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The works must be unpublished and refer to topics of Engineering, Chemical, Optical, Resources, Food technology, Anatomy, Nutrition and other topics related to Medicine and Health Sciences.

Presentation of the Content

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Biosolid quality evaluated by its stability (FDA, CO_2) and maturity (GI)

Calidad de un biosólido evaluada por su estabilidad (DAF, CO_2) y madurez (GI)

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Abstract

The aims of the work were: i) to obtain a biosolid of good quality with desirable characteristics of stability and maturity; ii) provide alternative use of sewage sludge mixed with sawdust and contribute to reduce the environmental impact generated by the inadequate disposal of these wastes. In an open pile system with turning (daily), sewage sludge was mixed with sawdust (1:1) keeping the humidity between 50-60%; after 42 days the biosolid was obtained and the stability and maturity was evaluated by means of the enzymatic assay with fluorescein diacetate, the static respirometry and the germination index. Based on the results and Mexican regulations, biosolid quality is of type A and excellent class. In addition, by stability and maturity tests, it is classified as Very stable. The contribution of the work is to present a stable and mature biosolid, which can be used in agriculture as a soil improver, or alternatively, to prove it as an attenuator in soils contaminated with agrochemicals. On the other hand, present the alternative to reduce the amount of waste generated, eliminate them properly and reduce the environmental impact and human health.

Sewage sludge, Sawdust, Compost

Resumen

Los objetivos del trabajo fueron: i) obtener un biosólido de buena calidad con las características deseables de estabilidad y madurez; ii) presentar una alternativa de uso de los lodos sewagees mezclado con el serrín, y contribuir a disminuir el impacto ambiental generado por la inadecuada disposición de dichos residuos. En un sistema abierto en pila con volteo diario, se mezcló el lodo sewage con serrín (1:1) manteniendo la humedad entre el 50-60 %; transcurridos 42 días se obtuvo el biosólido y se evaluó la estabilidad y madurez mediante el ensayo enzimático con diacetato de fluoresceína, la respirometría estática, y el índice de germinación. Con base en los resultados y la normatividad mexicana, la calidad del biosólido es de tipo A y clase Excelente. Además, por las pruebas de estabilidad y madurez, es clasificado como Muy estable. La contribución del trabajo es presentar un biosólido estable y maduro, el cual puede ser utilizado en la agricultura, como mejorador de suelo, o bien, probarlo como atenuador en suelo contaminado con agroquímicos. Por otro parte, presentar la alternativa para disminuir la cantidad de residuos generada, su adecuada disposición y aminorar el impacto al ambiente y a la salud humana.

Lodo sewage, Serrín, Compost

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Introduction

The generation of wastewater as a product of human activities is increasing rapidly, and worldwide sanitation and water treatment works are carried out for this type of water. The wastewater treatment is a process by which its characteristics are modified, with the aim of giving it a later use; according to Salgot and Folch (2018), the main use of this water is in agriculture (irrigation), urban use (not for drinking), in industry (cooling, cleaning, in processes), recovery of water bodies (increase in the volume of water) recharging aquifers, drinking water (direct use or for drinking) and in recreational areas (golf courses, parks, swimming pools).

During the wastewater treatment train, solid waste called sewage sludge is generated and accumulated, which in most cases is deposited in open dumps, causing public health and environmental problems, contaminating soil, water and air. To overcome this concern, effective management strategies must be adopted for the disposal of sludge from a wastewater treatment plant (WWTP); among the management options, composting is gaining great popularity due to the benefits that are obtained as: the sanitation of waste (reduction of pathogens), profitability and the conversion of waste to a value-added product, known as biosolids (Amuda et al., 2008).

Composting is defined as an aerobic digestion, it is a heterogeneous biochemical process that involves the mineralization of organic matter, its transformation into CO_2, NH_3, H_2O, and in incomplete humification; the result is a stabilized and mature final product with less toxicity and pathogenic organisms than the original material (Das et al., 2011). The decomposition process occurs under aerobic conditions in the presence of a substrate and is influenced by physicochemical parameters such as aeration, temperature, pH, particle size, moisture content, electrical conductivity and type of substrate, among others (Li et al., 2013; Juárez et al., 2015).

Once the transformation has been carried out, the resulting product (compost) has stability, a term related to the resistance of compost organic matter to degradation or greater microbial activity (Hachicha et al., 2009); on the other hand, the degree of maturity of the compost describes the capacity that it has to be used effectively in agriculture, that is, it does not present problems of phytotoxicity and does not inhibit the growth of the plants.

Oviedo-Ocaña et al., (2015) establish that the stability of a compost is not necessarily an indicator of maturity; therefore, for the assessment of stability and maturity are considered physicochemical parameters such as the ratio C: N, NH_4: NH_3, evolution of CO_2, pH, temperature, electrical conductivity (EC), moisture content, carbon (C) soluble in water, cation exchange capacity (CEC), Oxygen absorption rate, total organic C, volatile organic C, production of humic and fulvic acids; to evaluate the degree of phytotoxicity of mature biosolids, the germination index (GI) and the plant growth index are used, among others (Onwosi et al., 2017). In the present work we rely on the enzymatic assay with fluorescein diacetate (FDA) and static respirometry (CO_2 production) as an indicator of stability; and the germination index (GI) as an indicator of maturity.

A key element in the composting process is the substrate that is used. Negro et al., (2000) list 33 possible materials, all of them with different physical and chemical characteristics. However, it has been proposed that the material to be used should have at least three desirable properties: 1) have a C:N ratio between 20-40, 2) moisture content of 40 to 65%, and 3) a pH of 6.5 to 8.5. From the above, an option for composting is sawdust, a waste derived from carpentry and the manufacture of furniture; it is characterized by being a good adsorbent of humidity, its degradability is moderate to poor, it confers porosity and it is used to give volume (agent bulking, in English) providing excellent structure to the compost[1] (Negro et al., 2000). Sawdust is generally available wherever there is human activity and it can be used, and it has a relatively low cost compared to other materials.

[1] Del fr. **compost,** y este del lat. **composĭtus** 'compuesto'. Real Academia Española.

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In Bahías de Huatulco, Oaxaca, the government company FONATUR is in charge of wastewater treatment (WWTP), where 6 treatment plants operate and use 100% of the treated wastewater; however, the generation of sewage sludge is approximately one ton per day and its final disposal is the open-air municipal dump, generating environmental and public health problems. On the other hand, in the Universidad del Mar (Umar), in the area of carpentry, solid waste (sawdust) is generated whose final disposal is the rubbish bin.

In view of this panorama, in the present work the following objectives have been proposed: i) obtain a biosolid of good quality with the desirable characteristics of stability and maturity; ii) present an alternative use of both waste (sewage sludge generated in the WWTP and sawdust), and contribute to reduce the environmental impact generated by the inadequate disposal of such waste.

Methodology

Characterization of sewage sludge

The sewage sludge was obtained directly from the Chahué wastewater treatment plant (PTAR), located in Bahías de Huatulco, Oaxaca; whose final process consists of a mesophilic anaerobic digestion. Sufficient sludge was collected to fill two containers with capacity of 200 L each and was transferred to the laboratory of Environmental Biotechnology of Umar (Oaxaca) for its characterization (Table 2). The sludge was dried at room temperature, then a sample of 2 kg was taken to characterize it according to section five of the official Mexican standard 004 of the secretary of environment and natural resources (NOM-021-RECNAT-2000): fecal coliforms (CF) (most likely number), Salmonella spp, and helminth eggs (HH); heavy metals (Ar, Cd, Cu, Cr, Ni, Pb and Zn)). The physical and chemical properties of the sludge were determined using the techniques established in the official Mexican standard 021 of the Secretary of Environment and Natural Resources (NOM-021-RECNAT-200).0): pH, electrical conductivity (EC), real density (Dr), bulk density (Da), porous space (Ep), relative humidity, water retention capacity (WHC), texture, organic matter (OM), total nitrogen (TN).

Composting of sewage sludge

Due to its compactness and high water content (> 11% humidity), sludge can not be composted alone, must be mixed with bulking agents to provide structural support and create voids between particles (Eftoda and McCartney, 2004). Sawdust is a filler and waste material that is a good moisture adsorbent, have a high C:N ratio (> 30), pH between 6-8, among other characteristics (Table 1), It is generally used for composting.

The aerobic digestion of the sludge was carried out in an open system in pile with turning, placing sawdust as substrate and filling agent; it was mixed in a 1:1 ratio (sewage sludge: sawdust, w / w) as it is an adequate ratio for composting anaerobic sewage sludge (Banegas et al., 2007); a first layer of substrate (5 cm) was placed followed by a layer of 5 cm of sewage sludge previously dehydrated to form a pile; each layer was moistened using approximately twelve liters of water and thus maintain humidity around 50-60%.

To avoid anaerobic conditions, the mixture was turned daily with a shovel to keep the system oxygenated and alternately temperature and humidity were monitored. Once the digestion period was completed, the stability and maturity of the biosolids was evaluated using the enzymatic assay with fluorescein diacetate (FDA), the static respirometry with the production of CO_2 and the germination test (GI).

Characteristic	Igbal et al. (2010)	Zorpas and Loizidou (2008)
pH	6.3	8.0
O.M. (%)	91.0	90.1
N (%)	0.49	1.8
C (%)	45.5	55.5
C/N	92.3	30.5
NH_4 (mg g^{-1})	NR	19.7
PO_4 (%)	NR	2.6
EC (mS cm^{-1})	NR	1.1
Lignin (%)	NR	30.5
Cellulose (%)	NR	52.1
NR (Not reported).		

Table 1 Reported characteristics of sawdust and its use as agent bulking
Source: Self Made

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Enzymatic assay with DAF

The FDA test is a test of enzymatic activity used as an indicator of soil microbial activity (Adam and Duncan, 2001), has recently been used as an indicator for the stability of compost (Komilis et al., 2011). The test is based on the hydrolysis of fluorescein by extracellular enzymes and membrane, releasing the fluorescence, which can be read at a wavelength of 490 nm; the greater the enzymatic activity, the higher the fluorescein release rate and the readings obtained.

In the stability and maturity tests, a previous incubation of the biosolids was carried out for 7 days, using 30 g of the biosolide on a humid basis (humidity was adjusted to 50% of the water retention capacity) and introducing it in glass jars of 1 L next to a vial with NaOH (respirometry analysis). Later for the FDA analysis, 6 g of the biosolid was taken in wet base placing it in 50 ml Falcon tube, 50 ml of 60 mM phosphate buffer at pH 7.6 was added and agitated until a homogeneous sample was obtained; subsequently, 0.50 ml of the DAF solution (20 mg FDA substrate ® Sigma in 10 ml of acetone) were added, shaken and placed in a water bath at 37 ° C for 30 min, after which time, 2 ml of acetone were added to stop the hydrolysis of the diacetate; 30 ml of the solution were transferred into 50 ml Falcon tubes and centrifuged at 6000 rpm for 5 min, then filtered using Whatman # 2 paper.

Finally they were transferred to a spectrophotometry tube to measure the absorbance at 490 nm in a spectrophotometer (Beckman Du 530). The samples were analyzed on day 1, 3 and 7 of the incubation period, in triplicate. The standard curve is linear (R^2 = 0.982, y = 0.893x) in the range of 0.03 to 0.5 mg of fluorescein and covers the concentration of FDA in different types of soil (Green et al., 2006). The fluorescein concentration was calculated according to equation 1:

$$FDAt = CNF*Vfs/t*MS \quad (1)$$

Where: DAFt: net fluorescein release rate (mg fluorescein kg^{-1} h^{-1}); CNF: net concentration of fluorescein; Vfs: volume (L) of the soluble phase; t: incubation period in hours (h); and MS: dry weight of the biosolide (kg).

Static respirometry test

The stability test of the compost measured through the quantification of microbial respiration, is based on the production of carbon dioxide in the sample and expressed as the amount accumulated during a specific period of time (mg C-CO_2 / g C day). Samples were taken in triplicate on days 1, 3 and 7. The analysis consisted in taking each vial with 20 ml of 1 M NaOH and quantifying the CO_2 by titration with hydrochloric acid (0.5 N). The total CO_2 produced in the biosolid after 7 days of incubation was calculated according to equation 2 (Oviedo-Ocaña et al., 2015):

$$C\text{-}CO_2 = (B\text{-}M)* N_{HCl}* 4*12/P_{soil}* d \quad (2)$$

Where: B: consumed volume of acid used in the titration in the blank (mL); M: consumed volume of acid in the sample (mL); NHCl: normality of HCl (0.5 N), 4 is the dilution factor (20/5), 12 is the atomic weight of C; P_{soil}: weight of the biosolid on a wet basis (mg); d: days of incubation (7 d).

Maturity test

To demonstrate the maturity of the biosolids, it was evaluated using the germination index (GI) (Komilis and Tziouvaras, 2009) using certified red tomato seeds (Optimax). The biosolids extract was obtained by weighing 15 g (wet basis), placing it in plastic bottles of 100 ml capacity and adding distilled water in a ratio of 10:1 (water ml:g of biosolids), stirring for 30 minutes at 100 rpm in a reciprocating shaker (Eberbach) and allowed to stand for 15 minutes; of the supernatant 5 ml were taken and placed in petri dishes with 25 seeds of red tomato (Optimax), the incubation was for 7 days at a temperature of 22 ° C in the dark. The same procedure was carried out for the control (distilled water). The germination index (expressed as a percentage) was calculated as follows (Komilis and Tziouvaras, 2009), equation 3:

$$GI = \frac{\frac{\text{Germinated seeds (sample)}}{N}}{\frac{\text{Germinated seeds (control)}}{N}} x \frac{\frac{\text{TLRGS (sample)}}{\text{NGS (control)}}}{\frac{\text{TLRGS (sample)}}{\text{NGS (control)}}} \quad (3)$$

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GI: germination index; TLRGS: Total length of the root of germinated seeds; NGS: number of germinated seeds; N: number of seeds placed in the petri dish.

Results

Composting of sewage sludge

The effectiveness of the composting process is influenced by factors such as temperature, oxygen supply (aeration), moisture content, pH, C:N ratio, particle size and the degree of compaction (Juárez et al., 2015). Temperature is one of the main parameters to monitor the composting process and can vary according to the process phase. Chen et al., (2015) divide the composting process into four phases in relation to temperature: mesophilic (20-40 ° C), thermophilic (40-65 ° C), cooling (<40 ° C) and maturity (room temperature). However, Lazcano et al., (2008) propose only two phases: thermophilic (active phase) and mature (decreased temperature). In both cases, the common factor -independent of the number of phases-, is the change in the initial temperature of the composting process and its increase due to the biodegradation of organic matter by microorganisms (Raut et al., 2008). The temperature interval for each phase is particular in each composting process and will depend basically on the mixture used. Figure 1 shows the temperature profile of the sewage sludge composting (WWTP, Huatulco) mixed with sawdust (1:1 w / w).

The initial temperature of the process registered a value of 25 ° C and increased to 32 ° C in the first 10 days (mesophilic phase), then from day 11 to 20 the temperature increased until reaching the maximum of 45 ° C (thermophilic phase); the decrease in temperature (cooling phase) was recorded on day 21 to 30, and from day 31 the recorded temperature was 30 ° C, remaining constant and unchanged (maturity phase) until day 42. As it is observed in the temperature curve of the composting process (Fig. 1) it comprises a period of approximately 10 days between each phase, and compared with that reported by Banegas et al., (2007) the interval of days between phases is similar to the generated in this work (8 to 10 days). The thermophilic phase reached the maximum temperature of 45 ° C,

The presence of easily biodegradable material from the sewage sludge promoted greater microbial activity (Oviedo-Ocaña et al., 2015; Hassen et al., 2001). The temperature of 45 ° C recorded in the present work is reported for composting piles with anaerobic sewage sludge and sawdust (Banegas et al., 2007), and is below the reported temperature for the composting of aerobic waste sludge (> 50 ° C); the maximum temperature difference between the types of sewage sludge, may be due to the low organic matter content of the sewage sludge used in this experiment (3.0%), and therefore, a lower substrate availability and lower microbial activity; In addition, the anaerobic sludge contains more stable organic matter (lignin and cellulose) and a lower content of easily biodegradable compounds (Manios 2004), which are used by the microbial population (as a carbon source) present in the composting mass.

As in the thermophilic phase, differences in time have been reported to reach the maturity phase. Alidadi et al., (2008) reported that after 100 days the maturity stage was reached in the aerobic sewage sludge mixed with sawdust; and in the case of anaerobic and sawdust sewage sludge, the maturity phase was reached at approximately 60 days (Banegas et al., 2007). In our compost the maturity phase was obtained from day 31, less than half the time reported by Banegas et al. (2007); this was due to the proper handling of the compost pile.

