a moist curing room) specimens were removed for testing. For testing, specimens were cut to measurements required by official norm in Mexico (NMX-C-083-ONNCCE-2014). This norm controls the procedure for compression strength. Final measurements were cubes of 100mm per edge.

G. Testing and measurements

The main tests applied to specimens were compression strength and absorption. These tests are important characteristics in sidewalks to determinate a durability degree. Compression strength test was applied with parameters and procedures of official norm in Mexico NMX-C-083-ONNCCE-2014. For absorption test were applied the parameters and procedures of official norm in Mexico NMX-C-155-ONNCCE-2014. Testing was made in the laboratory of engineering faculty of Autonomous University of Querétaro (UAQ) with machines and apparatus certified. Specimens were called as: CS1 (Control specimen 1), CS2 (Control specimen 2), PBS1 (Pet-based specimen1), PBS1 (Pet-based specimen1). In the next table results are summarized:

Specimen	Compression Strength (kgf/cm²)	Absorption (%)	Volumetric Weight (kg/m³)
CS1	146.54	9.36	2237
CS2	148.33	8.97	2249
PBS1	112.83	7.46	2189
PBS2	115.57	7.09	2183

Table 3 Dates

III. RESULTS AND DISCUSSION

A. Concrete compression strength.

Results of compression strength are shown in table 3. As is measurable, compression strength in pet-based specimens are lower than control specimen. The reduction in compression strength is an average of 22.54 %. The reduction in compressive strength as a result of PET waste inclusion obtained in the current study is expected. There are many test data in the literature support this evidence. The loss in compression strength is related with non-homogeneous mix of concrete due to the pet particles. Perhaps it could be adherence problem and it would be an excellent field of investigation to enhance this idea of pet-based concrete.

In the next figure is shown the reduction in compression strength varying the pet volume in the mix (Mohammed, A. A. (2017). Flexural behavior and analysis of reinforced concrete beams made of recycled PET waste concrete. Construction and Building Materials, 593-604)
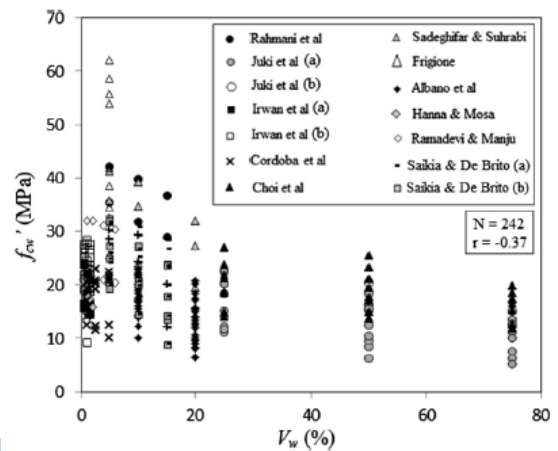
Fig 10 Flexural behavior

However, compression strength is not the only important characteristic for this investigation, in sidewalks compression strength is very low compared with structural elements in other buildings. Regularly strength in sidewalks is f'c=100 kg/cm2. For this reason, is important to think off in other benefits that pet-based sidewalks could give us. In this investigation is not considered the

cost/benefit ratio but it could be an important benefit of add pet in simple concrete.

B. Absorption

As is measurable in table 3, absorption in pet-based specimens was reduced in order of 1.89% in average. This characteristic is an important parameter of durability in concrete. For this case of sidewalks steel reinforcement is not required but in other case where there is steel reinforcement this characteristic would be an improvement due to it could to delay the corrosion in concrete. An important opportunity area of investigation could be the interaction between pet-based concrete and sea water.

At the end of the trials can be seen that it is possible to use recycled PET in concrete and mortar mixes, considering the final use of the mixture and the strength required depending on the destination of the materials, in our case for sidewalks.

ACKNOWLEDGMENT

The authors wish to acknowledge the support of the Autonomous University of Queretaro and the school of engineering.

IV. CONCLUSION

For this investigation we could to conclude that pet-based concrete is lower resistant than simple normal concrete but at the same time is lower permeable than the same. If we could introduce this prototype in the actual market it should have an important foundation on investigation, not only the mechanic properties otherwise in constructive process, cost/benefit, transportation, time, etc. (S. Akçaözoğlu, 2010)

We were concluded that there is a potential for the use of shredded waste PET granules as aggregate in the production of lightweight concrete.

The main idea of this investigation is not show that pet-based concrete is better than simple normal concrete. The main idea is show that in spite of it is worse than simple concrete; it could be used as a normal product with the goal of reduces the use of traditional materials in construction.

Furthermore, the use of industrial wastes such as PET granules provides some advantages: reduction in the use of natural resources, disposal of wastes, prevention of environmental pollution, and energy saving.

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Digital sensor of magnetoresistive properties of semiconductor materials

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Abstract— **A system able to sense the changes in electrical resistance of materials with magnetoresistive properties was designed and built, the magnetoresistance was evaluated with an external magnetic field coming from an arrangement of Helmholtz coils. The said system was used to characterize 2 different materials (Type N silicon and type P silicon) by modification of the magnetic field, thanks to the data acquisition stage the data could be monitored.**

Keywords— *magnetoresistance; Helmholtz coils; magnetic field; Hall effect;*

I. Introduction

In the science of materials is always necessary to have characterization either, optical, structural, electronic, electrical or magnetic to mention a few, the description of a material allows knowing the intrinsic properties of a material to be able to give a potential application in other sciences. The use of materials in industry or everyday life will depend on their physical, chemical, structural, etc. properties.

To characterize a material there are different techniques according to the interest aroused by said material, once the characteristics of the material are known, the nature of the material can be established, as well as its possible applications. An example of this is the characterization of semiconductor materials, which is vital to establish the subsequent use that can be given to them. The semiconductor materials have insulating properties in their pure state and it is when they are subjected to an electric excitation or they are introduced in an external magnetic field when they behave as conductors, for this reason their wide demand in the electrical and electronic industry. [8]

The extrinsic semiconductors are the most used in the electronic components industry because they are doped, that is they have impurities. There are 2 main types of extrinsic semiconductors depending on what type of impurities they have: P-type semiconductors and N-type semiconductors. Being more specific in semiconductor matters, these can be binary or ternary due to the number of elements present in the material, for example, Cadmium sulfide, cadmium telluride, gallium arsenide, etc., there are also ternary semiconductors derived from metal oxides. [10] It is vital that, no matter how semiconductors are composed, we know what properties make them unique for a specific application, for this we have sophisticated equipment capable of detecting nanostructural and quantum properties present in the material. In this project we will concentrate on knowing a property related to the resistivity and magnetism of the semiconductor called magnetoresistance.

Knowing the physical phenomenon involved and how a material behaves before an external influence it is necessary to know that a semiconductor has a property known as magnetoresistance in which the material changes its electrical resistance when an external magnetic field is applied to it, and given the susceptibility of this, the resistivity will be presented in different proportions being able to be: anisotropic, tunnel giant or colossal. [10]
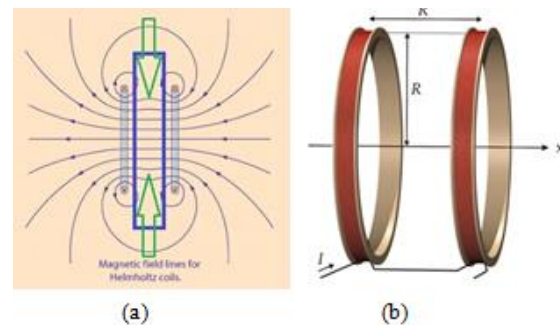
Figure 1. (a) Field lines in an array of Helmholtz coils. (b) Helmholtz coils scheme.

A magnetic sensor is defined as a device capable of translating certain property of an external magnetic field (intensity, orientation in space) in a variation of some of its physical properties, such as induced voltage, electrical resistance, etc. Among the family of magnetic sensors, magnetoresistive sensors are those that show a change in their electrical resistance in the presence of an external magnetic field. There are several mechanisms that cause a magnetoresistive response, which gives rise to different types of sensors and this project is based on the generation of a magnetic field generated by a Helmholtz coil, which is the simplest configuration to produce a uniform magnetic field and relatively constant. The Helmholtz coils are two coaxial

circular coils with the same radius that is equal to the distance between the planes of the coils. When the currents circulate in opposite directions, the configuration is called anti-Helmholtz coils, and is important in several applications such as measurements, biomedical research, calibration of tips and sensors etc. [7].

The investigation of semiconductor materials and device testing often involves determining the resistivity and Hall mobility of a sample. The calculation of its resistivity is obtained through Hall voltage measurements and the Van Der Pauw technique with the help of a SPCB-1 spring clip holder. The resistivity of the semiconductor material depends mainly on bulk doping. In a device, the resistivity can affect the capacitance, the resistance of the series and the threshold voltage. [3]

The resistivity of the semiconductor material is often determined using a four-point probe technique. With a four-probe technique, or Kelvin, two of the probes are used for the current source and the other two probes are used to measure the voltage. The use of four probes eliminates measurement errors due to the resistance of the probe, the scattering resistance under each probe and the contact resistance between each metal probe and the semiconductor material. Because a high impedance voltmeter draws very little current, the voltage drops across the probe resistance, the dispersion resistance and the contact resistance are very small. A common Kelvin technique for determining the resistivity of a semiconductor material is the Van der Pauw (VDP) method which involves applying a current and measuring the voltage using four small contacts on the circumference of a flat sample, arbitrarily, of uniform thickness. This method is particularly useful for measuring very small samples because the geometric spacing of the contacts is not important. The effects due to the size of a sample, which is the approximate spacing of the probe, are irrelevant. [9]

Using this method, the resistivity can be derived from a total of eight measurements that are made around the periphery of the sample with the configurations shown below:
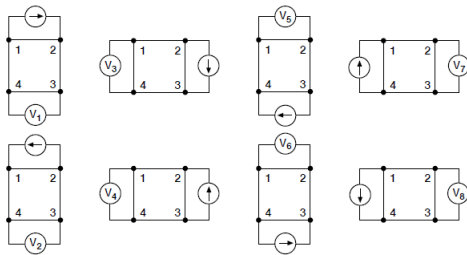

Figure2. Conventional measurement of van der Pauw resistance.

Once all voltage measurements are taken, two resistivity values, ρ_A and ρ_B, are obtained as follows:

$$\rho_A = \left(\frac{\pi}{\ln 2}\right) f_A t_S \left(\frac{V_1 - V_2 + V_3 - V_4}{4I}\right) \tag{1}$$

$$\rho_B = \left(\frac{\pi}{\ln 2}\right) f_B t_S \left(\frac{V_5 - V_6 + V_7 - V_8}{4I}\right) \tag{2}$$

- where: ρ_A and ρ_B are volume resistivities in ohm-cm;

- t_S is the sample thickness in cm;

- V_1–V_8 represents the voltages measured by the voltmeter;

- I is the current through the sample in amperes;

- f_A and f_B are geometrical factors based on sample symmetry.

They are related to the two resistance ratios Q_A and Q_B as shown in the following equations ($f_A = f_B = 1$ for perfect symmetry).

Once the resistivity values have been obtained, we will know in what proportions the resistivity of the material changed under the influence of a uniform external magnetic field and how sensitive it is magnetically.

II. EXPERIMENTAL METHOLOGY

A. Design and making of the external magnetic field

Theoretical design: the use of a Helmholtz coil system was chosen for its ability to generate uniform magnetic fields in the center of the coil set [1], as shown in Figure 1.

Taking in account the work done by David J. DeTroye and Ronald J. Chase [2] in the design, simulation and measurement of a Helmholtz coil arrangement. A MATLAB program was developed to estimate the magnetic fields from the number of turns, the radius of the coils and the amperage supplied.

With the value of the radius of the proposed 7.5 cm coils and using the program in MATLAB, the different field strengths were calculated for each ampere of the current supplied in the coils. Magnetic fields from 0 to 25 militeslas were searched.

In Figure 3, we can observe the theoretical estimate of the magnetic field generated by each ampere of supplied current.
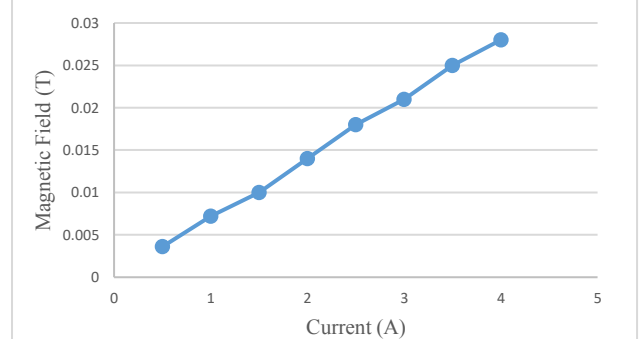

Figure 3. Magnetic field against supplied current evaluated theoretically
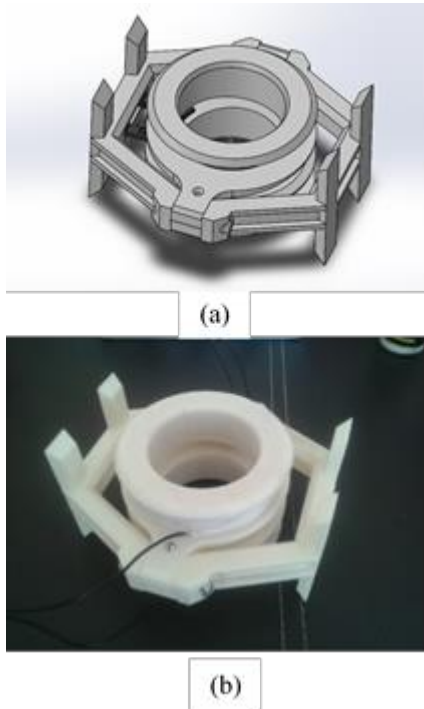
Figure 4. (a) CAD design in SolidWorks. (b) 3D printed design.

Using the data obtained in the simulations, characteristics of the system was determinate. The arrangement of Helmholtzcoils consisted by 300 turns by each coil of a cable that can drive up to 3 amperes, this arrangement gives a maximum uniform magnetic field of 25 mT in an area of 10mm^2 at the center of the arrangement

Physical design:Withthe data obtained in the theoretical design and the necessary symmetry scheme in the Helmholtz coils (Figure 1 (b)) thephysical design was developed. The design was made in the SolidWorks CAD software,5 parts make up the design, 2 are the reel base of the coils, another 2 of them are the supports of the system that assembly the 2-reel bases of the coils and finally a sample holder support base. The CAD design is shown in the Figure 4 (a).

Each piece of the design was 3D printed in ABS (Acrylonitrile butadiene styrene) that can be used between −20 and 80 °C. The final assembled design is shown in Figure 4 (b).Each coils of the system were coiled with a special #18 wire for electromagnetic arrangements. The coils in series had a resistance of 6 ohms.

B. Samples and sample holders

It was decided to analyze two semiconductor materials coming from the electronic industry given the quality of the material and experimental data existing in the literature. We use a P-type silicon semiconductor and an N-type silicon semiconductor, with the knowledge that each one has different doping and different behaviors before electrical and magnetic stimulation.

Pieces of silicon type P and type N of a square centimeter are cut to adapt the samples to the size of the sample holder and subsequently a decontamination and cleaning process is initiated due to the formation of silicon oxide on the surface of the wafer and dust particles that could introduce noise or erroneous readings during the characterization of the material.

The silicon wafers were cleaned with ethanol, isopropanol and acetone, gloves, pincers millimeter and mask were used during the process. Once the material was clean, it was fixed to the SPCB-1 sample holder and firmly holded the spring clips on the material located in each of the corners of the sample holder.

We must mention that the contacts (spring clips) of the sample holder are made of gold for better conductivity, contact and sensitivity in the readings, besides that it has four connection lines and a common line in case its use is necessary.

Figure 5. 4-way sample holder brand bridge technologies model SPCB-1 with 3D printed support.

For initial tests with the silicon wafers, the sample holder was fed with a voltage of 3.3 volts and a current of 200 milliamperes, in addition readings were taken of the resistance of the samples before and after applying the external magnetic field, it was possible to observe a high resistance behavior by both semiconductors without applying field, and once they were subjected to the magnetic field was reduced by 50 percent.

C. Amplification and processing

The fist calculus of the equipment was the resistivity of the material, in the calculus the influence of magnetic field is not necessary. And is described in the equations (1) y (2). Then based on the van der Pauw method and the method used by Ndlela, Z., & Bates [3] to calculate the Hall effect and its coefficient. it was possible to estimate the conductivity of the semiconductors analyzed.

The conductivity of a semiconductor in a magnetic field (with the field direction being perpendicular to the direction of current flow) can be expressed in terms of zero - field conductivity σ_o, the Hall coefficient R_H, the applied magnetic field B, and a coefficient β:

$$\sigma = \frac{\sigma_0}{1+\beta R_H{}^2 B^2 \sigma_0{}^2}(3)$$

The quantity called the "magnetoresistivity" is defined as the fractional change in resistivity due the application of magnetic field. That is, the magnetoresistivity is

$$\frac{\Delta\rho}{\rho} = \frac{\rho(B)-\rho_0}{\rho_0} = \beta\frac{R_H{}^2 B^2}{\rho_0{}^2} \qquad (4)$$

Where, in general, resistivity is $\rho = 1/\sigma$ and ρ_0 is the zero-field resistivity and β is the called "coefficient of magnetoresistivity" and depends on the scattering mechanisms and mean free times of the charge carriers If I is the sample current and d is the sample dimension used in the Hall coefficient calculation, then

$$\frac{\Delta\rho}{\rho} = \beta\left(\frac{d^2}{I^2\rho_0{}^2}\right)V_H{}^2 \qquad (5)$$

For the switching necessary to read all the combinations in the van der Pauw method, a circuit with relays that commute the combinations was employed. The INA219 shield read the different voltages and currents per combination (analysis) in the van der Pauw method.

D. Data acquisition

The digital data coming from the INA219 were connected to the Arduino shield through I2C communication protocols, all de data acquired: voltages of the van der Pauw combinations, Hall coefficient, Hall voltage, and the calculated resistance were saved in a computer, through a interface and program developed in LABVIEW. The user interface shown the combinations and the voltage read per combination. The user interface is shown in the Figure 6.
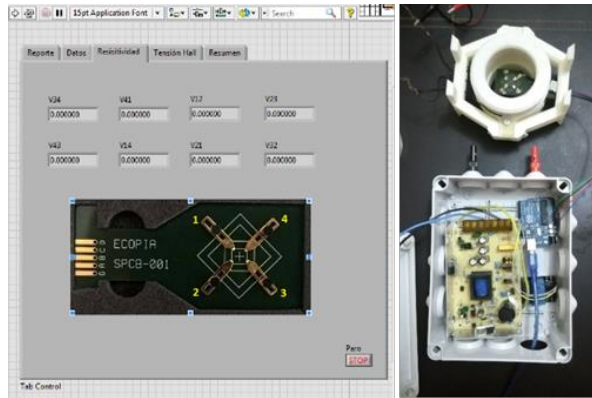

Figure 6. Stage of data acquisition. With power supply of constant 5v to power all the circuits, the Arduino shield and the amplification and processing stage.

III. RESULTS AND DISCUSSION.

A. Results

The samples used were evaluated at 0 militeslas (initial resistance), 5 militeslas, 10 militeslas and 18 militeslas. Each resistance value was recorded in table 1 and subsequently used to estimate the magnetoresistance value of the material with equations 3, 4 and 5.

The resistance readings were the following:

TABLE 1. Values of resistance in different intensities of magnetic field.

Joints of lecture		Initial values of resistance	Values with presence of magnetic field		
			5mT	10mT	18mT
Type N Silicon	BD	>200MΩ	0.23MΩ	0.67MΩ	1MΩ
	AC	>200MΩ	0.24MΩ	1.22MΩ	2MΩ
	AD	>200MΩ	0.68MΩ	2.57MΩ	3.7MΩ
	BC	>200MΩ	1.30MΩ	4.7MΩ	6.6MΩ
Type P Silicon	BD	>200MΩ			
	AC	>200MΩ			
	AD	>200MΩ			
	BC	>200MΩ			

In Table 1 it is possible to observe that the P type silicon is the one that does not present any change in its resistance due to an external magnetic field, which is due to the fact that in the type P material there are gaps and therefore no mobility is carried out electronics.

B. Discussion

The influence of the external magnetic field on the N-type silicon samples was significant, quite the opposite happened in the P-type silicon due to the fact that it has holes. Both semiconductors exhibited a high resistance behavior without the presence of a magnetic field, but when subjected to a magnetic disturbance the type N material reduced its resistance by more than 50 percent, while the P type remained without apparent change.

The properties of resistivity and magnetoresistance were modified in the N-type sample due to the alignment of the moments of the spins of the electrons as do the ferromagnetic materials.

Now we know that the magnetic susceptibility depends totally on the sample in question, whether it is insulating, semiconductor or conductive, of the number of carriers in the materials and the type of doping present in them.

IV. CONCLUSIONS.

The change in the resistance of the silicon when it is in presence of a magnetic field, the named magnetoresistance, could be observed. However, we could not calculate a correct value of resistivity or magnetoresistance of the material because we need to characterize our arrangement of Helmholtz coils, to know the exact value of magnetic field generated, and avoid the use of theoretical values. Also, for budget reasons we use a current of 200 mA for the measurements and we need a very small constant current (1 µA or less) to make an accurate measurement. Although we can emphasize that the presented results have great relevance when demonstrating significant changes in the resistance of the material, being able to denote that the materials studied have magnetoresistive properties.

V. Acknowledgments.

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Improvement of the mechanical properties of rigid pavements through polymeric additives

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I. ABSTRACT

This work consists in search and analyze different investigations where different types of additives are used, experimenting with different proportions, adding them to rigid pavements, in order to make a comparison to determine which are the best substances and the adequate amounts to improve the mechanical properties (mainly compression and flexion) of concrete on our roads.

Key words — Pavements, additives, compression, flexion.

II. INTRODUCTION

There is a growing demand in the road infrastructure and the rigid pavements have been transformed, aiming of improving their behavior and consolidating them as the structures with the longest durability. However, their mechanical properties are sometimes not enough due to the important vehicular flow which they are subjected and also their high cost in the short term can be the biggest disadvantages of concrete roads.

One of the main solutions that have been proposed to optimize the properties of the pavement is the use of additives, chemical substances that interfere directly in concrete by modifying their properties and particular qualities [1], they also help the concrete and reduce costs in construction, as well turn out to be perfectly compatible with the environment.

Therefore, with the use of acrylic polymeric additives in the rigid pavements of medium traffic, and improvement in its mechanical properties of up to 20% will be generated and by reducing the content of cement replacing it with additives, it will have as a consequence a reduction in its costs.

III. STATE OF THE ART

At the beginning of the time, the Romans added blood, bacon and milk to their concretes, possibly with the purpose of improving the conditions of placement.

In this way it is considered very likely that the durability that some of the structures of ancient Rome have been due to the action of natural agents, is precisely because of the influence that these products could have had on the behavior of concrete.

Later, they have been integrated into several methods to improve the pavements. The use of additives, which are incorporated before or during mixing and are generally used in small percentages by weight of the cement, which have been one of the innovative methods that aim to improve or modify one or several concrete properties. Its convenience always arose from a technical-economic study that determines the viability of the pavement.

However, the closest background to the use of chemical additives in concrete dates back to the 19th century, the first addition of calcium chloride as an additive to concrete registered in 1873, whose patent was obtained in 1885. Gypsum and calcium chloride were then used towards the end of the century, to control the hardening processes, simultaneously with the use of some type of lime and water-resistant materials.

Of the investigations that have been developed in the past related to this work, one carried out with respect to nano silica [2], has shown to have very good expectation, since replacing only 5% of cement with this innovative additive shows satisfactory results, even thus, the best results presented in the concrete are when 10% is replaced, after three days of curing. In turn, other authors [3] argue that the best replacement proportions should be around 10% by weight.

Nano silica is a colloidal silica consisting of fine micro particles of amorphous silicon dioxide (SiO_2) dispersed in

water. These particles increase the resistance at an early age and also improve the final resistances. [4]

Despite the differences that the authors find, most agree, that raising the content of nano silica in Portland cement achieves a significant improvement in the development of the resistance to compression, because the samples have denser textures and compact because the nano particles fill the pores, which in turn favors the impermeability of the concrete, combined with the formation of secondary tobermorite that contributes to the resistance.

More nano-materials have been investigated, besides the nano silica (Nano-SiO2), which has been applied to concrete due to its excellent performance. In this case, [5] two types of nano-particles were used, the already known Nano-SiO2 (NS) and Nano-SiC (NC) in which their optimum content was found in two percent (referring of the NS) while that in three percent their properties decrease again. On the other hand, the NC also shows improvements in three percent of proportion.

The results showed that with these proportions, flexural strength and compressive strength can be considerably improved as shown in the following figure.

Figure 2.- The compressive strength results
Source: Yingli *et al.* (2017)

Another work, [6] which deals with the sale of different contents of basalt fibers (1.2 and 3%) made three types of mixtures, the first one using 100% cement, while the other two did replace 10% cement with silica fume and metacaoline respectively.
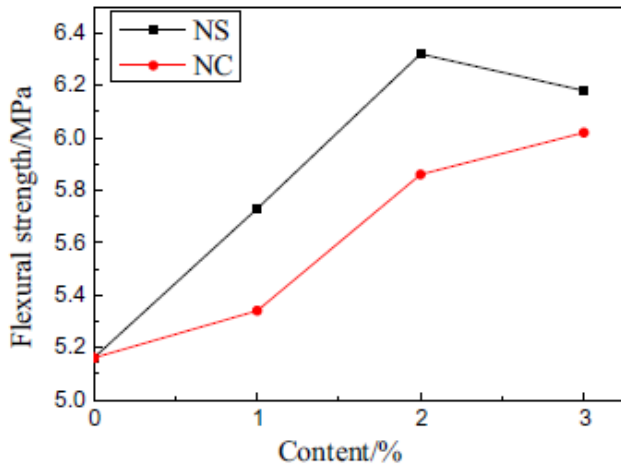

Figure 1.- The flexural strength results
Source: Yingli *et al.* (2017)

Figure 3.- Variation in compressive strength
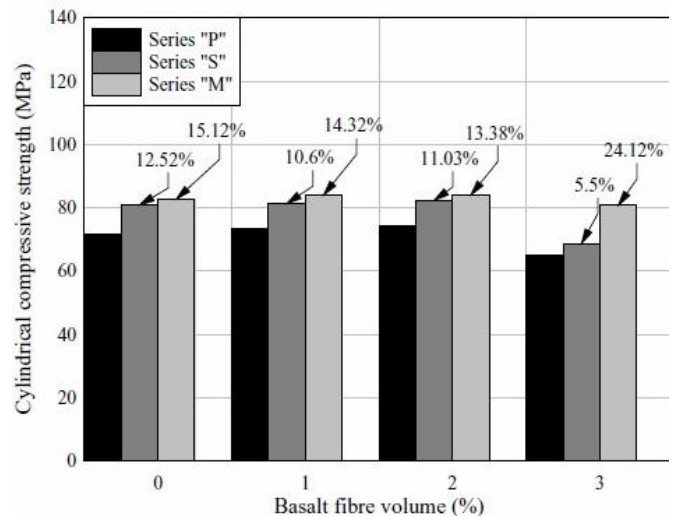Source: Tehmina *et al.* (2013)

Table 1.- Variation in the compressive strength according to different mixtures

Concretes	Basalt Fibre %				MPa
	0	1	2	3	
w/o mineral additive	*				71.87
10% silica fume	*				80.87
10% metakaolin	*				82.74
w/o mineral additive		*			73.52
10% silica fume		*			81.31
10% metakaolin		*			84.05
w/o mineral additive			*		74.16
10% silica fume			*		82.34
10% metakaolin			*		84.08
w/o mineral additive				*	65.08
10% silica fume				*	68.66
10% metakaolin				*	80.78

Source: Own elaboration

As you can see both in the figure and in the table, the optimum compressive strength is in the mixture with 10% kaolin and 2% basalt fibers, because when you have 3% basalt fibers it happens a slight drop in resistance.

IV. CONCLUSIONS

When analyzing the different works and their methodologies related to the improvement of the mechanical properties of rigid pavements with additives and considering the various factors that have been mentioned previously, such as the easy implementation of the substance, cost reduction and compatibility with the environment to mention a few, is very interesting the present of the nano particles, mainly nano silica, so we will continue the research of this work to deepen and obtain own results with emphasis on these additives. It should be mentioned that this has been only a few of the advances on the subject, there are more studies of great relevance which are aimed at deepening due to the benefits that nanoparticles contribute to the concrete.

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THE DAMAGE FACTOR OF PAVEMENT ON THE ROADS OF MEXICO IS INCLUDED IN THE TOLL RATE?

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Abstract

The article aims to identify and know if within the methodologies or models that use the roads in Mexico, are considered some of the physical parameters that affect the damage to asphalt pavements and include that cost within the toll, valuing what parameters could include or exclude about its methods of collection toll. The natural wear of the pavement is accelerated by freight transport that circulates in overweight conditions and that is when the negative effects arise: the deterioration and fatigue of the pavement. Trucks with fewer axles will have the greatest damage to the pavement with respect to the others, due to the punctual load acting on the axles. In Mexico, the damage factor in tolls is not included, only investors want to see their money grown during the concession time, regardless of anything. The toll rate must include the damage factor for trucks when they are overloaded, especially.

Keywords: (freight transport, damage pavement, toll rate)

I. INTRODUCTION.

In the case of Mexico, roads are the main means of communication used by the freight transport system. According to the Statistical Manual of the Transport Sector 2015 published by the Mexican Institute of Transportation, in Mexico the amount of 522 million tons was moved by this mode of transportation, giving 86% of the total domestic movement [1]. Currently, the road network of Mexico has a total of 393,471 kilometers, of which only 12.83% represents only the federal network, 10.33% to the federal network free to toll and only 2.5% to toll highways (9,818 km); the rest is made up of 87.16% of rural roads.

It should be considered, in roads with greater traffic flow, mainly those that are in the main axes, the freight transport has its movement in these areas to be able to carry the merchandise or services that the population requires in short times. For this reason, because of these actions, the freight transport circulates too much on these roads and most are overweight, and as a result the deterioration of the pavement, due to different aspects of safety such as economic and comfort [2].

Within this perspective, the presence of vehicles in the vehicle flow significantly impacts the operations of the roads due to its large size, causing a lower operating capacity than other vehicles [3]. In the same way, vehicle dynamics play an important role in deterioration, as well as vehicle body, suspension, braking and tires; which are those that have direct interaction with the bearing surface [4]. Therefore, it is known that the weight by the freight vehicles that circulate on the road, accelerate the process of fatigue and fracture of the pavement [5].

Obviously, load is the most basic and important factor in the problem of overweight in the vehicle, for this, the trucks have a capacity of both tonnage and volume and dimensions specified in the Official Mexican NOM-012-SCT-2-2017, which deals with the weight and maximum dimensions with which the motor transport vehicles that pass through the general communication channels of federal jurisdiction of the Secretary of Communications and Transportation [6], can circulate. In this deterioration of the pavement are involved physical factors of vehicles that interact directly with the surface and identified as: a) gross vehicle weight, b) tires of the vehicle, c) pavement temperature and d) weight per axle. These factors mentioned above have a relationship between vehicle-infrastructure, which will be those that ultimately damage the pavement.

Previously it was mentioned that the road network tolling has a lower percentage with respect to the total of the national network, and an advantage of these roads over the others, is that they have revenue insured for a set time by means of concessions of road sections , and these in turn, through the toll charged to the users of their roads perceive the figures that would have to cover part of the amounts allocated to conservation. In Mexico, for the period of January-August of 2016, the costs for conservation were high, 8,200 million pesos were allocated by the Government, this numbers only for federal highways, without considering the rural roads that likewise they have a high number [7]. However, this situation of overload on the roads in Mexico is more frequent every day and the affectations to the infrastructure are evident [8]. As this continues, the freight

transport exceeded in weight becomes increasingly present on the roads of Mexico, which leads to treat this problem so common that it has serious consequences to the infrastructure and at the same time, the idea to include the damage factor within the toll rate on the toll highways mainly.

In this sense, knowing the methods used by the concessionaires in charge of operating the toll highways to establish the rate system is a key element to understand which factors are included and which are excluded. In this case, the Secretary of Communications and Transportation is governing rates in Mexico which is responsible for providing the fees that concessionaires will charge on the roads under their authority. In this way, knowing the procedure you have is important to know if this damage factor is included. The fee charged to users in the collection booth is the key to recover the investment previously put on the table by the private, this is based. which is seen as a business model to generate the highest possible profits during the time it can operate the highway, forgetting the regulations and standards that must be met.

II. STATE OF KNOWLEDGE

1. Physical parameters

Starting by defining and analyzing the parameters that are being taken into account for the evaluation of the deterioration of the road, in the introduction it was mentioned that they have a relationship towards the bearing surface with in the first place and later, towards the structure of the pavement, each one It has its specific characteristics to damage the pavement, but at the end of the day it will end up wearing away the useful life of the road infrastructure. Following, the selected physical factors are listed with their characteristics.

a. Vehicle wheels

Starting to talk about the tires, it is known that a common practice among drivers of freight transport is to inflate the tires of their vehicle, there obtain better handling on the road that makes it easier and the cost of fuel decreases, but in the same way, it produces rough driving vibration conditions. The magnitude and load frequency that is transmitted to the tires towards the pavement surface can influence the contact area of the tyre and the contact pressure of the tyre [9]. Following this idea, they also found that the contact area of the tires will depend on the pressure or inflation to which they are subject, as well as the structure or type of tyre, which has a direct relationship with the deformation that occurs in the bottom of the asphalt layer. The over inflated of the tires results in a greater rigidity in them accompanied by an increase in the loads transmitted by the vehicles on the bearing surface. This increase in loads comes to produce a different potential damage based on the accumulated energy they towards the pavement, because of which they produce a greater longitudinal force during the acceleration and braking of the vehicle, therefore, a significant potential damage at the time of performing this action [5] presents a simulation of

the damage caused by a two-axle truck (C2) with rear-wheel drive on a flexible pavement, once each tire has been evaluated, the results show that the rear wheels represent about 65% of the total damage to the truck, leaving less damage to the front wheels. The total stored energy of the tires is measured in kilo joule (KJ), as shown in Figure 1.
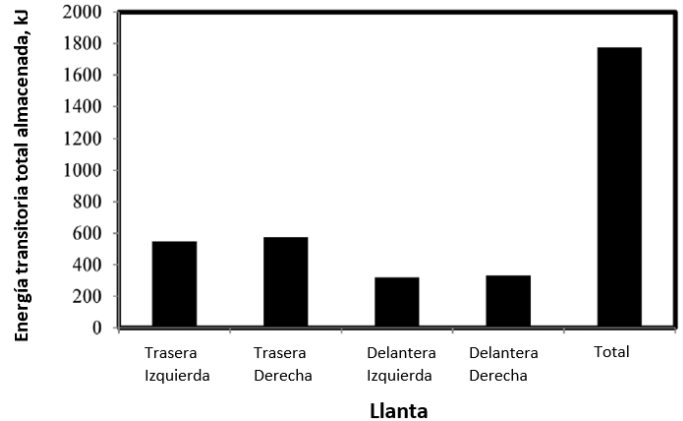

Figure 1. Comparison of the total energy stored for each of the tires and full truck. Romero J. A. *et al.* (2013).

b. Weight axle.

Weight axle is defined as the weight concentration that an axle transmits through all its tires to the surface. This parameter is completely related to the tires, in NOM-012-SCT-2-2017 the total weight of the axle is specified depending on the configuration of the freight transport of which one is talking about, varying from 6.5 ton for a truck type T-S and T-S-R up to 12.50 tons only for the configuration T-S, this data for a road type ET and A on a single axle of two or four tires and a simple engine of four tires, respectively. The more tires an axle contains, the greater the load that can be supported and the better distributed it will be, the maximum axle weight allowed for a tridem axis of twelve tires, for example, for a C-R and T-S-R is 23.5 ton and for a C and T-S is 26.5 tons, so that it is observed that the weight per axis depends on the configuration. In a study by [10], which discusses the effects of the weight of freight vehicles on the national road network in Mexico, it shows that unit damage (per vehicle) in an asphalt pavement is greater in larger vehicles, with a greater number of axles; for example, T3-S3 is the most affected, followed by T3-S2 and C2, however, by ton-km of merchandise transported, the damage to the pavement is different, being the largest in the direction of the smallest vehicles, with a smaller number of axles due to the fact that the load is concentrated more punctually; for example, C2 would be the most damaging, followed by the configuration T3-S3 and C3. Adding that, for vehicular overweight levels, the highest unit cost (per vehicle) of pavement deterioration / km of road was obtained for the T3-S3.

Similarly, the gross vehicle weight must be defined as the amount of the vehicle's own weight and the weight of the load it transports; In the NOM-012-SCT-2-2017 the values of this factor are mentioned according to the configuration of the vehicle, the gross vehicle weight in the same way the weight of the axles of the truck is routed. The excess of weight in the gross vehicular weight is an activity that is frequently practiced in the roads of the country, perhaps for reasons in terms of economy and speed to move merchandise, carry out more freight in the shortest possible time there will be a greater gain in the goods that are transported. Intervenes in this part, the revenue for the auto transporters, by operating large vehicles that allows moving larger quantities of freight, lower operating costs are obtained, therefore, a higher level of income and profits per unit [10]. However, exceeding the maximum gross weight allowed for the freight transport, the pavement begins to test deformations that are difficult to recover, and this is where deterioration begins. This way of traveling on the road has become a bad habit for transporters and there is no authority to take a firm stand to prevent this situation from happening and to keep happening. The next factor is important and unlike the previous ones, it is on the pavement and not in the vehicle.

d. *Pavement temperature.*

The next parameter to be treated is the pavement temperature; in flexible pavements this condition becomes more remarkable unlike rigid pavements. It is known that the higher the temperature of the flexible pavement, it will begin to flow as a visco elastic material, making it more susceptible to permanent deformations on the surface, and as the accumulated energy accumulates increasingly, there is no way that the pavement return to having its original shape causing these deformations. In Figure 2, the stored energy caused by a two-axle truck is observed at different temperatures, from 10 ° C to 40 ° C, in this way, the energy stored on the pavement is increased when it is at high temperatures, close to 40 ° C [5]. For example, in Figure 2, the variations of the total stored energy are shown, with an increase close to 1250% with respect to the lowest and highest temperature tested. The vehicle used for this simulation was a two-axle truck (C2).
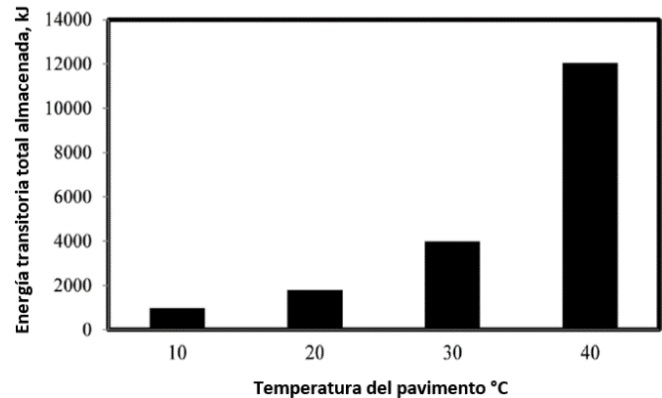

Figure 2. Variations of the total energy stored with the pavement temperature. Romero J. A. *et al.* (2013).

2. *Highway concession in Mexico and toll rates.*

The subject of highway concessions in Mexico is to extend and interesting, in the sense that most of these from a time to the present, are built through Public-Private Partnerships. According to the Secretary of Communications and Transportation and Banobras [11], a highway concession is: "an act by means of which the State grants a private individual the right to provide a public service and to exploit public domain assets, for a determined period of time (up to 30 years in Mexico), subject to various conditions that aim to preserve the public interest. The new concession scheme gives individuals the right to build, operate, conserve, maintain and operate a toll motorway. At the end of the concession period, both the highway and the rights that were highway return to the direct control of the State. " In effect, this type of public-private partnership in the road sector comprises three main types of long-term contracts that include "traditional" highway concessions, as well as projects for the provision of services and the use of assets. In Mexico, most of the time concessions are granted, which by law are put into practice by the Ministry of Communications and Transportation with a maximum of 30 years or up to 60 years in exceptional cases, to recover the initial investment of construction of the highway, once this period ends, the highway becomes free transit without charging any rates for users, where now the person in charge of repairs, maintenance and rehabilitation will be in charge of the Government of the State where this road is located.

The main component of recovery of the investment is the tariff, that which is charged to the users who circulate along the toll highway. The toll is defined to the quota related to the use of the facilities in the highway or road, which grants the right to use the infrastructure that is in it and that, with the income generated, to be able to maintain and increase the capacity; waiting, that in the long term it can be self-sufficient with the revenue generated during the operation that circulates in these road networks [12]; similar but simple definition that CAPUFE has about the toll, as an amount of the rate that the user pays in the toll booths to transit roads or bridges of the road's fee.

Starting from this point, the rate must contemplate all these factors to have a safe infrastructure where the vehicles decide to travel on that road for the quality service it offers because it is also paying for a service and the user has the right to demand.

The importance of charging a toll rate for the need to cover all costs of construction, maintenance, updating, maintenance, and operation of a highway, are key points to establish the amount of the fee for each type of vehicle [13].

According to the current internal regulations of the Ministry of Communications and Transportation, the General Directorate of Road Development (DGDC) is responsible for establishing prices on roads and bridges in accordance with laws, regulations, concessions, permits, authorizations, and official standards. The DGDC determines the type of concession model under which the highway will be managed, by determining the maximum average fare in the concession title granted to the concessionaire.

3. Methodology.

The methodology used for this investigation is in five steps, as shown below as a conceptual map.

Step 1.

> Identify and analyze the parameters that cause pavement damage.

Step 2.

> Selection of the field research: interviews and request information from different concessionaires.

Step 3.

> Analyze and know the methodology used by road operators to determine the toll in the collection booths.

Step 4.

> Proposal to include the toll cost based on the damage to the pavement.

Step 5.

> Analysis and comparison of results.

III. RESULTS AND DISCUSSION.

The damage to the pavement is reflected in the roads of Mexico, where different factors are involved such as the quality of materials of the road infrastructure, the vehicles that transit and, the weight of these that is the main cause of the pavement deterioration. By means of the results obtained by the measurement stations of weights and dimensions and the level of load transported by the trucks by [10], it shows that for the overall damage experienced in that section it was: 35% at T3-S2, 25% at C2, 20% at T3-S3, 15% at C3 and 5% at T3-S2-R4, show in Figure 3. For ton-km transported the proportions vary somewhat: 42% to C2, 23% to T3-S2, 20% to C3, 13% to T3-S3 and 2% to T3-S2-R4, show in Figure 4. With this it is observed that the vehicles T3-S2 and C2 are those that appear in the first places due to the combined effect of their frequency and the level of load.
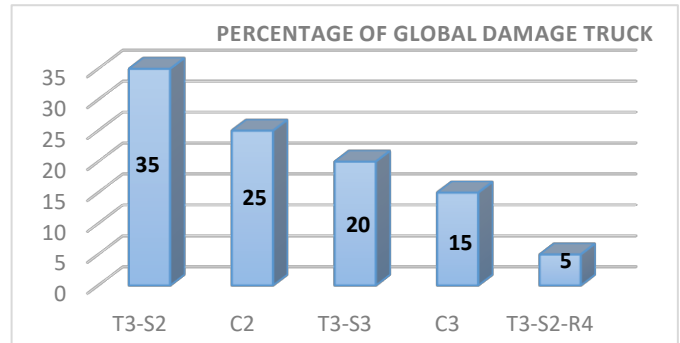
Figure 3. Percentage of global damage truck. [10].
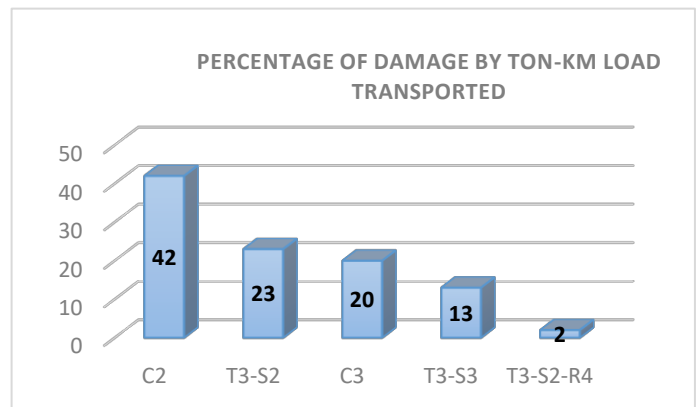
Figure 4. Percentage of damage by ton-km load transported. [10].

However, in recent years, that transportation planning has changed due to the increased need in the development of the road infrastructure, causing a financial problem within the public sector for its construction, as consequence emphasizes recourse to private sectors to achieve the goal of construction of the communication channel [14]. With this, public - private partnerships arise; responsible for the design, construction,

operation, and investment required for the road. The involved parties that make up this process are the transport agency, the private sector that wants to invest and the users that will use the road; each part has different functions and responsibilities within this model.

According to the investigation and the way to establish the toll rate of the roads, the General Directorate of Road Development determines the maximum average rate (MAR) and the rate regulation bases that allow the efficient use of the highway infrastructure. These bases of rate regulation only apply to the toll fee for the use of the project, in other words, it is a power granted by the Secretary of Communications and Transportation (SCT) to the concessionaires to charge on the highway the initial rates obtained through the Index National Consumer Price (INCP) published by the National Institute of Statistics, Geography and Information Technology; this index is taken into account at the prices of the last fortnight or month, this to reflect the impact of inflation in the country, the initial rates once established can be modified every four months according to the INCP.

Starting from the fact that the SCT determines the maximum average rate that can be applied on the road, by type of vehicle or vehicle group; the dealer determines the specific rate that will be charged to each type of vehicle considering the characteristics of each route. The maximum average rate is formulated in pesos per standard vehicle / km and is obtained through a calculation procedure that incorporates the total capacity expected for the communication channel and its vehicle composition, integrating an analysis and a recovery of the investments made in the project by the companies involved. That is, the Ministry of Communications and Transportation establishes the initial level of the maximum average rate without considering the value added tax (VAT) and prices of a date determined by means of the National Consumer Price Index (INCP). Standard / kilometer vehicles are calculated based on the physical characteristics of each type of vehicle. In this way the standard / kilometer vehicles are calculated based on the physical characteristics of each type of vehicle, in the following table the equivalences in standard vehicles are shown.

Table 1. Table of equivalences in standard vehicles.

Code	Description of type of vehicle.	Equivalences in standard vehicles
A	Car passenger	1.00
B	Bus of 2 y 3 axles.	1.75
CU	Truck unitary of 2, 3 y 4 axles.	1.75
CA1	Freight truck of 5 y 6 axles.	2.50
CA2	Freight truck for 6 axles or more	3.00

Source: SCT, 2008.

Concessionaires may vary the equivalence of standard vehicles depending on which is more convenient for highway revenues. The specific rates are set in closed pesos, once considering the VAT to be paid. This type of applicable rate cannot be higher than the specific rate applied to another type of vehicle with a greater number of axles. The average rate observed during the project may never exceed the maximum average rate once fixed by the Secretary of Communications and Transportation. The observed average rate results from dividing the total project revenues, between the total length of the road and the number of standard vehicles registered in the section, determined from the expected traffic that the highway will have. This observed average rate is expressed by the following formula (1):

$$\sum ING_i \; / \; \sum_{i=1}^{N} (VE_i * LONG_i) \; \leq \; MAR \quad (1)$$

INGi = Revenue without VAT generated in the section i generated in the calendar year of the analysis.

VEi = Total standard vehicles registered in section i, calculated by multiplying the total number of vehicles of each type by their corresponding equivalence factor.

LONGi = Length in kilometers of section i.

MAR = Maximum average rate.

N = Number of sections.

About the economic-financial issue, the fee charged on the fee roads is set by the Secretary of Communications and Transportation once it is granted the concession title of the road section to the concessionaire in question, this rate is determined since the road concession project is generated, the SCT practically tells the concessionaire what fees are charged to the users. Following the methodology described, the concessionaires are investigated regarding the toll payment methods and agreed that the toll collection has absolutely no relation to the damage to the pavement, because the concessionaires do not involve any technical aspect that damages the infrastructure in their rates, which is wrong from a road conservation point of view.

The parameters show that damage to the pavement structure due to cargo trucks is evident and that they significantly impact the road's useful life. Each of the parameters has its effects in a very particular but related to each other. Due to this, it is necessary to look for another type of solutions for the conservation of the pavement in this aspect and verify that the rate established in the toll are really destined for their purposes, one of them exclusively, with respect to the conservation of the highway infrastructure in question. Unlike this does not happen, the money on the highways goes to other economic aspects more important than maintaining a road in good condition.

IV. Conclusions.

The concession model in Mexico is designed to focus the cash flows received from a collection booth in a circle of investors, where the money is concentrated during the time of the concession in those small groups. An idea to avoid this type of situation is that in a certain fair way it was based on an Internal Rate of Return (IRR), where the investor recovers his money once the money invested is reached and in a much shorter time so as not to centralize the riches in the hands of a few people. In this business model that revolves around road concessions, the most unprotected is always the user, nobody thinks about security. Based on a collection system based on the principle that "the one that damages, pays", the rate is not to do justice to users in terms of damage and safety of the pavement, is designed to do business only, in a model purely economic-financial.

Since the General Direction of Road Development establishes the rates for future highway concessionaires through the concession title and the bases for tariff regulation, a restructuring of a new concession model would be a good measure considering the road infrastructure in long terms and not have making repairs at unforeseen times, this with the aim of having more in mind the user and not see 100% a business model to the roads. With this, that the toll rate is fairer for those who damage the infrastructure more, specifically the trucks.

The NOM-012-SCT-2-2017 must be executed without any exception, the regulatory authorities of the weights and dimensions must focus attention on the freight transport and regulate this situation; both parties (the authority / concessionaire and freight transport) have this obligation to comply.

Remarking that overloaded trucks are a very marked and frequent problem in the roads of the country, due to various factors that have been mentioned, that transporters facilitate their tasks and that they are reflected in the benefits through the movement of merchandise, giving more movement to goods in a shorter time, but at a high cost for flexible pavement. It is true, it is difficult to have to load trucking in terms of weights and dimensions, because the authorities charged with regularizing these aspects give attention to other interests and completely ignore the infrastructure of the road. That is why it is important to be making constant repairs to the road infrastructure, and at the same time, recognize what type of units are circulating and that are allowed within the NOM-012-SCT-2-2017, therefore, be in order in terms of their already established specifications, because they are the vehicles that most damage the pavement.

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Review of recent advances of four refrigeration cycles

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Abstract— **This document reviews the four types of refrigeration methods most commonly used in domestic refrigerators. As well as mentioning important data of each cycle, what they consist of, their performance and the environmental impact that they have. Refrigerators in general are based on a vapor compression cycle (VCC), so this cycle is the first to be reviewed. Non-in-kind technologies that are not based on VCC, such as the absorption, thermoelectric and adsorption cycle, are presented for the application of domestic refrigerators. Although they have not been widely used for domestic refrigerators due to insufficient reliability and poor performance, their performance and comparison with the VCC will be discussed in this document.**

Keywords— Refrigerator; vapor compression cycle; thermoelectric effect, adsorption cycle, absorption cycle.

I. Introduction

The demand for energy increases steadily every year due to the population growth and the improvement of life. The consumption of energy is one of the causes of the emission of carbon dioxide, which is a major concern due to this happens climate change, in addition to pollution. In residential areas, domestic refrigerators play an important role in the continuous consumption of energy. These respond for approximately 6% of the electric power produced worldwide [2]. Currently there are several refrigeration cycles [26], for example: vapor compression cycle (VCC) [25], thermoelectric effect or Peltier effect [22], thermoacustic effect, thermoelastic effect [2], magnetic effect [5, 21, 23, 24], absorption and adsorption method [26]. In this document we will discuss four of them, starting with the VCC technology that although it is one of the most energy consuming, it will also be discussed that its performance is optimal and is one of the best options in terms of performance. The technologies are not commonly used for domestic refrigerators, such as the thermoelectric cycle, absorption and adsorption, which will be discussed later. These technologies are not usually used for domestic refrigerators due to lower performance compared to VCC options. However, the adsorption cycle is the most promising solar cooling methods, in addition to being environmentally friendly, as well as low cost and very few maintenance requirements. For this reason, research is currently being carried out to improve the performance of this refrigeration cycle, since achieving this would result in better performance and significant energy savings.[28].

II. Vapor compresion cycle

Most refrigerators are based in vapor compression technologies. This consists of a capillary tube that is generally used as an expansion device for domestic refrigerators. For VCC-based refrigerators, the suction line heat exchanger (SLHX) is basically applied to improve the efficiency of the VCC. The heat is exchanged between the subcooled liquid refrigerant and the superheated steam refrigerant in the SLHX. The SLHX is located between the condenser outlet and the capillary tube inlet and between the evaporator outlet and the compressor inlet. VCC technologies are classified into three groups, which are: 1) evaporation cycles, 2) loss-loss recovery cycles and 3) multi-stage cycles. The double evaporator cycles include parallel circuit, bypass and parallel cycles, and Lorenz-Meutzner cycle (LM) according to the connection of the evaporators. Currently, serial, bypass and parallel circuit circuits are available in the market, but the LM cycle is being studied in the laboratory and the prototypes are in the development stages. The long-term reliability of the proposed coolant mixture for the LM cycle has not yet been resolved [2, 11]. The conventional steam compression cycle is currently marketed more than non-in-kind technologies [28]. The multi-stage cycles include a two-stage compression cycle and a double-loop system. The two-stage cycle is found as emerging technology to further improve the performance of the VCC cycle. Double loop systems are commercially available, but generally apply to large capacity refrigerators that cannot handle thermal loads with a single compressor. The compressor is the most expensive component and generally requires 8% to approximately 15% of the total cost of the material of a domestic refrigerator. Therefore, when two compressors are applied, the cycle increases in cost compared to the other cycles that have a compressor, since having two compressors must also be invested in additional devices that support it. [2].

III. THERMOELECTRIC CYCLE

For domestic refrigerators, non-in-kind technologies can't fully replace vapor compression technology. Thermoelectric cooling technology is one of the most developed non-in-kind technologies in recent years. Thermoelectric cooling involves the use of the Peltier effect to transform electricity into heat to cool and / or heat [22]. Thermoelectric cooling is operated by a direct current that passes through a circuit formed by two different conductors or semiconductors that produce a temperature difference at the junction of two conductors. This is called the Peltier effect and the thermoelectric cooler uses the Peltier module interspersed by two heat exchangers. The Peltier module consists of a series of n-type and p-type semiconductors connected in series by copper bands and covered with ceramic plates. The heat is pumped from one side of the module to the other through the heat exchangers. This technology is commercially available in small-scale refrigerators. The coefficient of performance (COP) of the thermoelectric cooler is also as low as that of the absorption coolers. The energy efficiency of the thermoelectric cooler is determined by the COP of the Peltier module and the effectiveness of the heat transfer of the heat exchangers. On the other hand, the low performance of this method prevents it from expanding. However, it is an effective method to cool, so the development of a domestic refrigerator, based only on the thermoelectric cycle, would be able to compete in the market with those based on VCC, as long as it has a higher performance than it currently has. [29, 30].

IV. ABSORTION CYCLE

Absorption cooling is mainly based on the affinity of two substances at different states to form a solution or a mixture. This process depends on the temperature and the pressure levels. At a low temperature and pressure level, the liquid absorbent absorbs the refrigerant vapor and at a high level it releases it. This phenomenon is exploited to pump the refrigerant from the evaporator to the condenser using a solution pump instead the intensive energy consuming vapor compressor .The first machine patented in 1859 by the French engineer Ferdinand Carré used water as absorbent and ammonia as refrigerant [19].The absorption refrigeration technology consists of a generator, a pump and an absorber that are collectively capable of compressing the refrigerant vapor. The evaporator draws the vapor refrigerant by absorption into the absorber. The extra thermal energy separates the refrigerant vapor from the rich solution. The refrigerant is condensed by rejecting the heat in a condenser, and then the cooled liquid refrigerant is expanded by the evaporator, and the cycle is completed. The refrigerant side of the absorption system essentially works under the same principle as the vapor compression system. However, the mechanical compressor used in the vapor compression cycle is replaced by a thermal compressor in the absorption system. The thermal compressor consists of the absorber, the generator, the solution pump, and the expansion valve [9].

The cooling technology based on the VCC is the most common and leading technology, but there are some disadvantages such as periodic compressor noise and the environmental impact of refrigerants associated with the ozone layer and global warming. For these reasons, the absorption cycle is being used for refrigeration applications.
A large number of absorption refrigerators have been designed and marketed with cooling capacities of between 10 and 1000 kW [2,10, 15].
The different absorption systems are classified as: 1) Single-effect solar absorption cycle, 2) Half-effect solar absorption cycle, 3) Double-effect solar absorption cycle and 4) Triple-effect solar absorption cycle.

V. ADSORTION REFRIGERATION CYCLES

Adsorption is a process by which the molecules of a substance are commonly fixed on a porous surface or material. Adsorption occurs at the surface, where the cohesion forces, including electrostatic forces and hydrogen bonds, act between molecules of all categories, regardless of their state of aggregation, and this process is reversible. Unbalanced surface forces at the phase boundary cause changes in the concentration of molecules at the interface of the solid or fluid. The adsorption process involves the separation of one substance and its concentration on the surface of another. The adsorption phase in the adsorbent, and the material concentrated or adsorbed on the surface of that phase in the adsorbate. Adsorption is an exothermic process associated with the evolution of heat, the amount of release of calories depends on the magnitude of the electrostatic forces involved, the late heat, the energies of electrostatic and chemical bonding. Since in the adsorbed phase, the adsorbate molecules are in a more, ordered, entropy, decreases [28].

A. Basic solar adsortion refrigeration cycle.

Solar energy is the source of most adsorption systems operating with the basic cycle. In the remaining cases the components are kept unchanged, the main difference being the heat collection method. A solar adsorption refrigerator based on the basic adsorption refrigeration cycle does not require any other energy, just thermal energy, and it operates intermittently according to the daily cycle. These adsorption systems are closed systems, like a simple vapor compression system, comprising a compressor, a condenser and an evaporator. However, in this case, the compressor is an adsorber powered by the thermal energy, and the cooling effect is achieved by the evaporation of a refrigerant while the vapor produced is adsorbed by the adsorbent layer in the adsorber. The adsorbed content of refrigerant varies cyclically, depending on the adsorbent temperature and system pressure, which varies between a maximum limit set by the condensation pressure and a minimum limit imposed by the evaporation pressure [16, 26].

The cycle consists of four processes [28]:
1. Heating and pressurization
2. Heating and desorption & condensation
3. Cooling and Depressurization
4. Cooling and adsorption & evaporation

B. Heat recovery cycle.

The heat recovery cycle begins when after switching between adsorption and desorption, the cooling or heating medium flows immediately between the hot adsorber and the cold adsorber in a closed loop. Then, a part of the heat of the hot adsorber is recovered and the coefficient of performance of the system increases. It is also used in the system with two or more beds. According to the corresponding research, heat recovery can improve COP by 25% [6, 8].

C. Heat and mass recovery cycle.

The massive recovery process occurs after the change between adsorption and desorption and before heat recovery, the mass channels between the high pressure desorbent and the low pressure adsorbent are connected together. The desorber desorbed more and the adsorber adsorbs more. This process increases the cyclic adsorption capacity and the specific cooling power (SCP) is correspondingly improved. The cycle of recovery of heat and mass, in most cases is the mass recovery and the recovery of heat in combination. The COP and SCP increase the recovery time and the recovery time of the adequate mass. The recovery cycle of calories and mass is one of the most used and successful cycles nowadays. The adsorption cycle with massive recovery also increases the capacity of an adsorption cooler to utilize low temperature heat sources. In working conditions, the cycle of recovery of the mass with the performance of the system, with the conventional cycle of feeding the low-temperature heat source [6, 28].

D. Thermal wave cycle.

The high temperature heat medium flows to the desorber once heated by the heater; the thermal medium is cooled by the desorber and then flows into the cooler; the temperature of the environment decreases in the cooler; and the low temperature heat medium flows into the adsorber to cool it; At the end, the heat cycle returns to the heater to warm up, this cycle is called the thermal wave cycle and a large temperature rise in the adsorber and a large temperature drop in the desorber are needed for this cycle. Then the high heat transfer performance of the adsorber / desorber is very important. But it is difficult to improve the performance of the transfer of calories to meet the requirements of the thermal wave cycle. Thermal wave cycle is better for the COP of the system, but not for SCP since it prolongs the fluidity of the heating medium in the beds or decreases the energy flow of the environment, the energy density of the systems will decrease [6, 8]. The concept of thermal wave cycle is firstly proposed by Shelton (March 10th, 1990) [31]. According to his analysis, 80% heat required in desorption process can be provided by the heat released in adsorption process. Therefore, the heat is effectively utilized in this cycle and the heat, from external heat source, needed in the desorption process is greatly reduced.