The frequency of (daily) turning of the compost mass in the early stages of the degradation of organic matter can result in a shorter time to reach the stage of maturity (Awasthi et al., 2014); the daily turning together with the application of water, allowed to maintain the moisture content by 50-60%, this percentage is necessary for biological activity during composting (Luangwilai et al., 2011); The above was achieved with the mixture of sludge and sawdust (1:1 v / v), since the latter has a high water adsorption capacity (Iqbal et al., 2010). In addition to the aforementioned, the environmental temperature is another factor that allowed the maturity phase to be reached more quickly; unlike cold and temperate climates where the increase in temperature is slower for the composting processes to take place (Margesin et al., 2006), the tropical climate seems to be more favorable in maintaining the proper temperature during composting (Nguyen and Shima, 2018).

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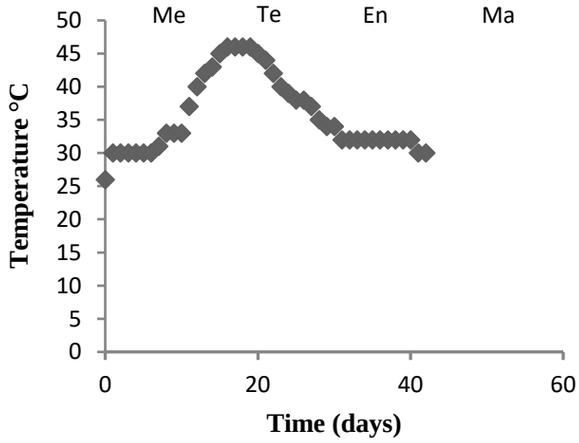
In the present work, the average daily temperature was 30 ° C (dry tropical climate), therefore, the time to obtain the compost was lower.



Graph 1 Monitoring of the temperature recorded during the composting process of the sewage sludge, and the stages of the process: Me (mesophilic), Te (Thermophila), En (cooling), Ma (maturity)
Source: self made

Physical-chemical and microbiological characterization of biosolids

In the Mexican regulations (NOM-004-SEMARNAT-2002), a biosolid is defined as "sludge that has been subjected to stabilization processes and that due to its content of organic matter, nutrients and characteristics acquired after its stabilization, can be susceptible to exploitation". In the same standard 004, criteria for the classification of the use of biosolids are established according to the minimum and maximum limits based on the content of heavy metals, and the content of pathogens and parasites.

In the present work, the content of heavy metals Cd, Pb, Ni and Zn registered in the biosolid (Table 2) is well below the minimum allowable limit according to the norm 004, therefore, the biosolid is classified as **excellent**. With respect to the bacteriological content of pathogens and parasites in the biosolids, the value is below the maximum limit allowed by NOM-004-SEMARNAT-2002 (Table 2), therefore, it is classified as **class A** biosolids.

According to the obtained results and the quality (class A) of the biosolids, the same norm 004 establishes that the biosolids can be used for urban use with direct public contact, forestry and agricultural use, as well as soil improver-degraded soils. However, in the environmental aspect it can be used for the remediation of soils contaminated with hydrocarbons, heavy metals, saline soils, among others. In general, the biosolids presented better characteristics in relation to the initial characteristics of the sewage sludge. The content of organic matter, from 3.0 to 3.7%, is considered a high content (NOM-021-RECNAT-2000); the water holding capacity in the biosolid was increased 1.3 times; the C:N ratio and the pore space increased by 2.6 and 1.1 times, respectively. The real and apparent density decreased by 3.5 and 15 times (respectively), which is reflected in the highest percentage of porous space in the biosolid (94.3%).

The content of helminth eggs and fecal coliforms decreased with composting (Table 2); however, according to the regulations, the sewage sludge did not present problems in this characteristic. The metals analyzed decreased or remained at the same concentration, with the exception of the Cd content in the biosolids, which increased 1.7 times, remaining below the permissible limits (Table 2).

The pH was maintained without significant change, step from 5.7 to 5.2, both classified as moderately acidic (NOM-021-RECNAT-2000). The electrical conductivity of the biosolid was 2.7 (dS m^{-1}) and according to NOM-021-RECNAT-2000 it is classified as moderately saline. In this last characteristic the biosolide must be used taking the pertinent precautions; although it did not present phytoxicity (see results of GI).

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characteristics	Sewage skudge	Biosolid	NOM-004
pH	5.7	5.2	NA
EC (dS m^{-1})	3.0	2.7	NA
OM (%)	2.32	3.7	NA
WHC (mL g^{-1})	4.21	3.07	NA
TN (%)	1.75	2.05	NA
TOC (%)	0.41	2.2	NA
C:N	ND	1.07	NA
Dr (g cm^3)	1.4	0.4	NA
Da (g cm^3)	0.30	0.02	NA
EP (%)	78.8	94.3	NA
HH	1	0.0	< 1
CF	3	2	< 1000
Cd	1.8	3.6	39-85
Pb	15.3	13.9	300-840
Ni	3.8	3.8	420
Zn	62.9	44.9	2800-7500
Ar	ND	ND	41-75
Cr	ND	ND	1200-3000
NA (not applicable). ND (not determined). The value of heavy metals is expressed in mg Kg^{-1} on a dry basis.			

Table 2 Physical, chemical and microbiological characteristics of the sewage sludge (from the WWTP in Bahías de Huatulco) and the biosolids (final product of the composting process)
Source: Self Made

Stability and maturity of biosolids

Stability is a term related to the resistance of the organic matter of a product (compost) against degradation or greater microbiological activity (Hachicha et al., 2009); In the present work, it was determined by two tests: the fluorescein diacetate enzymatic assay (FDA) and the static respirometry (CO_2 production). The low microbial activity in both tests (Table 3), is explained by the fact that the compost went through an active degradation stage and the majority of degradable carbon has already been eliminated, leaving only the recalcitrant material (Komillis et al., 2011).

For the average values obtained in the aforementioned tests: FDA 8.4 and C-CO_2 0.28 mg kg^{-1} (for both), the biosolid is classified as Very stable (Komillis et al., 2011). The stability in a compost is very important; an unstable or immature organic product prevents the growth of plants and negatively affects soil quality (Oviedo-Ocaña et al., 2015) if used for this purpose.

The result of the germination test (GI) with the application of the biosolids extract in the tomato seed was 84.15%.

According to the interpretation criterion of the GI, they are classified into three phytotoxic categories (Zucconi et al., 1981): i) severe, GI values ≤ 50% indicate that there is a strong presence of phytotoxic substances; ii) moderate, if a value between 50 and 80% is obtained, it is interpreted as the moderate presence of phytotoxic substances; and iii) mild, if the GI ≥ 80%, which indicates that there are no phytotoxic substances such as volatile organic acids or the content of phenols, or are in very low concentration (Zubillaga and Lavado, 2006). The biosolid in the described conditions, has the characteristic of desirable maturity to be used effectively in agriculture, as a soil improver or to test it as an attenuator of some type of contaminant in soil (eg. herbicides).

Sampling day	FDA mg kg^{-1} h^{-1}	C-CO_2 g kg^{-1}	Classification of biosolids
1	7.7	0.45	
3	8.1	0.19	Very stable*
7	9.6	0.22	

Table 3 Classification of biosolids with reference to their stability, calculated by enzymatic assay (FDA) and static respirometry (CO_2 production). * Classification according to Komillis et al. (2011). Values are reported on dry biosolid basis.
Source: Self Made

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Conclusions

At the end of the composting process, a final product (biosolid) of good quality was obtained with the desired physical-chemical and microbiological characteristics, and according to NOM-004-SEMARNAT-2002, the biosolid obtained is **type A** of **excellent** class. According to Oviedo-Ocaña et al. (2015), it is difficult to obtain a biosolid that complies with both stability and maturity properties; however, and based on the stability index and biosolid maturity index, which is classified as **Very stable**, and **excellent** class according to NOM-004-SEMARNAT-2002.

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We conclude that biosolids are suitable for use in different ways: 1) as a soil improver, it could be applied to agricultural crops in the coastal area of Oaxaca, including jamaica, papaya, corn, tomato and coffee; 2) in bioremediation of contaminated soils, as an attenuator of some type of contaminant (eg, herbicides, insecticides, among others), and 3) for urban, forestry and agricultural use.

In addition, we can say that by mixing both waste: sewage sludge and sawdust - a biosolid with the aforementioned quality - is an excellent alternative to reduce the amount of waste generated, its proper disposal and reduce the impact on the environment and human health.

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Molecular characterization of *Bacillus safensis* from cane rhizosphere

Caracterizacion molecular de *Bacillus safensis* a partir de rizosfera de caña

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Abstract

Sugar cane (Saccharum officinarum) is a very important crop for Mexico mainly in the municipalities of Tamaulipas Mante and González. 50% of the nutrients supplied are used by the plants, the rest being lost by leaching, causing serious effects to the environment. The use of bacteria specifically endophytes-diazotrophs, could contribute to economic and environmental sustainability, since they contribute to the restoration of soil conditions to obtain good results in the field. In the present work, the objective was to identify an isolate from the rhizosphere of the sugarcane crop, amplifying the 16S gene of the rRNA and its sequencing. The isolate sequence obtained was compared and made Blast in the NCBI database and was identified as *Bacillus safensis*, showing a 97% coverage and 93% similarity with several strains previously reported. It is important to molecularly characterize the beneficial microorganisms that could later be used as plant growth promoters (BPCV), because they contribute favorably to crops, especially if they are isolated and used in the same crop, such as sugarcane. South region of Tamaulipas.

Cane, Gene, Molecular

Resumen

La caña de azúcar (*Saccharum officinarum*) es un cultivo muy importante para Mexico principalmente en los municipios de Mante y González en Tamaulipas. El 50 % de los nutrientes suministrados son utilizados por las plantas, perdiéndose el resto por lixiviación, causando graves efectos al ambiente. El empleo de bacterias específicamente endófitas-diazotrofas, podría contribuir a la sustentabilidad económica y ambiental, ya que contribuyen al restablecimiento de las condiciones del suelo para la obtención de buenos resultados en el campo. En el presente trabajo tuvo como objetivo identificar un aislado a partir de rizosfera del cultivo de caña de azúcar, amplificando el gen del 16S del rRNA y su secuenciación. La secuencia del aislado obtenido se comparó y se hizo Blast en la base de datos del NCBI y fue identificada como *Bacillus safensis*, mostrando un 97 % de cobertura y 93 % de similitud con varias cepas reportadas previamente. Es importante caracterizar molecularmente a los microorganismos benéficos que podrían ser empleados posteriormente como promotores del crecimiento vegetal (BPCV), debido a que contribuyen favorablemente a los cultivos sobre todo si son aislados y utilizados en el mismo cultivo, como el de caña de azúcar de la región sur de Tamaulipas.

Caña, Gen, Molecular

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1. Introduction

Sugarcane (Saccharum officinarum) contains high concentrations of sucrose, currently it is a source of sugar worldwide (Martin, 2005) (*Rojas et al., 2015*). Also in Mexico it is a very important crop especially for the southern region of Mante and González, in Tamaulipas, where a hot and semi-dry extreme climate prevails, with an average annual temperature ranging from 22◦ C to 26◦ C, with rainfall that occur in summer, which reach 800 to 1000 millimeters and with an altitude of 80 meters above sea level, which favors this crop (Jimenez Cordova *et al*., 2004).

Due to the biology of the plant, the yield is decreasing, considering that cane cultivation presents high production costs related to applied nitrogen fertilization and that only 50% of the nutrients supplied are used by the plants, losing the rest by leaching, which causes an imbalance of soils and low availability of available nutrients for plants, which is why it is important to consider strategies to identify nutritional problems, not only to improve crop yields, but also to prevent the development of diseases, as well as reduce damage caused by insects or physiological damage (Vitousek *et al*., 1997) (Montealegre *et al*., 2018) (Rodríguez *et al*., 2018).

Therefore, the use of agrobiotechnological techniques that support the management of crops, including cultural practices, that provide the basis for the implementation of sustainable agriculture, for which the bacteria that promote plant growth are studied, which include bacteria that inhabit the rhizosphere, such as rhizobia and endophytic bacteria, which provide benefits to crops (Acemad and Kribet, 2014) (Peoples and Craswell, 1992) (Raymond *et al*., 2004) (Hernández *et al*., 2018) (Méndez-Úbeda *et al*., 2018). It is important the microbiological characterization of the isolates, such as knowing the specific nutritional requirements, their metabolic abilities, as well as their capacities to survive in different environments, However, it is necessary to complement this characterization with molecular methods, since in this last composition of the bacterium, the genes that encode enzymes or metabolites that provide resistance to pathogens are contained, with the ability to degrade pollutants in the environment or as nifH genes with the ability to fix nitrogen or other genes that encode other enzymes that solubilize other elements (Rojas *et al*., 2015).

(Stacey *et al*., 1992) (Chulia *et al*., 2018). On the other hand, in terms of molecular identification there are sequences conserved in bacteria such as the 16S rRNA, which is widely used to perform phylogenetic analysis, as well as for the identification of bacterial groups (Soares-Ramos *et al*., 2003) (Kim *et al*., 2014) (Valenzuela *et al*., 2015). In the present study, a rhizosphere bacterial isolate of sugarcane was characterized, by means of nifH genes, which codes for a nitrogenase enzyme involved in the fixation of nitrogen and this as a promoter of plant growth.

It was also identified by PCR amplifying the 16S rRNA gene and sequencing. This proposal for identification and molecular characterization is used as a tool, in order to complement the microbiological tests and as support in the agronomic area contributing to improve sugarcane crops in the southern region of Tamaulipas.

2. Methodology

Collection of samples

20 plants were collected at random from a sugar cane crop with everything and soil from the region near the city of Mante, Tamaulipas. These were transported to the Experimental Biotechnology laboratory of the Genomic Biotechnology Center of the National Polytechnic Institute, where 2 unique plants containing nodules were selected, since it is known that very likely they may contain beneficial bacteria associated with the rhizosphere. (Grinder *et al*., 2002).

Obtaining the isolated

0.5 cm pieces of cane roots were cut with a scalpel, the roots were washed with 3% sodium hypochlorite solution and then three times with sterile distilled water, each sample of each plant was identified as M1 and M2. To obtain plant growth promoting bacteria, specifically endophytes-diazotrophs. It was inoculated in semi solid medium WAT4C, to isolate nitrogen fixing bacteria at 25 ° C for 24 hours. From which the isolates were obtained being of the following way of M1 samples were obtained (7, 8 and 10) and of M2 they were sample (3, 4, 5, 6, and 11).

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Obtaining genomic DNA

Once there was growth, an isolated colony was resected in Luria Bertani broth at 25 ° C for 18 hours, then DNA extraction was performed, using the Wizard Genomic Cat. A1120 Kit. Which was made according to the instructions of the commercial case.
The quality and concentration of each of the samples of the isolates were determined by reading in a nanodrop 2000 and by electrophoresis in a 1% agarose gel. Electrophoresis was carried out at 80 Volts for 1 hour. Once the sliding time was over, the gel was visualized with UV light in a photodocument coupled with a Kodak Molecular Imaging Software program., (Version 5.0., Park West, New Haven).

PCR of nifH genes and the 16S rRNA gene

The nifH (nitrogenase enzyme) gene from the endophyte-diazotrophic isolates was amplified by PCR, and the 16S rRNA gene was carried out under the same conditions. The PCR was performed under standardized conditions in a Perkin Elmer Biosystems Gene Amp thermal cycler. PCR System 9700 (Singapore Norwalk). For visualization of the amplified products, an electrophoresis was performed to visualize the PCR products of the nifH gene of the isolates and the 16S gene of the rRNA. This is under the same conditions similar to that for genomic DNA.

Sequencing of the rRNA 16S gene

It is worth mentioning that only the identification of an isolate of M2 sample (3) was carried out and the PCR product of the 16S rRNA gene was then cleaned with an enzyme from ExoSAP-IT (USB Corporation 2000) and then the reaction of the sequencing was carried out according to the instructions of the BigDye Terminator V3.1 Cycle Sequencing Kit, Cat. 4311320 and runs on the automated sequencer AB 3130 (Applied Biosystems) of the Service Laboratory of the Genomic Biotechnology Center, of the Polytechnic Institute National Park in Reynosa Tamaulipas, Mexico. Once obtained the sequences in format. ab1, these were analyzed with the software package Chromas version 2.4.4 copyright 1998-2016 Technelysium Pty Ltd. They were then analyzed and compared in the BLAST Nucleotide Standard of the National Center for Biotechnology Information (NCBI).

For the elaboration of the dendrogram, the program CLC sequence viewer 8.0.0 was used. Text written inTimes New Roman No.12, single space.