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Portable optical device for the non-destructive and *in situ* measurement of lycopene and degree of maturity in ball tomato.

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Digital image processing has proved to be useful for the analysis of organic compounds. Therefore, the present project proposes the development of an optical system for non-destructive and *in situ* lycopene quantification, as well as its classification by maturation stage by studying the coloration present on the surface of ball tomato fruits. This by means of a CMOS sensors arrangement and segmentation techniques based on by thresholding and photometry.

Keywords: Lycopene; portable; in situ; non-destructive; image processing

I. INTRODUCTION

Lycopersicum sculentum is the scientific name given to the fruit of the tomato, this name has its origin from the nahuatl word "*xitomatl*". Its chemical composition is affected mainly by its maturation, where about 400 compounds participate that are responsible for determining its flavor, aroma, texture, firmness and color. In Mexico, the main varieties of tomatoes are: bola, saladette, cherry and large river. The ball tomato is characterized by its round shape with an average weight between 70 and 100g and, with a diameter that goes from 4 to 8cm [1].

The tomato contains natural substances called carotenoids, which are organic pigments that are found on the surface of the plant. Carotenoids are composed by carotenes and xanthophylls. Within the group of carotenoids is the lycopene, which is the compound responsible for red pigmentation of the fruit [2] and also has high antioxidant activity. Lycopene acts against the destruction of free radicals, preventing the generation of degenerative diseases [3].

Experts in neurobiology [4] link lycopene with the prevention of different types of cancer (lung, prostate, tumors, atherosclerosis, among others) and with the prevention of heart attacks. The lycopene content in a fruit depends mainly on the degree of maturation and is directly related with the red coloration, lycopene also is dependent on the selected variety and the cultivation practices (light exposure, soil type, irrigation).

The Secretary of Economy and SAGARPA generated a document called "Mexico supreme quality" for the specific use of the brand "MADE IN MEXICO" [5]. The certification contains specific requirements regarding the attributes of the tomato fruit. The documents has as objective the development of high value markets with high quality products, assuring the consumer that the product they are acquiring has a high quality fruit of tomato. For this, six stages of maturation of tomato were defined based on the physical characteristics of the fruit. The physical features related with each ripening stages are presented in Fig. 1 and described in Table 1.

Fig. 1. Ripening stages for the red tomato.

TABLE 1. STAGE OF MATURITY OF RED TOMATE DEFINED BY [5]

Stage	Color	Characteristics
1	Green	Tomato skin of green color.
2	Breaking	Breaking of the green color towards yellow, pink or red colors in no more than 10% of the surface of the fruit.
3	Scratched	Between 10 and 30% of the surface of the fruit shows a change of nest from green to yellow, pink or red, or a mixture of them.
4	Pink	Between 30 and 60% of the tomato surface is pink or red.
5	Light Red	Between 60 and 90% of the surface of the tomato shows pink or red colors.
6	Red	More than 90% of the super cinema of the tomato has red color.

A. Hypothesis

The quantification of color by digital images processing of a surface area of at least 40% of the tomato ball (*Lycopersicum sculentum* var. Beef), will generate a predictive model to determine *in situ* and non-destructively, the amount of lycopene

and the stage of maturation with an accuracy equal to or greater than the optical systems so far developed.

B. General Purpose

To develop a non-destructive optical system for *in situ* determination of the amount of lycopene and the ripening stage of the tomato (*Lycopersicum sculentum*) by analyzing its coloration using digital image processing to obtain an accuracy equal to or greater than the optical systems so far developed.

II. BACKGROUND

Usually for the maturity degree identification of the tomato it is necessary to recur to expert personnel, who determine the quality of the fruit and the time in which they must be harvested based on their physical appearance. These types of decisions are usually subjective due to there is no way to ensure the content of organic compounds inside it. Currently there are several techniques for identifying the internal attributes of a fruit.

[6] optimized the technique of high performance liquid chromatography (HPLC) for the determination of lycopene and β-carotene with an accuracy of 100 - 109%, however; this type of tests involve the use of specialized and expensive laboratory equipment and the destruction of the sample.

On the other hand, technologies based on optical systems such as spectrophotometers have been developed for lycopene quantification, this compound absorbs light at 530 nm wavelength [7]. [8] made a comparison of the advantages and disadvantages involved in the use of non-destructive techniques for the determination of ripeness in fruits and thus define an optimum harvest time, this analysis is shown in Table 2.

TABLE 2. COMPARATIVE OF THE TECHNIQUES USED BY [8]

Measurement technique	Advantages	Disadvantages
Colorimeters	Record accurate color information.	Only for individual fruits.
2D Images	They represent larger areas and can be placed on mobile platforms.	They can only obtain color information that is not suitable as an indicator of the maturity of all fruits.
Fluorescence	Detects color change, especially the chlorophyll content change	
Spectroscopy VIS/NIR	The region correlates with attributes of color and internal quality providing a better prediction of fruit maturity.	Sophisticated high-cost technology
Hiperspectral images	Same advantages as spectroscopy and 2D images	High cost and large generation of data sets is mainly used in the laboratory
Multispectral images	Overcomes limitations of multispectral imaging	The reliability of the measurement in the field should be further investigated.

In terms of the detection of organic compounds, [9] developed an algorithm for the estimation of lycopene and β-carotene with VIS / NIR spectroscopy and multiple regression models obtaining an R^2 of 0.97 for lycopene and 0.85 for β-carotene, by means of multispectral images along with chemometrics, [10] determined that it is possible to detect the amount of lycopene and other bioactives in ball tomato with a prediction coefficient of 0.938. Nevertheless; despite the good approximation obtained and allowing *in situ* analysis, methods such as spectroscopy and multispectral imaging compared to 2D imaging techniques are known to be a sophisticated and costly technology, which is often considered inaccessible for small or medium producers.

Due to aforementioned reasons, image processing techniques have been optimized, which turn out to be economical and efficient, which together with the generation of predictive models and/or intelligent controllers provide a good approximation. Examples of the results obtained by means of image processing for the classification of tomatoes by ripening stage are [11], [12], [13] with a 94.29%, 96% and 93% of classification accuracy, respectively. It's necessary to mention that some of these test were not done *in situ*.

On the other hand, in the matter of organic compounds detection by means of image processing, a correlation between color-lycopene has been found by [14]. [15] selected 6 tomatoes with different maturation stages where they found the existence of a relationship between color parameters (L*, a*,b* and hue) and the present maturation as well as the concentration of lycopene and β-carotene with the help of a neural network. Likewise, in [16] has been reported a high relation between lycopene with index values a*/b* for Laura tomatoes with linear regression models, this relates the amount of lycopene with the degree of maturity of the tomato. Finally, [17] showed that with the RGB values and their transformation to the CIEL*a*b* color space by means of a colorimeter, the internal evaluation of the quality of the tomato fruits including the Brix degrees and the lycopene content can be determined.

III. METHODOLOGY

The methodology that will be carried out in the development of this project is the following:

1) Select and validate the sensors and the embedded system to be used for measuring the coloration of tomato (Lycopersicum sculentum var. Beef) with respect to resolution, response curve and ease of use and comparing those applied in the works consulted.

a) Identification and revision of materials and equipment applied to the measurement of color by means of digital image processing.

b) Selection of color sensors with respect to the technical specifications (resolution, response curve and ease of use).

c) Comparison of images obtained with respect to the working spectrum (Visible vs. Infrared).

d) Comparison and selection of the embedded system for the digital processing of images.

e) Selection of the lighting source to be used to obtain a diffused light to avoid the generation of shadows and internal reflections.

2) Design and manufacture a robust and versatile mechanism for the non-destructive and in situ measurement of the coloration of the tomato ball (Lycopersicum sculentum var. Beef), using the SolidWorks software.

a) Conceptual design of the prototype for the non-destructive and *in situ* quantification of lycopene in ball tomato by optical systems.

b) Manufacturing and assembly of the prototype and integration of sensors and actuators with the manufactured housing.

3) Generate a model based on the existing correlation between lycopene - color - maturity stage through the analysis of images that allows a correlation greater than or equal to those proposed by existing optical devices.

a) Calibration of the selected sensor for the image acquisition and light testing system in the inspection chamber.

b) Selection of 25 ball tomatoes with different maturation stages.

c) Acquisition and pre-processing of images obtained.

d) Conversion of the image to CIEL * a * b * color space and application of the processing method to the obtained images.

e) Obtaining the lycopene quantity of the tomatoes selected by HPLC tests.

f) Generation of the model based on the relationship between lycopene - color - maturity stage to obtain a correlation greater than or equal to those proposed by existing optical devices.

4) Implement the algorithm with the model generated for non-destructive and in situ quantification of lycopene and maturity stage in tomato (Lycopersicum sculentum var. Beef) with an accuracy greater than or equal to the models currently generated.

a) Development of the programming code for the estimation of lycopene in ball tomato with respect to its coloration.

b) Implementation of the algorithm in the selected embedded system for the non-destructive and in situ quantification of lycopene in tomato ball to obtain an equal or greater accuracy to the optical systems found.

5) Reduce the system error by means of HPLC to a percentage of accuracy greater than or equal to the systems developed until now.

a) Experimentation, data analysis and validation of the generated model.

b) Decrease in the error rate found by means of hardware / software adjustment.

c) Field tests will be done at the Autonomous University of Querétaro, Amazcala.

d) Synthesis of results and improvements to the prototype.

e) Generation of the margin of error obtained in the field for an adjustment not to the model and / or prototype to obtain an accuracy equal to or greater than the optical systems found.

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Impact of a photo-transistior's, collector current, equivalent resistance and process temperature on ouput voltaje

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Abstract—Nowadays different devices such as military, industrial and appliance depends for its performance on electronic systems and boards. Electronic boards or printed circuit assemblies (PCBA's) consist in different electronics components mounted on a printed circuit board (PCB) and assembled by a welding process in which the temperature is one of the key control variables.

One component commonly found on an electronic board is the phototransistor; the phototransistor is a semiconductor device, which delivers an output signal in response of an electric input. Being the phototransistor a semiconductor device, it works by producing a resistance that cab be adjusted in a percentage; Their conducting properties may be altered in useful ways by the deliberate, controlled introduction of impurities (doping) into the crystal structure along with controlling or variating their operating temperature or the temperature of the manufacturing process[1].

The purpose of this work is the assessment of the impact of key variables of the PCBA manufacturing process and phototransistors characteristics on the components output efficiency; factors like intrinsic equivalent resistance, collector current and process temperature. A design of experiment was planned and implemented to test two levels of each variable, see Table 1. The experiment´s goal was for characterizing the factor´s optimal levels and it was designed based on the findings in the literature.

Table 1 DoE factors levels

Factor	Low level	High level
Power supply (PS)	3.3	5
Temperature (T)	230	241
Equivalent resistance (Req)	<11 K	>1 M

Keywords—phototransistor; equivalent resistance; PCBA; electronic components.

I. INTRODUCTION

In Mexico, the electronic equipment industry has been a pillar in the manufacturing sector. It had its higher growth on the nineties and its higher impulse with the America Free Trade Agreement (NAFTA). The sector growth as far as 16.4% between 1994 and 2000 and the labor increased from 192 thousand ton 384 thousand in the same period [2].

According with INEGI the electronics components manufacturing is one of the fastest growing industrial sectors in Mexico. The consumer electronic sector that operates in Mexico consist in 730 manufacturing plants and 709 companies dedicated to electronic and 197 companies dedicated to the production of appliance [3].

A PCBA is the main component of most electronics systems. PCBA including phototransistors are used in bill recognition for validation systems, between many other applications.

The objective of this document is to identify process parameters and each individual component variables that need to be consider in order control the output voltage on an electronic circuit using phototransistors through the state of the art review and experimental analysis.

II. PRINTED CIRCUIT BOARD ASSEMBLY

The PCBA is the main component for an electronic system. There exist two methods to fabricate a PCBA, one is the through hole technology and the other is the surface mount technology.

Both methods need of a PCB in order to be able to assembly the components, multiples studies have shown that the soldering on PCB can be affected by the Surface finish of it. That, there is a correlation between the temperature and the Sn morphology in the solder joints. Generally samples solidified at higher temperatures show beach ball structure, while smaller samples that undercool more show interlaced Sn grain morphology [4].

Previous studies revealed that during isothermal fatigue tests, single Sn grain solder joints of particular orientations

failed early, as compared to multi-grain SnAgCu solder joints [4]. It was demonstrated that solder quality and solder process is a main contributor on components performance, such as the phototransistors. The consequences on components are reducing component life span and reliability.

The designer must therefore be vigorous in his application of the relevant design codes, confident he can properly determine the operating conditions of stress, temperature and environment and sure that the materials properties on which his design is based will in fact be realized in practice. Unfortunately, for a wide variety of reasons, it has been the case that one or other of these criteria has not been met in practice and the resultant failures have led to very significant, and occasionally catastrophic, financial penalties.

III. PHOTOTRANSISTOR CHARACTERISTICS

A phototransistor is a silicon semiconductor device with photosensitive base. It consists of photodiode followed by a transistor as shown in Fig. 1. The photodiode supplies base current to the transistor and the transistor multiplies the base current by its gain. The device responds to wide range of wavelength varying from infrared to ultra violet. Phototransistor also responds to fluorescent and incandescent lights [5].

The output collector current is given by :

$$Ic = h_{fe} I_p \qquad (1)$$

Where:

Ic : The current flowing to the collector of the phototransistor.

h_{fe}: Gain of the phototransistor.

I_p: Photocurrent.

In this document, in order to determine the impact of the equivalent resistance of a phototransistor, a circuit array similar to Darlington in order to proper identify equivalent resistance contribution.

On **¡Error! No se encuentra el origen de la referencia.** can been seen the circuit designed to analyze de contribution of the equivalent resistance of the phototransistor.
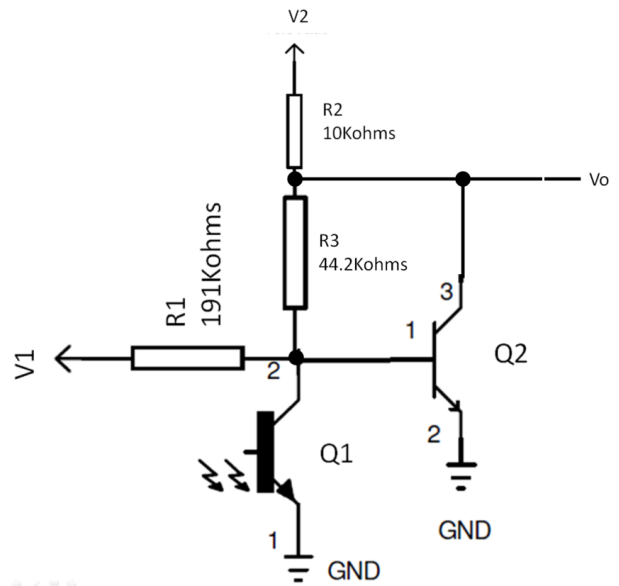

Fig. 1. Circuit for analysis of equivalent resistance source: own elaboration.

On the ideal case, a phototransistor works as an open circuit when light it is apply to its base. When no light it is applied the phototransistor is works as a close circuit. Multiple studies had shown that phototransistor present a fast absorption to photoconductivity and exhibit a high equivalent resistance in absence of light[6]–[8].

This means a phototransistor can be switched from a low current "off" state to a high current "on" state with an optical pulse. The transition is characterized by a region of negative dynamic resistance.

Fig. 2 change common symbol for phototransistor Q1 to its equivalent symbol of resistance in order to exemplify how a phototransistor works in an equivalent resistance state. It can also been inferred that current of the phototransistor is independent of the light intensity and the output of it will be mostly affected by the equivalent resistance and the resistance of circuit design.
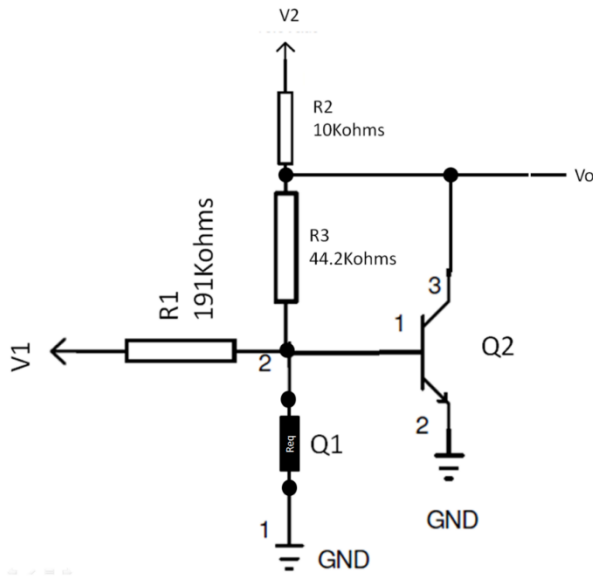
Fig. 2. Circuit for analysis of equivalent resistance modified source: own elaboration

In order to calculate the equivalent resistance of the phototransistor we use a mesh analysis on the circuit, resulting in the following equation:

$$I_B = I_1 + I_3 - Ieq \qquad (2)$$

IV. METHODOLOGY

In order to be able to develop the analysis presented in this document. Is proposed a design of experiments (DoE) using the variables defined above, equivalent resistance (req), collector current measured through the voltage input (Ps) and process temperature (t).

For the DoE, a full factorial design was chosen to develop the experimental trials. This way the DoE will be formed by eight experimental trial runs in three replicates as show in Table 2.

Table 2 DoE proposed

Trial	Power Supply	Temperature	Equivalent Resistance
1	3.3	230	< 11 K
2	5	230	< 11 K
3	3.3	241	< 11 K
4	5	241	< 11 K
5	3.3	230	> 1 M
6	5	230	> 1 M
7	3.3	241	> 1 M
8	5	241	> 1 M

Output voltage will be measured through an analogic digital converted using a receiver board and an analysis software for internal use only.

To develop the DoE, eight electronic boards with phototransistors were selected in order to have these components unaffected by any kind of handling and low and high Req levels respectively. For the remaining factor levels, boards will be modify as necessary following IPC-A-610F standard.

An ANOVA analysis will be done to compare treatment contribution to response. Then a homogeneity test will be perform to the variance and residual results for data validation of the ANOVA, ANOVA will be perform with a confidence level of 95% and realized on RStudio 1.1.423.

V. RESULTS

After the analysis of the results of the DoE proposed in this document, is expected to find the equivalent resistance of the phototransistors as a significant parameter for the output voltage in an electronic circuit, so that a combination of levels can be proposed in order to achieve the objective presented within this document.

Whit this validation equivalent resistance can be consider as an important factor on the design of electronic circuits and PCBA in order to improve devices reliability.

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Asphalts Mixtures

Asphalt Rubber Mixtures

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"The Warm Mix Asphalt (WMA) technology has become an important new research topic in the field of pavement materials as it offers a potential solution for the reduction of energy consumption and GHG emissions during the production and placement of asphalt mixtures"[1]

Keywords—asphalt rubber; pavement noise; pavement desing; hot mix asphalt; plastic waste;

I. INTRODUCTION

"The waste of tire rubber becomes a major environmental concern. The use of crumb rubber, which is the recycled tire rubber, as an additive in hot mix asphalt mixture is considered as a sustainable construction method." [2] " Asphalt rubber mixtures continue to receive great attention from many transportation agencies world-wide because of their ability to improve pavement performance compared to conventional designs."[3] In this work we wanna present the main idea or the importance of reducing the waste of rubber tires employing this material in a new method of pavements in which we can reduce the contamination all over the world and the new highways will be more efficient.

II. PRECEDENTS

"The seasonal change in temperature and loading nature has a significant effect on asphalt behavior because of its visco-elastic nature. Several types of flexible pavement failure/distress occur due to this behavior of asphalt binder, among which rutting and fatigue cracks are very common."[4]

"Mexico according to the National Association of Distributors of Rims (Andellac), every year 40 million old tires are rejected.

Between the possible applications in the public work, one of those of major interest is the manufacture of asphalt miscellanies for highways, since the rubber of the tires endures progress in its behavior, it is more economic than other alternative modifiers and it allows to consume a considerable residue quantity." [5]

The rims for vehicles at the end of its useful life cycle, turn into not biodegradable waste. Also its physical form and its geographical dispersion raise a big challenge for its handling and final disposition.

The elimination of the rims of waste is a world serious problem. Due to the big number of rims of waste generated annually and its long life, the rims have a substantial problem in its handling like garbage. At present most of the rims of waste are piled up or used like filling in big area extensions, creating you would be sanitary and environmental threats.

The rims rubbish dumps have been from time behind, subjects of big discussions; still before there were the modern technologies in the manufacture of rims and the complex and vast system of distributors worried by the ecology.

Although in fact, the industry of the recovery of the rubber of the rims, it started practically as soon as the first tires of the first vehicles came to its final wear and were rejected. When the rims manufacture became more sophisticated with the incorporation of synthetics and radial belts of steel, the process of re-using the rubber was more and more difficult.

A. Rubber recycling and two methods

The dust of rubber recycling it is obtained crushing the entire tires up to the wished size and separating the metals and textiles that they could incorporate. The form of grinding, the grain of the particles and the metallic and textile remaining content of pollutants affect to the properties of the dust of obtained rubber. The use in asphalt miscellanies requires that the recycled rubber should be in the shape of thin particles of sizes lower than 2 mm, or 0,5 mm, according to the applications. The incorporation of pneumatic dust to an asphalt miscellany modifies its properties reológicas and improves its services as material for highways. This incorporation can be done of two ways: One of them is the miscellany previous to the rubber dust with the asphalt for its later employment as ligante in the asphalt miscellany. This form of incorporation of the pneumatic dust to the asphalt miscellanies for addition before to the asphalt is known as "a humid route". The second procedure consists of introducing the pneumatic dust straight in the plant of manufacture of asphalt miscellanies, together with the asphalt and the aggregations. The tire dust acts partly how arid, but the thinnest particles intergesticulate with the asphalt modifying its properties, managing to improve this way the behavior of the asphalt miscellany. This form of modification in which the pneumatic dust joins straight like one more component of the asphalt miscellany, is known as "a dry route".

B. Asphalt

In the first term it is necessary to know the conceptual part of what is the asphalt as ligant material derived from the refinement of the oil and of supreme importance for the construction industry for its properties of consistency, adherence, impermeability and durability. Nevertheless, it is a very capable product to the changes of temperature, the aging for elements, the oxidation and the photo degradation. The asphalt is composed of asphalt molecules, the same ones that shape chemical structures (linear), aromatic and cyclical alifáticas.

It is good to know with largeness what means the chemical structure of the asphalt in order to determine its real behavior and it not to work simply like a residual refinement material.

So next the types of asphalts are described most used at present for the production and use in the construction industry:

1. Rusty or blown asphalts:

   These are asphalts submitted to a process of dehydrogenation and then to a process of polymerization. An air current one makes him go on to high temperature with the target to improve its characteristics and to adapt them to more specializing applications.

2. Solid or hard asphalts:

   Asphalts with a penetration to temperature ambience less than 10ºC. In addition to its agglutinative properties and impermeabilizantes, it possesses typical of flexibility, durability and high resistance to the action of most of the acids, you go out and tar.

3. Fluxante or oil fluxante:

   Fraction of relatively slightly volatile oil that can be used to moderate to the asphalt up to the wished consistency; often it is used like commodity for the manufacture of asphalt materials for covering revetments.

4. Asphalts fillerizados:

   Asphalts that contain mineral matters elegantly ground that spend for the sifter # 200.

5. Liquid asphalts:

   Also so called reduced asphalts or cutbacks, there are asphalt materials of soft or fluid consistency for what they leave of the field in which normally there is applied the essay of penetration, which maximum limit is 300. They are composed by an asphalt phase and a volatile fluidificante, which can be a benzine, kerosine or oil. The fluidificantes evaporate (I process of treated), staying the asphalt residue which wraps and cohesiona the particles of the aggregation. Liquid asphalts are the following products:

6. Asphalts emulsions:

   1. Asphalt emulsions: There are a part of the liquid asphalts. It is a heterogeneous system of two phases normally inmiscibles, as there are the asphalt and the water, into that surface activator incorporates a small quantity of an agent, tensoactivo or emulsifier, of soapy base or alkaline solution, which maintains in dispersion the system, being the phase continues the water and discontinues the globules of the asphalt, in size, between one to ten microns.

   2. Inverse asphalt emulsion: asphalt emulsion in which the continuous phase is an asphalt, usually of liquid type, and the discontinuous phase is constituted by tiny water globules in relatively small portion. This type of emulsion can be also aniónica or catiónica.

On the market they can be a big variety of additional asphalts to earlier mentioned this because the action of the modifiers collaborates in the tendency to which the asphalt presents less consistency changes for changes of temperature. With the use of modified asphalts, the asphalt miscellanies can optimize its performance; the grade and type of improvement will depend on the interaction asphalt - modifier. Between the possible progress they can be mentioned:
· To diminish the thermal susceptibility
· To increase the internal cohesion
· To improve the elasticity and flexibility to low temperatures
· To improve the behavior to the fatigue
· To increase the resistance to the aging
· To reduce the permanent distortion
It is necessary to mention that only one modifier cannot achieve all this progress in the performance of the modified asphalt miscellany; in fact, the substantial progress of an important property (example, permanent distortion) will bear to the decrease of other one (example, fatigue).
Composition of the rubber
The changes in the composition of the rubber proceeding from the tire of waste are not usually significant.
Incorporation of compatible oils and other additives
The main function of the oils is to limit the stickiness to facilitate the application of the product, as well as to diminish its module to low temperatures. Other frequent additives are polymers with suppressed high place of natural rubber, which decompose and incorporate in the asphalt to temperatures lower than the tires rubber, providing to the biggest modified ligante adherence and flexibility but they do not reduce the thermal susceptibility so much like the tires rubber.
Rubber content in the miscellany
On having increased the content of the rubber, there increases the grade of modification of the asphalt modified with rubber. After 60/70 realize tests with an asphalt AC-20 of approximately penetration, with less rubber to 1. 25mm, the interaction period was 90 minutes to 176°C and using the same miscellany method it goes over to the conclusion that to major

rubber content on the asphalt, the stickiness increases clearly, as well as the point of softening and the percentage of flexible comeback.

Grain of the rubber

Less all that is the size of the particles of rubber, major will be its specific surface and with her the interaction grade with the asphalt; as the opposite effect has observed that the smallest particles tend to despolimerizarse, what supposes a decrease of the stickiness.

Specific surface

This property not only depends on the grain of the rubber but also it is related to the procedure of grinding to which it has been submitted.

Impurities of the rubber

These impurities are from moisture, steel and fibres, up to any pollutant. The moisture can provoke water vapor on having mixed rubber and asphalt. For it, the rubber must be analyzed periodically introducing samples in heater to 100°C, up to constant weight

Used mixer

In general, the asphalts modified with rubber made by appropriate mechanical means present a less dispersion in the stickiness (homogeneity) and a slightly more placed decrease of cyclical, talking each other therefore of an interaction asphalt - rubber more finished.

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Evaluation of the properties of concrete with the addition of rubber particles for structural elements
Review

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Abstract

In the development of the review, we will revise the behavior under tests that have been made in concretes that work with crushed rubber particles, which have been carried out in different countries around the world, you are tests of compression, bending, Flotation among others, giving results varied according to the methodology that was followed. It will show some results compared in tables pretending to have a greater perception of the situation.

Keywords: Concrete, rubber, environmental care, recycling.

I. INTRODUCTION

Tires pollute the environment from its manufacture since only one tyre requires 35 liters of oil for its production. The tires are made of various materials such as steel, sulfur, copper, cadmium and lead, so the waste of these materials is an environmental problem of great importance. The component that interests us most in this research is the rubber of the tires discarded.

The number of tires that contribute to environmental pollution is of great concern as they are an important part of the solids that currently contaminate the country. In Mexico there is no strategy to reduce the damage they cause. Research has made known that over 90% of these wastes end up in vacant lots, rivers, roads and other inappropriate places. The use of rubber is increasing while its decomposition takes a very slow process (it takes about 100 years), being higher production than its degradation.

All this happens without having an idea of the properties that these materials possess, properties that, explotándolas in an efficient way in the area of the construction could bring benefits. We talk about acoustic and thermal properties, which allow to eliminate the radiation generated at temperatures higher than 30 degrees Celsius as well as isolate sound frequencies.

There have been studies of the behavior of rubber added in other materials such as asphalt and concrete, in order to reduce the percentage of waste on the planet, which attracted our attention and gave rise to this research.

In this review is intended to gather the largest number of articles and theses developed to put in context readers of what was done and is currently done worldwide and review what is missing to do or in what field has not been investigated enough to reach Concl Usiones and determine a way to go with respect to rubber waste on the planet.

II. RECYCLED RUBBER

It is not new that in the world there is concern about pollution of the environment, and speaking in terms of rubber as material from tyres, there are already several investigations concerning the importance of recycling this material that is very difficult To degrade as this process takes according to some references 100 years, while others mention it takes 600 years.

In the research carried out by Pan Song, Xiaoyu Wu and Shifeng Wang (2017) [1] There is talk about the difference between the degradation of SBR rubber and natural rubber (NR). Research was conducted on the evolution of morphology and the degradation mechanism; In addition, we tested Fourier transform infrared spectroscopy and a thermogravimetric analysis. The results obtained were that the degradation between SBR and NR differed at 300 °c and in terms of molecular chains, the increase in SBR content, the sun fraction consisted mainly of small chains of NR, and the fraction of gel was chains Molecular of SBR crosslinked.

A. SELF-COMPACTING CONCRETE

In 2016, Nahla Naji Hilal [2] assessed the effect of size and rubber content on self-compacting concrete, performing tests

on different mixture designs to a constant ratio of water to binder of 0.35 and 520 kg/m3 of folder contents. The results obtained from the use of crumb rubber are negative in the hardened properties of self-compacting concrete, while there was an improvement in ductility when all types of tyre waste were added.

B. ASPHALT

In addition to finding results in the research on rubber added in particular, there are also studies on asphalt, among these, we can mention the work done by Shubham Bansal, Anil Kumar Misra, and Purnima Bajpai (2017) [3] who in addition to using Rubber wastes use polyethylene plastic bags, bottles and glass parts, these materials partially replaced the asphalt. The following results were obtained: the mixture with rubber increased by 50% the resistance compared with the conventional mixture, whereas the one that had plastic increase by 16% in the resistance; Thus obtaining favorable results.

On the other hand, we also have the study carried out by Luis A. Moreno Anselmi [4] in his document on the behavior of asphalt mixtures added with rubber and leather, where he conducted the study of the deformation parameter in his samples with the Marshall press; Having as a result the conventional asphalt mixture had a minimum deformation of 2.90 mm, whereas in the samples manufactured with rubber-leather addition to 1, 2, 3 and 4% had minimal deformations smaller than that of the conventional one. Obtaining that the specimens that had less deformation were those added to 1%.