3. Results

We obtained eight isolates from the rhizosphere of sugarcane of the two plants that were identified as M1 and M2, and its distribution was as follows, M1 three isolates were obtained (7, 8 and 10) and M2 were five isolated (3, 4, 5, 6 and 11) obtained as pure colonies, from the semi-solid medium WAT4C. The genomic DNA of each of the isolates was obtained, an electrophoresis was run and in figure 1, the bands representing their nucleic acids are shown

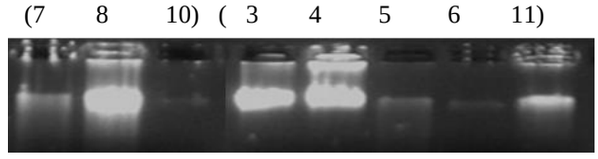

Figure 1 Image showing the genomic DNA bands of each one of the isolates obtained, for M1 (7, 8 and 10) and for M2 (3, 4, 5, 6 and 11)

The DNA concentration was obtained for most of the samples was found in a range of 50 to 100 ng of concentration. The amplification of the nifH gene was carried out, which codes for one of the structural subunits of the nitrogenase enzyme, key in the process of biological nitrogen fixation [4]. Figure 2 shows the PCR amplification products of the nifH gene, from the genomic DNA, of each of the isolates.

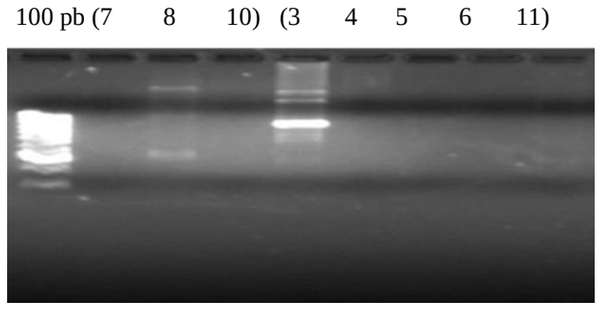

Figure 2 The order of left to right of the lanes is shown, Marker 100 bp of promega, lanes for M1 all negative and of M2 only the isolated one (3), it was positive by PCR for the nifH gene

Amplification of the expected nifH gene fragment of about 800 bp was obtained, at least for 1 sample. For M1 all were negative and for M2 the sample (3) was positive.

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Therefore, it was decided as a strategy to complete its characterization and identification, since only this isolate presented this characteristic.

Then the 16S rRNA gene was amplified by means of the Polymerase Chain Reaction (PCR), from the genomic DNA of each one of the isolates, the image was shown with the amplified products of the 16S rRNA in the Figure 3.

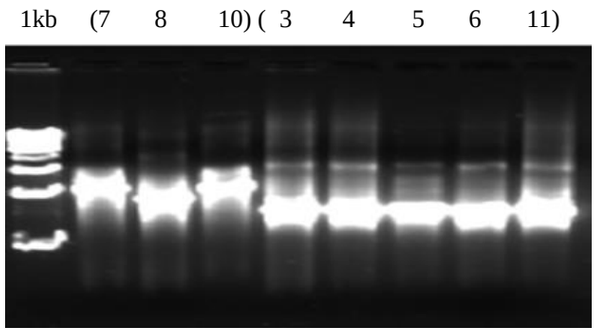

Figure 3 The order of left to right of the lanes is shown, Marker 1 kb of promising, lanes for M1 samples were obtained (7, 8 and 10) and of M2 were the samples (3, 4, 5, 6 y 11), positive by PCR for the 16S rRNA gene

All samples showed a fragment of 1500 bp, both M1 and M2. Therefore, the latter was selected, sequenced and analyzed from the 16S gene of the rRNA, showed a coverage percentage in its sequences of 97% and a percentage of identity of 93%, with those previously reported in the base of NCBI data. An alignment was performed with the Bacillus safensis strain JQ818355.1 previously reported in the genetic data bank of the National Center for Biotechnology Research (NCBI). In the following image you can see the Blast made in the NCBI database showed its coverage and identity for the 16S rRNA gene, Figure 4.

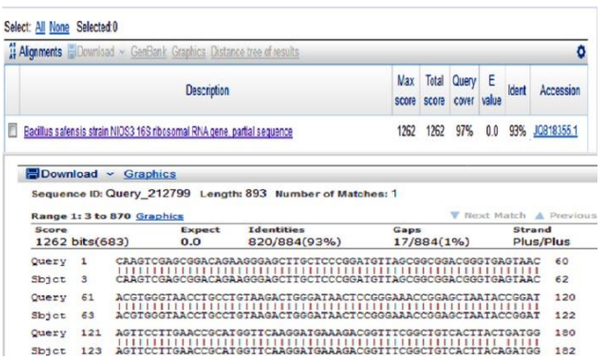

Figure 4 Image of the sequence obtained with those reported in the NCBI Blast, two showed around 93% identity for the 16S rRNA gene, showing few differences between their sequences, when performing a multi-alignment

After having made an alignment of the own sequence, with one reported by other authors in the NCBI, few variable regions were observed between both analyzed sequences, having this coincidence between their sequences. To confirm the genus and species in our work we proceeded to perform molecular analysis of the isolates obtaining different similarities within the genus Bacillus. With the application of molecular techniques and 16S amplification of the rRNA, the similarity of the bacteria was confirmed, presenting 99% in 6 of the samples and 2 of 100% of homology, based on the NCBI data.

Subsequently these sequences were submitted with the CLC program sequence viewer 8.0.0. Obtaining the genetic distances between the strains analyzed (Figure 5).

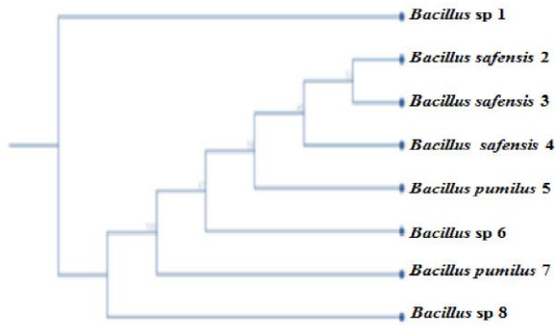

Figure 5 Dendogram obtained from the 16S rRNA gene sequences

4. Acknowledgement

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5. Discussion

Biologically, nitrogen fixation is catalyzed by nitrogenogens, is a complex of enzymes that encode the nifD and nifK genes and dinitrogensase reductase subunit encoded by the nifH gene, the latter reduces N2 to NH3, leaving this element available for the plants to assimilate and grow more vigorous (Cleveland *et al*., 1999) (Gaby and Buckley, 2014) (Kim *et al*., 2014) (Valenzuela-González *et al*., 2015). For the nifH gene, at least 1 sample was positive.

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For M1 all were negative and for M2 sample 3. The fact of finding nifH genes in the isolates indicates that they may have the capacity to fix nitrogen. Therefore, the application of this bacterium could be feasible that could be able to metabolize nitrogen and provide it more assimilable for plants. It is worth mentioning that this isolate was applied to *B. safensis*, in another experimental work demonstrating to have a very good effect on the growth and development of a sugarcane crop in the south of Tamaulipas.

On the other hand, the use of molecular methods as strategies for the characterization of bacteria of biotechnological importance, could contribute enormously to the development of a sustainable agriculture. There are bacteria in various environments with the ability to fix nitrogen, because they have the nifH genes, very likely they can be applied in different crops, as breeders in production (Farnelid *et al*., 2011) (Montealegre *et al*., 2018) (Rodríguez *et al*., 2018). As well as some bacteria of the genus Bacillus sp produce proteases and other enzymes that inhibit and antagonize phytopathogenic fungi such as Fusarium sp, which produce rot in stems and roots of crops (Hernández *et al*., 2018) (Méndez-Úbeda *et al*., 2018).

There are currently databases of genes for nitrogen-fixing bacteria with which ecological and evolutionary studies are carried out (Gaby and Buckley, 2014), which will serve to understand the abilities and abilities of various bacteria and for the improvement of field crops (Hebert *et al*., 2003) (Martin, 2005) (Sidnei *et al*., 2003). On the other hand, the sample that was selected from the 16S rRNA for sequencing for identification purposes, showed a 97% coverage percentage in its sequences and a 93% identity percentage, which indicated that the molecular marker is reliable for the identification of the bacterium, most likely as B. safensis. Very similar results have been reported with the use of rRNA 16S, in the identification of bacteria by several authors (Soares *et al*., 2003) (Yarza *et al*., 2014). In addition, this molecular tool is completely standardized for the identification of existing bacteria in different environments (Grinder *et al*., 2002). As well as the relatively long size of the sequences of the 16S rRNA of 1500 bp of nucleotides minimizes the fluctuations and in the conservation of the sequences, which favors the precise alignment during the comparison of sequences (Velázquez *et al*., 2008).

In a more recent study revealed values of 98.65% similarity of the 16S rRNA gene can be used as a threshold for the differentiation of two species (Jimenez *et al*., 2004) (Vitousek *et al*., 1997) (Chulia *et al*., 2018). On the other hand, it has been established that a similarity between two 16S rRNA equal or less than 94.5%, 86.5%, 82.0% or 75.0% establishes the distinction of gender, family, order, class and edge, respectively (Velázquez *et al*., 2008). As noted, there are distinctions to the use of the 16S rRNA marker, depending on the specific use, so to be able to carry out more in-depth studies in the search for specific genes of the species identified as *B. safensis*, it is necessary to work with the particular sequences associated to characteristics of interest that could lay the foundations of later studies.

6. Conclusion

In this study we found the presence of nifH genes, from a sugarcane plant called M2, from where the isolate 3 came from.

Which was identified, by sequencing the 16S gene of rRNA as B. safensis. In addition, the genetic distance, based on their sequences, was obtained from our strain of B. safensis, compared with other strains of Bacillus sp, previously reported in the NCBI database. It is worth mentioning that this is the first time that this species of *B. safensis* has been reported, as an endophytic strain that improves the cultivation of sugarcane in the Northeast of Tamaulipas region. In addition, this proposal for identification and molecular characterization was used as a tool, in order to complement the microbiological tests and as support in the agronomic area contributing to improve sugarcane crops in the southern region of Tamaulipas.

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Redesign, adaptation and control of a thermal cycler module

Rediseño, adaptación y control de un módulo termociclador

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Abstract

This paper presents the study, re-design and adaptation of a thermal cycler. The aim of this work is to increase its performance and capacity without diminishing the durability of the equipment. The Cole Parmer 1095-00 model is used for the study. It is proposed to modify the current temperature selector by a digital one that allows controlling the temperature in a range of 0-100 ° C. In addition, it is proposed to include a controller to maintain the water level at the desired operation point, including the system to add a replenishment stage. New components are included as a screen to show the operating temperature, the start date of the process, the remaining time and an alarm to indicate the end of the cycle. An interface is also developed to monitor and control the operation of the remote system in real time. The monitoring system is developed using the Labview platform®.

Thermal Cycler, Reverse Engineering, Classic Contro

Resumen

En este trabajo se presenta el estudio, re-diseño y adaptación de un termociclador con el objetivo de actualizar su operación, aumentar su capacidad de trabajo, sin disminuir la durabilidad del equipo y mejorar su rendimiento. Para el estudio se utiliza el modelo Cole Parmer 1095-00 y se propone modificar el selector de temperatura acutal por uno digital que permita controlar la temperatura en un rango de 0-100°C. En el sistema, Además, se plantea incluir un controlador para mantener el nivel del agua en el punto de operación deseado, incluyendo al sistema agregar una etapa de reabastecimiento. Se incluyen nuevos componentes como una pantalla para mostrar la temperatura de operación, la fecha de inicio del proceso, el tiempo restante y una alarma para indicar el término del ciclo. También se propone el desarrollo de una interfaz para monitorear y control en tiempo real la operación del sistema a distancia a través de un programa ejecutable y otro fijo, ambos desarrollados en la plataforma de Labview®.

Termociclador, Ingeniería Inversa, Control Clásico

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Introduction

Polymerase chain reactions (PCR) are simple techniques widely used in the field of molecular biology to amplify and detect sequences of deoxyribonucleic acid (DNA) and ribonucleic acid (RNA), especially to perform serological tests, incubation procedures, agitation, activation, biomedical, pharmaceutical, among many others (Tamay de Dios, et al., 2013). A thermal cycler or thermal sequencer is used to carry out the tests of the chain reactions, whose purpose is to duplicate DNA fragments to obtain multiple copies in an automated way, controlling the chain reaction efficiently and quickly, both for qualitative amplifications and for quantitative (Armas, 2006).

According to Cortazar et al. (2004), the first thermocyclers that were used worked with mechanisms that moved a tube rack between several thermostatic baths at pre-established times. However, modern termocyclers use metal blocks to control temperature, especifically the heating-cooling process, offering the possibility of programming temperature and time. Decisive factors in the quality of the amplification are the stability of the temperatures and the rapidity in the passage from one temperature to another. It is important to note that this type of process from the point of view of control are considered slow or slow response systems.

In current thermocyclers available on the market, heating and cooling occurs thanks to the cells or the Peltier effect, which consists of heating or cooling a junction between two different metals (isothermal interface) when passing current through it. When the current is reversed, the flow direction of the heat is reversed (Sandoval, 2012). The cost of thermal cyclers can vary greatly depending on the number of functions they have. In general, for the purposes of this work, thermocyclers are grouped into analog and digital, as shown in the figure 1. The main characteristics of both equipment are the agitation system that prints the heating medium a carefully controlled movement to keep the temperature as uniform as possible, the temperature selector and the choice of time or duration of the process (MTAS, 2004). Unlike analogs, digitals offer other functions such as liquid level control and system monitoring (Reyes et al., 2018).

In thermocyclers, water is usually used as a liquid medium, but it also allows working with oil. The temperature ranges in which the thermal cyclers are operated normally oscillate between the ambient temperature and 60 ° C. Table 1 shows the temperature range and the means used for operation in commercial thermal cyclers.

(a)

(b)

Figure 1 Thermocycler (a) analog and (b) digital available in the market

Class	Rank
Low temperature	25-60°C
	25-100°C
High temperature	25-275°C

Table 1 Operating ranges of commercial thermal cyclers

When it is required to operate at temperatures above 100 °C, it is essential to use fluids other than water because its boiling point is 100 °C. So for higher temperatures oils are used (whose boiling points are much higher).

Currently the Faculty of Marine Sciences of the Ucol has the thermocycler model Cole Parmer 1095-00, this device is used for the cultivation of bacteria, micro algae, fungi, phytoplankton and other organisms. This model has basic functions for temperature control, however, it is desired to improve its performance at low cost. At this time, there are cultivation processes that must be monitored by a certain perso to verify that the process has not been interrupted (causing loss of data), so it is necessary to review the process constantly.

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Another disadvantage is that in the current model there is evaporation of the liquid (water), so it is necessary to monitor the process and add water to maintain the desired level. So thinking about improving the performance of the currently equipment was born the proposal of this work that is to automate and maximize the operating functions of the thermal cycler. To reach the objective, it is proposed to modify the temperature selector that is performed manually in the current model and modify it by a digital selector that allows to control the temperature in a range of 0-100 ° C.

In addition, it is proposed to include a controller to maintain the water level at the desired operating point automatically, for which a replenishment system must be added and new components are included, such as a display to show the operating temperature, the start date of the process, the remaining time and an alarm to indicate the end of the cycle. It also proposes the development of an interface to monitor and control in real time the operation of the remote system through an executable program and a local one, both developed in the Labview® platform.

Design and description of the system

For demonstration purposes, figure 2 shows the figure of the Cole Parmer 1095-00 thermal cycler.

Figure 2 *Cole Parmer 1095-00 Thermal Cycler*

In general, the design of thermocyclers can be divided into two areas. An stage that includes the control algorithm, the energy regulation and the measurement system (for sensors).

The other stage involves the design of the thermomechanical system: the sample tray (the metal alloy that makes up the block), the sensors, the cooling module or Peltier cell, the insulation of the tray, the protection stages and the cooling system for the electronic boards. Figure 3 shows the proposed block diagram. The main block includes the framework for the thermal cycler and the interface for reading and processing data.

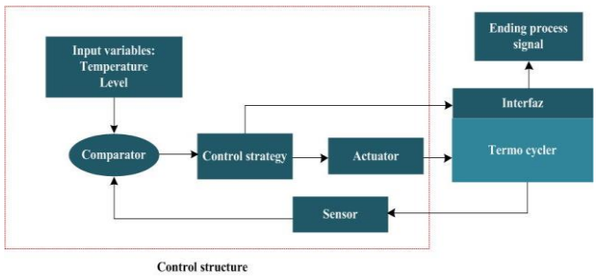

Figure 3 Generalized block diagram of the main components of the thermal cycler

Figure 4 shows the proposed design including the improvements described. The schematic was developed in Solidworks®. Above figure 4(a) se muestra una vista dimétrica del prototipo. Figure 4 (b) the trimetric perspective of the prototype. By means of the numerical matrix (keyboard) that is observed in figure 4 (b), it will be possible to enter the values for the temperature, the level of the desired liquid (important to maintain the crops) and the time of the process; these data can be displayed on the LCD screen. In addition, the system has a temperature sensor that feeds back the current values to the control algorithm, and this data is updated on the indicator screen.