C. RUBBER FLOTATION

An important aspect to evaluate according to Han Zhu, Bin Rong, Rong Xie and Ziheng Yang [5], is the flotation of rubber particles, since they consider already has been reported on the favorable qualities that presents the concrete of crumb rubber. For its investigation, this equipment tested the compression resistance of the rubber concrete cube, the density and distribution of rubber particles in the specimens to measure the flotation. The results for the flotation are that it is more evident when there is more vibration time. With regard to settlements, if these are low, the floating of the particles is not apparent, while the high and rising settlements yield a more apparent floating effect.

D. TENACITY AND ELÁSTICIDAD MODULE IN CONCRETE ADDED WITH RUBBER.

The tenacity and modulus of elasticity of the concrete added with rubber are two concepts of utmost importance because they allow us to know what is the greatest resistance that the concrete has before breaking or breaking. For the study of these concepts are necessary tests of circular plate, square plate and residual tension in beams like those carried out by Javier R. Alfonso Rodríguez and Oscar O. Badillo Peralta [6], in which the results that threw all his tests carried out in Added

concrete with rubber (not crushed rubber, if not in strips), they obtained that the contribution in terms of tenacity to the concrete added with rubber, is low, due to the little adhesion presented between the two materials. In one of his essays in this type of concrete they obtained an absorbed energy at the 40mm of displacement of 20.4 joules. The rubber strips did not fail, but instead, they detached from the concrete matrix, generating a mechanism of failure that does not bring tenacity to the concrete. The low compatibility of deformations between the concrete and the rubber strips allowed them to Desprendieran, because their cross section decreases and loses contact with the concrete matrix.

On the other hand referring to the studies of Herwin Felipe Eraseo and Natalia Ramos [7] In his study on the modulus of elasticity in the substitution of ground rubber by fine aggregate in a mixture of concrete, obtained that the modulus of elasticity decreases to As the percentage of ground rubber is increased in the mixture, due to the decrease of the compression resistance as the aggregate of crushed rubber is increased. They obtained, also speaking of the absorption of energy, that as the deformation of the concrete with rubber is greater compared with that of the normal concrete with respect to the same load applied; This opens up new research on this subject.

E. CONCRETE ADDED WITH THICK PARTICLES OF RUBBER.

The mixtures with a percentage of coarse crushed rubber, as mentioned by Juan C. Pérez Oyola and Yeison L. Arrieta Ballén [8] In his study on the addition of this material to concrete, provide better characteristics to concrete and even improve the Adhesion between the concrete mixture and the rubber, this could be observed because when applying the load to the specimens, these thanks to the properties of ductility of the rubber and its capacity of absorption of energy.

F. IMPROVEMENTS TO THE COMPRESSION RESISTANCE, CONCRETE WITH RUBBER.

The main problem of the addition of rubber to concrete mixes with different proportions is its resistance to compression, because it decreases greatly. Unlike bending strength where the concrete added with rubber is placed almost at the level of conventional concrete.

An observation that is made in the document of Paola G. Bastidas Sosa and Mauro P. Viñán Audino [9] In his analysis of the physical and mechanical properties of the concrete in question, where they obtained a decrease in the resistance to the compression of 28% at 28 days , is that a way to improve the compression resistance in the addition of rubber to concrete this aggregate should undergo a pre-treatment which can ensure a good addition between the rubber particles and cementing mixture.

In a study carried out at the University of Civil and Transportation Engineering, Guangdong University of

Technology in China [10], where five types of mixtures were proposed with different percentages of rubber ranging from 10 to 50%, comparison with the mixture Conventional and what was obtained is shown in the following charts:

Static compressive properties of rubber concrete.

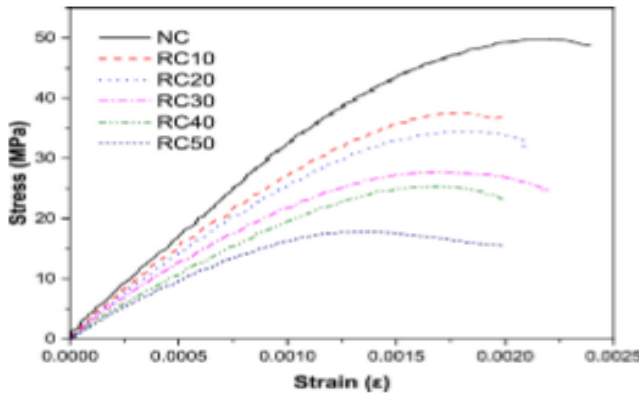|	Compressive strength (MPa)	Elastic modulus (GPa)	Poisson's ratio	Peak strain
NC	50.12	33.2	0.21	0.00221
RC10	37.76	29.8	0.19	0.00173
RC20	32.90	27.5	0.18	0.00171
RC30	27.93	25.6	0.19	0.00164
RC40	25.50	21.3	0.19	0.00163
RC50	17.91	19.3	0.19	0.00133

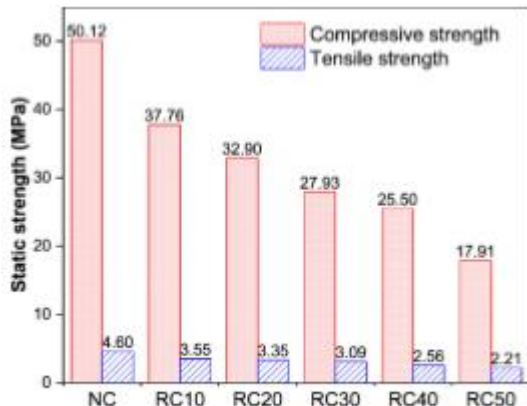*Figure 1. Types of mixtures and graph of stress deformation [10].*

Fig. 6. Static compressive and tensile strength of concretes.

Figure 2. Comparison of the resistances of the different types of mixtures [10].

The results shown in this study show that the introduction of the rubber particles reduce the resistance to both traction and compression and that we can not replace beyond between 10% and 20% of the fine aggregate, because the reduction of resistance can Be more than 50%.

G. *CONCRETE RUPTURE MODULE ADDED WITH RUBBER.*

At the University of New South Wales, in Australia [11] The experimentation of concrete beams added with rubber was carried out, this project shows the particle size of the material they used, which is shown in the following graph:
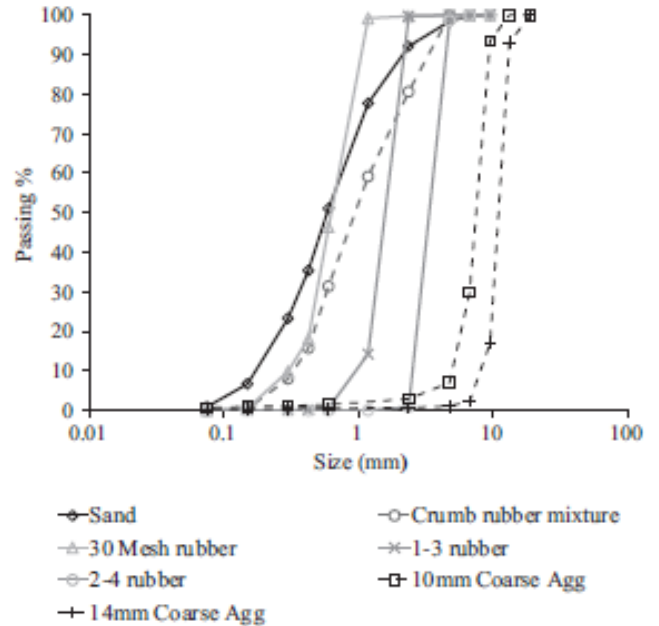

Figure 3. Comparison of the resistances of the different types of mixtures [11].
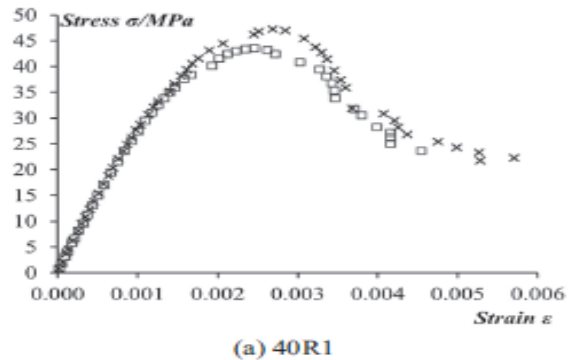
The results of the mixing design:

(a) 40R1

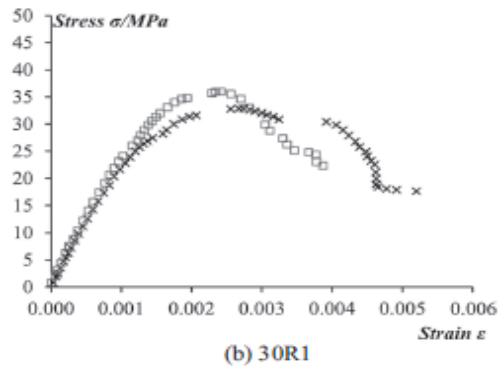*Figure 4. Graphic of effort deformation of the concrete type 40R1 [11].*

(b) 30R1

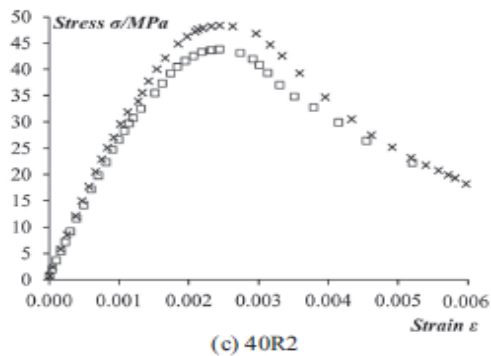*Figure 5. Graphic of effort deformation of the concrete type 30R1 [11].*

(c) 40R2

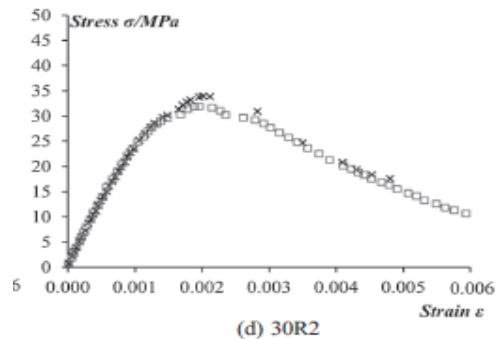*Figure 6. Stress graphic deformation of concrete 40R2 type [11]*

(d) 30R2

Figure 7. Stress graphic deformation of concrete 30R2 type [11].
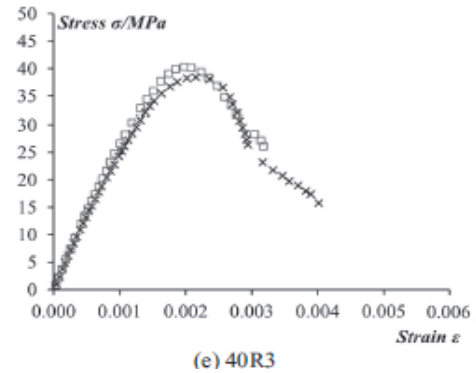

(e) 40R3

Figure 8. Stress graphic deformation of concrete 40R3 type [11].

(f) 30R3
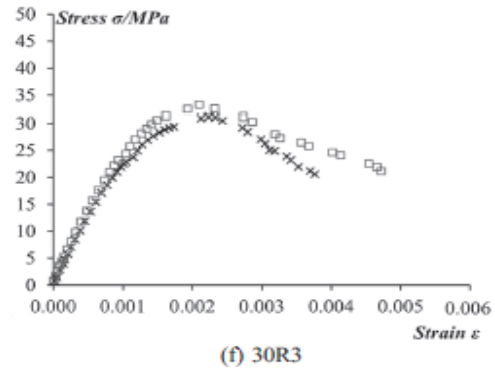
Figure 9. Stress graphic deformation of concrete 30R3 type [11].

In this work, the cutting behavior of CRCs reinforced beams of similar compression strength was investigated. Adjustment of stirrups, capacity of cutting of reinforced beams, pattern of fault and the behavior of deviation of the load, were examined from experimental study. In addition, the cutting capacities were compared with the design guidelines available for conventional concrete. Finally, the compatibility of using available material models of conventional concrete for the numerical analysis of the shearing behavior of the CRC beam was evaluated.

In the experiments, the stirrup-free beams failed due to cutting after reaching their cutting capacity. The experimental results showed that there is a 10-15% variation in the cutting-to-flexion capacities between beams made from CRCs of similar strength. They also indicate that the rubber content had an impact on the CRC's cutting capacity. However, the results were insufficient to conclude determining the relationship between the rubber content and the cutting capacity of the rays that emphasizes the need for further research.

It is noteworthy that the failure patterns of the beams were very similar to those of a conventional concrete beam system..

Figure 10. Fault patterns of the different types of beams with the specifics mentioned in previous tables [11].
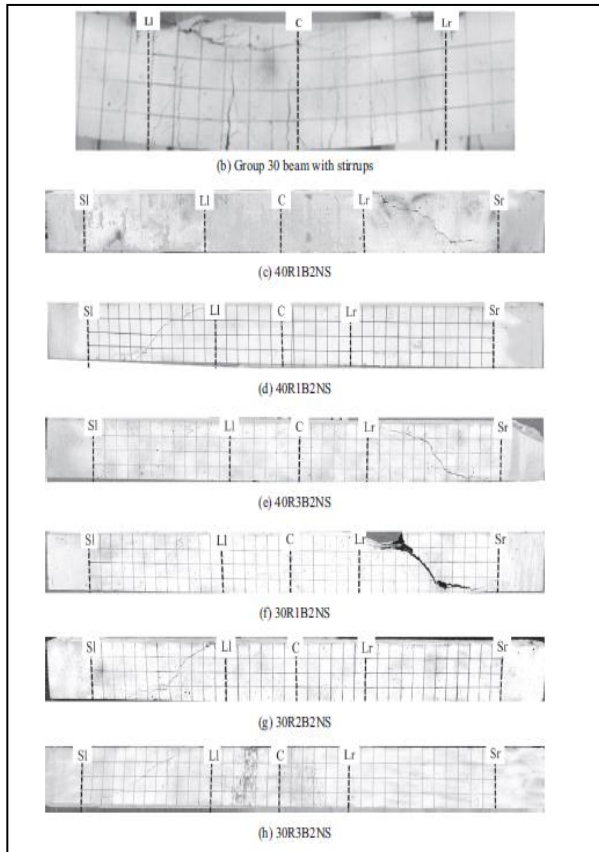
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Quantum mechanics: simulation and calculations CdSe and PbSe

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Abstract—**In this paper, a complete ab initio calculations of energy bands, density of states and electronic density are presented. Two compounds (semiconductors) have been analyzed, PbSe and CdSe, using computational software Quantum Espresso® as simulation program and Linux as SO. The results have been compared with experimental data with good agreement, and an error less than 1% was obtained for two compounds.**

Keywords—cadmium selenide, lead selenide, semiconductor, ab initio, electronic structure.

I. INTRODUCTION

Cadmium selenide and lead selenide are used in many applications, such as: thermoelectric, cooling materials, optical filters, optical recording materials, solar cells, biosensors, etc. [1], [2] due their properties.

Quantum Espresso® is a software based on set of density functional theory (DFT) codes, which is employed when an analysis of compounds is needed, i.e., Cadmium selenide (CdSe) and lead selenide (PbSe), these are two semiconductors with body centered cubic (BCC) structure, space group [225] and applications in electronics. Table 1 presents the basic information necessary for the analysis of these compounds.

TABLE I.   BASIC INFORMATION OF CdSe AND PbSe

Compound	Space group	Lattice parameter [Å/Bohr]
CdSe	225	5.748/10.862
PbSe	225	6.227/11.767

Previous works have studied the mechanical properties and the electronic structure of these compounds using scalar-relativistic full-potential linearized augmented plane wave (FP-LAPW) method. The first comparative of both compounds was developed using PBE (Perdew-Burke-Erzenhof) pseudopotencial.

Computational Simulations with good accuracy, are important because they give information with a considerable low time compared with experimental processes

II. PROGRAMS AND INFORMATION

In this paper the information and the pseudopotencials used were obtained from two major databases "Materials Project" and "Quantum Espresso" web site [3], [4]. The computers used were personal, a Lenovo ideapad 500-15ACZ with Mint Linux, AMD FX-8800P Radeon R7 processor, 12 Compute Cores 4C+8G 2.10 GHz, 16 GB in RAM, and a Gateway with Ubuntu Linux, Intel Core i5 processor and 4 Gb in RAM memory.

As basis program, the Open Source Suite Quantum Espresso was used, this suite is integrated for electronic-structure calculations developed in computers and materials modeling at nanoscale.

III. RESULTS

Simulations for CdSe and PbSe have been realized, and the main obtained results are shown in this section.

Structure of CdSe is shown in Figure 1, and convergence values of Total Energy for the two compounds were obtained with equation (1) for two compounds (CdSe and PbSe), here *value(i)* refers to current value and *value(i-1)* to previous value. A convergence criterion of 1e-3 has been set for Total Energy

for three parameters (Energy Cuttoff, K-points and lattice parameter). Figure 2 and 3 show the variations of Total Energy with Energy Cuttoff, for CdSe and PbSe. A significant variation of this parameter cannot be seen for Energy Cutoff values of 50 and 60, for CdSe and PbSe, respectively. Table II shows the final values for the three parameters according to convergence criterion.
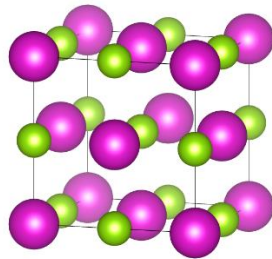

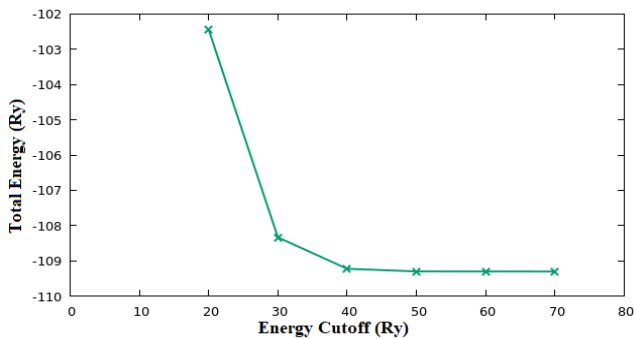Fig. 1. CdSe structure.

$$convergence = |value(i) - value(i-1)|$$

Fig. 2. Energy Cutoff vs Total Energy for CdSe.
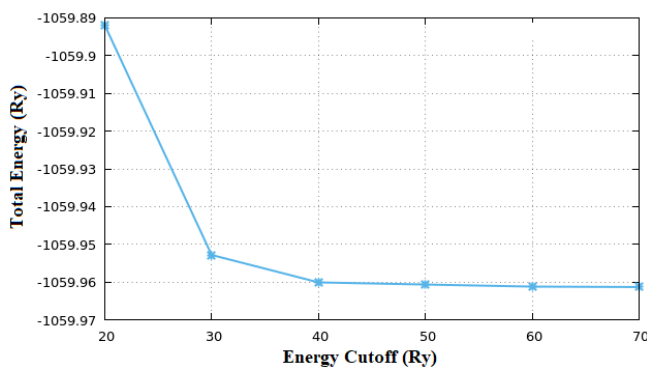

Fig. 3. Energy Cutoff vs Total Energy for PbSe.

Calculation of lattice parameters were, and they were compared with experimental data obtained from Materials Project web site [4]. Table III shows the absolute errors, which were obtained from equation (2).

$$\left| \frac{Experimental\ value - Calculate\ value}{Experimental\ value} \right| x100\% = \%error \quad (2)$$

TABLE III. DATA COMPARISON

Compound	Experimental lattice parameter	Calculated lattice parameter	Error [%]
CdSe	5.748/10.862	5.771/10.905	0.39
PbSe	6.227/11.767	6.191/11.7	0.56

Good agreement with experimental data was obtained in this work, as can be seen in Table III, an absolute error less than 1%, which gives a warranty of simulations can predict experimental behavior with good accuracy.

IV. CONCLUSIONS

The total Energy gets convergence criterion at almost the same value of Energy Cutoff and Lattice parameter for both, CdSe and PbSe.

When simulation results are compared with experimental data, good agreement is obtained, the absolute error was less than 1%, this is significant when others parameters are calculated with simulations; i.e, the band structure will be calculated with the help of software Xcrysden® and, therefore to build the way of K-points.

ACKNOWLEDGMENT

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An study of classification movements of the lower limb based on up to 4-EMG channels

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Abstract—**The quantity and origin of the EMG signals have been studied extensively due to the necessity to improve the precision of the classification from de intention movement. Nevertheless, by increasing the number of channels used for the classification, the processing time also increase. This work presents a comparison of precision of the classification based on the different amounts of EMG signal channels (one to four) placed in a right lower limb from four healthy subjects (one male and three females). The analysis was made using Mean Absolute Values, Zero Crossings, Waveform Length and Slope Sign Changes. The algorithm used for the classification is the Support Vector Machine after to applied a Principal Component Analysis to the features. The results show that it is possible to high more than 90% of classification accuracy using four or three channels while using only barely more than 50%.**

Keywords—*intention movement classification; EMG signals; Support Vector Machine.*

I. INTRODUCTION

In recent decades, the use of signals taken from de muscles has become popular for its demand for different uses, such as health monitoring, assistive technology, and prosthetic control. This is due to the increase of technological development in wearable electronics for the exploration of muscle signals.

When a contraction or relaxation muscle occurs, it generates an electrical potential that is measured by an electromyography sensor. Exists two different ways to place this kind of sensor, the invasive and the non-invasive methods. The second one is the surface electromyography (sEMG) and is the most common technique due to not needs surgical intervention through the sensor is placed on the skin surface.

In this paper, sEMG signals were recorded over four opposite muscles on the lower limb are used to compare the classification accuracy offered by each of them and the combination of different amounts. The muscles selected to place the sensors were *tibials anterior* (TA), *gastrocnemius medials* (GM), *biceps femoris* (BF) and *vastus lateralis* (VL), which presents the better signal of the movement [1].

The analysis signal methods involve time-domain and frequency-domain features, time-frequency analysis methods, power spectrum density and higher order spectra [2]. To analyze the sEMG signals, this work only considers time-domain features, due to they are easy to calculate and not required any transformation. Mean Absolute Value (MAV), Zero Crossings (ZC), Waveform Length (WL) and Slope Sign Changes (SSC) are recommended for a better classifier performance [3]–[8].

Because of the dimensionality problem, the desired performance of the classifier is deteriorated with the increase in the number of channels [9]. There are some tools that can be used to analyzed signals in order to improve the classification accuracy without increase the quantity of analyzed signals like the Empirical Mode Decomposition used only in a single-channel [10].

In contrast, other researchers have looked for other ways to attack the dimensionality problem, by the reduction, like Principal Component Analysis (PCA), Independent Component Analysis (ICA), Linear Discriminant Analysis (LDA), Canonical Correlation Analysis (CCA), among others.

The PCA principal goals are to find an optimal linear transformation that represents the data and reduce the dimensionality of the features vector [11]–[13]. But in this research only it was used to improve the classification accuracy by the linear transformation.

For the classification, the Support Vector Machines (SVMs) were used, due to they have a high potential to classify in myoelectric control systems since they are capable to recognize patterns that are more complex [14].

The remaining paper is organized as follows. Section II gives a brief background of the conventional techniques used for sEMG signals analysis and the most common used features. General description of the Support Vector Machine algorithm and Principal Component Analysis are also explained here. In section III, the experimental design and the analysis of sEMG signals are described. Comparison results from the SVM classifier varying the amount of channels and their origin are presented in section IV. Section V concludes the work.

II. BACKGROUND

A. Analysis of sEMG signals

Myoelectric control success depends highly on the classification accuracy. Classification methods and feature extraction are important to reach high performance in the classification of pattern recognition [14].

Depending on the level of muscle contraction, they vary the amplitude, variance, energy, and frequency of sEMG signals, due to this a variety of features is extracted from them to their analysis. Then, the most recommended [3]–[5], [7], [8], [14]–[16], Mean Absolute Value (MAV), Zero Crossings (ZC), Slope Sign Changes (SSC) and Waveform Length (WL) are described.

Considering x_i as *i-th* sample of an arrangement of input, x_{i+1} the next sample and x_{i-1} the previous sample. With a total of N samples:

1) MAV: It consists in obtain the average of the sum of the absolute values that make up the whole input signal, as in ☐☐1).

$$MAV = \frac{1}{N}\sum_{i=1}^{N}|x_i| \qquad (1)$$

2) ZC: It consists in count the number of times that the signal crosses by a cero, whether it goes from a negative value to a positive one or the other way around, as in ☐☐2).

$$ZC = \sum f_{ZC}(x) \qquad (2)$$

Donde:

$$f_{ZC}(x) = \begin{cases} 1, & \text{if} \quad x_i > 0 \ \& \ x_{i+1} < 0 \\ & \text{or} \quad x_i < 0 \ \& \ x_{i+1} > 0 \\ 0 & \text{other case} \end{cases}$$

3) WL: It is the accumulated variation of a signal that can indicate the grade of signal oscillation and is given by ☐☐3).

$$WL = \sum_{i=1}^{N-1}\left(|x_{i+1} - x_i|\right) \qquad (3)$$

4) SSC: It counts the number of times that the slope of the signal change of sign, which make necessary to evaluate where it is, where it was and where the signal goes. SSC is calculated with ☐☐4).

$$SSC = \sum f_{SSC}(x) \qquad (4)$$

Donde:

$$f_{SSC}(x) = \begin{cases} 1, & \text{if} \quad x_i < x_{i+1} \ \& \ x_i < x_{i-1} \\ & \text{or} \quad x_i > x_{i+1} \ \& \ x_i > x_{i-1} \\ 0 & \text{other case} \end{cases}$$

B. Principal Component Analysis

PCA is a statistic technic that performs a linear transformation from an original set of values into a smaller one of correlated variables; which represents the most information from the original set. This reduces the dimensionality of it. The idea was conceived by K. Pearson [17] and later developed by Hotelling [18].

PCA technique uses the covariance matrix from the original set (X) and the correlation between every one of this components, in such a way that a smaller Y output space is found, representing the statistical information given in X, of form ☐☐5)

$$Y = XC \qquad (5)$$

Where C_{mxn} is the matrix with the principal component selected, where $n < m$, which implies the dimensionality reduction from the original set.

The procedure to find C consist in to construct the covariance matrix, then find eigenvalues and eigenvectors to project the data matrix with the eigenvectors corresponding in order. Finally, it is only necessary to consider the desired information and select the number of vectors that compose it.

C. Support Vector Machines

SVMs are very used as classification algorithm, either of body movements, images, sounds, etc. An SVM builds an optimum separation hyperplane in a feature space which is said to be of high dimension when the inputs are mapped using non-linear functions, for to be able to distinguish between two or more object types. In 1995 this theory was introduced by [19].

In an SVM, the training algorithm is reformulated as a problem to solve using Quadratic Programming (QP), which is global and unique. For input training data $(x_1, y_1), \text{K}, (x_m, y_m) \in R^N \times \{\pm 1\}$, where x_i corresponds to the input value and y_i the assigned value of the object type to which it belongs (also it knows as a class); if these data are not linearly separable, they are a map (linearly transforms) by $\phi : R^N \ \alpha \ F$ within a characteristic space. In this way, the obtained linear hyperplanes that separate the object types can be seen as ☐☐6).

$$w \times \phi(x) + b = 0 \quad w \in R^N, \quad b \in R \qquad (6)$$

Constructing an optimal hyperplane with the maximum value of the separation margin and a closed error ξ in the training of the algorithm, the QP problem is proposed as (7):

$$\min_{w,b} \frac{1}{2}\|w\|^2 + C\sum_{i=1}^{m}\xi_i \qquad (7)$$

s. a.

$$y_i(w \times \phi(x_i) + b) \geq 1 - \xi_i, \quad i = 1, K, m.$$

The first term in cost function generates a maximum separation margin between classes, while the second provides an upper bound for mistakes in training data. Finally, the constant $C \in [0, \infty)$ creates a compensation between the number of poorly classified samples from training set and the separation of the rest of samples with a maximum margin [14].

III. METHODS AND EXPERIMENTATION

A. Data Collection

The data in this research were acquired from four healthy subjects, three females and one male. All subjects, which were aged between 23 and 27 years old, were normally limbed and without muscle disorders.

The sensors system were placed on the skin on the surface of the muscle, and it contains nine electrodes, eight of them functioned as an acquisition the potential difference from muscles, and the last one functioned as a reference. Signals were amplified and filtered by an analog 60 Hz Notch filter to remove line interference. It was used INA114 as an amplification instrument and sampled by using a 10-bit converter (The Arduino Nano) at 1000 Hz (Fig. 1).
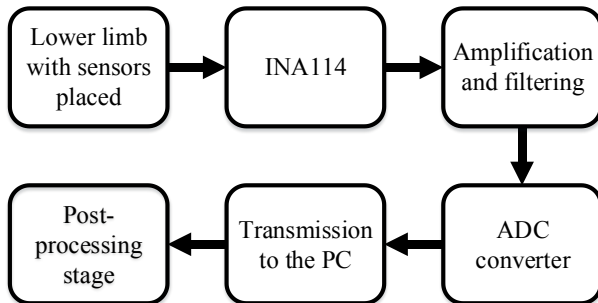

Fig. 1. Basic experiment diagram.

Every sensor was placed following the distances and separated 2.5 cm between the electrodes described in [1] in order to obtain the better signal quality: for VL the best place is at 66% from muscle length while for the TA is at 47.5%. The electrode position in GM at 38% of its length and in BF at 50% presents the better signal.

B. Data processing

For the data processing, it was used MATLAB® and the LIBSVM library version 3.2 was used in this work [20]. This library provides a section dedicated to apply a variety of kernels, as linear, polynomial, RBF (Radial Basis Function) and sigmoid, but none was used.

In software, they were applied two different digital filters filtered the collected sEMG signals, first 60 Hz Notch filter and second an elliptical bandpass filter between 10 and 500 Hz.

The feature vector was built with MAV, ZC, WL, and SSC of windows of different sizes and each one of the channels, so as to make different comparatives of the results. Then a PCA analysis was made without removing vectors from the transformation matrix.

C. Experimentation

Six classes of foot movement plus rest were considered for the research: lift the toe (LP), lift the heel (LT), move the toe to the right (PD), move the toe to the left (PI), recharge on the heel (AT), recharge on the toe (AP) and rest of the foot (RR). In the experiment, the subjects were sitting and started from a relaxation state and the followed by holding the movement for a period of 5 s. The movements were repeated 20 times with 25 s of resting period between the trials by each subject.

Finally, the collected data were divided into two groups, the training, and the testing data. Ten samples for each one.

IV. RESULTS

The results of the classification accuracy made with the four channels shown in Table 1. The variation is not more than 15% of each number of samples per subject, and the minimum is only 5.71%.

TABLE 1 ACCURACY WITH CHANNELS TA, GM, BF Y VL.

Channel	Channel TA, GM, BF y VL			Highest difference
No.	250	500	1000	
Female 1	84.29%	90.00%	90.00%	5.71%
Female 2	80.00%	87.14%	90.00%	10.00%
Female 3	65.71%	80.00%	80.00%	14.29%
Male 1	91.43%	97.14%	98.57%	7.14%
Average	80.36%	88.57%	89.64%	9.29%

Table 2,

Channel	Channel TA, GM y VL			Highest difference
No.	250	500	1000	
Female 1	80.00%	90.00%	90.00%	10.00%
Female 2	77.14%	85.71%	88.57%	11.43%
Female 3	67.14%	67.14%	75.71%	8.57%
Male 1	94.29%	100.00%	97.14%	5.71%
Average	79.64%	85.71%	87.86%	8.21%

Table 4 and Table 5 show the accuracy classification obtained by combining the variation of three different channels, besides the change in the number of samples used for feature extraction. In this case, any sample is not superior to 10%, but in

Channel	Channel TA, GM y VL			Highest difference
No.	250	500	1000	
Female 1	80.00%	90.00%	90.00%	10.00%
Female 2	77.14%	85.71%	88.57%	11.43%
Female 3	67.14%	67.14%	75.71%	8.57%
Male 1	94.29%	100.00%	97.14%	5.71%
Average	79.64%	85.71%	87.86%	8.21%

Table 4, the only without TA channel, the results are the best, with the highest difference equal to 5.71% and the lowest to 1.43%, which corresponds to a one sample.

TABLE 2. ACCURACY WITH CHANNELS TA, GM Y BF.

Channel	Channel TA, GM y BF			Highest difference
No.	250	500	1000	
Female 1	80.00%	88.57%	88.57%	8.57%
Female 2	78.57%	80.00%	84.29%	5.71%
Female 3	70.00%	80.00%	80.00%	10.00%
Male 1	91.43%	92.86%	98.57%	7.14%
Average	80.00%	85.36%	87.86%	7.86%

TABLE 3. ACCURACY WITH CHANNELS TA, GM Y VL.

Channel	Channel TA, GM y VL			Highest difference
No.	250	500	1000	
Female 1	80.00%	90.00%	90.00%	10.00%
Female 2	77.14%	85.71%	88.57%	11.43%
Female 3	67.14%	67.14%	75.71%	8.57%
Male 1	94.29%	100.00%	97.14%	5.71%
Average	79.64%	85.71%	87.86%	8.21%

TABLE 4. ACCURACY WITH CHANNELS GM, BF Y VL.

Channel	Channel GM, BF y VL			Highest difference
No.	250	500	1000	
Female 1	90.00%	92.86%	90.00%	2.86%
Female 2	90.00%	88.57%	90.00%	1.43%
Female 3	78.57%	72.86%	78.57%	5.71%
Male 1	94.29%	90.00%	94.29%	4.29%
Average	88.21%	86.07%	88.21%	2.14%

The previous results are not yet completely determinant about the influence of each of the channels on the classification

accuracy. Due to this, experiments were also carried out with the combinations of two channels (Table 5 -Table 10).

TABLE 5. ACCURACY WITH CHANNELS TA Y GM.

Channel	Channel TA y GM			Highest difference
No.	250	500	1000	
Female 1	81.43%	82.86%	88.57%	7.14%
Female 2	61.43%	80.00%	87.14%	25.71%
Female 3	61.43%	68.57%	78.57%	17.14%
Male 1	88.57%	94.29%	92.86%	5.71%
Average	73.21%	81.43%	86.79%	13.57%

TABLE 6. ACCURACY WITH TA Y BF.

Channel	Channel TA y BF			Highest difference
No.	250	500	1000	
Female 1	75.71%	81.43%	80.00%	5.71%
Female 2	65.71%	85.71%	78.57%	20.00%
Female 3	68.57%	77.14%	75.71%	8.57%
Male 1	85.71%	92.86%	95.71%	10.00%
Average	73.93%	84.29%	82.50%	10.36%

TABLE 7. ACCURACY WITH CHANNELS TA Y VL

Channel	Channel TA y VL			Highest difference
No.	250	500	1000	
Female 1	75.71%	78.57%	77.14%	2.86%
Female 2	64.29%	77.14%	84.29%	20.00%
Female 3	50.00%	57.14%	61.43%	11.43%
Male 1	88.57%	88.57%	90.00%	1.43%
Average	69.64%	75.36%	78.21%	8.57%

TABLE 8. ACCURACY WITH CHANNELS GM Y BF.

Channel	Channel GM y BF			Highest difference
No.	250	500	1000	
Female 1	82.86%	84.29%	81.43%	2.86%
Female 2	72.86%	78.57%	85.71%	12.86%
Female 3	57.14%	71.43%	78.57%	21.43%
Male 1	81.43%	85.71%	85.71%	4.29%
Average	73.57%	80.00%	82.86%	9.29%

TABLE 9. ACCURACY WITH CHANNELS GM Y VL.

Channel	Channel GM y VL			Highest difference
No.	250	500	1000	
Female 1	84.29%	90.00%	91.43%	7.14%
Female 2	77.14%	80.00%	82.86%	5.71%
Female 3	68.57%	62.86%	77.14%	14.29%
Male 1	84.29%	85.71%	88.57%	4.29%
Average	78.57%	79.64%	85.00%	6.43%

TABLE 10. ACCURACY WITH CHANNELS BF Y VL.

Channel	Channel BF y VL			Highest difference
No.	250	500	1000	
Female 1	77.14%	88.57%	90.00%	12.86%
Female 2	84.29%	85.71%	90.00%	5.71%
Female 3	71.43%	68.57%	75.71%	7.14%
Male 1	87.14%	90.00%	92.86%	5.71%
Average	80.00%	83.21%	87.14%	7.14%

Channel	Channel VL			Highest difference
No.	250	500	1000	
Female 1	70.00%	65.71%	68.57%	4.29%
Female 2	68.57%	75.71%	77.14%	8.57%
Female 3	50.00%	51.43%	65.71%	15.71%
Male 1	75.71%	81.43%	88.57%	12.86%
Average	66.07%	68.57%	75.00%	8.93%

The best results were obtained when the sensors combination were placed in muscles with opposite function, i. e. by considering one muscle in front and one in the back. Also, the best results were obtained without channel TA. When 1000 sample are used, the results do not vary much between every pair of signals.

Finally, the results obtained with a single channel are shown in Table 11 to Table 14. The TA and BF channels show the most consistent results having the smallest variation, as well in TA the most of the differences are the minimal and in GM the maxims. Although, in TA the classification accuracy is lowest than in the other three.

TABLE 11. ACCURACY WITH CHANNEL TA.

Channel	Channel TA			Highest difference
No.	250	500	1000	
Female 1	68.57%	67.14%	68.57%	1.43%
Female 2	58.57%	52.86%	58.57%	5.71%
Female 3	57.14%	44.29%	57.14%	12.86%
Male 1	82.86%	78.57%	82.86%	4.29%
Average	66.79%	60.71%	66.79%	6.07%

TABLE 12. ACCURACY WITH CHANNEL GM.

Channel	Channel GM			Highest difference
No.	250	500	1000	
Female 1	72.86%	81.43%	84.29%	11.43%
Female 2	45.71%	58.57%	65.71%	20.00%
Female 3	52.86%	61.43%	64.29%	11.43%
Male 1	70.00%	80.00%	84.29%	14.29%
Average	60.36%	70.36%	74.64%	14.29%

TABLE 13. ACCURACY WITH CHANNEL BF.

Channel	Channel BF			Highest difference
No.	250	500	1000	
Female 1	57.14%	70.00%	62.86%	12.86%
Female 2	60.00%	65.71%	70.00%	10.00%
Female 3	60.00%	64.29%	64.29%	4.29%
Male 1	80.00%	82.86%	88.57%	8.57%
Average	64.29%	70.71%	71.43%	7.14%

TABLE 14. ACCURACY WITH CHANNEL VL.

Finally, in order to make a final comparison, the averages obtained from comparatives tables are shown. In Fig. 2 the calculated results with a single channel, VL exhibits the best rank of 88.57%.

Fig. 2. Classification accuracy with a single channel.

Fig. 3 shows the comparative between two channels, BF and VL present a better performance with respect to the others including the result with 250 samples. Besides, the performance with 1000 samples is more consistent than the others. Fig. 4 shows that the combination with GM, BF y VL is better than the others that include channel TA. This combination offers similar results to those obtained by the combination of the four channels.
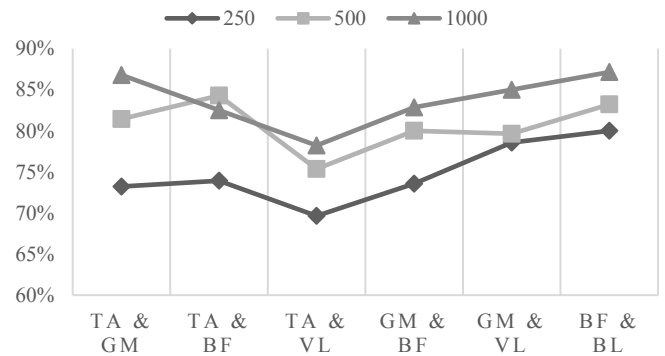

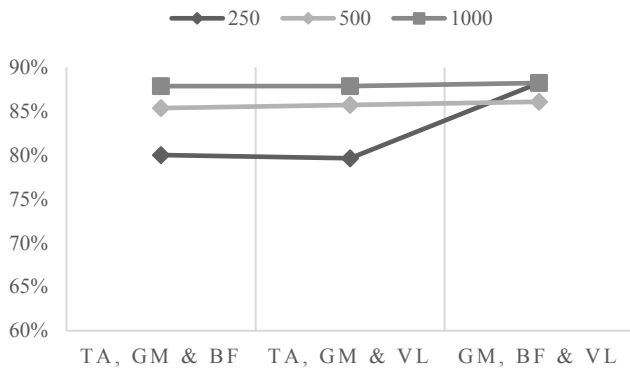Fig. 3. Classification accuracy with two channels.

Fig. 4. Classification accuracy with three channels.

V. CONCLUSIONS

The obtained results with four channels were better that those with a single channel but the difference between two and three channels is not very high. The muscle with the worst performance was the TA. Also, the best results are obtained by taking the signal of the muscles above the knee. Increase the number of channels also provides some times 100% of the classification accuracy, but computational cost also augment. If the purpose is always, get 100% of classification accuracy without increasing both the processing time, the best way is to use another kind of tools.

ACKNOWLEDGMENT

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Applications of recycled polyethylene terephthalate (PET) and its use in construction

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Abstract—*In this research, the use of recycled PET containers is proposed for the manufacture of ribbed slab moulds. The aim is to characterize compounds based on recycled polyethylene and resin, to evaluate their physical properties such as hardness, tensile strength and modulus of elasticity in traction. The expected results are a resistant material, with a low level of absorption, that can easily be produced in mass.*

Keywords—*polyethylene; recycled material; ribbed slab mould.*

I. INTRODUCTION

The materials that are currently used in ribbed slab moulds can cause environmental problems since there is a mishandling of these wastes. Having as an alternative a ribbed slab mould made of recycled materials, in this case polyethylene, would represent a lower cost since it has a longer useful life than the one existing in the market.

On the other hand, it is intended to innovate in the construction field because in this area there is a very low applied innovation and it is still an expensive product that is available to very few people.

The present review is a compilation of the state of the art on the use of recycled polyethylene in construction materials, where different properties and scopes that can be achieved with this material are shown.

A. The Sustainable Innovation Forum [1]

During the United Nations Conference on Climate Change, held on December 12, 2015, 195 nations reached an historic agreement to combat climate change and promote measures and investments for a future that is low in carbon emissions, resilient and sustainable. The Paris Agreement and the results of the conference cover crucial areas considered essential for an emblematic conclusion:

Mitigation: reduce emissions fast enough to achieve the temperature objective. A system of transparency and global balance: an accounting for climate action. Adaptation: strengthen the ability of countries to cope with climate impacts. Loss and damage: strengthen the ability to recover from climate impacts. Support: including financial support for nations to build clean and resilient futures. [2]

Mexico must take actions that reflect its commitment to the Paris Agreement, so it must question the materials it uses today and look for the best alternatives that allow sustainable development. According to the National Inventory of Greenhouse Gases (GHG), issued by the INECC (2015) with data from 2013, Mexico issues: 665,304.92 Gg of CO2e, which represents 1.4% of global GHG emissions. The Mexico climate action plan seeks an unconditional reduction of 25% of GHG emissions and short-lived climate pollutants (CCVC), that is, 22% of GHG and 56% of black carbon.[3].

B. The world's rubbish dump: a tip that stretches from Hawaii to Japan

Among the consequences of the contaminants that can be found in the trash or garbage, is also known. It is an extension of the cable with a capacity of up to 500 nautical miles. (Figure 1)
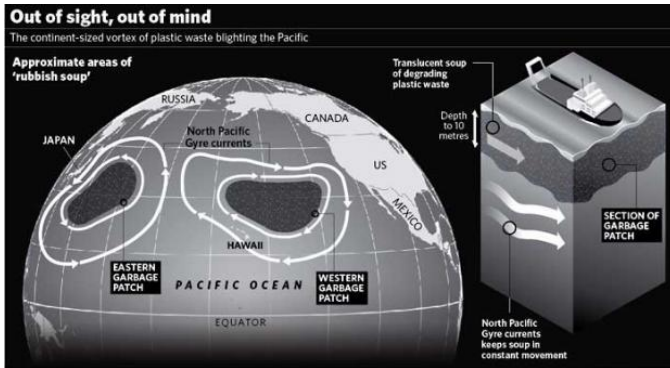
Figure 1. Graph of the zones of concurrence in the pacific ocean. (Papanlian and Bradley)

The oceanographer Charles Moores, moved this area of convergence that did not reduce the use of disposable plastics is doubled in size in the next decade, it requires more research on this and take action to counteract it because the sea of garbage is translucent and It is located just below the surface of the water, it is not detectable in satellite photographs.

According to the United Nations Environment Program, plastic waste causes the deaths of over one million seabirds each year, as well as more than 100,000 marine mammals. Syringes, lighters and toothbrushes have been found inside the stomachs of dead seabirds, which they mistake for food.

It is believed that plastic is 90% of all garbage that floats in the oceans. The United Nations Environment Program estimated in 2006 that every square mile of ocean contains 46,000 pieces of floating plastic [4]

C. *Waste in Mexico*

The current lifestyle of high consumption has lead to the manufacture of non-biodegradable products that meet the demands of the market, but have a short lifespan which leads to the accumulation of large volumes of waste.

In the particular case of Mexico, there is no adequate management of these wastes; Around 40 million tons of waste are generated each year. Specifically in the city of Querétaro (in 2015), a monthly production of 28 thousand tons of garbage is reported. The goal of waste management is to manage the resources in such a way that they are compatible with the environment and public health through an integral management of solid waste, the recovered materials are reincorporated into the economic and productive cycle in an efficient manner.

"In the country, during the last years the technology to recycle solid waste has evolved, not so the practices to create incentives to recover them in an economically viable way. In 2008, only 3.6% of the recoverable waste was recycled, with paper and cardboard being the main ones. Plastics, in general, represent 11% of urban solid waste in Mexico. The plastics industry in the country grows at a rate of more than 7% per year, generating a per capita consumption of 50 kg / year. In the specific case of PET, it is one of the most used materials by the beverage bottling industry, due to its durability, chemical resistance, low weight and adequate energy dissipation capacity in the face of the application of external forces, among others. . Which places it as the third most used plastic. In Mexico in 2008, each inhabitant consumed approximately 250 bottles per year. For 2010, the country became the first consumer of bottled water worldwide (in one part for advertising and in another for the poor quality of water supply in most states of the country) and the second in beverages carbonated (carbonated) Finally, it is necessary to consider that a PET bottle takes about 500 years to degrade, so that the first PET waste generated in the world has not yet been degraded. It is important to take into account that the reuse of plastics in Mexican companies, as raw material, is minimal. In most cases, the process of transforming PET bottles into new raw material is only carried out until the bottles are crushed. "[5]

II. REVIEW

A. *Development of a habitation module from recycled material*

The work involves the installation of a habitation module, through the design and construction of plastic bricks and beams. For this purpose, we used plastic waste packaging processes in different companies. As sustainable housing are used photovoltaic and solar collector systems to supply electricity and heat demands, besides having rain waterstorage tank.

This is the construction of houses by blocks and modular bricks made of waste material in packaging processes of soft drinks and chips, the type of plastic used in low and high density polyethylene, polyethylene terephthalate PET (bottles) and polypropylene (PP). [6]

B. *Recycled plastic bricks and panels for self construction*

This paper is about a research carried out in Centro Experimental de la Vivienda Económica (CEVE) on constructive elements made of recycled plastics materials. The research had a series of objectives which were reached as followed: The technological objective was to develop light constructive components with a good thermal insulation, and mechanical resistance to be used in housing side closing function. The ecological one was to collaborate in environmental decontamination. The economical was to lower costs of social housing construction creating cheaper housing construction materials. The social one was to provide self – constructors with the know how to make construction

materials. The fi eld objective to develop a constructive technology easier to use by women due to the lightness of the material Recycled plastics materials Aare used as raw material, promoting the rational use of the available resources instead of end as Atrash buried or burnt in garbage dumps, using non contaminating elaboration procedures; therefore it is a sustainable technology. [7]

C. Utilization of candeia (Eremanthus erythropappus (DC.) Macleish) wood residues in the production of particleadboad with addition of pet [8]

This work aimed to evaluate, through the physical and mechanical properties, the panels production viability with inclusion of candeia (Eremanthus erythropappus) wood residues and the influence of different percentages of PET (polyethylene terephthalate), as well as the presence and absence of paraffin on the properties of particleboard. There were used candeia wood residues, after oil extraction, in association with eucalypt wood in the proportion of 25:75 and urea-formaldehyde adhesive (12%) for panels production; besides the PET incorporation in particle form, which were originated from soft drink bottles and included in three percentages (0%, 25% e 50%) in treatments in the presence (1%) and absence of paraffin emulsion.

The panels pressing cycle occurred under electric heating at 160°C, 0.4 MPa of pressure, during 8 minutes. The experimental design was entirely randomized with three repetitions. The properties evaluated were: internal bonding; static bending (modulus of elasticity – MOE and rupture – MOR); compression parallel to the panel surface; water absorption and thickness swelling, after 2 and 24 hours water soaking. The panel mechanical properties decreased with increasing in PET level; in general, paraffin addition did not improve the wood/plastic panels resistance and higroscopicity; the utilization of candeia wood residues is viable, in association with eucalypt wood, for the wood/plastic panel production, since the properties attended the minimum demands of the standards, except static bending

D. Physical and mechanical properties of bark flour or wood flour of Pinus radiata recycled polyethylene composites [9]

Composites made of recycled low density polyethylene and wood or bark flour of Pinus radiata D. Don were tested, the effect of the flour content and density of the composites on physical and mechanical properties were determinated. These both types of composites were prepared by injection moulding and without chemical additives at 20/80, 40/60 and 60/40 of flour/polyethylene (w/w). Several physical and mechanical properties were measured. The results were tested for comparison of means and Multiple Linear Regression Analysis (ARLM), followed by the method stepwise (SWM). The results indicate that the physical properties and the E increased with increasing flour content, while the tensile strength and the hardness tended to decline. The composites made with bark flour had higher stiffness, absorbed less water and swelled less, and show similar hardness than the composite made with wood flour, but only the composite with 20% (w/w) of bark flour showed greater tensile strength than the others composites. The content of flour was the variable that most affects the properties evaluated, except to the E and the hardness of the wood flour composites, they were most affected by their density.

III. MANUFACTURE OF RIBBED SLAB MOULD BASED ON RECYCLED POLYETHYLENE.

One of the most used ribbed slab muold is polystyrene due to its low cost and fast handling that streamlines the construction process and also has a large offer in the market which makes it easy to access.

Polystyrene is a chemically inert non-biodegradable material, this makes it an environmental problem since it is considered as an eternal material. One ton of discarded polystyrene covers a volume of 200m3, which is a really big volume for so little material since it is composed of 98% air and 2% of the raw material. After use, the polystyrene ends up in landfills or is incinerated, which causes serious environmental problems, and chemical techniques that exist to recycle it involve the use of hazardous solvents. [10]

The PET is a thermoplastic polymer of which there is no type of chemical bond between chains and it takes between 100 and a thousand years to degrade or decompose.

In the country, approximately 140 thousand kilograms of plastic bottles are produced as waste.

In the last four years, the collection of post-consumer PET in Mexico has been the highest in America. During 2015, 364 thousand tons of used PET were recovered in the country, 50.4 percent of the national apparent consumption.

The recovery of PET containers to date means 60 percent of national consumption, so there is still a way to go, but it is a

level that is above what Brazil has achieved (42 percent), Canada (40 percent), the United States (31 percent) and the European Union (25 percent).

Said storage has been equivalent to stop ejecting 6.6 million tons of CO_2 into the environment, which would be an amount equivalent to the emissions that capture 556 million trees and more than 70 million cubic meters saved from landfills or landfills.

Another relevant aspect is that, although in the first years the PET was taken abroad to be recycled, currently 38 percent of the stockpile remains in Mexico for the consumption of the plants that operate ECOCE, which have the capacity to process 208 thousand tons a year of resin and that have meant an investment of more than 272 million dollars [11]

A. Methodology

1) Collection of test material

a) It will go to collection centers and collectors to collect PET bottles

b) The bottles collected will go through a cleaning process, where mainly material that is not relevant for the investigation will be removed, such as taparroscas and labels.

2) Crushed PET

a) The material collected will be crushed in the mechanical prototype manufactured by the university to absorb costs and electricity expenditure.

3) Foam fabrication

a) Using formwork wood, a mold for a cassette with standard measurements will be made.

4) Cassette manufacturing

a) With the help of a binder material and a hydraulic press, the PET will be compacted in the mold to form the caissons.

b) The procedure will be repeated in different proportions in order to compare and find the quantities of material needed for the cassette with the best results

5) Physical and mechanical tests to measure properties

a) We will submit the prototypes to tests of elastic stress, strain and resistance.

b) Their weight, density and volume will be measured so that they can be compared with those currently used

c) A capacity test for use will be made using different prototypes in the casting of a grid slab.

d) Analysis of results and conclusions

B. Preliminary results

Some prototypes were made (see Figure 2.0 and 2.1), which have not been subjected to the necessary physical and mechanical tests since the stability of the product, its behavior when using certain resins, is still being observed.

Satisfactory resistance has been observed, in which the product fulfills its function as a formwork, this includes a low level of absorption.

Figure 2.0 Cassette prototype made with PET.

Figure 2.1 Prototype being exposed to weather conditions.

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Undestructive Methods: An Alternative to Determine Capsaicin

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Abstract— **The traditional methods to measure the capsaicin molecule are expensive, slow and usually are in places outside the crop, looking to substitute with the following investigation and that could be the guideline to measure the capsaicin in situ, in stages including the fruit in the plant that allow to respond towards the best harvest time; with the complications of what the capsaicin molecule representsas the one of being its greater percentage in the internal part of the fruit imbibed in vesicles, this search presents possible solutions by the engineering to determine its capsaicin concentration.**

Keywords—capsaicin, bioimpedance, electric nose, infrared spectroscopy

Introduction

Capsaicin determination is very important for the scientific reasons, for therapeutic reasons and for agroindustrial production. Analytical techniques have been varying for determining capsaicin in chili pepper, it´s very important to have a direct method where the producers could confidence because the quantity, the quality obtained of capsaicin gives economic advantages. Capsicum genre produces one of the most popular additives of the world [13] capsaicin. Capsaicin produces hot or pungency only in mammals by eating capsicum fruit.

Capsaicin is a lipophilic alkaloid [29] the biosynthesis occurs in the placental epidermis cells, where they are secreted towards the outer cell wall, and finally accumulate within structures named ''blisters'' located on the placenta surface [2], defining the capsaicinoid presence on the seeds or pericarp. The proportion of capsaicin varies between 0,1 to 1% in weight [3]. Capsaicinoid accumulation is a genetically determined trait in chili pepper fruits as different cultivars or genotypes exhibit differences in pungency; furthermore, this characteristic is also developmentally and environmentally regulated [2].

The chemist Wilbur Scoville in 1912 developed a scale of pungency degree chili pepper through an organoleptic examination [21] , the scale is from 0 for sweet pepper to 300,000 or more like habanero pepper.

The researchers and producers require reliable, safe and standardized methods for comparing levels of pungency between different samples of chili pepper. Detecting the non-pungency trait in chili peppers during the early stages of development can certainly reduce the selection time for breeding programs that cater to consumer and industrial requirements [2].

Table 1. Pungency degree of chili peppers[21] **.**

Fruit	Pungency degree
Sweet pepper	< 100
Mexican pepper	100-500
Cayena pepper	30 000-50 000
Habanero pepper	100 000-350 000
Capsaicin	16 000 000

The most developed instrumental methods for determining the capsaicin molecule are such as Gas Chromatography (GC), Mass Spectrophotometry and Mass Chromatography (GC-MS) and with greater performance is liquid chromatography (HPLC) with more confidence and accuracy. In the last years surge a method called ultra performance liquid chromatography (UHPLC) derive of HPLC which allows shorter times o9f answers of all compounds of capsaicinoids in less than 9 minutes [1], these methods are equivalent to sending the samples makes an analysis with long wait times,

this represents a difficulty for decision making in the field, itself equipments are of a high economic value.

Analytical approaches such as immunoassays, voltammetric determination [29] and electronic noses [14] have been suggested. Taking into account the variability of the content of capsaicin in the fruits of chili and the quick answer, this review takes this necessity and presents different methods that allow for the reader which and how a non-destructive method would make possible determine quantitatively the presence of capsaicin in the fruits of chili.

I. UNDESTRUCTIVE METHODS

a) Capsaicin Common Methods
The first method developed for pungency of pepper chili was Scoville Organoleptic Test [21] consisted of a group of five evaluators which taked to taste of chili and registered the flavor level. In the actuality was replaced for various methods based in chromatography and spectrophotometry either in mass or liquid are being been more reliable and precise (Marston, 2007). Usman et al. in 2014 [27] reported a method called Ultra Fast Liquid Chromatography (UFCL) that multiple samples analised with higher speed but is more expensive than the previous methods. All of this methods have some common that destroy samples, high cost, time to responses and is neccesary to send the test to laboratory for know the answers.

B) Undestructive methods: Overview for capsaicin.
The producers make the decision on when to harvest the fruits based mainly on experience; however, human judgment is always subjective. The development of new technologies is supported by the collection decision so has the highest priority for producers before and after harvest (Herrera et al., 2003). All imply needed to develop a standardized and automated technology for evaluating the ripeness of the fruit (capsaicin concentration) quickly and objectively in the field. These with undestructive methods, not altering the permanent shape and its physical, chemical, mechanical or dimensional properties, and without involving a perceptible damage.

Undestructive techniques for the determination of the properties and characteristics of vegetable fruits play a role fundamentally for quality and innocuousness control. The sensors development has been key to identify the product properties, constituting an active research area (Diezma Iglesias et al., 2006). The biological fruits are material that is affected by the time, the processes, the environmental conditions, generally any process which are subjected. The quality inspect makes essential in each of the phases, where only the sensors can provide objective and economically viable solutions (Diezma Iglesias et al., 2006). Therefore, the application of undestructive technologies requires combining sensors with sophisticated models and mathematical algorithms to establish a robust connection between the physicochemical properties and the quality attributes of the product (Diezma Iglesias et al., 2006).

The main undestructive technologies have a different degree of introduction in the commercial sector of fruits and vegetables, first, the mechanical methods are for firmness, size and shapes; then the artificial vision is for internal evaluation and external quality (hyperspectral image, thermography image, X-ray, UV / VIS/NIR and fluorescence spectroscopy); later the acoustic systems, the nuclear magnetic resonance, the wireless sensor and radio frequency identification (RFID) networks for monitoring enclosed and open spaces and for last the sensors for the identification of volatile gases. There are more than fifty methods to determine the maturity of the fruits (Diezma Iglesias et al., 1994).

The electronic nose was used to evaluate the maturity of tomatoe [8] this approach by volatile aromatic compounds is an option to use in the fruits of Capsicum spp, not done and reported so far. The undestructible technologies have been used in the maturity of the tomato are chemometric methods, magnetic resonance [30], optical techniques such as near-infrared spectroscopy [25], the Raman spectroscopy [22], the image formation (Rupanagudi et al., 2014), the mechanical learning and diffuse classification (El-Bendary et al., 2015, Goel and Sehgal, 2015), the carbon nanomaterials with chemical sensors (Greenshields et al. ., 2015). All these methods have been used several plants whose secondary metabolites have characteristic color unlike capsaicin important point that is colorless, due to which it represents a challenge for researchers to provide these technologies.

c) Images: Undestructive Methods.
The pungency distribution of the red chili pepper is in relation between the dry weight and the capsaicin content in each part of the dried pepper; on the placenta is of 3.9% of the total weight and contains almost 96.9% of all capsaicinoids which form the pungency component (Figure 1).The chemical assays such as HPLC, GC or NIRS uses a small amount of sample or takes measurement at a single point then show large deviations of pungency that depends on the location, distribution and inclusion of placenta in red powder chili

pepper.Therefore, it is necessary to improve the accuracy of the pungency measure by scanning a large number of points continuously to minimize the deviation in pungency caused by the influence of the placenta on red pepper powder. In addition, the unequal compact levels or surfaces in red pepper powder may correspond to different levels of dispersion and reflectance spectra even in the same sample, and therefore, equipment that can form uniformly consistent surfaces and automatically is required[16] .

d)Near Infrared Spectroscopy.

Near-infrared spectroscopy (NIRS) is a spectroscopic method using the near-infrared region of the electromagnetic spectrum and analyzes the degree of NIR absorption. It consists of measuring the light spectrum reflected or transmitted through the sample for an identification process to estimate interest variables. The estimation method is based on the Beer-Lambert law, which states that the absorbance sample is proportional to the concentration of each constituent within the medium. However, this law isn`t met when a diffuse reflectance (ie, scattering within the berry) occurs [20] [20] . The NIR spectra are possible to relate to the maturity variables with an empirical analogous relationship to the Beer-Lambert law.

$$\text{Log} (1 / R) = kC \quad (1)$$

Where R is dispersed light through to detector, C is unknown concentration and k is constant [20] .