In the proposed system, the user can place the time that the process will last in hours and minutes. The system allows a maximum time of 96 hours to be set. On the other hand, figure 5 shows in greater detail the cooling system and the refueling tank that is proposed to compensate for the evaporation of the liquid during the process in the thermal cycler.

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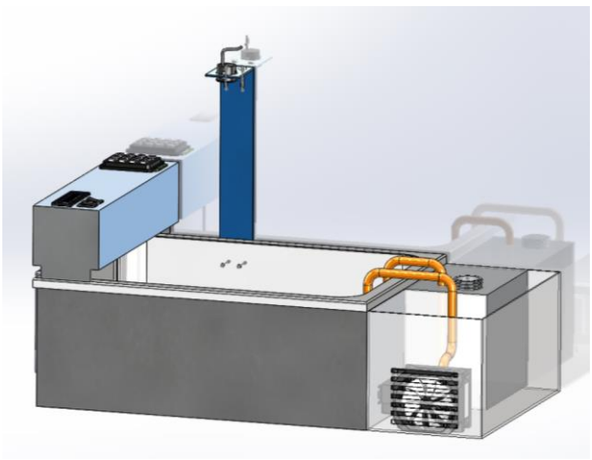
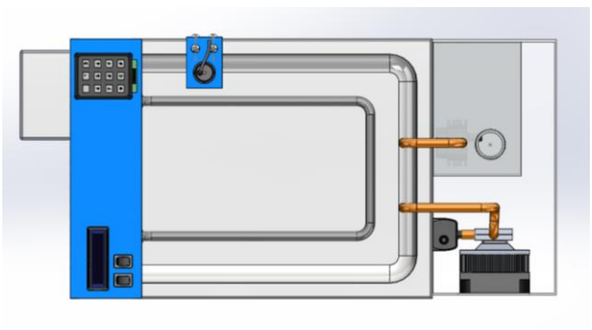


(a)



(b)

Figure 4 Modifications proposed the Cole Parmer1095-00 thermocycler, (a) dimmetric view of the structure, (b) aerial view

To circulate the water was included a submersible pump that has interchangeable nozzles for rigid or flexible hoses and an oxygenated hose.

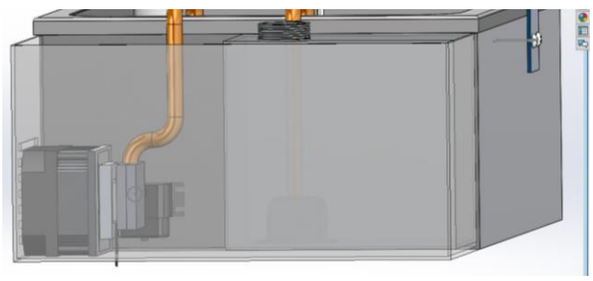


Figure 5 Refueling tank and cooling system

The pump is sealed to prevent water from permeating the electrical and electronic system. It also has a flow regulator of four levels and a regulating knob with a capacity of 280 liters per hour. Peltier cells were used for the cooling system.

Figure 6 shows the electronic components that will be responsible for carrying out the proposed tasks in the thermal cycler.

Two Arduino® systems are used to achieve the proposed objetives. The Arduino® Mega is responsible for detection, level control, time control and user interface (keyboard and display). On the other hand, the Arduino® UNO is responsible for temperature control, activation of water pumps, circulation system and activation of Peltier cells. It is important to note that the output of the temperature sensor sends information to the two Arduino® cards and that these two communicate through the serial port. Then, in the following sections, each of these stages is described.

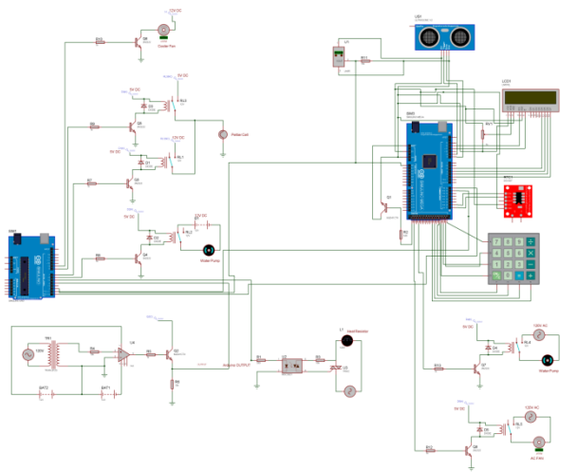


Figure 6 General electronic diagram proposed the thermal cycler

Temperature control

To monitor the temperature, the YSI 44018 sensor is used, which has an accuracy of ±0.15º C (it guarantees that the DNA samples to be replicated do not degenerate). In addition, a conditioning stage was included to linearize the thermistor output, as well as an INA125 instrumentation amplifier to condition the output range (0-5V) and to couple the digital signals. Figure 7 shows the circuit used for the simulations. According to the current specifications of the thermal cycler, it is required to control the temperature in the range of 0 to 100 ° C allowing steps of ±0.5 ° C.

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As for the control stage, this will be responsible for generating the necessary operating conditions to maintain the desired value at the point of operation knowing the temperature value, the desired operating time and the water level. In this way, the control algorithm sends a signal to the power stage so that it is responsible for increasing or decreasing the temperature in the system.

On the other hand, the power stage will be responsible for regulating the temperature and the cooling system. For the above, TRIACs of type BTA 24800 with operating ranges that support up to 25 A and 800 V are used. These devices are used to control the firing of the thermal resistances (operating at 12 A) and to enable the cooling system using pumps to send the hot water Peltier cells that help in the cooling process (Ayllón, 2012).

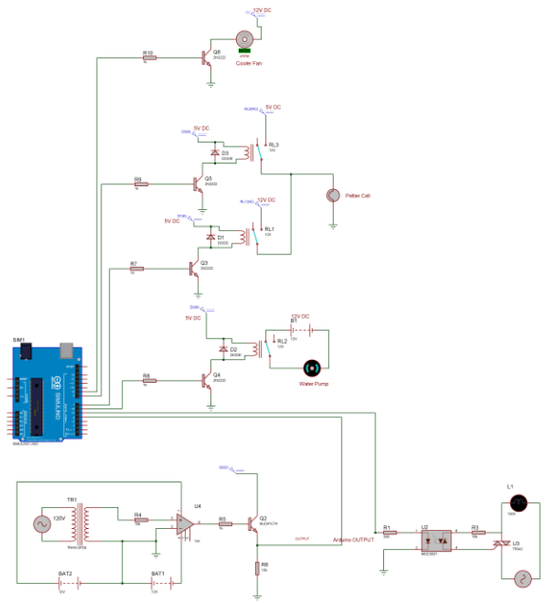

Figure 7 Electronic circuit proposed for temperature control

In this proposal, the Peltier cell is activated by means of 2 relays that receive the information sent by the power stage through an active IGBT switch; such that a 5V signal is fed back when the temperature error is within a range of 1-10 ° C and 12 Volts when the error is greater than 10 ° C. Within the modifications, a ventilation system was fitted to help the cooling of the electronic components. It should be noted that these monitored signals are sent for processing to the Arduino® UNO.

Level control and process time

To monitor the variable level in the thermal cycler, the ultrasonic sensor JSN-SR04T was used. This sensor is able to resist humidity and high temperatures. On the other hand, the Maxim / Dallas DS1307 integrated circuit, which is compatible with the Arduino® cards, is used to record the date and the real-time count of the duration of the process. Among the features of this integrated circuit it can be mentioned that the date is automatically adjusted at the end of the month for months with less than 31 days and it even includes corrections for leap year. Figure 8 shows the proposed electronic circuit for level, time and interface control. It can be seen that the Arduino® Mega will carry 2 AC actuators, such as the re-supply pump and the thermocycler's propeller that allows the temperature to be spread uniformly in the water (García et al., 2018). Both will be activated by means of relays.

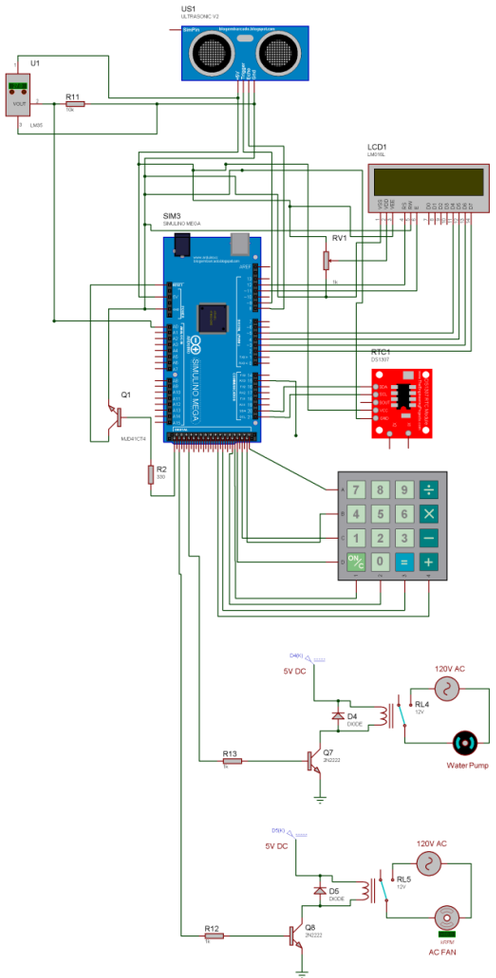

Figure 8 Proposed electronic circuit for level, time and interface control

Implementation of the thermal cycler

Below are the different modifications that were made to the thermal cycler.

Figure 9 shows the adaptation of the system for entering and displaying data, at the beginning of each process the user is asked to enter the desired temperature values, the duration of the process (time) and the desired water level. Once the data has been entered, the user can view the values entered through the LCD screen. The keys allow the following actions: A = enter data, B = delete data, C = restart the system, D = pause, # = "enter".

Figure 9 Keyboard and display of the thermal cycler

As can be seen in figure 10, on the side is located the start button and the communication port that links the thermal cycler with the control interface in Labview®.

Figure 10 Communication port and on / off button

The cooling system is achieved with the arrangement of a pump resistant to high temperatures that drives the hot water to an aluminum coil that is coupled to the Peltier cell, as shown in figure 11. By circulating the hot water through the aluminum coil, the temperature drops quickly and is fed back into the main vat.

Hydraulic hose resistant to high temperatures was used for the connections of the cooling system to give greater durability to the equipment and a purge was placed to empty the water from the main tub if necessary, in a fast and safe way.

The control of the Peltier cell is of the ON / OFF type and manages 2 intensities, depending on the percentage of error the adequate intensity will be given to the cooling system. For the above, 5 states were assigned that help determine the level of the liquid, each level has a difference of 1.5 cm. The circuit contains 8 leds which will work as level indicators (1cm per level). Through the interface, the user will be able to enter the desired level in the thermocycler and level control system will allow to maintain that current level throughout the cycle, with a duration of time given by the user.

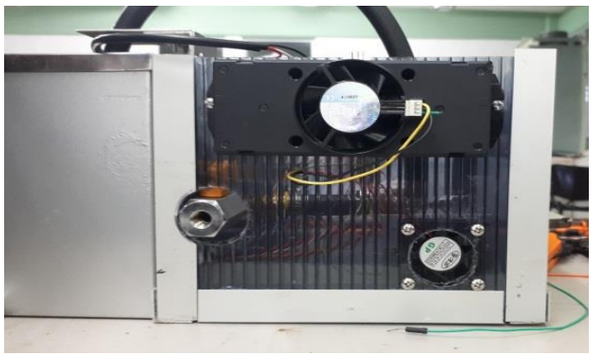

Figure 11 Regulation and cooling system for water in the thermal cycler

Control interface in Labview®

As mentioned in the introduction, within the proposed improvements to the thermal cycler, it is proposed to monitor the thermocycler process in real time and with the ease of doing it remotely (if necessary); to achieve the above, an executable interface was made using Labview® software that can be run on any computer equipment. The program allows to evaluate the status of the temperature and the remaining time of the cycle in the thermal cycler.

Figure 12 shows the block diagram that is used to generate the graphic interface in Labview®. Because the variable to control is the temperature and its response is slow, it was decided to implement a controller of the proportional type, capable of regulating the output at the desired value.

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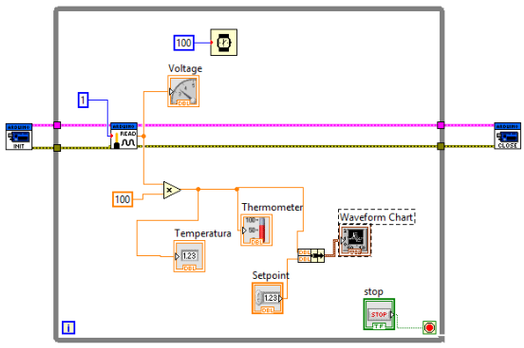

Figure 12 Block diagram in Labview®

Figure 13 shows a screen print of the main operation window generated in Labview®. In the upper left part, the time set for the process is shown and in the lower part, the desired value at which the temperature is to be regulated, both graphically and numerically. For demonstration purposes, the experimental results are shown for a process in which the temperature was set at 45 ° C and the time interval was set at 5 hrs. It is important to mention that according to the laboratory specifications, the executable program is used only for monitoring purposes. However, the program is also installed in a central computer that establishes a link between Labiew® and Arduino® and that allows making changes into the system, such as modifying the operating point of the thermal cycler or the time.

Experimental tests were carried out with different temperatures and at different levels. The stabilization time was set at 200 ms; this respone is considered adequate for this type of systems, classifed as slow. Figure 14 shows the results for a test in which the temperature was modified from 35 to 45 ° C with a liquid level of 40% of the total capacity, in the graphic it can be observed how the variable changes to reach the desired value shown in figure 13.

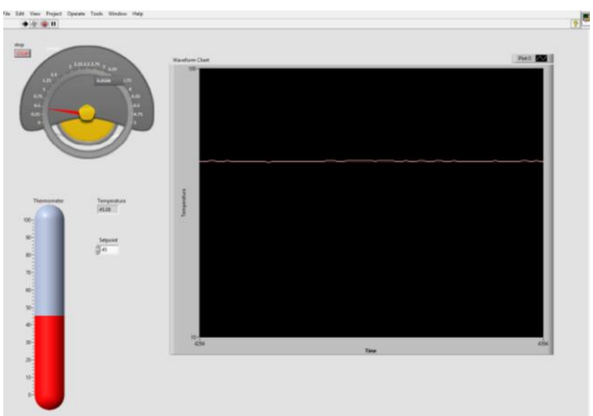

Figure 13 Proposed electronic circuit for level, time and interface control

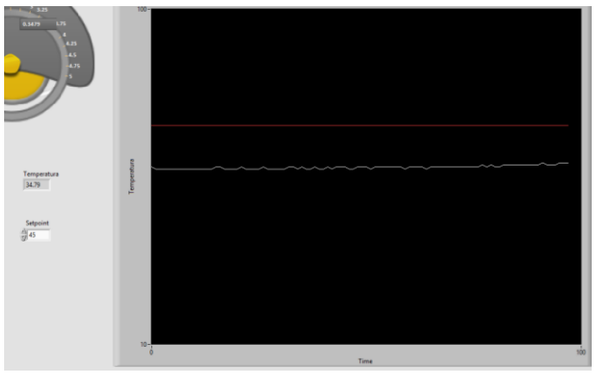

Figure 14 Transient temperature from 35 to 45 ° C

Conclusions

In this work, a proposal to improve the performance of a commercial thermal cycler for the model Cole Parmer 1095-00 was presented. Among the improvements made to the system, it can be highlight the modification of the temperature selector for a digital one that allows introduce the desired temperatures in the range of 0-100 ° C with variations of ± 0.5 ° C and that includes a controller to maintain and regulate the level of the temperature liquid used in the process through a replenishment system. In addition, an interface was developed to monitor the operation of the remote system in real time through an executable program developed in Labview®, which allows control actions to be exercised from the central system in Labview®. The developed system is low cost and allows to continue using an old model.

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Direct and inverse kinematic model of the OMNI PHANToM

Modelo cinemático directo e inverso del OMNI PHANToM

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Abstract

In this work we describe the kinematic and inverse model of an Omni Phanton haptic device with three degrees of freedom. For direct kinematic analysis the Denavit-Hartenberg methodology is used since it is an open chain robot, and for the inverse kinematics the geometric method is used, since the solution is not trivial. The mathematical analysis to obtain the kinematic model of the haptic device is validated in SolidWorks, Matlab® and experimentally.

Haptic device, denavit-hartenberg method, direct and inverse kinematics

Resumen

En este trabajo se describe el modelo cinemático e inverso de un dispositivo háptico Omni Phanton de tres grados de libertad. Para el análisis cinemático directo se emplea la metodología Denavit-Hartenberg ya que es un robot de cadenas abierta, y para la cinemática inversa se emplea el método geométrico, ya que la solución no es trivial. El análisis matemático para obtener el modelo cinemático del dispositivo háptico es validado en SolidWorks, Matlab® y experimentalmente.