The NIRS is widely used in agriculture to quickly and undestructively determine the internal or external qualities of agricultural products. The NIRS was used for the first time in the measurement of moisture content in grains, and then it has been used to quickly measure moisture content, proteins and fat in agricultural products [6]. In addition, several studies have been conducted using NIRS to measure physical-chemical characteristics and organoleptic properties such as soluble solids content (SSC), acidity and firmness of apples, mandarins, peaches and pears[4].

A partial least squares regression model (PLSR) is the most popular regression model in chemometrics, chemistry and engineering. The NIRS has been combined with PLSR that employ in diverse applications for the qualitative and a quantitative analysis of food and agricultural products [16] . Recently, a PLSR model was developed using NIRS with a wavelength range of 1,100-2,300 nm for rapid and undestructive prediction of capsaicinoid content in red pepper powder [16].

A pungency value system was designed and manufactured to explore the surface of red pepper powder by visible and near-infrared spectroscopy (VNIR) in an effective wavelength range of 450 to 950 nm (Lim et al., 2015) with the order to reduce the deviation in the pungency caused by the influence of the placenta and makes a uniform mixture that allows stable reflectance spectra. NIR spectroscopy is a method widely developed but still exploring improvement for the study of capsaicin,   but finding many applications in shortwave NIR (spectral range below 1100 nm), which shows that the multivariate analysis tools can effectively identify the concentrations like the capsaicin with an acceptable precision [15].

e) Bioelectromagnetic Images (BEM).

The recently developed technology based on the Kirlian effect to register the human/vegetable bioelectromagnetic field (BEM) uses the Gas Discharge Visualization (GDV) that provides potential information about the biophysical and/or psychic state of the object/person (1). The BEM fields registered also called crowns can be processed with specialized software that describes a set of numerical parameters, where the subsequent analysis is based on these parameters [23].

The motivation for measuring BEM fields of leaves and fruits of plants with Kirlian photography (Fig. 1) is derived from three observations[23]:

(A) the relatively successful use of Kirlian photography for medical diagnostic purposes, especially warning system to detect changes in the state of an organism (Korotkov, 1998; Zrimec and Kononenko, 1998);

(B) previous research showed that it is possible to detect and find useful information in seed fields of BEM plants (Čater and Batič, 1998), as well as other non-human objects (Kononenko et al., 1999; Skocaj et al., 2000 Kononenko et al., 2000);

(C) A method to acquire information about the state of a plant would be very useful.
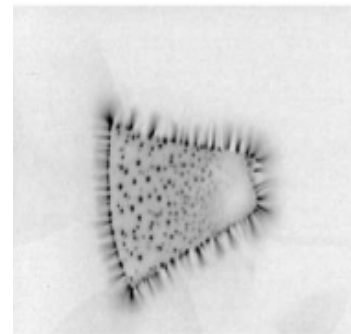
Figure 1. Apple piece crown [23].

A study was carried through the processing of data on bioelectric fields of grape berries with a learning machine by mathematical algorithms, this technique has been applied successfully in different experiments (Kononenko et al., 1999, Trampuž et al., 1999; Čater and Batič, 1998).The vitality of the plants subjected to various scenarios monitored with the use of Kirlian photography, emphasizing the early detection of the decrease of the vitality of the plants due to infections or inadequate conditions [23].

Sadikov and Kononeko [23] describes some of the numerical parameters used to support the hypothesis that the BEM fields of leaves and fruits contain useful information to evaluate the state of a plant are: absolute area of the crown, noise suppressed from the image, coefficient form, shape deviation, crown entropy, fractal dimension, medium brightness, brightness deviation, brightness appearance, brightness stability, brightness entropy, number of separate fragments in the image and 7 parameters based on the geometric moments defined by Hu [11].

f) Electronic nose (E-nose) Organoleptic Method.

The instrumental viewpoint has an obvious correlation between the human senses and the application of optical, chemical and tactile sensors. The instrumental measure of fruit quality has been based mainly on properties such as texture and firmness [28]; An extensive research has focused on the development of undestructive techniques to measure the quality of fruit attributes and the detection of aromas is a promising method [8].

Alternative strategy to determine the state of maturity is from the volatile aromatic compounds emitted by the fruits using electronic olfactory systems[8]; these systems are concerned with the exploitation of the information contained in the surface of fruits where some specific compounds have been identified as responsible for the particular fruit aroma.

In the last decade, the e-nose technology has opened to the possibility of exploiting the information contained in the aromatic space where the food analysis is certainly one of the most practiced. The e-nose offers a fast and undestructive alternative to detect the aroma can be used to predict the optimal collection date [9] of vegetables and fruits, with possible applications to avoid the concentration of capsaicin.

Some authors reported positive applications of the electronic technology of the nose to the discrimination of the quality of the different fruits, and many experiments were carried out, such as: oranges, melons, berries, pears, peaches , bananas, apples [24] and nectarines.

g) Bioimpedance.

All biological bodies have electrical properties according to the physical structure, to the internal chemical processes and / or the combination of both [3]. Electric impedance is a passive electrical property that determines how a flow of alternating current applied by an external electric field is "impeded" by biological tissues (or any other material) [19]. The response of electric fields in a biological tissue can be considered as a volume transistor-conductor (due to specific conductivities) or a dielectric (due to relative permittivities), and ions as charge carriers [18]. Generally, a cell membrane can be represented as a capacitor because it is considered a dielectric field, while intracellular and extracellular fluids can simulate a resistance [19] . The electrical energy that flows through the biological tissue (or any material) by means of charge carriers can be dissipated by said resistors, and stored by capacitors. Electrical impedance is a passive electrical property that determines how an alternating current flow applied by an external electric field is "impeded" by biological tissues (or any other material) [19] .

Electrical impedance measurements have been studied to determine the physiological state of the plant, such as [17] who analyzed potato tubers and carrot roots using a double layer model; [12] detected damaged tissue in bruised apples; [17] determined a relationship between the electrical impedance and the biochemical properties of the fruit (pH, sugar content, maturation).

There are few impedance studies for the nutritional states of the plants, where Greenham and collaborators[19] studied the electrical impedance in measurements taken from plants Trifolium subterraneum deficient in phosphorus and potassium, and Tomckiewicz and Piskier [26] evaluated stress caused by lack of nutrients.

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Use of Unmanned Aircraf Vehicle (UAVs-drone) as main tool of work in engineering. A review.

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Abstract— **As incredible as it may seem, in civil works, in any of its different modalities, there is a great security risk because the different tasks to be executed require a preliminary visualization for the activities to be carried out, such as, among others: slope stability, supervision of construction of high buildings, which entails in most of the cases not to have easy access and safety means for the worker, mainly. Recently, the development of technology and the availability of the Unmanned Air Vehicles (UAVs-drones) can provide a better point of view and it can determine the feasibility and work actions before the exposition of a real human life. UAVs could be used, in certain cases, as the same instrument for the execution of the maneuvers; reducing labor risk, stoppage of industrial activities due to maintenance work, analysis and interpretation of a particular area, among others. This paper presents different, and original applications of this technology, and presents a possibility to explore new applications that can help to reduce human risks, costs and work time.**

Keywords— UAV, unmanned air vehicles, drone, flight, construction, engineering.

I. INTRODUCTION

Autonomous unmanned aerial vehicles (UAV - Drone) recently have been received increasing interest for environmental and natural disaster areas monitoring, border, and general surveillance, emergency assistance, search and rescue missions, and relay communications even only geo-position location [1-7]. UAVs, also call drones, do not carry a human operator, they fly remotely or autonomously, and they can carry lethal or nonlethal payloads [8]. Recent achievements made in digital technologies, and additional methods of documentation have emerged, owing to the enhanced affordability and accessibility of UAVs [9-11]. Many Information of Technology platforms are based on technologically simple devices, like sensor or small actuators. Other solutions require more complex devices [12]. Additionally, technological development and the cost reduction of drones are encouraging their use for industrial and professional systems [13-15]. Approaches for controlling drones would be classified in: Direct teleoperation, and

Specifying flight plants/destination point. Moving drones in outdoor environments is usually easier than moving in indoor environments. Most flight plans are based on GPS locations [16]. Advances in fabrication, navigation, remote control capabilities, and power storage systems have made possible the development of a wide range of drones which can be utilized in various situations where the presence of humans is difficult, impossible, or dangerous, [17-18] the main problem is the battery, those devices have, commonly, only a free support of fifteen minutes.

The system is also valid for monitoring tasks, it shows data from drone sensors, and it is designed for including extra external sensor. Drones can provide assistance in different tasks at a minimum cost [19-20] by reducing, almost in the most of time, the cost of operator. In addition to that, for fewer financial restrictions, other important benefits of drone technology include the ability to acquire high-resolution vertical and oblique imagery or low altitude, cloud-free imagery, the ability to program precise flight paths, and easy-to-master manipulation of drone [21-22].

Martin et al [23] and Greenwood [24] have stressed that despite the obvious benefits of drones, there a variety of technical and operational limitations, such as fisheye photography distortion, weather dependency, and consideration of aviation safety regulations and licensing, which may complete the routine usage of drones, as well as have a limited flight time.

For time-critical missions with changing objectives, distributed coordination and reliable sensing and networking are required, the path plan can be generated before the mission in a centralized station, and sensed data can be processed offline, relaxing the constraints on communication, the diversity of application demands supports the analysis of multiUAVs systems from coordination, sensing and communication viewpoints [25].

Depending on the flight missions of the drones, the size and type of installed equipment are different [6]. Watts et al. [26] described a variety of platforms, they identified advantages of each as relevant to the demands of users in the scientific research sector, and also they classified the drone´s

platforms for civil scientific and military uses based upon characteristics, such as size, flight endurance, capabilities. About their drone´s classification, they classified them as MAVs (Micro or Miniature Air Vehicles), NAVs (Nano Air Vehicles), VTOL (Vertical Take-Off & Landing), LASE (Low Altitude, Long Endurance), and HALE (High Altitude, Long Endurance). Furthermore, Arjomandi et al. [27] classified drones on the basis of weight, range and endurance, wing loading, maximum altitude, and engine type, they classified drone as super-heavy with weights more than 2000 kg, heavy with weights between 200kg and 2000 kg, medium with weights between 50kg and 200 kg, light/mini with weights between 5 kg and 50 kg, and finally micro drones with weights less than 5 kg [27].

Nowadays, there is a serious effort to design and fabricate air drones that are very small for special missions. These efforts have resulted in the development of different types of small drones with various shapes and flight modes. As shown in the Fig. 1, a comprehensive classification of all of existing drones is shown, with HTOL is abbreviation of Horizontal Take-Off and Landing. The offered classification of drones shows different models of drones as a function of their configuration, also considerers the bio models of micro, and nano air vehicles [28].
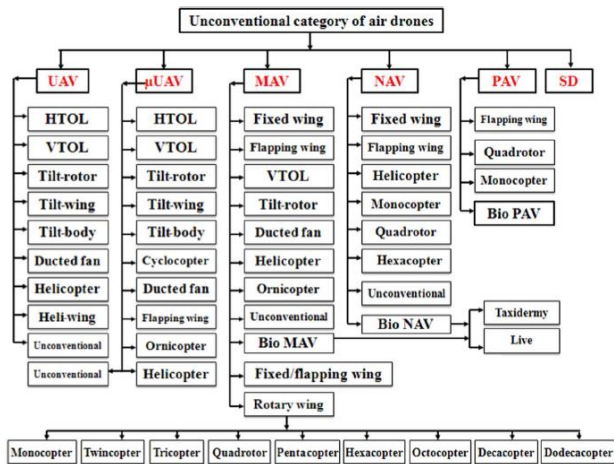

Fig 1. Different types of drones.

II. DEVELOPMENT

The most common tasks within the civil work, are referred mostly to those that characterize the maintenance, not only preventive but also corrective, that in its majority those last induce a high risk in the safety of the worker, such as factors of height, heavy materials to improve to considerable heights, stability of the infrastructure, facilitated means for the correct execution, or the security at the level of the land that can be maneuverable.

Most of the occasions where corrective maintenance occurs do not include security measures that can guarantee the correct execution of the actions without having to stop the activities that are carried out within the complex where the service will be provided, and if it is not possible to stop the activities, it is only possible to work in maintenance under certain strict standards that do not to affect the same maneuvers of the company, work or complex.

The development of UAVs have been possible to access mechanisms and materials that facilitate work and that do not put on risk the safety of users of complexes as well as the workers who will perform the maneuvers, which have characteristics of lightness and high range of reach in most models.

In order to determine the best drone for the realization of some activities, the scope to be obtained must be taken into account, and the place where the maintenance will be done, the use of materials and the skills of the operator, in case of be necessary are some important topics to determine it.

In some cases, the work are considered inaccessible, in these cases the drones are highly useful because they have the capacity to reach high altitudes, once the recognition of the work area, surroundings, and the access points and exit, the inherent risks that the equipment could suffer, it will proceed to do the photographic and/or video survey to obtain a database complementing it with data of initial or previous projects, such as plans, calculation memories, and work logs. Once the database is generated, the analysis could be continued to determine the best work plan and actions and the optimal materials to carry out the maneuvers. So, the development of this technologies allows us, once the maneuver action front has been chosen, we can choose the UAV model that best suits the requirements of work, weight, height, battery, range. Within the total weight to be raised, we could consider the weight of the equipment as well as the add-ons and the inputs to raise the drone, being the battery or work time that can be executed highly relevant, since most of the equipment, when added extra load tends to decrease the workable hours of work.

As it could be seen, the generation of numerical methods for the directed flight of the system and know the behavior within the complex of work, since in many of the situations cannot generalize a model, since the environments could vary considerably and the variables of work could be as arbitrary as inconstant, wind, humidity, materials, in these cases the actions and plans tend to be in a particular way, but maintaining a work scheme (analysis, data collection and attack fronts) in a generalized manner.

The progress and acceptance of the use of drones as a main tool of work, allows to finalize the maneuvers, a cleaning and final revision of the same to verify on site, a release and acceptance of the actions, and in its case take a decision on release the service performed or perform some other service on the same complex or previous work, without having to wait for a certain period of time or reassemble the structures for the realization as usual in conventional work.

Of course, one of the main problems is considering the normative of each country and/or each place because we have different rules near to an airport in comparison with an open area. As a summary, we have a good opportunity to develop our own methodology, model or logarithm embedded in a properly drone in order to distinguish between a good or bad preliminary reconnaissance before spend money, time or put a human life in serious risk.

CONCLUSION

The UAVs can allow us to explore new areas avoiding the conventional risks of the workplace by obtaining better accessibility, mainly because the drone can provide us the facility of executing actions of reconnaissance on an irregular surveying or even in evaluation of natural and anthropic disasters. The high cost for use of moving the necessary equipment in a conventional technique, by reducing maneuver times as well as to ensure the safety of the workers or even the reduction due to the stop control of regular activities in the workplace by reducing and leaving traditional techniques that increase human risks. All this characteristics give the properly drone a surplus over other conventional techniques.

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Biogenic volatile organic compounds a tool to defend the crops

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Abstract— **Plants are sessile organisms with complex metabolism, to survive the attacks of pathogens, herbivores and the difficulties of the environment, have developed a variety of biochemical compounds called secondary metabolites these act either directly or indirectly over the source of stress. Some of these compounds are volatiles and released to the atmosphere, several plants have developed the ability to read them as a cue of possible danger and prepare their defenses, these phenomena it's called priming and has a wide range of possibilities in agriculture. The global trend is to enhance de yield of crops while reduce consumption of hazard agrochemicals. Here we analyzed some of the biosynthetic pathway that leads to generate biogenic volatile compounds, how they are uptake and how they could generate the priming effect.**

Keywords—BVOC´s, GLV´s, elicitation, priming, terpenoids, phenylpropanoid, ROS, sustainable, agriculture

I. INTRODUCTION

The plants are sessile organisms whom can't escape while been under attack, nevertheless, instead of being a passive victim of the environment they have developed a plethora of biochemical defenses to face the different sources of stress to which they could be exposed, this biochemical compounds are called phytochemicals or secondary metabolites, because of their origin in the secondary metabolism, i. e. g. flavonoids, carotenoids, biogenic volatile compounds (BVOC's) Figure 1, although all the mechanisms involved in generation, interaction or liberation of plant defense molecules haven't totally been described it is well known that there are highly conserved stress responses, as the generation and liberation of reactive oxygen species (ROS) and plant hormones as jasmonic acid (JA), salicylic acid(SA), ethylene(ET), abscisic acid(ABA) and brassinosteroid(Br), the type and quantity of hormone and their posterior transduction into secondary metabolites depends on the stress stimuli received. [1] These phytochemicals are important for humans because they have highly biological activity and have been widely used in food and pharmaceutical industries among others.

The defense responses can be categorized as direct when the secondary metabolite act directly on the stress factor i.e.g. it has been reported that *Illicium anisatum* releases derivates of eugenol with a phenolic hydroxy group that displays antifungal activity against a fungal pathogen[2], and indirectly when the disruption of the stress is mediated by an intermediary i.e.g. when an herbivore starts to injure the plant it generates and release volatiles which attracts carnivores whom finish the plagues [3]

Is through these metabolites, that plants can interact with the environment, not only to defense itself or to cry for help but as a way to exchange information with the neighbors or even to its distant self with or without the influence of the vascular systems, the communication between plants has been reported either through common mycorrhizal networks [4] or through volatile organic compounds [3].

This work's porpoise is to explore the interactions of BVOC's as a possible tool to enhance yield crops, nutrition value and
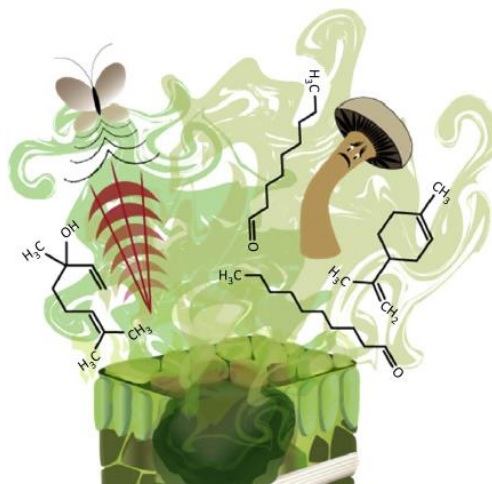

Figure 1. After damage plants releases BVOC´s such as linalool that repels herbivores and compounds that have antibacterial properties. Taken from Johan A. Stenberg *et al* 2015

reduce the consumption of agrochemicals by their ecological interactions with neighboring plants.

II. ELICITATION & PRIMING

Originally an elicitor was a substance that triggered the production of phytoalexins in plants, but now an elicitor is any stimuli that can trigger the plant defense systems, their nature can be biotic like the cell wall of a yest or bacteria, membrane glycoproteins, peptides, polysaccharides, lipids, volatiles and recently has been reports that even self DNA can induce defense responses [5, 6]; or can be abiotic like UV light, salinity, drought, metal ions, injuries among others.

Although the elicitors were originally used to enhance the yield in the production of commercially important compounds, as taxol a diterpenoid used in the treatment of ovarian cancer.[5]. Nevertheless elicitors have received attention of scientists because their ability to induce **priming**. This is the phenomena in which a stimulus positively affects future plant resilience, their defense responses are deployed in a faster, stronger, and/or more sustained manner if the plant is exposed again to either the same or even some different stress condition i. e. g. navel oranges *Citrus sinensis* L. *Osbeck* whom were treaty with chitosan (a common polysaccharide in exoskeleton of insects and in the cell wall of fungi) showed an enhanced the resistance against *Penicillium italicum* and *Penicillium digitatum*[7] In parallel to the term priming, other terms are also used i. e. g. systemic acquired resistance (SAR) when referring to enhanced resistance of plants against phytopathogens or environmental conditions [8].

Even though this is not a novel concept, the practical use of elicitors and priming have not been exploited at their full potential, nevertheless the efforts to improve the yield of crops and minimize the impact of agrochemical products play in favor of the use of this knowledge and generate technologies, here we propose that BVOC's could be the elicitors since they come from a natural source and do not require a complex extracting process.

III. BIOGENIC VOLATILES ORGANIC COMPOUNDS

The BVOC´s are small molecules with low-molecular weight (generally <300Da) and low polarity hence, they have high vapour pressures under normal environment conditions, their origin and nature can be diverse since they may come from several biosynthetic pathway[5]to date it has been reported over 1700 BVOC's among isoprenoids volatile fatty acid derivatives such as different C5 and C6 alcohols, aldehydes and ketones, terpenoids amino acids and various benzenoids being quantitatively the most important compound classes [10].

The emissions of volatiles can occur either with or without stress stimuli although only a few plants releases high quantities of constitutive volatiles, but these emissions can often dominate the ecosystem, region and global emissions. Even though, stress can induce BVOC emissions in practically any plant species, and this can have a major impact on BVOC release from stressed ecosystems. The induced emission of volatile organic compounds due to mild abiotic stress could
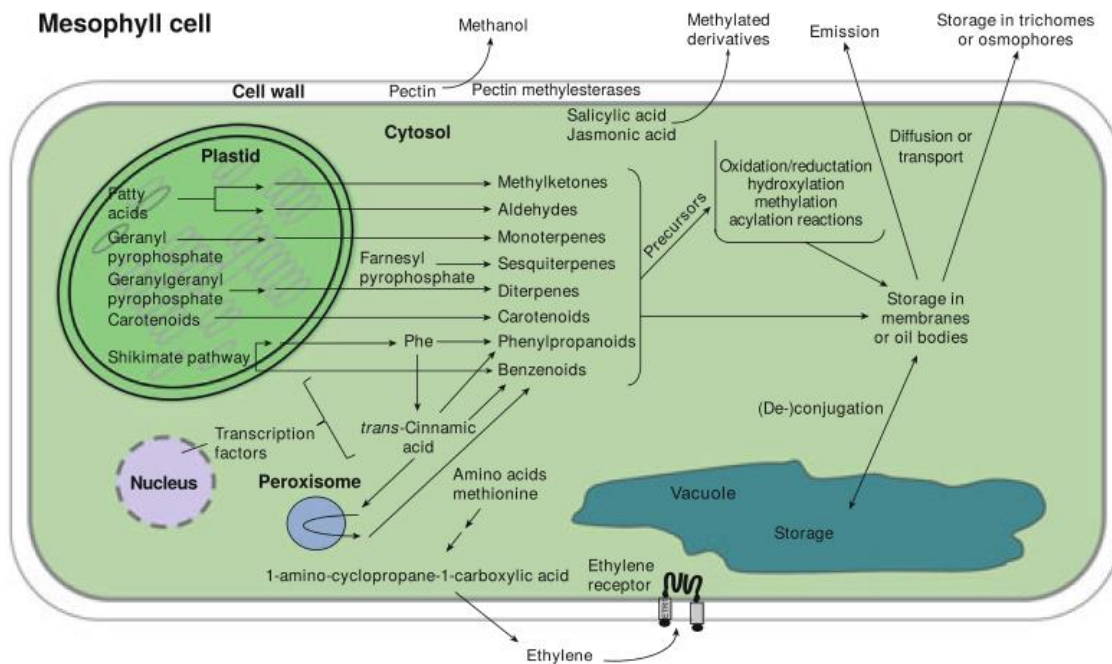

Figure1. Shows the sites of generation depending on the type of BVOC taken from Schuman C. *et al* 2016.

prime the defense responses of plants upon exposure to a biotic stress [**12, 13**]

The liberation of these compounds depends on light temperature, the site of synthesis depend of the type of compound see Figure 2.

A. Terpenoids

This is the most diverse group of secondary metabolites. Also called isoprenoids are synthesized from isoprene a five carbon (5C) units derivate from two common 5C precursors, isopentenyl diphosphate (IPP) and dimetylallyl diphosphate (DMAPP). In higher plants two independent pathways are responsible for the formation of these isoprene units, the mevalonic acid pathway which results in volatile sesquiterpens (15C), whereas the isoprene units synthesized in the methylerythritol phosphate pathway leads the formation of volatile hemiterpenes (5C), monoterpenes (10C), or diterpenes (20C). The two different pathways are compartmentalized and separated, while MAV happens in the cytosol, endoplasmic reticulum and peroxisomes the MEP pathway occurs in the plastids. [**10**].

Monoterpenoids and sesquiterpenoids are generally volatile when not conjugated to polar or large (> 200 Da) moieties. Higher order terpenoids are generally not volatile. [**14**]

In vivo the functions of terpenoids involve primary and secondary metabolism since binding with proteins so these become hydrophobic and participate as electron transporter, participate in the photosystem as carotenoids or protecting the plant from different abiotic stress among others. [**14**] These molecules also function as volatile messengers Marlies Riedlmeier *et al.* In 2017 reported that monoterpenes α-β pinene released by *Arabidopsis thaliana* induced the defense system en neighboring plants.

B. Phenylpropanoids and benzenoids

It´s estimated that this group constitutes the 20% of the BVOC´s and thus the second most diverse. These compounds are generated in the cytosol through the conversion of L-phenylalanine into trans-cinnamic acid via L-phenylalanine ammonia lyasa (PAL) further conversion of trans-cinnamic acid to other phenylpropanoids is shared with the lignin biosynthetic pathway through the steps of monolignol biosynthesis. Benzenoids originate from the same biosynthetic pathway, but the side chain of trans cinnamic acid is enzymatically shortened by two carbons. L -phenylalanine derivatives with a C2 side chain compete with phenylpropanoids and benzenoids for substrate and are synthesized via different pathways [**7**]

It has been reported many function of l benzenoids since attractor molecules for pollinators, as a constituent of flavor, even involved in tritrophic relations attracting carnivores among others [**9, 11, 15**]

C. Amino acids derivates

These group is constituted by acids aldehydes, alcohols, esters, nitrogen and Sulphur containing BVSc's derived from amino acids such as alanine, valine, leucine, isoleucine, and methionine, or intermediates in their biosynthesis, and contain nitrogen and sulfur but no L-phenylalanine, the synthesis of these compounds is conserved through bacteria and yest[**7**] these are synthesized when amino acids are deaminated or transaminated to form α -keto acids, which are carboxylate and may subsequently be reduced, oxidized or esterified. Amino acids may also be precursors for acyl coA molecules used in esterification reactions catalyzed by alcohol acyltransferases Ethylene is derived from methionine and thus belongs in this category [**9**].

These volatiles are involved in the scent and flavor of many fruits i.e. (2- and 3-methylbutanal, 3-methylbutanol derivate of isoleucine and leucine contribute positively to tomato flavor [**16**] Volatiles derived from amino acids are major contributors to melon aroma. Both aromatic and non-aromatic varieties possess amino acid derived volatiles. In the aromatic varieties these volatiles are mostly esterified, and their levels are usually higher than in the non-aromatic varieties. In the non-aromatic varieties, they occur as aldehydes and alcohols. [**17**]

D. Fatty acid derivates

These can be categorized in jasmonates, green leaf volatiles 6C and nine carbon volatile aldehydes alcohols and esters, these, arise from 18C unsaturated fatty acids, linoleic or linolenic fatty acid, which is deoxygenated either by a lipoxygenase (LOX) the lipoxygenase can act either over the 13C or the 9C which are further metabolized via the two branches of the LOX pathway yielding volatile compounds, Although for the formation of 6c and 9 C both compounds 9-hydroperoxy and 13-hydroperoxy are intermediaries the jasmonic acid pathway can only be synthesized from and 13-hydroperoxy.[**11**]

The jasmonic acid, play a major role in the activation of downstream defense responses, and these can be triggered either by biotic and abiotic stress as herbivores, necrotrophic pathogens, nematodes and other micro-organism besides alleviating abiotic stresses including UV-stress, osmotic stress, salt stress, cold stress, temperature stress, heavy metal stress, ozone stress etc. [**18**].

GLV´s are triggered when the tissue is wounded, they are the reason of the characteristically odor of "cut grass", they are important in the recognition of flavor components, serve to repel or attract herbivores and their natural enemies; and they can induce plant defenses or prime plants for enhanced defense against herbivores and pathogens and can have direct toxic effects on bacteria and fungi. Unlike other volatiles, GLVs are released almost instantly upon mechanical damage and abiotic stress and could thus function as an immediate and

informative signal for many organisms in the plant's environment. [19]

IV. UPTAKING & SENSING

It has been reported that many plants react to the volatiles released by their neighbors, nevertheless the reasons of the releaser plant to "alert" their neighbors remain unclear because there have not been identified benefits to justify the metabolic expense that this implies. On the other hand it has been hypothesized that the liberation of the volatiles is just the response against hostility and the neighboring plants use them as a cue to prepare themselves against a possible threat [20].

The transport of volatiles form the environment to their site of action has often been discussed in the context of the toxicological effects of volatile pollutants in the atmosphere, and it has been described that plants take up volatiles through the stomata and by adsorption on the leaf surface and that the efficiency of transdermal uptake from the air depends on the proper ties of each volatile compound, such as hydrophobicity and molecular weight, implying that the uptake is a physicochemical process[21,22].
In order that a cell responds to a volatile "call" it has to be able to "hear" it, usually this should occur by the intervention of membrane receptors, but to date there have not been reports of novel receptors other than those for ET and JA that are also phytohormones, nevertheless it is hypothesized that due their low polarity volatiles can cross through plasmatic membrane and interfere in the chemical balance of the current biochemical process [22].

V. CONCLUTIONS

Although there are several unanswered questions about the mechanisms involved in the releasing, storing, sensing and the general effects of BVOC´s for their use as an elicitor, the interest in the concept of priming through natural compounds is gaining ground, and would become an interesting tool to face the coming food crisis.

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[23]

Conceptual Design of Transtibial Prosthesis*

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Abstract—In the present work, the conceptual design of a transtibial prosthesis for amputations below the knee is shown. The design is based on the implementation of an actuator for dorsiflexion and plantarflexion movement; and in a buffer system for the eversion and inversion movement, which reduces the cost of building a possible prototype.

Keywords—prosthesis; prototype; transtibial; dorsiflexion; plantarflexion; eversion; inversion

I. INTRODUCTION

The loss of lower limbs is one of the main causes of disability in the world. Amputations are associated with several factors, such as diseases (vascular, metabolic, cancer, etc.) and accidents (traffic, anti-personnel mines, weapons wounds, etc.).

According to the World Health Survey, in which 59 countries (64% of the world's population) participated, there is 15.6% of the population over 18 years old with disabilities. The World Health Organization (WHO) states that almost 10% of the world population suffers from diabetes and this multiplies by 10 the probability that a lower limb should be amputated [1]. Approximately 2,800 daily amputations are performed in the world as a result of diabetes, which gives us more than one million amputations each year [2].

In Mexico, 6% of the population has a disability, which 64% have difficulty for walking and only 10% of that population uses prosthesis [3]. In Mexico, an average of 78 amputations per day are performed, that is, a total of 28,500 amputations per year [2].

Speaking of the State of Querétaro, according to the census made by the National Institute of Statistics and Geography (INEGI) in 2010, 5.6% of the population has some type of disability, which approximately 14,100 inhabitants have a disability related to walking or moving [4]. What leads them to the use of devices such as the prosthesis to lead a good life and the population with disabilities can be included in activities that were once private for them.

The prosthesis is an external device used to replace totally or partially an absent or deficient limb segment. When the amputation is performed below the knee and a prosthesis is used, it is known as a transtibial prosthesis. These prostheses are composed by the foot, socket and connector [5].

The advance that has been obtained in the prosthesis throughout the years is amazing from the origins, in the ancient Egyptian culture, these were made of wood and leather belts; currently, they are made with the use of microprocessors and stainless steel, titanium or exoesqueletal carbon.

One of the current prostheses is from the ÖSSUR brand, in 2010 this brand took out the Re-Flex Rotate, which has a titanium spring that provides shock absorption and a dynamic energy return. Another prosthesis of the same brand is the SYMBIONIC LEG 3, which contains microprocessors that allow the flexion of the knee and ankle [9]. The work of these commercial prostheses is to allow the user daily activities, such as walking.

Unlike commercial prosthetics, the one proposed in this work has a single actuator which allows movement corresponding to walking, that is, movement of dorsiflexion and plantarflexion, and a system of damping for the movement of inversion and eversion, which is proposed to absorb possible road irregularities.

II. PROBLEM STATEMENT

In this section, the parameters considered for the conceptual design of the transtibial prosthesis for amputations below the knee are presented.

To perform the conceptual design of the prosthesis, it is necessary to know the required movements for the limb, in this case, for the foot. The movements of the

foot are divided according to the plane to which they become, that is, sagittal, frontal or transverse, as shown in Figure 1. In each plane, a perpendicular axis is presented around which it is possible for the foot to rotate.

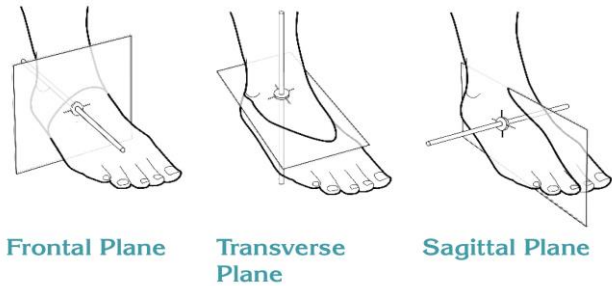Frontal Plane   Transverse Plane   Sagittal Plane

Figure 1. Axes of movement in the foot [9].

The fundamental planes for the gait cycle are the sagittal and frontal plane, in the sagittal plane dorsiflexion and plantarflexion and in the frontal plane eversion and inversion, as shown in Figure 2.
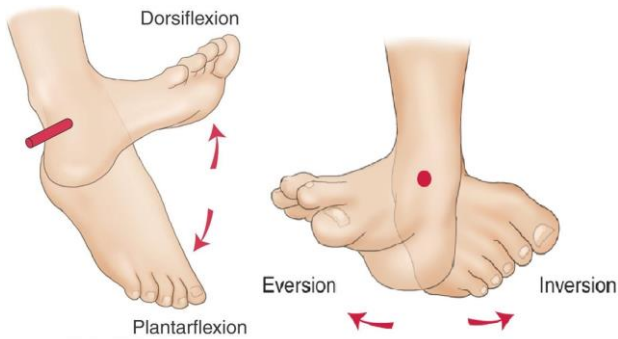
Figure 2. Movements of the foot [10].

The movements that are mainly used for the walking cycle are those of the sagittal plane, that is, the dorsiflexion movements (upward foot flexion) and plantarflexion (downward foot flexion). Meanwhile, the movements of the frontal plane, eversion (movement of the sole of the foot towards the outside) and inversion (movement of the sole of the foot inwards), serve for the balance in the gait cycle.

Most prostheses provide only dorsiflexion and plantarflexion movements, so when stepping on an irregular surface, the user may have problems walking. The prosthesis proposed in this work, provides the four movements mentioned above, so that it is possible to maintain the cycle of walking on irregular terrain.

III.   CONCEPTUAL DESIGN METHODOLOGY

To create the conceptual design of the prosthetic transtibial, a servomotor Dynamixel AX-12 is proposed as an actuator of a possible prototype to scale, since later it is intended to make a prototype of the prosthesis with a servo motor of the same line but that complies with the necessary torque requirements. In this way, since the Dynamixel engines retain the shape and change only the size, as the torque capacity increases, the proposed design will not change when the servo motor is scaled. The design starts with the motor support, to allow the coupling of the motor with a base as shown in Figure 3. This support will connect the part of the foot with the motor, and another will connect the motor to the part of the leg.
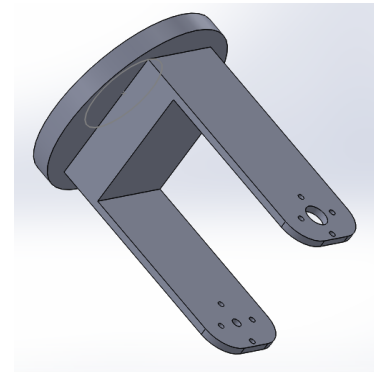

Figure 3. Support for motor coupling.

A. First Design

In the first design, a shock absorber was added as part of our connection of elements (leg), this shock absorber will help to absorb impacts; and an engine that allows the movements of dorsiflexion and plantarflexion, as shown in figure 4.

Figure 4. First prototype of prosthesis design.

However, this design does not give us the desired movements, which leads us to the second design of the prosthesis prototype.

B. Second Design

In the second design we decided to add two shock absorbers to obtain the movement of the frontal plane, that is, the eversion and inversion movement; and the motor was left to allow the movement of the sagittal plane, as we can see in figure 5.
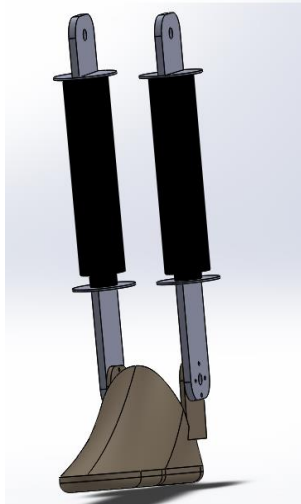
Figure 5. Second prototype of prosthesis design.

Even with the fact of with the help of the shock absorbers, it was sought to have the required movements; the design does not contain the necessary piece to allow the free movement of the frontal plane. So to improve the design we have to add a piece that allows such degrees of freedom and have the movements that we are looking for, which leads us to a third design.

C. Final Design

In the final design, a different support of figure 3 was added, this new support contains extra limbs, as shown in figure 6.
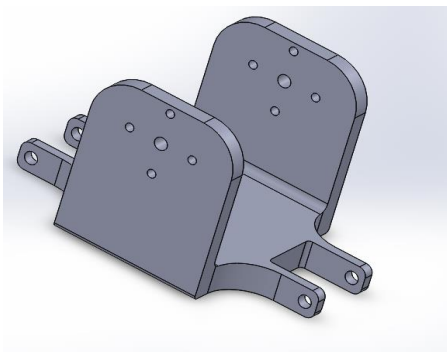
Figure 6. Support for the coupling of the third design.

With this new limb and with the help of a Hooke joint, the coupling between the motor, the foot, and the shock absorbers is achieved, as well as the coupling between the motor, the

connection element and the shock absorbers; which achieves the desired movement for the frontal plane, as we can see in figure 7.

Figure 7. Third prototype of prosthesis design.

IV.   CONCLUSIONS

With this new limb and with the help of a Hooke joint, the coupling between the motor, the foot, and the shock absorbers is achieved, as well as the coupling between the motor, the connection element and the shock absorbers; which achieves the desired movement for the frontal plane, as we can see in figure 7.
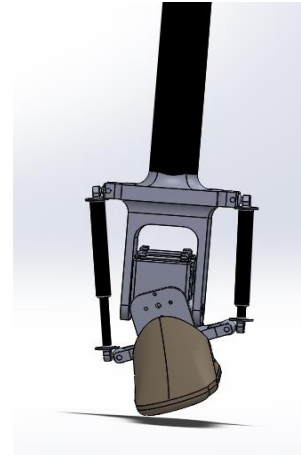
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Implementation of different position controllers for servo motors in a serial robot R||R

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Abstract — This paper presents the implementation of the PD, PD control with gravity compensation, PD control with desired gravity compensation and, PID controller in a planar serial robot of 2DoF using the Dynamixel AX-12. The experiments of the four controllers were realized interfacing the 2DoF system, an Arduino Mega 2560 board, and Matlab ©. The experimental results show that the controller based on the dynamic model of the system achieves the desired position without overshoot while controllers individually present overshoot. This suggests that control based on dynamic model improves the internal controller of the servo motors depending on the application and involves the complete robot model.

Keywords—Dynamixel AX-12; dynamics; controller; Arduino.

I. INTRODUCTION

Servo motors are rotary actuators often used in closed-loop control systems; consist of a motor with a sensor attached to the system for position feedback. These actuators have different components as CC motor, a gearbox, and a microcontroller; the last one regulates the position or velocity output of the system. Most of the time, sensors for position or velocity feedback are encoders.

Robots utilize these servo motors which use joint position as input to control the actuator output. As mentioned in [1] there are disadvantages for controllers that only relies on this type of input:

- The inner-controllers of the servo motor are not designed for acting as a whole system, controllers act individually for each servo motor, and this means the position only depends on the input no matter the location or position of the servo motor in the system.
- Position control of servo motor does not take care of external forces or distances between links, servos rely on the internal position of the control.
- Inverse dynamics control take into consideration constraints that may affect the system like the center of mass of links or torque limits that a position controller does not examine.

In [2], a multi-Dynamixel control to replace with conventional motor control it is applied to RX-28 servo motors for controlling a cockroach robot. The results show that Dynamixel servo motors have better performance than conventional motor control, but no dynamic model is applied.

The goal in [3] was to create a rehabilitation system composed with Dynamixel motors for a motion forearm supportive mechanism; the Dynamixel servos were used in wheel mode and a 1:3 gearbox ratio was added to increase torque. A PID controller was added to make the motor moves with the exact position in joint mode operation. Without PID controller, wheel mode cannot control the position of the supportive forearm mechanism as desired.

A simple torque to position conversion method was proposed in [1] for implementing torque control in position commanded servo motors. It was assumed that the internal operating controller of the Dynamixel RX-28 servos was P type. This method relies on the knowledge of internal controller of the servo motor, information about certain motor parameters that can be estimated but it may lead to degradation of performance, torque controller for high-velocity operations can produce constraints and the time delay estimation requires the joint acceleration which is difficult to obtain when the sensor data is corrupted with noise.

This study aims to apply the dynamic model of a 2DoF system to a position controller and compare the

error response of this system with the default controller used in AX-12 Dynamixel servo motors.

II. SYSTEM DESCRIPTION

In this section, the description of the system used is presented. First of all, the hardware used is described individually and finally the description of the complete system is made.

A. AX-12 Dynamixel servo motor

The Dynamixel AX-12 servo motor is a smart actuator system developed to be the exclusive connecting joints on a robot or mechanical structure. These servo motors are designed to be modular and daisy chained on any robot or mechanical design for powerful and flexible robotics movements. Consist of a DC motor, reduction gear head, controller, driver, and network.

The position of the AX-12 consists of 1024 steps in 300 degrees that gives a resolution of 0.29 degrees. Voltage operation from 9V to 12V. Speed of 1Mbps and a specific protocol communication. Each servo motor has its own ID and up to 254 Dynamixel actuators can communicate through the data bus.

Different parameters can be set in one instruction package; to control the Dynamixel actuators; the main controller needs to convert its UART signals to the half duplex type. To achieve this, an octal buffer/line driver 74LS241N was used with an Arduino Mega acting as main controller.

B. Arduino Mega 2560

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560 chip. This board was chosen due to its higher characteristics in flash memory, SRAM, and EEPROM, parameters needed to store variables.

The library used with the Arduino Mega 2560 is in [4], the initialization and use of this library is well documented and should not be problem. The Arduino Mega 2560 will storage the dynamic model of the system and some parameters like the error of the servo motors or the action of the controller.

C. 2 DOF robot

The 2 DOF robot arm is shown in figure 1. The values of the parameters are as shown in Table 1.
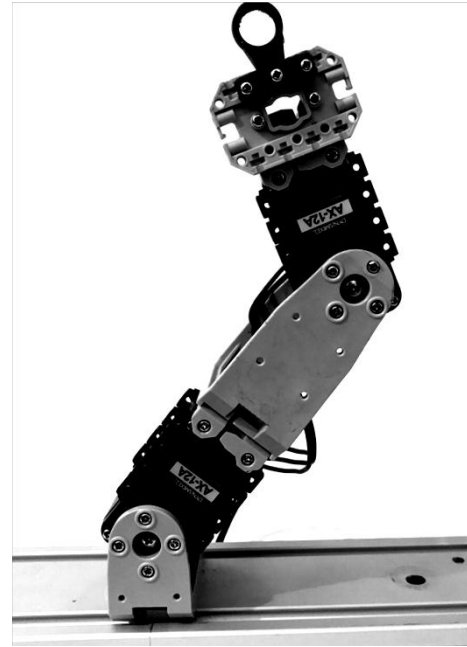

Figure 1. 2DoF robot arm

Table. 1 Robot Parameters

Element	Notation	Value
Length of link 1	l_1	0.093 m
Length of link 2	l_2	0.073 m
Distance to the center of mass link 1	l_{c1}	0.0326 m
Distance to the center of mass link 2	l_{c2}	0.0126 m
Mass of link 1	m_1	0.065 kg
Mass of link 2	m_2	0.055 kg
Inertial rel. to the center of mass link 1	I_1	0.0113 kg.m^2
Inertial rel. to the center of mass link 2	I_2	0.00116 kg.m^2
Gravity acceleration	g	9.810 m/sec^2

The Table 1 defines all the values needed for the control system; some parameters are obtained by measuring the robot, others by datasheets.

D. PCB shield for Arduino communication

The communication speed of the Dynamixel is serial at 1MBps; to communicate the Arduino Mega 2560 with several Dynamixel servo motors an integrated circuit is needed. A 74LS241N tri-state buffer is used. The connections are shown in Figure 2.
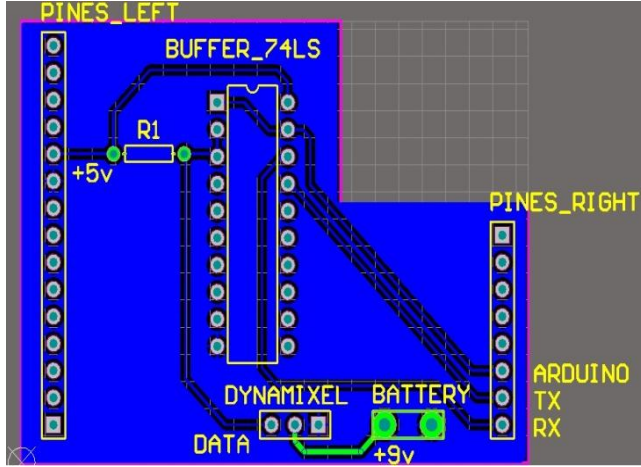

Figure 2. PCB Buffer

This PCB works as a shield mounted on top of the Arduino Mega 2560, the Arduino Mega powers the shield. Additional +9V power source is needed as a source for Dynamixel servo motors.

III. THEORETICAL FOUNDATIONS

In this section, the theoretical foundation for the implementation of the controllers of the 2 DoF serial robot based on the dynamic model will be shown.

A. Dynamic model of 2 DoF robot arm

According to the figure 1 the dynamic equations of 2 DOF serial robot are:

$$\tau_1 = [m_1l_{c1}^2 + m_2l_1^2 + m_2l_{c2}^2 + 2m_2l_1l_{c2}\cos(q_2) + I_1 + I_2]\ddot{q}_1$$
$$+[m_2l_{c2}^2 + m_2l_1l_{c2}\cos(q_2) + I_2]\ddot{q}_2 - 2m_2l_1l_{c2}\sin(q_2)\,\dot{q}_1\dot{q}_2$$
$$-m_2l_1l_{c2}\sin(q_2)\,\dot{q}_2^2 + [m_1l_{c1} + m_2l_1]\sin(q_1) +$$
$$+m_2l_{c2}g\,\sin(q_1 + q_2) \tag{1}$$

$$\tau_2 = [m_2l_{c2}^2 + m_2l_1l_{c2}\cos(q_2) + I_2]\ddot{q}_1 + [m_2l_{c2}^2 + I_1]\ddot{q}_2$$
$$+m_2l_1l_{c2}\sin(q_2)\dot{q}_1^2 + m_2l_{c2}g\,\sin(q_1 + q_2) \tag{2}$$

Where q_i are the joint positions of joint i for $i = 1, 2$; $\dot{q}_i$ are the joint velocities and, $\ddot{q}_i$ are the joint accelerations,

The compact form of the model is:

$$\begin{bmatrix} M_{11}(q) & M_{12}(q) \\ M_{21}(q) & M_{22}(q) \end{bmatrix}\ddot{q} + \begin{bmatrix} C_{11}(q,\dot{q}) & C_{12}(q,\dot{q}) \\ C_{21}(q,\dot{q}) & C_{22}(q,\dot{q}) \end{bmatrix}\dot{q} +$$
$$\begin{bmatrix} g_1(q) \\ g_2(q) \end{bmatrix} = \tau \tag{3}$$

Where

$$M_{11}(q) = m_1l_{c1}^2 + m_2l_1^2 + m_2l_{c2}^2 + 2m_2l_1l_{c2}\cos(q_2) \tag{4}$$
$$+ I_1 + I_2$$

$$M_{12}(q) = m_2l_{c2}^2 + m_2l_1l_{c2}\cos(q_2) + I_2 \tag{5}$$

$$M_{21}(q) = m_2l_{c2}^2 + m_2l_1l_{c2}\cos(q_2) + I_2 \tag{6}$$

$$M_{22}(q) = m_2l_{c2}^2 + I_2 \tag{7}$$

$$C_{11}(q,\dot{q}) = -m_2l_1l_{c2}\sin(q_2)\dot{q}_2 \tag{8}$$

$$C_{12}(q,\dot{q}) = -m_2l_1l_{c2}\sin(q_2)[\dot{q}_1 + \dot{q}_2] \tag{9}$$

$$C_{21}(q,\dot{q}) = m_2l_1l_{c2}\sin(q_2)\dot{q}_1 \tag{10}$$

$$C_{11}(q,\dot{q}) = 0 \tag{11}$$

Regarding state variables, the dynamic model is written as:

$$\frac{d}{dt}\begin{bmatrix} q_1 \\ q_2 \\ \dot{q}_1 \\ \dot{q}_2 \end{bmatrix} = \begin{bmatrix} \dot{q}_1 \\ \dot{q}_2 \\ M(q)^{-1}[\tau(t) - C(q,\dot{q})\dot{q} - g(q)] \end{bmatrix} \tag{12}$$

From equation 12 we obtain the accelerations for the robot, these accelerations are integrated by the Euler method to obtain velocity and, integrated a second time by the same method to obtain the position that will be sent to the servo motors.

The program in the Arduino Mega use variants of these equations for the implementation of the controllers. Every variant is shown.

B. PD controller

According to [6] the controller is defined as:

$$\frac{d}{dt}\begin{bmatrix} \tilde{q} \\ \dot{q} \end{bmatrix} = \begin{bmatrix} -\dot{q} \\ M(q)^{-1}[\,K_p\tilde{q} - K_p\dot{q} - C(q,\dot{q})\dot{q}\,] \end{bmatrix} \qquad (13)$$

The difference with other controllers is when calculating the torque for the servo motors; this controller does not take care of the gravity compensation, leaving the torque calculation in function of the joint error and the *th* joint velocity.

The PD controller calculates torque based on position error

$$\tilde{q}_n = q_{dn} - q_n \qquad (14)$$

Where q_d the vector of desired joint position is, q_n is the vector of joint positions; then, for this case, the velocity error is given by:

$$\dot{q}_n = -q_n \qquad (15)$$

C. PD control with gravity compensation.

The control law of this controller is given by:

$$\frac{d}{dt}\begin{bmatrix} \tilde{q} \\ \dot{q} \end{bmatrix} = \begin{bmatrix} -\dot{q} \\ M(q)^{-1}[\,K_p\tilde{q} - K_p\dot{q} - C(q,\dot{q})\dot{q} - g(q)\,] \end{bmatrix} \qquad (16)$$

The torque is defined with the joint position error, velocity error, and parameters of Table 1.

As the PD controller, the velocity error is defined by robot velocity due to the input velocity is zero for the constant position.

D. PD control with desired gravity compensation

PD controller with pre-calculated compensation also uses the values in Table 1, but the positions of each joint are obtained from the desired position and not from the actual position of the robot.

The difference with the PD controller with gravity compensation is the use of the desired position instead of the actual position of each joint.

E. PID controller

This controller uses q and multiplies it by a gain K_i obtain

the integral parameter of the controller, this value is called:

$$\dot{\varepsilon} = \tilde{q} \qquad (17)$$

The calculation of for this controller is obtained by the Euler integration method and the addition of epsilon for torque output is set.

IV. EXPERIMENTAL RESULTS

The servo motors have an inner-controller that receive a value between 0-1024 for the position and the servo motors moves to that value mapped from 0° to 300°. With this inner-controller the error graph is shown in figure 3.
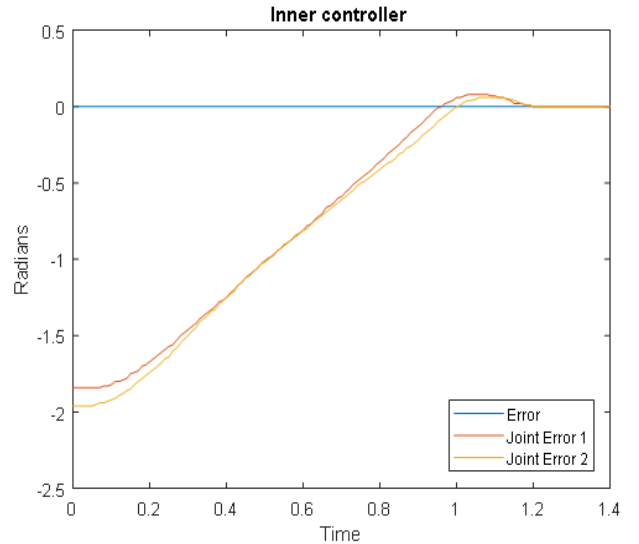

Figure 3. Zero error inner controller

After reaching the zero error point, the error presents an overshoot goes back to zero.

With the dynamic model of the 2DoF serial robot, the control flow program in the Arduino, after defining the desired position, is as follows:

- Read actual servo motor position (q_n)
- Calculate error position ($\tilde{q}_n$)
- Calculate gravity compensator (g_n)
- Read servo motor velocity ($\dot{q}_n$)
- Define gains of the controller K_p, K_i , K_v.
- Calculate the torque (τ_n).
- Calculate dynamic matrix of the serial robot (M_{mn})

- Use Euler method to obtain velocity and joint position ($\dot{q}_n$)
- Send position and velocity to the servo motor ($q_n, \dot{q}_n$)
- If the error is less than an adjustable acceptable error the program ends and prints vector error in serial port for exporting data.

The PD, PD control with gravity compensation, PD control with desired gravity compensation and, PID controller controllers were tested on the platform. The error graphs are shown in figure 4-7.

The gains K_p, K_i, K_v of each controller are the same and were selected based on the behavior of the system.

Some parameters were limited by programming to avoid internal damage in Dynamixel servo motors, for example, joint position and velocity.
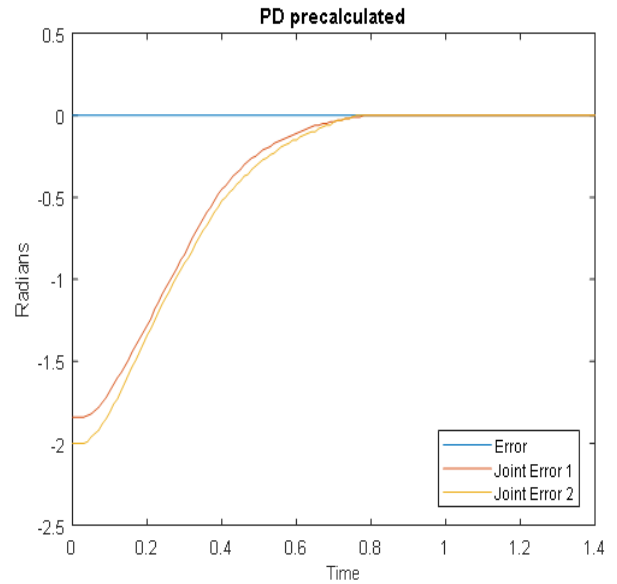

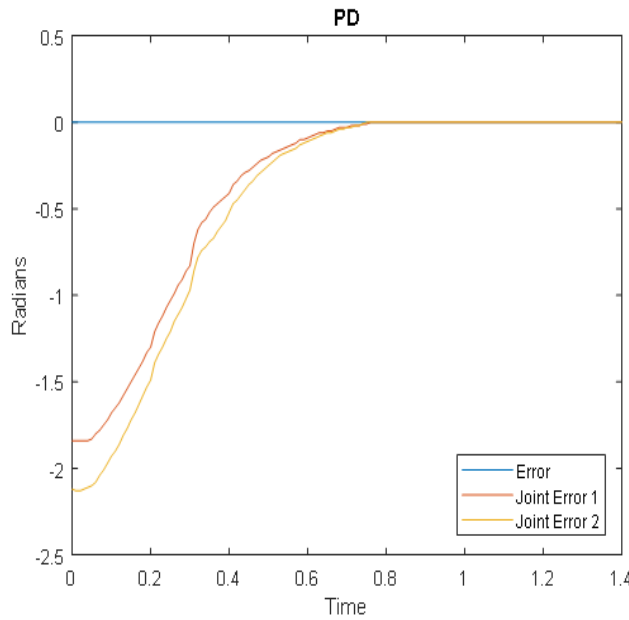
Figure 5. Zero error PD pre calculated
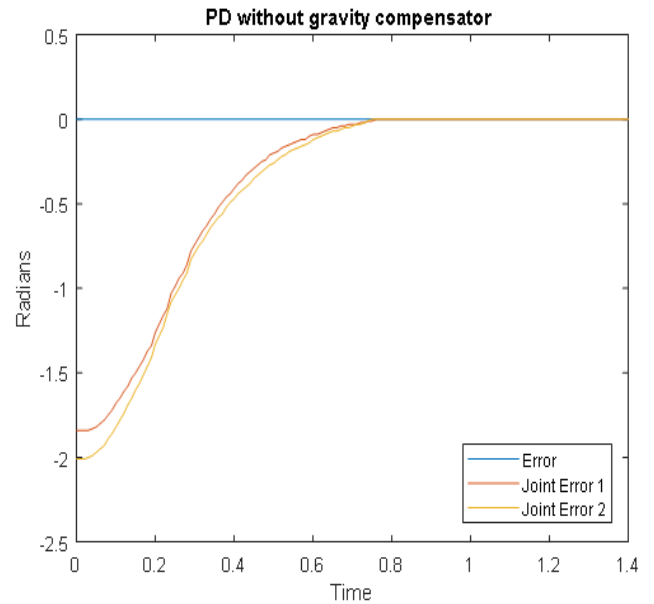

Figure 4. Zero error PD

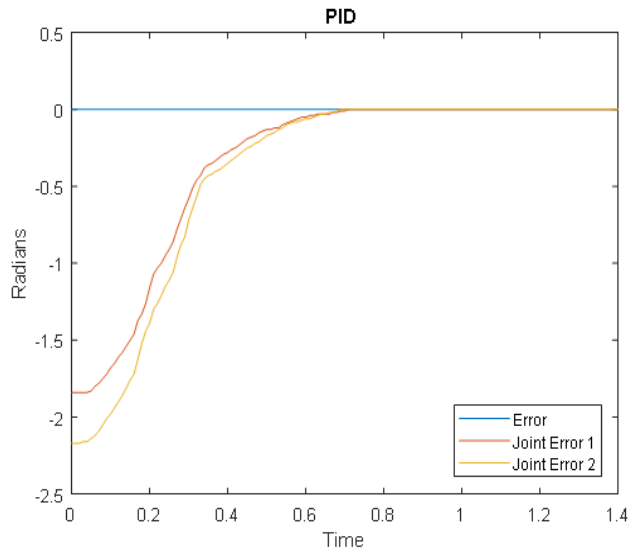*Figure 6. Zero error PD without gravity compensator*

Figure 7. Zero error PID

IV. CONCLUSION

The experimental results show that compared with default inner-controller of the Dynamixel servo motor (figure 3), the controllers programmed with the dynamic model have better response in time and without overshoot (figures 4 to 7).

In some cases even with a greater initial position, the controller was faster, reaching the zero error at 700ms average. Another factor to consider is the shape of the graph; can be seen, according with the shape, that PD pre calculated has a better form compared to the other controllers.

Varying the gains of the controllers helped to improve the response, but the model started to move unexpectedly and suddenly. These gains were proved to avoid this behavior.

The shield and the system can be used to prove different law controllers and gains, and it is an embedded solution, limited to transmit data over serial port.

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Evaluation of technological interactions of public space by the urban design sector in the state of Queretaro

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Abstract

The present complexity found in cities and particularly in their public spaces give a diversity of study elements. One of them, and perhaps the most recent one, is interaction with technology, which is becoming more and more frequent. In the case of Querétaro city, it is viable in the short term.

There are different types of propositions in diverse sectors that allow to develop designs that are applicable to cities, some of them having been done from the perspective of the users. Studying the actions made in interactions allows for feedback for future projects, as well as new vale propositions to be made.

Keywords—Interaction, Public Space, Qualitative, Strategies,

I. INTRODUCTION

The lack of sufficient methods and the complexity have made it difficult to understand cities and their public spaces (PS), which define the characteristics of a city. PS is a place used by anyone and which is accessible to everyone, it also allows for various activities and it is non-profit.

Additionally, it is important to understand that, by 2050, 75% of people will live in urban areas. For that reason, it is important to properly develop public spaces.

A PS can enable or disable an activity and it can stimulate the people. One of the features of the cities with the highest quality in PS is that they represent 50% of them, (35% being roads and 15% other).

Public spaces can be classified in at least three categories: multipurpose, open spaces and urban services. Within public spaces, there are icons and styles, which are adopted by urban cultures for their development and benefit.