Dispositivo háptico, Metodo denavit-hartenberg, cinemática directa e inversa

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Introduction

The beginnings of robotics are given by the year 1801 when Joseph Jacquard invents a programmable textile machine using punched cards, but it is until the year of 1917 when the term robot is first used that comes from the Czech word "robota", which means servitude or forced labor. The beginnings of robotics are given by the year 1801 when Joseph Jacquard invents a programmable textile machine using punched cards, but it is until the year of 1917 when the term robot is first used that comes from the Czech word "robota", which means servitude or forced labor.

The characteristics of the kinematic model to be studied, is a haptic device Geomagic® Touch TM (OMNI PHANToM®) of Figure 8 provides an authentic three-dimensional navigation and feedback force and integrate the sense of touch in 3D modeling systems, as well as in commercial and research applications. This 3D Systems haptic device can accurately measure the 3D spatial position (along the X, Y and Z axes) and the orientation (turn, tilt and direction) of the hand pencil. It uses motors to create the forces of return in the hand of the user to simulate the touch and interaction with virtual objects, that is, it provides a feedback of force of 3 degrees of freedom (DOF) (3DSystems, 2013 and Silva, 2009, Vidrios- Serrano, et al., 2018, Yiannoutsou and Price, 2018).

Table 1 shows the technical specifications of the OMNI PHANToM haptic device and figure 1 shows the device. As you can see, it can be modeled kinematically as a manipulator robot, Almasi and Behzad, (2018).

Description	Characteristic
Work area	160An × 120Al × 70P mm
Range of movement	Movement of the hand with twist of the wrist
Nominal resolution	0.055mm
Maximum strength	3.3N
Force feedback	X and Z
Port interface	Ethernet conforming to RJ45

Table 1 Geomatic® Touch device specifications

Figure 1 Geomagic® TouchTM (OMNI PHANToM®)

A robot arm can be modeled as an articulated chain in open loop with rigid bodies (links) connected in series by revolute joints or prismatic driven by actuators. One end of the chain is attached to a fixed coordinate system at the base of the manipulator while the other end is free. For the control of the manipulators we want to know the spatial description of the free end with respect to the fixed reference coordinate system of the base (Spong & Vidyasagar, 1989, Schilling, 2000, Tsai, 1999).

The analytical study of the geometry of the manipulators with respect to a fixed reference coordinate system without considering the forces / moments that originate said movement is known as kinematic study (Barrientos, 1999, Fu, 1987). There are two problems to solve in terms of the kinematics of a robot arm; to the relationship that exists between the joint coordinates (θ) with the Cartesian coordinates (x) and its orientation is known as direct kinematics, while the inverse function is known as inverse kinematics, as exemplified in Figure 2. The kinematics is divided into three: position, speed and acceleration.

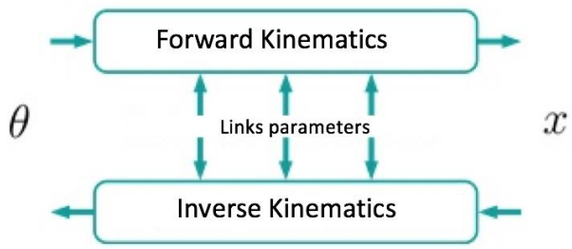

Figure 2 Direct and inverse kinematic problem

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Kinematic position model

The problem of direct kinematics is reduced in finding the homogenous transformation matrix that relates the end of the manipulator to a reference system in the base of the device. The homogenous transformation matrix is composed of a rotation matrix (R), a position vector (P) Cartesian, a perspective vector (f) and the scale as shown in equation 1. By the year 1955 Denavint and Hartenberg creates an algorithm to find this matrix, which describes the spatial geometry of a robot arm with respect to a fixed coordinate system.

$$T = \begin{bmatrix} \mathbf{R}_{(3\times3)} & \mathbf{P}_{(3\times1)} \\ \mathbf{f}_{(1\times3)} & 1 \end{bmatrix} \quad (1)$$

a) Parameters of Denavit - Hartenberg

This method is based on determining four parameters: θ_i, α_i, d_i and a_i, related to the links i of the robot, to define the homogeneous transformation matrices of each link ${}^{i-1}A_i$ they are represented as a product of four basic transformations, as shown in equation 2, (Angeles, 1997, Fu, 1987, Kelly, 2003, Reyes, 2011).

$${}^{i-1}A_i = Rot_{z,\theta_i} Trans_{z,d_i} Trans_{x,a_i} Rot_{x,\alpha_i} \quad (2)$$

Where:

- θ_i The angle from the axis $X_{sc_{i-1}}$ to X_{sc_i} measured around the axis $Z_{sc_{i-1}}$
- α_i The angle between the axis $Z_{sc_{i-1}}$ and Z_{sc_i}, measured around the axis X_{sc_i}.
- d_i The distance along the axis $Z_{sc_{i-1}}$ of the coordinate system $O_{sc_{i-1}}$ to the intersection of X_{sc_i} and $Z_{sc_{i-1}}$.
- a_i The distance along the axis X_{sc_i} of the coordinate system O_{sc_i} to the intersection of the axis X_{sc_i} and $Z_{sc_{i-1}}$ to Z_{sc_i}.

The homogeneous transformation matrix proposed by Denavint and Hartenberg is shown in equation 3.

$${}^{i-1}A_i = \begin{bmatrix} \cos\theta_i & -\sin\theta_i\cos\alpha_i & \sin\theta_i\sin\alpha_i & a_i\cos\theta_i \\ \sin\theta_i & \cos\theta_i\cos\alpha_i & -\cos\theta_i\sin\alpha_i & a_i\sin\theta_i \\ 0 & \sin\alpha_i & \cos\alpha_i & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad (3)$$

Figure 3 shows the assignment of the coordinate systems for the OMNI PHANToM® device according to the Denavint-Hartenberg algorithm, considering that its initial position where the angles θ_1, θ_2 and θ_3 are 0°.

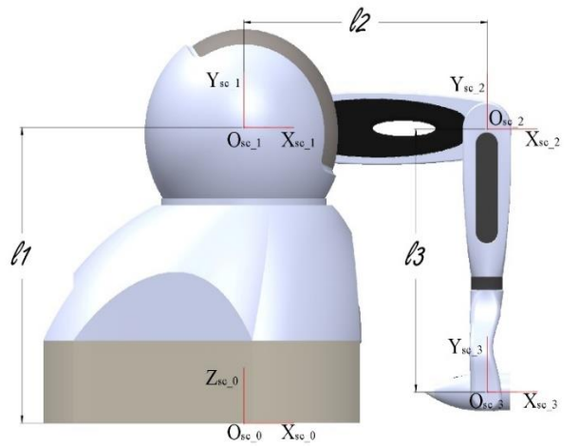


Figure 3 Assignment of coordinate systems

Table 2 shows the parameters of Denavint - Hartenberg for each link of the OMNI PHANToM®.

Joint	θ_i	α_i	d_i	a_i
1	θ_1	90°	l_1	0
2	θ_2	0°	0	l_2
3	$\theta_3 - 90°$	0°	0	l_3

Table 2 Parameters of Denavit – Hartenberg

The haptic device has a particularity in its link 2, because when it rotates the coordinate system {O_{sc2})} remains in the same orientation, which only undergoes translation. So the matrixes ${}^{i-1}A_i$ for joints 1 and 3 are obtained according to equation 4, while for articulation 2 only a translation matrix is applied. For the purpose of simplifying the equations one has to $cos(\theta_i) = C\theta_i$ y $sin(\theta_i) = S\theta_i$ as well as using the trigonometric property $\cos(\theta_3 - 90°) = \sin(\theta_3)$ y $\sin(\theta_3 - 90°) = -\cos(\theta_3)$.

$${}^{0}A_1 = \begin{bmatrix} C\theta_1 & 0 & S\theta_1 & 0 \\ S\theta_1 & 0 & -C\theta_1 & 0 \\ 0 & 1 & 0 & l_1 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad (4)$$

$$ {}^{2}A_{3} = \begin{bmatrix} S\theta_3 & C\theta_3 & 0 & l_3 S\theta_3 \\ -C\theta_3 & S\theta_3 & 0 & -l_3 C\theta_3 \\ 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

While the translation matrix for joint 2 on the x axis is given by equation 5.

$$ {}^{1}A_{2} = T_x = \begin{bmatrix} 1 & 0 & 0 & l_2 C\theta_2 \\ 0 & 1 & 0 & l_2 S\theta_2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad (5) $$

The homogenous transformation matrix that relates the final end to the reference coordinate system results from the multiplication of the matrices of the equations 4 and 5, $T = {}^{0}A_{1} \cdot T_x \cdot {}^{2}A_{3}$, where $l_1 = l_2 = l_3 = l$.

$$ \begin{aligned} T &= \begin{bmatrix} C\theta_1 & 0 & S\theta_1 & 0 \\ S\theta_1 & 0 & -C\theta_1 & 0 \\ 0 & 1 & 0 & l \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & lC\theta_2 \\ 0 & 1 & 0 & lS\theta_2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} {}^{2}A_{3} \\ &= \begin{bmatrix} C\theta_1 & 0 & S\theta_1 & lC\theta_1 C\theta_2 \\ S\theta_1 & 0 & -C\theta_1 & lS\theta_1 C\theta_2 \\ 0 & 1 & 0 & lS\theta_2 + l \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} S\theta_3 & C\theta_3 & 0 & lS\theta_3 \\ -C\theta_3 & S\theta_3 & 0 & -lC\theta_3 \\ 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \end{aligned} \quad (6) $$

Developing equation 6, you have

$$ T = \begin{bmatrix} C\theta_1 S\theta_3 & C\theta_1 C\theta_3 & S\theta_1 & l\left(C\theta_1 S\theta_3 + C\theta_1 C\theta_2\right) \\ S\theta_1 S\theta_3 & S\theta_1 C\theta_3 & -C\theta_1 & l\left(S\theta_1 S\theta_3 + S\theta_1 C\theta_2\right) \\ -C\theta_3 & S\theta_3 & 0 & l\left(-C\theta_3 + S\theta_2 + 1\right) \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad (7) $$

From the equation 7 we extract the position vector $P_{3\times1}$ that solves the direct kinematic problem of position, and we obtain the direct kinematics, as shown in equation 8.

$$ \begin{aligned} x &= l\left(C\theta_1 S\theta_3 + C\theta_1 C\theta_2\right) \\ y &= l\left(S\theta_1 S\theta_3 + S\theta_1 C\theta_2\right) \\ z &= l\left(-C\theta_3 + S\theta_2 + 1\right) \end{aligned} \quad (8) $$

Inverse kinematic position model

One of the most used methods to solve the inverse kinematic problem in manipulators with few degrees of freedom is without doubt the **geometric**.

Its main characteristic is based on finding a sufficient number of geometric relationships (mainly triangles) in which the Cartesian coordinates of the robot end $P\left(X_{sc_0}, Y_{sc_0}, Z_{sc_0}\right)$, its joint coordinates and the dimensions of its links are related to each other (Craig, 2003, Paredes, 2018, Reyes, 2012, Siciliano, 2009, Spong &Vidyasagar, 1989).

Figure 4 shows a top view of OMNI PHANToM®, projecting the point $P\left(X_{sc_0}, Y_{sc_0}, Z_{sc_0}\right)$ on the plane X_{sc0} Y_{sc0}, a right triangle is formed that allows finding the value of θ_1.

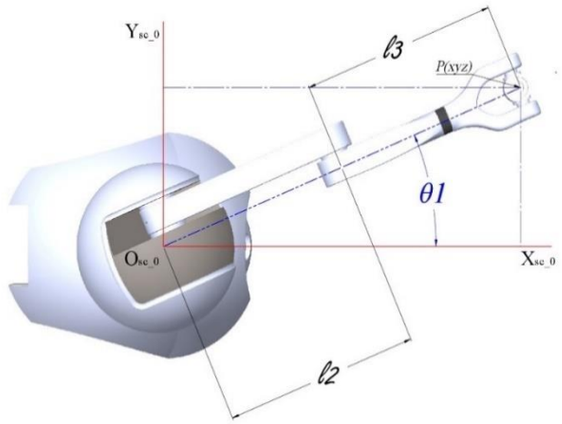


Figure 4 Top view to get the value of $\boldsymbol{\theta_i}$

Applying trigonometric properties we have equation 9, which represents the value of θ_1.

$$ \theta_1 = \arctan\left(\frac{Y_{sc_0}}{X_{sc_0}}\right) \quad (9) $$

A side view of the device is made as shown in figure 5, where only links 2 and 3 that are in the plane are considered. $X_{sc_0} Z_{sc_0}$. Due to the mechanical configuration of the haptic device it is analyzed in the elbow configuration above that observed in the figure. The value θ_2 this given by the value of the auxiliary angles as is the case of α and β.

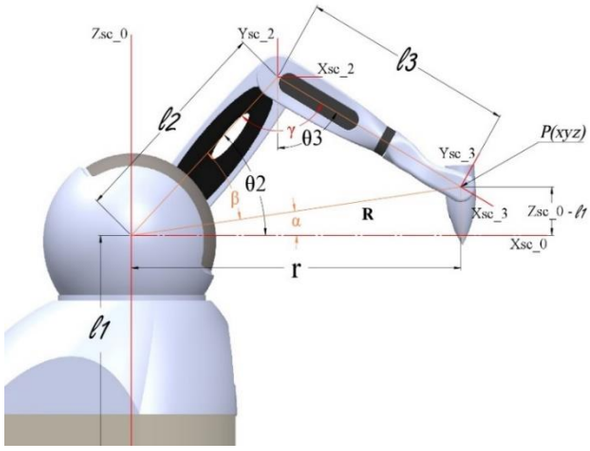


Figure 5 Side view for obtaining angles $\boldsymbol{\theta_2}$ and $\boldsymbol{\theta_3}$

The value of α is obtained from the right triangle formed by the vectors r, R and $Z_{sc_0} - l_1$, where r is the vector $P(X_{sc_0}, Y_{sc_0}, Z_{sc_0})$ proyectado sobre el plano $X_{sc_0}Y_{sc_0}$ from figure 3 and they are obtained by means of equation 10.

$$r = \sqrt{X_{sc_0}{}^2 + Y_{sc_0}{}^2} \tag{10}$$

The vector R of equation 11 is the result of the point $P(X_{sc_0}, Y_{sc_0}, Z_{sc_0})$ with the origin $Z_{sc_0} - l_1$, Also remember that $l_1 = l_2 = l_3 = l$

$$R = \sqrt{r^2 + \left(Z_{sc_0} - l\right)^2} \tag{11}$$

applying trigonometric identities we obtain the value of α

$$\alpha = \arctan\left(\frac{Z_{sc_0} - l}{r}\right) \tag{12}$$

For the angle β part of the triangle formed in orange and by law of the cosines is equation 13.

$$\beta = \arccos\left(\frac{R}{2l}\right) \tag{13}$$

The angle θ_2 of equation 14 is the sum of the angles α and β of equations 12 and 13 respectively.

$$\theta_2 = \alpha + \beta \tag{14}$$

The angle θ_3 is obtained through the auxiliary angle γ, the value of θ_2 in equation 14 and the 90° between the negative axis Y_{sc2} and the positive axis X_{sc2}, as shown in Equation 15.

$$\theta_3 = \gamma + \theta_2 - 90^{\circ} \tag{15}$$

where γ is obtained by equation 16

$$\gamma = \arccos\left(\frac{2l^2 - R^2}{2l^2}\right) \tag{16}$$

Experimental results

a) Experimental team

For the validation of the kinematic model, a computer used for the development of this project whose characteristics are shown in table 3, and an OmniPhantom haptic device, as shown in figure 6, is used.