A tool such as Placemaking is developed over design parameters that have to take into account few resources and fast executions, as well as manageable elements.

Another tool is interactive design, which uses five basic elements: word use, visuals, objects/space, time, and behavior. The tool has three principles: it is easy to predict; it is easy to learn; and it is easy to use.

New or modified spaces require certain attractive features capable of generating interactions that lead to positive experiences.
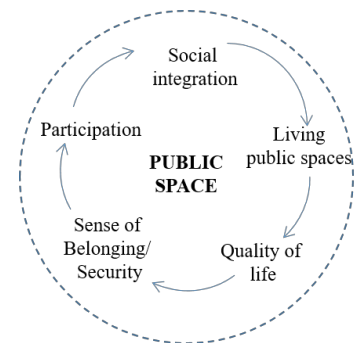
Figure 1 Public spaces cycles, with information of Clos, J

One of those features is technology, which can be high-tech or low-tech, they should provide resources that benefit society. Another feature of these public spaces is to establish relationships with people through design procedures, taking into account the people and their emotions.

II. METHODOLOGY

Nine different technological interactions that corresponded to different public spaces were analyzed using focus groups for someone specialized in design and development of public spaces. In this case, the Departamento del Diseño Urbano, a part of the Secretaría de Desarrollo Urbano y Obras Públicas (SDUOP) del Poder Ejecutivo del Estado de Querétaro was contacted.

Once the link was established with DUD, the study on foreign cases of the IPS, conducted in previous years, was conducted. These projects were easily visualized in a video format, which made it easy to understand the relevant data.
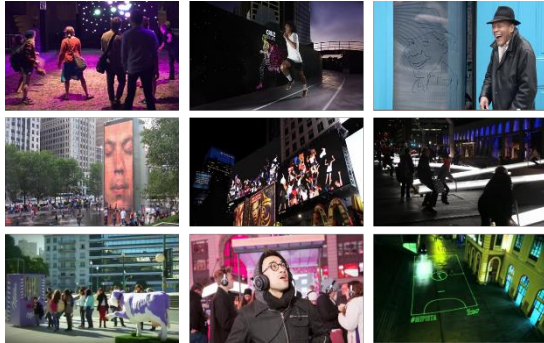

Figure 2 Screenshots of different examples of interactions in public space

In order to understand the interactions and their relationship with the people, as well as their relationship with the design procedure, said interactions were studied with some tools such as Human-Centered Design (HCD).

Below is a list of cases and countries that were presented in the focus group: Case 1 (C1) 'Encounters' in Australia, case 2 (C2) 'NIKE's unlimited stadium' in The Philippines, case 3 (C3) 'In Paris have doors to other European cities' in France, case 4 (C4) 'The Crown Fountain' in the USA, case 5 (C5) 'Storming time square' in the USA, case 6 (C6) 'Impulse' in Canada, case 7 (C7) 'Cadena de ternura' in Argentina, case 8 (C8) 'Jungle-ized' in the USA and case 9 (C9) '#MiPista' in Spain.

At the beginning of the focus group, there was an open discussion regarding the elements and variables that the participants considered to be present in the different interactions. It is worth noting that only the audiovisual materials were considered. This discussion allowed an opening and to visualize partial analyses.

To give continuity to the focus group, there were a series of questions, as shown in table 1, for the participants to answer. The questions were multiple-choice in a Likert scale. The possible answers were the following: Completely disagree (1), Partially disagree (2), Neither agree nor disagree (3), Agree (4) and Completely agree (5). They were used to evaluate the level or degree of the interaction for each question.

Question	#
Were the users taken into account as a starting point for the interaction design within the PS?	P1
Were emotions taken into account for the execution of the interaction?	P2
Was a link to the users established?	P3
Does the interaction present a light, fast and economic focus?	P4
Does it have interaction elements (objects/space, time and behavior)?	P5
Is the interaction predictable, easy to learn and easy to use?	P6
Is it taking into account low-tech?	P7
Does the use of technology lead to resources that benefit society?	P8

Figure 3 Table of questions applied

A survey was conducted with each of the ten participants of DUD, considering each of the nine cases mentioned previously.

III. DISCUSSION OF RESULTS

The results of the previous questions regarding the different interactions give significant data that were evaluated from the perspective of the designer of DUD.

Below is a table with the result values of each case presented. It is generated from the mean of the answers to the questions of each person surveyed, the greatest grade being 5. Its percentage value is next to it.

Example	Mean	Percentage
C1	3.85	77.0%
C2	4.01	80.3%
C3	4.25	85.3%
C4	4.25	85.0%
C5	3.10	62.0%
C6	3.98	79.5%
C7	4.46	89.3%
C8	3.66	73.3%
C9	3.98	79.5%

The results of the focus group were put together with the study of each of the eight questions posed by designers. Taking into account the mean of each question within the study cases, the results are shown in the table below.

Figure 4 Table of data of averages and percentages of different examples of interactions

C7 has the highest value and C5 the lowest one. The differences between both cases are evident as they are elements developed in different places and different foci. Nevertheless, after analyzing the comparison, it is apparent that the former goes for a direct interaction among the users, while the later does that indirectly. C7 uses technology as support for interaction, while C5 does that directly through such technology. The answer given by the people of the first interaction is the result on the whole, including context, while C5 is done individually (context is optional).

In Depth analysis, the highest value within C7 came from question P6 with a score of 4.7 out of 5.0. That question allowed the user to understand what happens in the interaction (in other words, the interaction gave a clear message). The lowest value within the same case came from question P5, possibly because it lacked the necessary elements. However, the result value can be considered to be positive at 4.0 out of 5.0.

Question	Mean	Percentage
P1	4.31	86.2%
P2	4.07	81.3%
P3	4.11	82.2%
P4	3.94	78.9%
P5	3.74	74.9%
P6	3.91	78.2%
P7	3.39	67.8%
P8	4.12	82.4%

Figure 6 Table of data of averages and percentages of different questions applied by total

The question with the lowest value was P7, which is no resented as a constant in the interactive exercises studied. Nevertheless, one must consider that low-tech, mentioned in P7 can give benefits in its use, such as allowing easy adaptation of the interaction to the context or a great range of usefulness regarding the people. Also, one can consider that with complex technological elements, the interactions carried out may present difficulties in accomplishment or to be executed as unique elements.
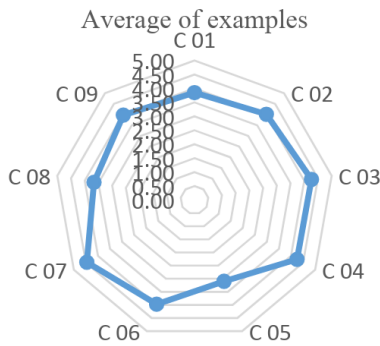

Figure 5 Graphical of average of examples

In C5, the highest value was found in the item P3. This lets determine the efficiency of creating a link to the users. However, it can denote a certain level of individual actions during the interaction. This is because the result values got a 3.9 out of 5.0. The lowest value for the case was found in P7, being a 2.0 out of 5.0. Perhaps this result appears to be evident by the very nature of the question and the type of interaction.

Nevertheless, although the value of P7 will significantly increase, the overall value of C5 will continue to the lowest one. That leads to the assumption that it is not a punctual grade that affects the case, but the overall amount of obtained values for the interaction mentioned. It can be inferred that, in those cases where technology is prevailing and the user is not, the interactions may be unfavorable.
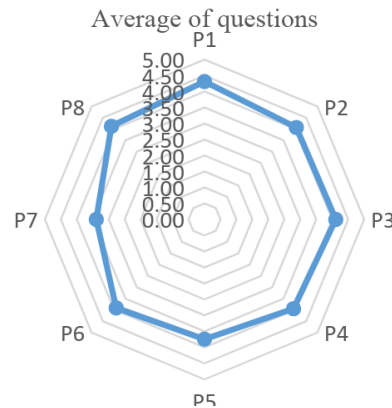

Figure 7 Graphical of averages and percentages of different questions applied by total

The results obtained from the study cases and the questions help in the analysis of items. They also help to establish mainly qualitative elements in the development of applicable interactions in future ones. Obviously, it is

necessary to consider their nature and objectives, as well as the user within design procedures. Also, they help to both establish evaluation tools in similar design sectors and allow create strategies to make technological interactions in different PS.

IV. CONCLUSIONS

With the different elements found in the cities, as well as the constant change within in favour of their own development, the study of the components of a city is a task with multiple variables. Establishing success routes from notable projects may allow for the creation of new strategies that include a constant feedback, while at the same time allowing a link to the users, a link to the place of execution, a type of pertinent technology and the correct execution to reach the planed objectives.

It is understandable that subjectivity represents a relevant factor in the qualitative validations. However, the media that allow the comprehension of interaction will not only guarantee the execution, but also gather data for their study and implementation in future actions. Future jobs in diverse technological interactive design areas for public spaces will have to comprehend the relationship between their factors, planed or otherwise.

A city's, or its components' design must not be exclusive to a sector, but inclusive. The relationship it has with its users must not be forgotten either because in it lies mainly a generator of interaction values.

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Retrieval of materials in civil construction for its reuse in creating new construction materials.

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Abstract — **In recent years, a whole recycling and non-pollution movement has established in almost every country in the world. Each day, it's more evident that the planet is being polluted by different situations, like garbage, industries, water contamination, CO2 emissions and the amount of people living in cities that everyday increase. Although it's not very common to listen about polluting structures, it is a problem that increases world pollution. Producing construction materials such as steel, blocks and concrete requires a big amount of energy and many times the structures built with these end up with no use and even sometimes demolished. It is estimated that 80% of the energy required to produce these materials is consumed in the production and transportation. This project looks forward to recycle construction materials, such as steel, concrete, filling, brick and some other common materials used in residential, commercial and public structures. Through the analysis of the elements of a house plan, we could determine which elements could be reused or recycled in the supposed situation of a demolition or not use of the house at all. This analysis was based on Mexican norm NADF-007-RNAT-2004. As a result, approximately 25% of the materials used in a house or facility can be reused. Specifically, concrete, compression layer, red brick, steel, filling and lime.**

Keywords — **Construction materials, recycling, retrieval, pollution, demolition, sustainable, optimization.**

I. INTRODUCTION

In recent years, an increasing amount of CO2 levels has been registered and a high pollution index in all of the world. This situation is due to different factors and situations such as the increasing number of population, water contamination, aquifer exploitation, garbage accumulation through years, unlimited water usage, CO2 emissions and industrial waste thrown into rivers and sea, provoking earth's deterioration and a pollution increase that has never been seen. Anyway, we can number a lot of factors affecting the planet but definitely CO2 emissions are the most determinant. These emissions affect directly to earth's deterioration and unfortunately it is a situation that hasn't been able to control. Figure 1 shows the increment of CO2 emissions through years. This graph was made by "The 2 Degrees Institute", one of the most important organizations regarding environmental recovery.
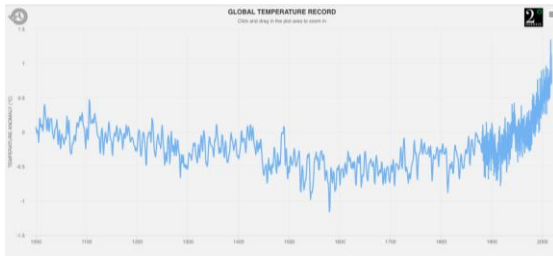
CONCYTEQ

CONACYT
Consejo Nacional de Ciencia y Tecnología

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XIV CONGRESO INTERNACIONAL
DE INGENIERÍA

Fig. 1
Annual CO2 register measured by "The 2 Degrees Institute".
[14].

Figure 1 shows CO2 levels have increased every year since 1990, which is an alarming situation. In all the factors mentioned before, there is one that produces a lot of polluting emissions; construction materials fabrication. These materials are extremely important to society, because they are necessary to build structures and they are used everyday to develop infrastructure in every part of the world. It is estimated that 80% of the energy used to produce a civil construction is used in the production and transportation of materials. The 20% is attributed to construction processes and workforce. Some of the materials that are considered (according to the European Waste Catalogue), C&D (Construction & Demolition) wastes are classified as:

• Concrete, bricks, tiles and ceramics.
• Wood, glass and plastic.
• Bituminous mixtures, coal tar and tarred products.
• Metals.
• Soil (including soil excavated from contaminated sites), stones and dredging spoil.
• Insulation materials and asbestos-containing construction materials.
• Gypsum-based construction material.

It is important to mention that reinforced concrete made buildings have an estimated lifetime and in many occasions when they reach this lifetime they are demolished to build a new structure or use the space. Every construction phase of a building generates waste, this is inevitable. The point is recycling this materials so they can be used more times or use them to create a new material. The intention is to use as much material possible to avoid it going to waste and therefore increasing pollution. The following graph shows the percentage of material that is being recycled by different European countries:

TABLE 1. RECYCLED MATERIALS IN EUROPE

	Amount of recycled materials		
	Country	Tons of material (million tons)	Percentage (%)
1	Austria	6.6	60
2	Belgium	11.02	68
3	Denmark	5.27	94
4	Estonia	1.51	92
5	France	85.65	14
6	Germany	72.4	86
7	Netherlands	23.9	98
8	Poland	38.19	28
9	Portugal	11.42	5
10	Slovenia	2	53
11	Spain	31.34	14
12	UK	99.1	75

(European Waste catalogue - 2011)

Table 1 shows that some countries like Poland and Denmark are recycling more than 90% of material waste, reducing drastically the pollution. Also recovering millions of euros that would have otherwise gone to waste.

The Concrete waste can go through a trituration process, which can be used to make more concrete structures. Or even plastic waste can be used to make pet bricks. We can analyze all constructions, and theoretically review how much material could be recycled if the construction were to be demolished according to regulations from each country. Economically we can review the profit from recycling as much material as possible. Environmentally we can review the amount of waste reduction. We will review the different processes that the materials have to go through and analyze how much material can be recovered from demolished buildings.

II. THEORETICAL CONSIDERATIONS

The minimum size for the recycled coarse aggregate is of 4.75mm (mesh #4). The content of particles that pass the mesh #4 should not be higher than 5%. The content of lumps of clay in the recycled coarse aggregate should not be higher than 0.6% and in the natural coarse aggregate to 0.15%. In the recycled concrete with content of recycled coarse aggregate lower than 20%, the absorption of this aggregate needs to be lower than 7%, in addition, the absorption of the natural coarse aggregate needs to be lower than 4.5%. For the weathering resistance of the gravel the requirement applied for the natural aggregates maintains: Coefficient not gather than 40% in resistance to degradation (Los Angeles Machine).

According to the norm "NORMA AMBIENTAL PARA EL DISTRITO FEDERAL NADF-007-RNAT-2004" at least 25% of the virgin materials must be replaced by recycled materials.

TABLE 2 PROPOSED USES OF CONSTRUCTION AND DEMOLITION WASTE MADE BY THE CMIC.

	Recycled Materials Classification		
	Residue	*Recycled Material*	*Application*
1	Mixed rubble from concrete and mortar.	Recycled aggregate	Hydraulic bases on roads and parking lots.
2	Milling of asphalt binders	Asphalt material mixtures	Asphaltic or black bases. Hot, temperate and cold asphalts Highways.
3	Mixed rubble	Solid material.	Solid material.
4	Mixed rubble	Recycled sand	landfills, substitute for tepetate. Manufacture of blocks, partitions, adocretos, adopastos, tiles, poles, curbs, linings.
5	Mixed rubble	Fine aggregates	Walkers and bike path
6	Mixed rubble	Recycled aggregates	Pipe beds, ribs and filling. Filling of foundations Pedraplenes Fillings of roofs and planters. Conformation of land
7	Concrete waste	Recycled gravel and sand	Sidewalks Concrete Construction of walls
8	Hydraulic concrete	Recycled in cold	Black and hydraulic base.

Classification of recycled materials by CMIC.

Table 2 gives us information about types of residues and what type of material they are. Then each material has some examples in the construction field in which we can use those recycled materials we extracted.

TABLE 3 DEMOLITION ELEMENTS

	Demolition elements		
Activity	*Object*	*Principal components*	*Observations*

Demolition	Household	Old: masonry, brick, wood, plaster, tiles.	The materials depend on the age of the building and the concrete use of it in the case of services.
	Other buildings	Recent: brick, concrete, iron, steel, metals and plastics.	
	Public Work	Industrial: concrete, steel, brick, masonry.	
		Services: Concrete, brick, masonry, iron, wood.	

Table 3 shows in specific constructions like which are the main materials we can extract to recycle. It is very important that that person who is in charge of the demolition observe the age of those material so to be sure how possible would it be to recycle them.

III. METHODOLOGY AND RESULTS

By using the architectural plan of a common house, the amount of materials used to make slabs and walls was analyzed and accounted. This in order to analyze according to the country in subject (Mexico) and its norms and regulations regarding recycled materials, to account how much material can be retrieved if this house were to be demolished. Everything based on the theoretical considerations detailed before, the total weight of materials recycled is analyzed, to list the environmental benefits of this practice. The ideal demolish process is considered for the results.
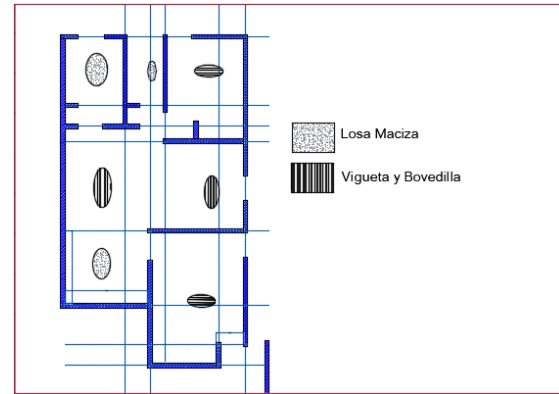

Fig 2, Slab and joist vault plan

Figure 2 shows the slab and joist plan for the common house which is being analyzed. It uses the architectural plan and it clearly shows the the distribution of slab and joist. In the following table, materials are quantified by thickness and weight.

Tables 4 and 5 show specifically all the components of a slab. Then gives us how much does it weights and loads that this types of slabs will present

TABLE 4. MATERIALS BREAK DOWN FOR JOIST AND VAULT

Joist and vault			
Material	Thickness (m)	Volumetric weight kg/m3	W kg/m2
Waterproofing	0	0	0
Concrete	0.03	2400	72
Vault 90-20-13			90
Mallarmex	0.004	1.32	0.00528
Filling	0.04	1200	48
Steel Rod 3/8	0.0095	7800	74.1
Lime caulking	0.01	1100	11
Additional dead load	By concrete		20
	By mortar		20
Total Dead Load			335.105
Live Load (rooftop)			100
Total Load in the slab			435.105

Joist and Vault Materials breakdown in the plant.

Fig. 3 Joist and Vault

Fig. 4 Solid Slab

Solid slab profile plan is shown in figure 4. From this figure the break down of materials for table 5 can be more clearly analyzed.
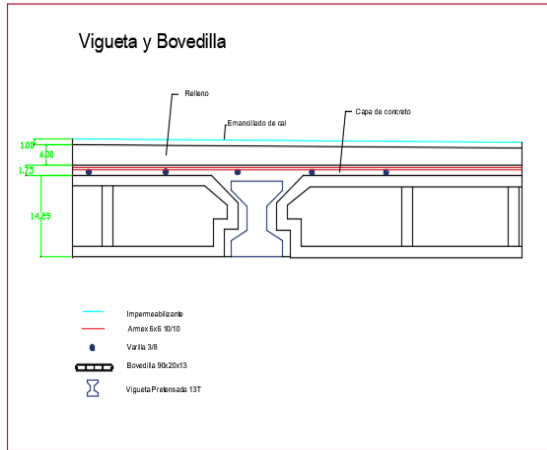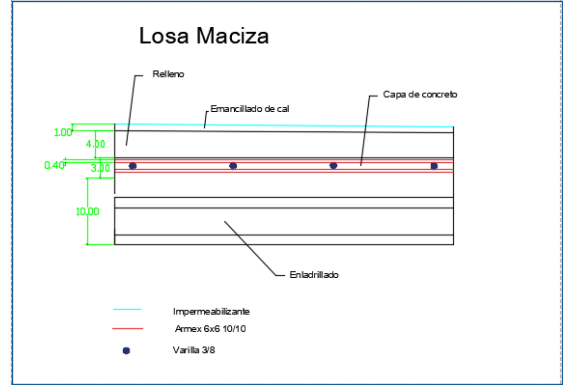
Figure 3 shows the joist and vault profile plan. Lengths taken by the waterproofing, and other materials can be analyzed from the figure. Following table shows the break down for solid slab. Break down from table 4 corresponds to Figure 3.

A. Architectural plant

The architectural design of a home is defined by: dimensions, characteristics and spaces, all of this to make a clear and specific project. The dimensions of the house are the following:

The top floor has the following chambers:

a) Principal chamber (4 m x 4.5 m)
b) Service chamber (4 m x 3.5 m)
c) Full bathroom (1.35 m x 3m)
d) Kitchen (2.15 m x 3 m)
e) Living room (3 m x 2.50 m)
f) Dinning room (3 m x 3.50 m)
g) Garage (5.50 m x 3 m)
h) TV room (4 m x 3m)
i) Yard 5.50 m x 7 m
j) Garden 4.20 m x 4 m

The total ground area is 140 m^2. The construction area is 52.32 m^2.

B. Materials description

Definition of the different materials which are used in the construction of a house:

● Vault

Vaulted space which is used to cover the gap between two beams, reducing the forged weight. It may be formed by timber, bricks, etc. It's application is fast and easy.

● Welded mesh

Steel network of small diameter, which contact points are united by electric welds, each side is used as a reinforcement armed of steel rod and it is put above the rod, in the case of solid slabs. It absorbs the contraction and temperature efforts por slabs with big surfaces.

TABLE 5. MATERIALS BREAK DOWN FOR SOLID SLAB

Solid slab			
Material	*Thickness (m)*	*Volumetric weight kg/m3*	*W kg/m2*
Waterproofing	0	0	0
Concrete	0.03	2400	72
Compression layer	0.03	2400	72
Red brick 7x14x28	0.1	1600	160
Mallarmex	0.008	1.32	0.01056
Filling	0.04	1200	48
Lime caulking	0.01	1100	11
Additional dead load	By concrete		20
	By mortar		20
Total dead weight			403.01
Live load (rooftop)			100
Total load in the slab			503.01

Solid Slab breakdown in the plant.

Material	Thickness (m)	Volumetric weight (kg/m3)	W (kg/m2)
Mortar	0.02	1500	30
Red annealed partition 7x14x24	0.14	1500	210
cast	0.015	1500	23
		Dead load	263

- Prestressed joist

Annealed mud, without presenting any imperfections.

- Mixtures

Also known as mortars, are made of pebble materials (sand and gravel), binders and water. It is used to bound pre made or natural materials.

- Wire

Also called steel reinforcement, it is principally used to take diagonal tension efforts. It is made from steel fy=2320 kg/cm^2.

- Concrete

Sole material which has its resistance rise within time, as long as the humidity process after its fabrication is correctly made. If the concrete dries the chemical reactions in its interior will stop, and these are the ones responsible for the increase in the resistance. This material is made from cement, pebble materials (sand and gravel), water and additives for different specifications.
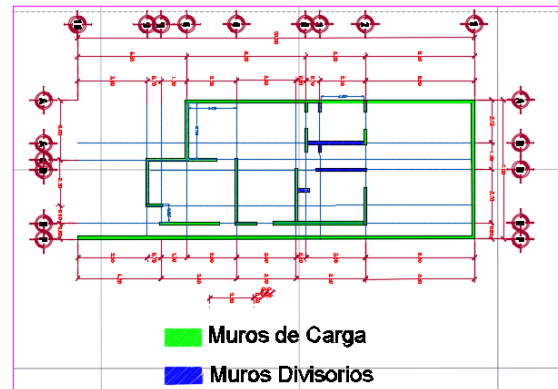

Fig 5.   Load division walls

C. Results

Tables 6, 7, 8 and 9 shows us the parts of some walls the thickness of each layer and the weight of every component and finally the load that it has

TABLE 6.   BATHROOM WALL (DIVIDER)

Material	Thickness (m)	Volumetric weight (kg/m3)	W (kg/m2)
Tile	-	-	15
Mortar	0.03	2100	63
Red annealed partition 7x14x24	0.14	1500	210
Mortar	0.02	1500	30
		Dead load	318

TABLE 7.   LOADING WALL

TABLE 8. HOUSE'S MATERIAL AMOUNT

Total material amount		
Material	Volumetric weight (kg/m3)	W (kg/m2)
Concrete	4800	148
Compression layer	2400	72
Red brick (7x14x28)	1600	160
Mallarmex	2.64	0.01584
Filling	2400	96
Lime caulking	2200	22

Total amount of materials from plant.

According to the norms and specifications of "NORMA AMBIENTAL PARA EL DISTRITO FEDERAL NADF-007-RNAT-2004", we could come up to results that express how much material can be recycled from a demolition or a non-used facility. Some of the materials shown in the next table would have to pass through a trituration process in order to reuse them. They are marked with a "*".

TABLE 9. HOUSE'S MATERIAL RECYCLED AMOUNT

Total recycled material		
Material	*Volumetric weight (kg/m3)*	*W (kg/m2)*
Concrete*	*1200*	*37*
Compression layer	*600*	*18*
Red brick (7x14x28)	*400*	*40*
Mallarmex	*.66*	*0.00396*
Filling	*600*	*24*
Lime caulking	*550*	*5.5*

IV. CONCLUSIONS

Since current norms referring to materials that can be retrieved from demolitions for recycling are not clear (in Mexico) we conclude that the total of amount of material which can be recycled is totally dependent from the demolition process as well to the retrieval process. We know that all retrieved materials must go through certain processes and treatments for their further use, which is mostly as a concrete aggregate after trituration. The lack of regulations in the country is impressing. The is an urgent need for regulations and specifications, for this will increase the use of recycled materials, which have a direct impact in the environment and in the economy. In the results it can be clearly seen the total amount of different materials, which with the correct process and retrieval can be used as recycled materials instead of going to waste.

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Parameters of crispness in a breakfast cereal enriched with nopal powdered

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Abstract— **Different studies mention the incorporation of nopal powdered to different food products, to integrate this ingredient the texture changes. The crispness in cereals for breakfast is one of the important attributes to be considered by consumers, an essential property in the quality of the breakfast cereals, which is lost when exceed the 15% humidity. In the present study compared a formula of cereal for breakfast of amaranth with nopal, in relation to 2.3:1 respectively, against a control sample of trademark. It was found that the quality parameters analyzed are the same for both samples, so that this type of food accepts a higher percentage of nopal powder without changing the quality standards for the texture in a cereal for breakfast.**

Keywords—Crispy, Nopal, breakfast cereal, texture, moisture.

I. INTRODUCTION

Different studies mention the incorporation of nopal powdered to different products such as bread, soups, pies and puddings, which have been able to add in different percentages ranging from 16% to 5%, since adding more nopal texture of the food changes, resulting in unpleasant [1][2].

It is common knowledge that the texture plays an important role, as this affects the sensory quality in terms of food [3]. The crispy in breakfast cereals is one of the important attributes to be considered by consumers.

The analysis of texture of foods are made with various tests, such as the compression, the penetration and the bending of three points, and the graphs of displacement of force resulting. The analysis of the data was considered in the first place in terms of rheological parameters [4].

The property of the crispy texture is also associated with other physico-chemical parameters, one of these is that the moisture remains below 15% to ensure a satisfactory quality [5].

The objective of this work is to evaluate the crunchiness of an amaranth breakfast cereal, enriched with dehydrated nopal pads, in a ratio of 2.3: 1 respectively, compared to a branded breakfast cereal already established in the market, taking into account the moisture as parameters of quality in the texture of the same.

II. MATERIALS AND METHOD

A. Biological Material

It was used Nopal pads (Opuntia Ficus Indica) powdered which was acquired in Silao, Guanajuato.

The amaranth used was purchased in whole grain and toasty, also used a control sample, of a trademark with oatmeal whole grain and whole wheat flour, which were bought in a self-service store in the city of Querétaro.

B. Texture Analysis

The texture analysis was done in a texturometer TA Plus Lloyd Instruments An AMETEK Company, together with the NEXYGEN Plus program, a compression force of 1mm to 15mm before and after, at a distance of 5mm, with an angle of 45°, 15 repetitions was done to the test. For the test of crispy the number of peaks was takin into account and in the case of hardness data were reported in newtons (N).

C. Moisture

The analysis was done based on the AOAC method 925.09 of 2002 [6]. It was used 2g of each sample. Were placed in an oven at 110°C for 2 hours. Subsequently took the samples to a desiccator, record the weight. The entire procedure was performed in triplicate. The percentage of moisture was obtained using the equation 1.

$$\% \, Moisture = \left[\frac{initial \; weight \; of \; the \; sample - final \; weight \; of \; the \; sample}{initial \; weight \; of \; the \; sample} \right] x100$$

D. Statistical analysis

The statistical analysis was done with the program Statgraphics Centurion XVI, an ANOVA test was applied to compare with a commercial product used as a control sample, with a confidence level of 95%, in case of statistical difference

found, the Tukey test was applied to determine in sampling differences.

III. RESULTS AND DISCUSSION

No statistically significant differences were found in any of the three parameters assessed and described in the methodology, in Table 1 is the average of the number of peaks, newtons and humidity, both for the formula developed as of the control sample.

TABLE I.   AVERAGE FOR NUMBER OF PEAKS, NEWTONS AND MOISTURE

Samples	Parameters		
	Number of peaks	*Newtons*	*Moisture*
A-03	4.93± 1.48	32.02± 6.04	5.19± 0.54
CN-01	4.53± 1.59	27.96± 11.41	4.70± 0.15

A-03 corresponds to the formula 2.3:1 and CN-01 corresponds to the control sample.

The total number of peaks is a main parameter that identifies the crispness [7]. Both samples have similar number of peaks, this fact indicate that the prototype of cereal developed is comparable with the commercial sample.

However, the hardness is a bit higher than expected, since the foods that are considered crispy must fracture at a lower hardness [8], this could be due to the amount of fiber that samples of prototype contain, the nopal powdered contains 60% insoluble fiber and 25% soluble fiber [9] and the sample control declares, in its nutritional information, 9g of dietary fiber per 100g of product.

On the other hand, the percentage of moisture remained below 7%, which ensures the crispness texture because above of this percentage begins to lose the crunchy texture [10].

IV. CONCLUSION

It is possible to enrich a food, such as breakfast cereal, with a high percentage of nopal powdered, this food to be of low moisture content agree better the amount of fiber that contains the nopal, so their physical quality characteristics do not change compared to branded breakfast cereal.

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