First name	Characteristic
Brand	HP Brand
Model	Model xw6600 Workstation
Intel processor	Intel ® Xeon ® Processor CPU E5420 @ 2.50 GHz
Installed memory (RAM)	8.00 GB
Type of system	64-bit operating system
Windows edition	Windows 7 Ultimate

Table 3 Computing equipment specifications

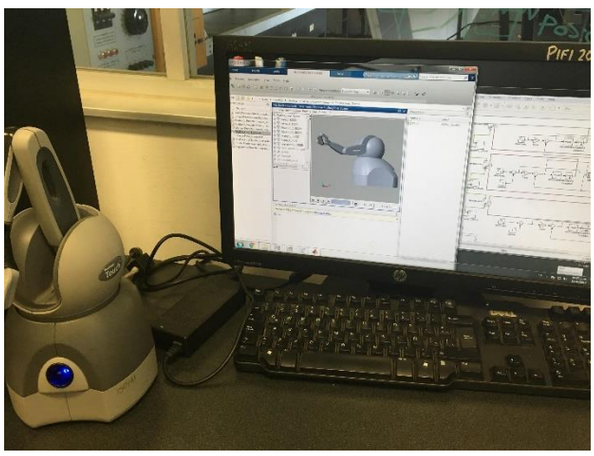
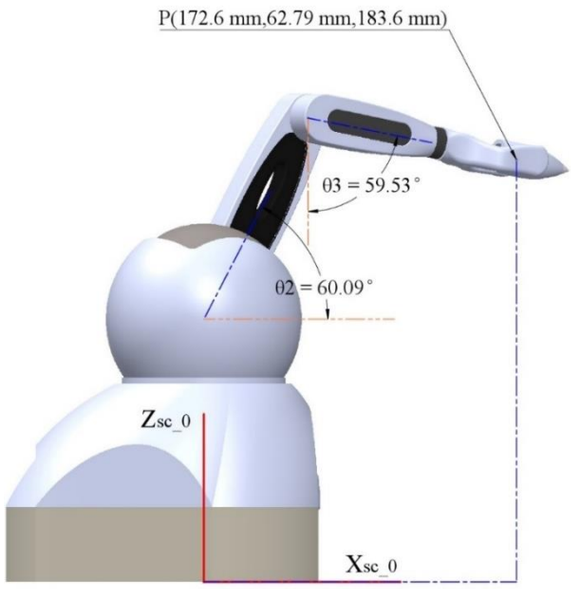


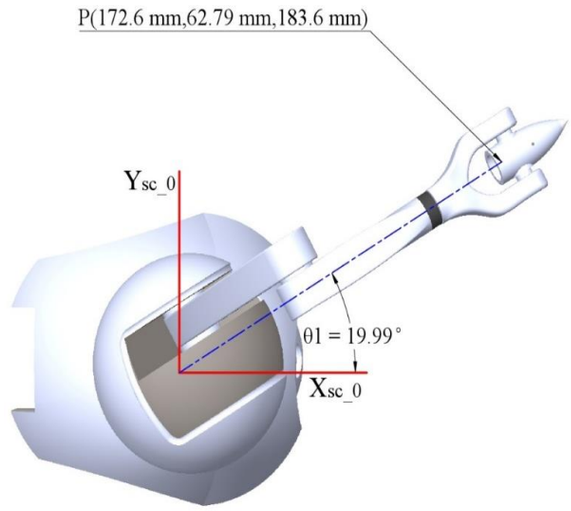
Figure 6 Experimental team

b) Forward Kinematics

The experimental validation of equation 8 representing the Cartesian position of the final effector projected in the coordinate system O_{sc0} is shown in figure 7, where the angular values are assigned to each of the joints: θ_1 =19.19°, θ_2 =60.09° and θ_3=59.53°. Where it is appreciated that the Cartesian position is $\boldsymbol{P}(172.6mm, 62.79mm, 183.6mm)$.



(a) Plane projection $\mathbf{X_{sc_0}Z_{sc_0}}$



(b) Plane projection $\mathbf{X_{sc_0}Y_{sc_0}}$

Figure 7 Validation of the direct kinematics of the OMNI PHANToM®

PHANSIM is a tool for Simulink of the haptic devices of Sensable, this tool is for academic purposes and developed for the control of robot movement and teleoperation. Traditionally, to use these devices, it is necessary to generate codes in C / C ++ using the OpenHaptics® libraries (SDK), which are provided by the manufacturer. With the use of this tool the use of the devices is facilitated.

The OMNI PHANToM® device is brought to the aforementioned angular position to validate the Cartesian position, with the use of the PHANSIM library in Matlab's Simulink the interface shown in figure 8 is made.

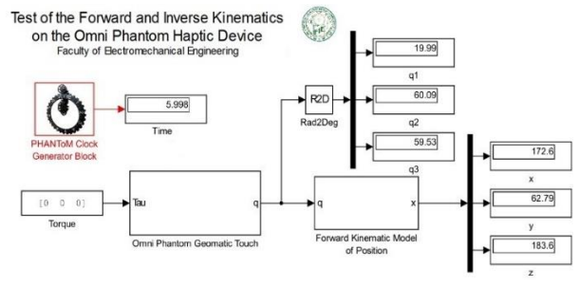
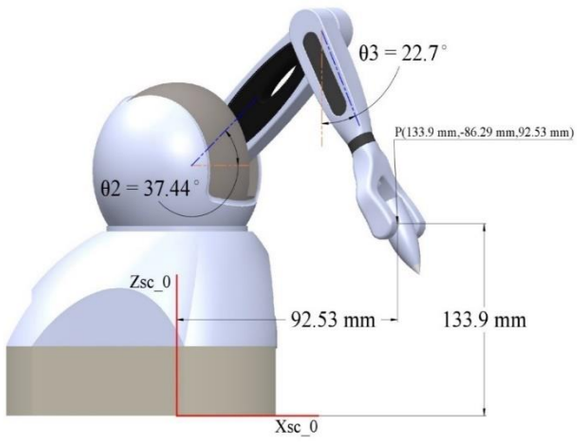


Figure 8 Validation of the OMNI PHANToM® direct kinematic model in Simulink

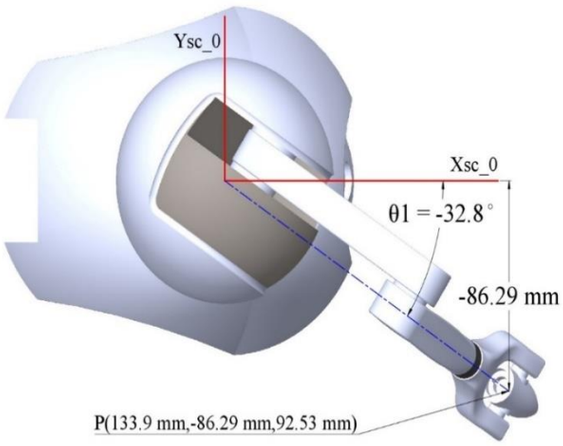
To allow the free movement of the device, a zero torque vector is sent to it, in the second block from left to right, the reading of the angular position of the device is read to later enter the block that calculates the direct kinematics, in which it is checked that the values of the Cartesian position coincide with those of the point $P\left(X_{sc_0}, Y_{sc_0}, Z_{sc_0}\right)$ shown in figure 7.

b) Inverse position kinematics

For the validation of the inverse kinematic position model, the values of $X_{sc_0} = 133.9\,mm$, $Y_{sc_0} = -86.29\,mm$ and $Z_{sc_0} = 92.53\,mm$ of the final effector with respect to the coordinate system O_{sc_0}, with the help of the model made in SolidWorks the values that the angles must take are verified θ_1, θ_2 y θ_3, as shown in figure 9.



(a) Plane projection $\mathbf{X_{sc_0}Z_{sc_0}}$



(b) Plane projection $\mathbf{X_{sc_0}Z_{sc_0}}$

Figure 9 Validation of the inverse kinematics of OMNI PHANToM®

Figure 10 shows the experimental validation with the OMNI PHANToM® through the PHANSIM library in which it is verified that for the given position the angles are: $\theta_1 = -32.8°$, $\theta_2 = 37.44°$ and $\theta_3 = 22.6°$.

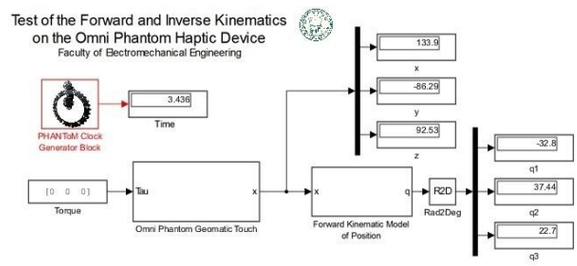


Figure 10 Validation of the inverse kinematic model of the OMNI PHANToM® in Simulink

Conclusions

In the present work, the direct and inverse kinematic model of the OMNI PHANToM® haptic device is shown, which is essential for the modeling and simulation of mechanical systems. A simple mathematical analysis is presented to facilitate the reader. A three-dimensional model is developed on the SolidWorks platform for the validation and understanding of the behavior of direct and inverse kinematics.

Through the use of the PHANSIM library, the experimental validation is carried out in the Matlab Simulink platform, where it is appreciated that the proposed model is correct.

The experimental results obtained from the OMNI PHANToM® are correct, that is to say, for the direct kinematics several angles were introduced and the Cartesian position is obtained correctly, the same is done for the reverse kinematics valication, the position is introduced of the end effector and the angles of each article of OMNI PHANToM® are obtained, so it is concluded that the mathematical analysis of the direct and inverse kinematics are correct. For future work in the area of control of robot manipulators the dynamic model is developed.

Acknowledgement

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Transmition System Design for a Green Cane Conveyor

Diseño del sistema de transmisión para una transportadora de caña en verde

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Abstract

This work proposes a design of a conveyor for a prototype of mechanized harvester of green sugar cane. This way of harvest represents a technological opportunity that reduces costs, improves the harvest and minimizes the negative impacts to the environment generated by the traditional method of burning. The design of a green cane harvester consists of several subsystems that start from cutting, defoliation, transportation and a temporary storage. The present work shows the methodology to design the transmission system for a bucket conveyor that will be responsible for the transfer of cane to a container. Within the design, operating factors are taken into account, such as the amount of cane to be transported, the weight of the components, speeds, the power required to move the conveyor, and the type of chains, sprockets, are defined material and diameter of the transmission shaft.

Shaft, Design, Simulation

Resumen

Este trabajo propone un diseño de una transportadora para un prototipo de cosechadora mecanizada de caña de azúcar en verde. Esta forma de cosechar representa una oportunidad tecnológica que reduce costos, mejora la cosecha y minimiza los impactos negativos al medio ambiente que genera el método tradicional de quema. El diseño de una cosechadora de caña en verde consiste de varios subsistemas que parten desde el corte, deshoje, transportación y un almacén temporal. El presente trabajo muestra la metodología para diseñar el sistema de transmisión para un transportador de cangilones que se encargara del traslado de caña hacia un contenedor. Dentro del diseño se toman factores de trabajo en operación como la cantidad de caña a transportar, el peso de los componentes, velocidades, la potencia requerida para mover el transportador, además que se definen el tipo de cadenas, catarinas, y se concluye definiendo el material y diámetro del eje de trasmisión.

Ejes, Diseño, Simulación

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Introduction

Mexico produces around 5 million tons of sugar, with a value of more than 3 billion dollars per year, which represents about 12% of the value of the primary sector. The cane production is carried out in 664 thousand hectares that supply 57 sugar mills in 15 sugarcane states. (Colombia, Ceni Caña, 2002)

The traditional practice in the sugar mills for harvesting cane is to burn the plantation to facilitate the harvesting of the stems. However, the burning of a single hectare of cane plantation means that more than 160 kg of carbon dioxide and carbon dioxide are released into the atmosphere. During the harvest season, the sugarcane areas tint their skies of reddish tones due to the large amount of smoke and pieces of burnt leaf that the wind carries to the nearby towns, causing problems with drainage.

By harvesting the cane in green and avoiding combustion in the sugarcane fields, the impact on water pollution is reduced and the environment, the flora and fauna of the sugarcane agro-system is protected. In addition, less application of herbicides is required in the initial stage of crop growth that would translate into higher sugar yields.

The mechanized harvesting of sugarcane represents a window of technological opportunity that not only reduces costs and streamlines the harvesting and delivery of cane to the mill, but also minimizes the negative impacts on the environment, contributing to the productivity of the mills and the improvement of the standard of living of the producers and inhabitants of the sugarcane areas of Mexico.

The technology for the management and harvesting of cane in green is not yet fully developed, due to the fact that its disadvantages are that the soil must be uniform and socially it would not require a large amount of labor. An important step in the design of a harvester in green is the transportation of the cane after a process of cutting and defoliation.

This project determines the necessary design characteristics that the power transmission system must have for a conveyor, which is part of a subsystem of a green cane harvester.

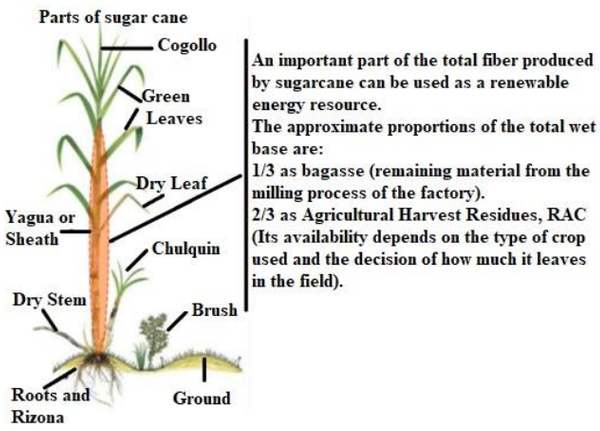

Figure 1 Parts of sugar cane

Description of the Method

The conceptual design of the power transmission system for a sugarcane transporter will be carried out. This design will be applied in a subsystem of transportation, cutting of the bud and storage within the process of harvesting cane in green.

The conveyors are machines of horizontal, vertical or sloping design that are used for the continuous transport of materials in a determined trajectory, until the final point or discharge. They consist of a surface belt that circulates in rollers and pulleys, by a propulsion motor, and all arranged in a structure or support. (Selesiana, 2011). There are conveyors that are driven by gravity and others by motive power such as belt conveyors, slats, drag, tires, vibratory, rollers, screws and bucket elevators. Among the common transporters in the agroindustrial branch we have:

1. Roller conveyors.
2. Band conveyors.
3. Bucket or shingle conveyors.

The roller conveyor is not suitable for transporting cane since the space between rollers will cause waste of the product, as well as encrustations may occur, making it difficult to move the load.

The disadvantages of the belt conveyor is that the material of the textile belts has a short duration when they work with abrasive materials or large pieces and they are more used in the transport of loose material and moderately small pieces. (Budynas, 2012).

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The bucket conveyor has the following properties:

– Carries large and heavy loads
– It's slow-moving
– Resists large tensile forces
– The buckets are used to transport different loads
– Supports tilt angles greater than 18°.

The harvest technology in green cane implies the presence of large amounts of foreign matter and buds. By these considerations it is defined that the best option to transport cane in green is the transporter of buckets.

Initial parameters

The initial parameters to develop the design calculations of the bucket conveyor are:

– Amount of sugarcane in green to transport.
– Bucket dimensions.
– Total length of the conveyor.
– Density of the bucket material.
– Density of the cane in green.

(Torn, 2018), establishes that the subsystem 1 of the harvester in green has a mass flow of cane at the output of 75,000 kg / hra. (Mott, 2004) considers a design factor of 1.15 to 2 for structures under static loads with a high degree of confidence in the design data. The mass flow of cane in green for design was calculated as shown:

$$\dot{m_d} = 75{,}000(1.15) = 86{,}250\,\frac{kg}{hra.} \qquad (1)$$

Torn also developed a procedure to determine the density of sugar cane in green. This procedure consists of cutting equal pieces of cane and making dimensions in different sections. The results that were obtained can be seen on table 1.

Measurements made in sections of cane	Values (averages)
Transverse diameter $D_{caña}$	0.035 m
Mass $m_{caña}$	1 *kg/m*
Density $\rho_{caña}$	1058.8996 *kg/m*^{3}

Table 1 Average values in cane sections in green

Torn defines that the length of cane at the exit of the cutting subsystem is 2 meters on average. Therefore, with the data from Table 1, the mass flow was calculated according to cane numbers per second.

$$\dot{m}_d = 86{,}250\frac{kg}{hra.}\left(\frac{1\ caña}{2kg}\right)\left(\frac{1\ hra}{3600\ seg}\right) = 11.979\ \frac{cañas}{seg} \cong 12\ \frac{cañas}{seg.}$$

The bucket was designed so that it can transport 3 rods in its interior, therefore, in the area of admission of the transporter it is necessary to pass 4 buckets per second, so that it receives 12 rods in this time. The bucket is composed of 2 rectangular sections of wood. The dimensions of the bucket can be seen in figure 2.

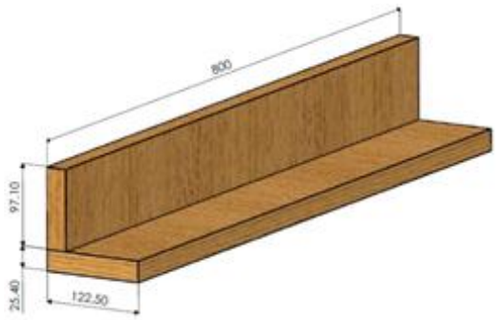

Figure 2 Dimensions of the bucket of matera for the cane transporter in green

The linear speed of the conveyor was calculated according to the dimensions and number of buckets that must pass per second.

$$V = \frac{122.5\ mm \times 4}{1\ seg.} = 490\,\frac{mm}{seg} \cong 0.5\,\frac{m}{seg}$$

Calculation of the force in the periphery of the drum of the driving head

The buckets are made of oak, (Reforestal, 2012) establishes that the density of this material is 650 *kg/m*^{3}.

The conveyor belt will have 14 buckets to ensure proper operation. The buckets will be transported by means of a commercial steel chain. Figure 3 shows the distribution of the buckets on the chain.

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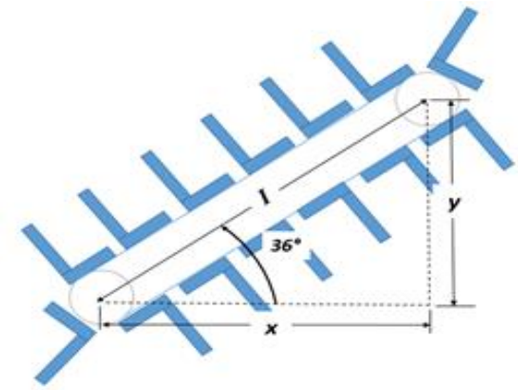

Figure 3 Distribution of the buckets on the roller chain

The total weight of the buckets Q_{p1} is 40.6042 kg., while the approximate length of the chain is calculated according to the number of buckets:

$$L_{Aprox} = 122.5mm \times 14 = 1715mm = 1.715m$$

For design purposes, it is proposed to use an ANSI 50 chain. Table 2 shows some characteristics for standard American roller chains.

Chain Number ANSI	Pitch in (mm)	Width in (mm)	Minimal Resistence to Stress lbf (N/m)	Average Weigth lbf/ft (N/m)	Roller Diameter in (mm)	Spacing of Multiple Standars in (mm)
25	0.250 (6.35)	0.125 (3.18)	780 (3470)	1.09 (1.31)	0.130 (3.30)	0.252 (6.40)
35	0.375 (9.52)	0.188 (4.76)	1760 (7830)	0.21 (3.06)	0.200 (5.08)	0.399 (10.13)
41	0.500 (12.70)	0.25 (6.35)	1500 (6670)	0.25 (3.65)	0.306 (7.77)	———
40	0.500 (12.70)	0.312 (7.94)	3130 (13920)	0.42 (6.13)	0.312 (7.92)	0.566 (14.38)
50	0.625 (15.88)	0.375 (9.52)	4880 (21700)	0.69 (10.1)	0.400 (10.16)	0.713 (18.11)

Table 2 Characteristics for standard American roller chains (Budynas, 2012)

The weight of the chain Qp2 is calculated as follows:

$$Q_{p2} = \left(10.1\frac{N}{m}\right) * \left(\frac{1KG}{9.81N}\right) * (1.715\ m) = 1.7657\ kg$$

The weight of the belt and the rolling parts Q_p is obtained from the sum of the weight of the buckets Q_{p1} and the weight of the chain Q_{p2}

$$Q_p = 40.6042kg + 1.7657\ kg = 42.37\ kg$$

Once Qp has been determined, the weight of the tape is calculated according to the length qp defined by the following equation:

$$q_P = \frac{Q_P}{I} * g \quad (1)$$

Where I is the wheelbase of the conveyor pulleys. Considering 6 canjilones and 5 separations according to figure 3 we have I = 0.8575 m approximately. Substituting the values in equation 1 you get:

$$q_p = \frac{42.37\ kg}{0.8575m} = 49.411\ \frac{kg}{m} * \left(\frac{9.81m}{s^2}\right) = 484.722\ N/m$$

The distance between centers is divided horizontally and vertically as shown in figure 3, because the conveyor has an inclination angle of 36°

$$\frac{0.8575\ m}{sen\ 90} = \frac{x}{sen\ 54} \quad x = 0.6937\ m$$

$$\frac{0.8575\ m}{sen\ 90} = \frac{y}{sen\ 36} \quad y = 0.5040\ m$$

A fictitious assumption is calculated to increase the distance between axes I0 with equation 2.

$$I_0 = \frac{50 - 0.2\ x}{2} \quad (2)$$

In this case, we have the approximate distance defined $I_0 = 0$.

The force required to move the belt in vacuum is calculated using the following equation:

$$P_1 = f'q_p(I + I_o) \quad (3)$$

To find the value of P_1, a coefficient of friction or friction is selected, using $f' = 0.03$ (Mott, 2004).

Substituting in equation 3 you get:

$$P_1 = (0.03)\left(484.722\ \frac{N}{m}\right)(0.8575\ m) = 12.4694\ N$$

Force needed to move the material P_2

The equation to determine the force needed to move the material P_2:

$$P_2 = f'q_m(I + I_o) \quad (4)$$

Where q_m is the weight of the material transported per linear meter of the conveyor (kg/m).

$$q_m = \frac{\dot{m}_d}{3.6\ V} * g \quad (5)$$

$$q_m = \frac{23.9583\,\frac{kg}{s}}{3.6\,\left(0.5\,\frac{m}{s}\right)} * (9.81\,\frac{m}{s^2}) = 130.571\,\frac{N}{m}$$

With the results obtained, it is substituted in equation 4 to obtainP_2.

$$P_2 = (0.03)\left(130.571\,\frac{N}{m}\right)(0.8575\,m) = 3.358\,N$$

Force needed to move the material vertically P_3

Because the conveyor has an angle of inclination, not only transport the material horizontally but also vertically, that is why the force required to move the material P_3 vertically with the following equation is calculated:

$$P_3 = \frac{\dot{m}_d y}{3.6V} * g \qquad (6)$$

$$P_3 = \frac{\left(23.9583\frac{kg}{s}\right)(0.5040m)*(\frac{9.81m}{s^2})}{(3.6)(0.5m/s)} = 65.8055\,N$$

Finally, adding the three loads P_1, P_2 and P_3, we obtain the value of the total force P_T in the periphery of the sprocket wheel:

$$P_T = P_1 + P_2 + P_3 \qquad (7)$$

$$P_T = 81.636\,N$$

Calculation of power absorbed by the conveyor

Known the efforts in the periphery of the wheel Catarina and the speed of the tape, it is immediate the calculation of the respective powers absorbed by the transporter defined by the following equation:

$$N_T = \frac{P_T}{75} V \qquad (8)$$

Substituting the values obtained in equation 8 is obtained:

$N_T = 0.5442\,CV$ = 0.537 hp

It is defined that the commercial engine to be selected will have a power of 3/4 Hp.

Selection of the chain

The next step was to determine the type of roller chain that supports N_T power to move the conveyor properly. The speed of entry and exit of the conveyor remains constant, (Budynas, 2012) proposes a procedure for the selection of chain at different speeds of rotation. The design data is shown in table 3.

Ratio of speeds n1 / n2	1
Power absorbed by the N_T conveyor	0.537 Hp
Service factor Ks	1.3
Design factor nd	1.5
Number of teeth of the driving Catarina for low speeds N	17
K1 preextreme power	1
Number of strands K_2	1

Table 3 Design data for the selection of the roller chain

Equation 9 determines the necessary power capacity. Thus

$$H_{TAB} = \frac{\eta_d k_s H_{nom}}{k_1 k_2} \qquad (9)$$

$$H_{TAB} = \frac{(1.5)(1.3)(0.537)}{(1)(1)} = 1.047$$

According to the compiled information of the ANSI B29.1-1975 standard described by (Budynas, 2012) it is defined that the chain to be used is ANSI 50 with a step p of 15.88 mm since it supports a nominal capacity of 1.34 hp at a 100 rpm speed.

The selection of the roller chain is a function of the revolutions per minute at which it rotates. The diameter of Catarina D was calculated as shown:

$$D = \frac{p}{sen(\frac{180}{N})} = 8.642\,cm$$

To determine the angular velocity ω the approximation of the linear velocity V was taken into account, considering the passage of 4 buckets per second.

$$\omega = \frac{2V}{D} = \frac{2 \cdot 0.5\,\frac{m}{s}}{0.0864m} = 11.5741\,\frac{rad}{seg} = 110\,rpm$$

In this way it is checked that the roller chain selection is correct.

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The commercial engines of 0.75 hp rotate at higher speeds, to reach the speed ω it will make use of a speed reducer.

(Mott, 2004) suggests a maximum of 50 steps for the distance between centers C of the ladybirds so that the chain does not fail. If we consider that the approximate center distance I is 85.5 cm, then we can define the distance between centers C of 48 steps.

The length of the chain is defined by:

$$L = 2C + \frac{N_1+N_2}{2} + \frac{(N_2-N_1)^2}{4\pi^2 C} \quad (10)$$

$$L = 2(48) + \frac{17+17}{2} + \frac{(17-17)^2}{(4\pi^2)(48)} = 113\ pasos$$

The appropriate type of chain to use for the design of the conveyor is the ANSI 50 chain with a single strand with 113 steps, in addition to the use of type B stainless steel 17-tooth model 50B17SS. (Gear, 2013)

Design of axes

The conveyor shaft will be subject to the following loads:

- Weight of the ladybirds
- Load to transport
- Weight of the buckets
- Weight of the chain
- Tensions in the chain

The correct diameter of the arrow must be designed to ensure satisfactory resistance and therefore correct operation in work operations.

Calculation of the tensions of the chains

At the moment of transmitting the power, F1 is generated in the chain on the taut side. Unlike a band, on the loose side the chain does not exert any force F2 on the loose side. The strength of the taut side is calculated with the following equation (Mott, 2004):

$$F_1 = \frac{33000(H)}{V} \quad (11)$$

The power to transmit H is the result of the power of the commercial motor selected. Substituting data in equation (11) we have:

$$F_1 = \frac{33000(0.75Hp)}{98.5\frac{ft}{min}} = 251.269\ lb = 1117.7N$$

Calculation of all the loads that act on the axis

Calculation of all the loads that act for calculation purposes, a resultant force F_C is considered, which is the sum of the forces produced by the 14 buckets, the 2 chains and the cane that is transported as shown in figure 4 on the axis.

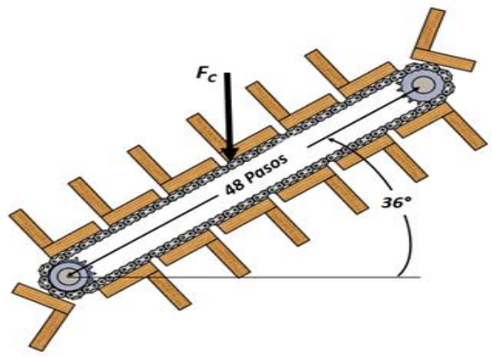

Figure 4 Resulting force applied to the centroid of the conveyor

Table 4 shows all the forces that apply on the centroid of the assembly.

Buckets (14 pieces) F_D	398.5 N
Chain F_E	18 N
Cane F_F	358.5 N

Table 4 Forces produced by several elements

For the lower shaft the force produced by the chain counteracts the resultant force F_C. Therefore, the design calculations are based on the upper axis, which receives the highest load. Figure 5 shows the free body diagram. The force F_G corresponds to the weight of the Catarina that is of 8 N. The forces R_{AX}, R_{AY}, R_{EX}, R_{EY} correspond to the reactions that are generated in the zone of support of the axis.

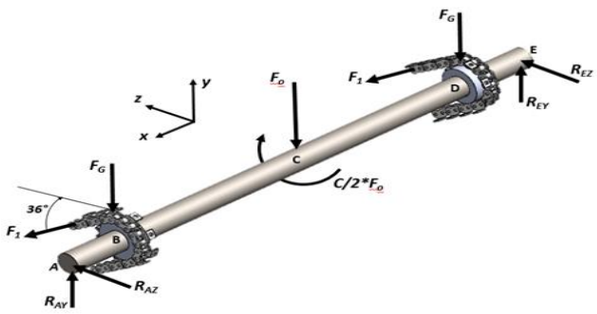

Figure 5 Reactions that are generated on the upper axis of the conveyor

Applying the equations of static equilibrium, the reactions in the supports were determined which are shown in table 5.

R_{AY}	1052.47 N
R_{AZ}	904.238 N
R_{EY}	1052.47 N
R_{EZ}	904.238 N

Table 5 Values of the reactions in the supports of the arrow

Critical point of the axis

To determine the critical point of the axis, the diagrams of the distribution of the bending and torsion moments were made. These diagrams are shown in figures 6-8.

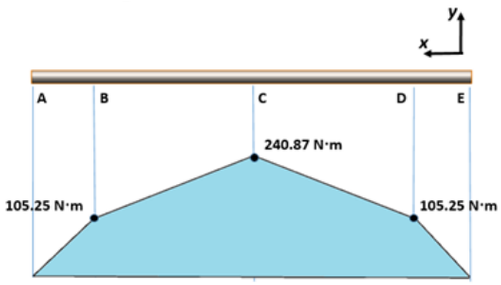

Figure 6 Diagram of bending moments in the flat xy

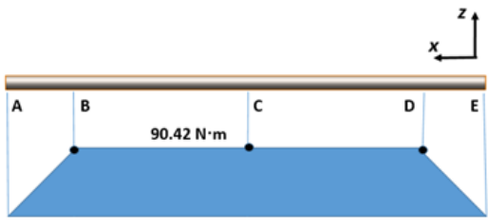

Figure 7 Diagram of bending moments in the xz plane

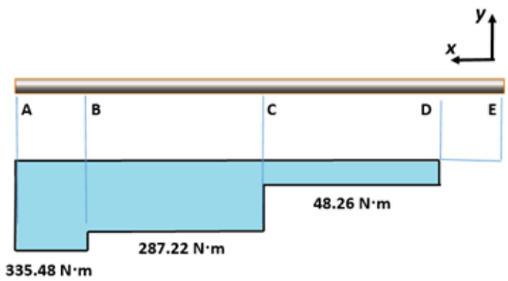

Figure 8 Diagram of torsional moments.

According to the diagrams, it can be seen that the critical zone is point C, since it is the place where the bending moment is maximum. Determining the magnitude of the bending moment.

$$M_c = \sqrt{240.87^2 + 90.42^2} = 257.282\ Nm$$
$$T_c = 287.22\ N \cdot m$$

Shaft design under static loads.

At moments at point C, a safety factor of 2 will be added because this mechanism will operate in non-uniform places and will be subject to vibrations and therefore increase impact efforts.

Many axles are made of low carbon steel, cold drawn steel or hot rolled steel such as ANSI 1020-1050 steels (Budynas, 2012). The material selected for the axis is an ANSI 4140 steel, with yield strength Sy of 665 MPa and ultimate tensile stress Sut of 758 MPa.

The minimum diameter required for the arrow is calculated as shown:

$$d = \left(\frac{32ns}{sy\ \pi}\sqrt{(M_c)^2 + (T_c)^2}\ \right)^{\frac{1}{3}} \quad (11)$$

$$d = \left[\frac{32(2)}{\pi(655 \times 10^6)}\sqrt{(257.282)^2 + (287.22)^2}\right]^{\frac{1}{3}}$$
$$= 0.0228\ m \approx 22.8\ mm$$

The SolidWorks software was used to verify by means of a finite element analysis the results obtained analytically. Figure 9 shows the results of the safety factor.

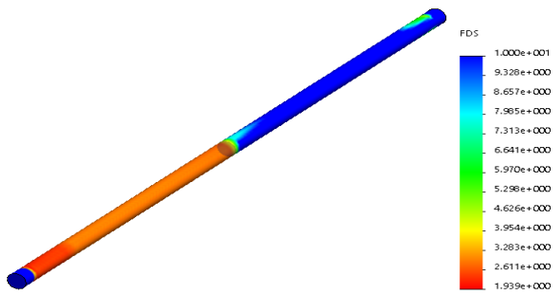

Figure 9 Distribution of the safety factor in the arrow

It can be seen that the safety factor approaches 2 as established in the calculations.

Shaft design under dynamic loads.

The behavior of parts of machines is different when subjected to varying loads. The case of the transporter arrow has a sinusoidal stress ratio completely reversed because it rotates at a constant revolution.

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The minimum diameter of the arrow can be determined by combining the forces by the energy of the distortion and using elliptical ASME as the criterion of failure.

$$d = \left\{ \frac{16n}{\pi} \left[4\left(\frac{K_f M_a}{S_e}\right)^2 + 3\left(\frac{K_{fs} T_a}{S_e}\right)^2 + 4\left(\frac{K_f M_m}{S_y}\right)^2 + 3\left(\frac{K_{fs} T_m}{S_y}\right)^2 \right]^{\frac{1}{2}} \right\}^{\frac{1}{3}} \quad (12)$$

In the design of the arrow is considered the absence of irregularities or discontinuities, such as holes, grooves or notches that significantly increase the efforts. Therefore, the factors of axial stress concentrator Kf and shear Kfs are equal to 1.

In the case of a rotating shaft with constant bending and twisting, the bending stress is completely reversible and the torsion is constant. Equation 12 can be simplified by matching Mm and Ta to 0, which simply eliminates some of the terms (Gear, 2013).

Considering a factor of surface, size and modification per load, it is determined that the limit of fatigue resistance is 254,466 Mpa. If you take a safety factor of 1.5 for the design and substitute in equation 12 you have:

$$d = \left\{ \frac{16(2)}{\pi} \left[4\left(\frac{(1)(257.282(2))}{254.466\times10^6}\right)^2 + 3\left(\frac{(1)(287.22)(2)}{655\times10^6}\right)^2 \right]^{\frac{1}{2}} \right\}^{\frac{1}{3}}$$

$$d = 0.0282m = 28.2\ mm$$

The result obtained represents the minimum value for the diameter of the arrow to resist the dynamic loads.

Shaft design under critical speeds

When an axis rotates, the eccentricity causes a deflection due to the centrifugal force that is resisted by the flexural stiffness of the EI axis. As long as the deflections are small, no harm is caused. However, another potential problem is the critical speeds where at certain speeds the axis is unstable and the deflections increase without an upper limit (Budynas, 2012).

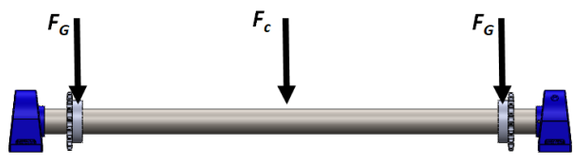

Figure 10 Loads on the arrow for calculating the critical speed

For calculating the critical speed of the arrow, the weight of the FG sprockets will be disregarded, since it is small compared to the resulting load F_c.

For an axis with a single mass, where the mass of the axis is small compared to the mass that is attached, the first critical velocity can be calculated approximately as a function of gravity g and the deflection of the axis at the location point of the mass δ:

$$\omega_c = \sqrt{\frac{g}{\delta}} \quad (13)$$

To determine the deflection at the location of the force Fc, the method of moments area was used.

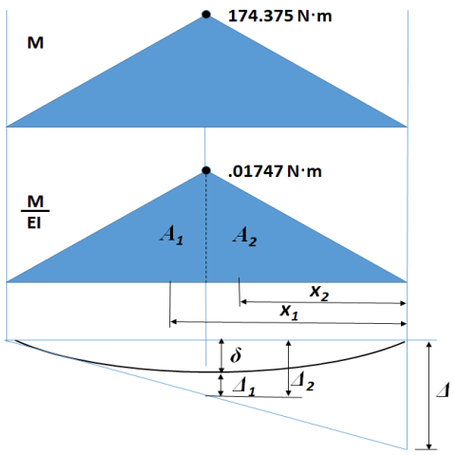

Figure 11 Moments area

The results are shown in table 6.

A_1, A_2	3.9307x10^{-3} m^2
x_1	0.6 m
x_2	0.3 m
Δ	3.5376x10^{-3} m
Δ_1	5.8960x10^{-4} m
Δ_2	1.7688x10^{-3} m
δ	1.1792x10^{-3} m

Table 6 Moments Area Values

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By replacing the value of the deflection in equation number 13, the value of the first critical velocity is obtained:

$$\omega_c = \sqrt{\frac{9.81\frac{m}{s^2}}{101.1792x10^{-3}m}} = 91.20\frac{Rad}{s} = 870.9\ rpm$$

It is observed that the critical speed is above the operating speed ω = 110 rpm. This confirms that there will be no large deflections of the arrow in normal operation of the machine.

A frequency analysis was carried out in the SolidWorks software, in order to check the results obtained analytically.

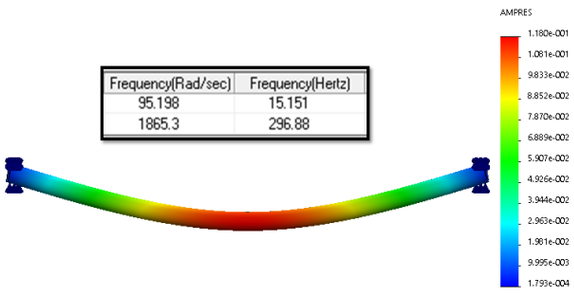

Figure 12 Frequency simulation results

As shown in figure 12. A natural frequency of 95,198 rad / sec is obtained result very similar to that obtained analytically.

Results

To obtain a correct design of the power transmission system it is necessary to design with static and dynamic loads and analyze the critical speeds. It is observed that the diameter obtained by static loads would not be able to support the dynamic loads, since the piece would fail after a certain cycle of workloads. Therefore, the minimum diameter will be 28.2mm.

Commercially the steel bars are in standardized measures, so the diameter approaches a dimension of 1.25 inches (31.75mm) that is common to find in establishments selling steel.

Figure 13 shows the results of the safety factor considering a diameter of 1.25 inches, it can be observed, as is logical, that the safety factor increases to 4.79 in the critical zone.

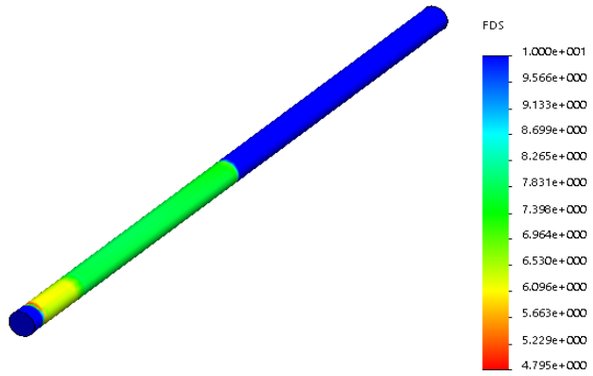

Figure 13 Distribution of the safety factor in the arrow with a diameter of 1.25 inches

A dynamic analysis was developed to check the damage that can be generated in the arrow. It is considered 1x106 work cycles under normal load conditions. Figure 14 shows that there will be no damage produced with these considerations.

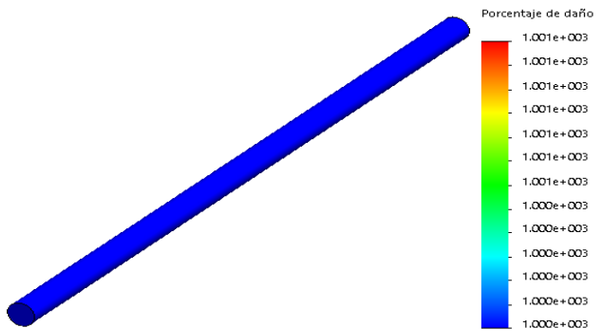

Figure 14 Percentage of arrow damage produced by dynamic analysis

It is verified that the arrow does not fail due to static loads or dynamic loads. Based on this study, the virtual model of the cane transportation system has been developed, the commercial components were adapted and the structure on which the power transmission system will be assembled was developed as shown in figure 15. It is observed that the transmission system was hidden with the side hoppers avoiding any contamination to the cane

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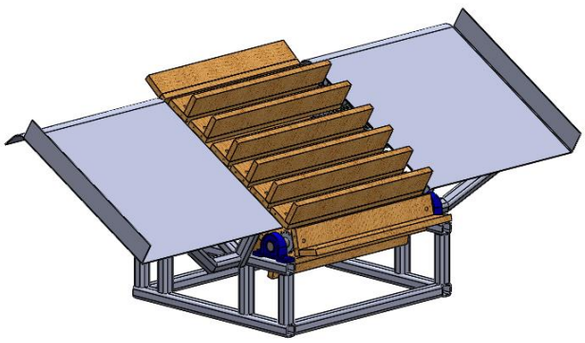

Figure 15 Virtual model of the cane harvester conveyor in green

Conclusions

The correct design of the sugarcane transporter in green was determined based on research and development of calculations. They went determining parameters of entrance, according to the special characteristics that have in a process of mechanized harvest.

The selection of materials and components are the result of calculation memory, coupled with the characteristics and mechanical properties provided by suppliers.

To determine the diameter of the arrow it is fundamental to make the static and dynamic analysis, since a variation in the result was observed, which can cause a bad design in the mechanical component. The analytical model by static charges was verified by a finite element analysis, concluding that the result of the determination of the minimum diameter by static charges is correct.

Recommendations

For future work we have the following points:

1. The prototype must be built in real scale to verify the results obtained in this present work.
2. It is proposed to perform different simulations in CAD by changing the type of material.
3. Complement the study with the analysis of selection of other mechanical components such as bearings, couplings, pins, etc.
4. Select the commercial motor 0.75 hp and a speed reducer to reach the value of $\omega = 110\ rpm$

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WBAN oriented for Smart Health

WBAN orientado para Smart Health

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Abstract

The wireless body area network, WBAN (Wireless Body Area Network) is defined as a wireless communication between the devices used on the human body. These devices are low-power sensors to control the vital parameters of the patient. The objective of these networks is the medical care and continuous monitoring of the vital parameters of patients suffering from chronic diseases and are continuously monitored. Therefore, this project focuses on the evaluation of a Level 1 WBAN to offer Smart Health (s-health) through its implementation with the IEEE 802.15.4 standard. The sensors to be used are: the AD8232, the pulse and the temperature. Data collection and data processing are performed on the Intel Galileo Gen2 development card, which is also configured as an HTTP server to display a graphical interface that represents the values of the heart rate and the patient's body temperature.

WBAN, Smart Health, 802.15.4

Resumen

La red inalámbrica de área corporal, WBAN (Wireless Body Area Network) se define como una comunicación inalámbrica entre dispositivos utilizados sobre el cuerpo humano. Estos dispositivos formados por sensores de baja potencia controlan los parámetros vitales del paciente. Estas redes surgen con el objetivo primordial de la asistencia médica y la vigilancia continua de los parámetros vitales de los pacientes que padecen enfermedades crónicas y necesitan ser monitoreados continuamente. Por lo anterior, este proyecto se enfoca en la evaluación de una WBAN a Nivel 1 para ofrecer Smart Health (s-health) a través de su implementación con el estándar IEEE 802.15.4. Los sensores a utilizar son: el AD8232, el de pulso y el de temperatura. La recolección de los datos y el procesamiento de éstos se realizan en la tarjeta de desarrollo Intel Galileo Gen2, la cual también se configuró como servidor HTTP para mostrar una interfaz graphic que representa los valores de la frecuencia cardiaca y la temperatura corporal del paciente.

WBAN, Smart Health, 802.15.4

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Introduction

The prosperity of a nation is measured by the quality of health services offered to its citizens. The quarters of public health hospitals and doctors' offices are populated with patients, and in addition to this, the lack of medical personnel means that a lot of time is lost and patient care becomes more expensive. Therefore, there is an active need to improve the provision of health services for patients [1].

Smart Health (s-health) defines the integration of portable devices, wireless communications and Big Data so that biomedical data are collected, processed and analyzed in real time to provide a diagnosis to the patient [2]. In this way s-health provides an opportunity for the accurate and efficient prevention of various diseases and accidents. However, s-health is still in its early stages and many of the concerns remain to be solved for practical applications [3].

Within this s-health concept, in [4] IEEE 802.15 defines the WBAN as "a standard communication optimized for low power devices and operation around the human body (but not limited to humans) to serve a variety of applications, including medical, consumer electronics, personal entertainment and others ". The main objective of this technology is to reduce the burden on hospitals and provide efficient sanitary facilities remotely through the medical implant communication system (MICS) and the wireless medical telemetry system (WMTS). Controlling patients in their natural environments is not practical when devices or sensors are connected through a cable. In this way the use of the WBAN carry out the daily activities discreetly, economically, easily and quickly [5].

There are works that address the idea of a distance communication to provide health services, such as E. Dolatabadi and S. Primak 6, which present a remote monitoring system for patients under the scheme of a WBAN, where the personal server developed in MATLAB is responsible for providing the storage and analysis in real time of the vital signs of the patient. M. Roşu and S. Paşca [7], present a focus on the healthcare solution.

Based on WBAN with ZigBee technology, for the transmission of a real-time ECG signal for long-term monitoring. WSN technology is applied in this system to transmit the ECG data wirelessly at a short distance, from the patient's body to a Central Control Unit (CCU) placed in an accessible location. On the other hand, L. Wang et al. [8], perform the detailed descriptions of the design of an integrated circuit for the acquisition of data from an ECG and the measurements of the results based on the IEEE 802.15.4 standard, thus defining the system-on-a-chip.

This work will provide an analysis of the performance of the Intel Galileo Gen2 card for s-health through the implementation of a WBAN level 1 network, considering only a point-to-point connection to know the scope and limitations of the card for the storage of data in real time. The information collected from this sensor network will be stored in a database configured on the same Galileo card, which represents the server and in other jobs can be used in the cloud computing so that those in charge of these areas can consult its due.

Architecture of a WBAN

The WBANs are a new technology for wireless communication, they have the ability to solve a variety of problems, especially for s-health [9]. The communication of a WBAN is based on a series of stages that go from the acquisition of the information to the management of the data. The architecture of the WBANs is classified as Level 1: Intra-WBAN Communication, Level 2: Inter-WBAN Communication and Level 3 Beyond-WBAN Communication. In Figure 1 you can see these levels of the WBAN [10].

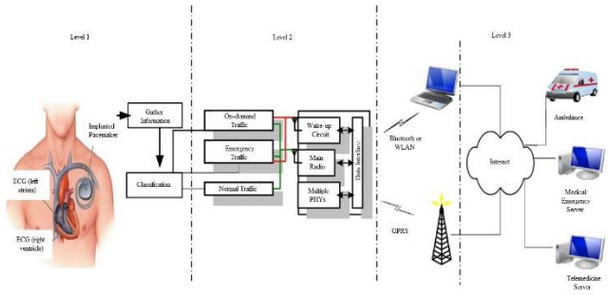

Figure 1 Architecture of a WBAN
Source U. Sana, et al., A Comprehensive Survey of Wireless Body Area Networks, Journal of Medical Systems, vol. 36, Issue 3, pp 1065–1094, 2012. https://doi.org/10.1007/s10916-010-9571-3

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1. Intra-WBAN

In [11] the term "Intra-WBAN Communications" is presented in reference to radio communications of approximately 2 meters around the human body. It is made up of devices attached or implanted to the human body or devices around it. This type of devices are the sensors, actuators and the control device (BDU, Body Gateway, PD or PS). The data that is collected at this level is subsequently sent to level 2 of the architecture.

2. IEEE Standard 802.15.4

The most important requirements of the WBANs are the energy efficiency of the system, the quality of service (QoS) and the reliable transmission of data. The control layer (MAC) is the most appropriate level to address energy efficiency and effective data transmission while preserving QoS as it is responsible for node access to the shared wireless medium [12]. Therefore, we must look for the technology that covers the appropriate characteristics to carry out this series of requirements that make the WBAN implemented efficient.

IEEE defines the PHY layer and the MAC layer for low-rate wireless personal area networks, which is why a WBAN is a type of a personal area network (WPAN). The standard that supports the WBANs is the IEEE 802.15 TG6 group. IEEE 802.15.6 is a standard for short range, low power and high reliability in wireless communication. The IEEE 802.15.4 technology is currently the most relevant for the implementation of the physical layer (PHY) and the Medium Access layer (MAC) in the implemented motes. IEEE 802.15.4 has been widely used in applications that include industrial automation, home control and wireless sensor networks. Compared to the IEEE 802.11 and 802.15.1 standards, the 802.15.4 standard offers low complexity and low power consumption that makes it suitable for implementation in a WBAN.

Methodology for the Design of the WBAN

The implemented scheme was based on the level 1 that corresponds to the Intra-WBAN communication.

Figure 2 shows the complete set of the network implemented, the connections with the different devices and the way in which they are communicated in order to take the information obtained to the end user.

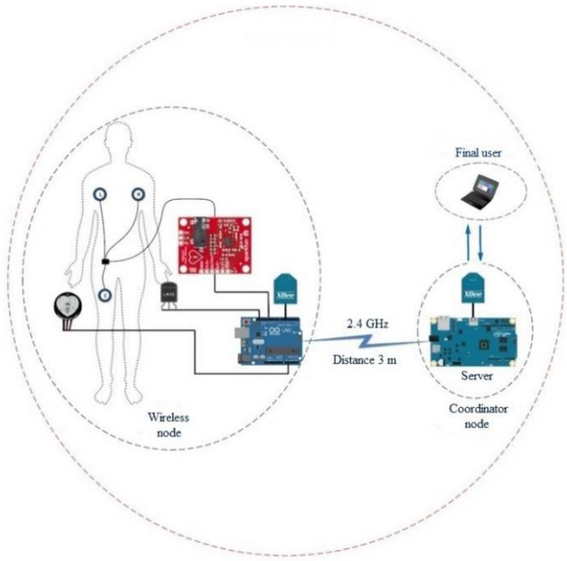

Figure 2 Implementation outline for INTRA-WBAN

As can be seen in Figure 2, an AD8232 sensor, a pulse sensor and an LM35 sensor were used for the implementation. For the calculation of vital signs an Arduino UNO was used and for the wireless transmission a pair of motes XBee PRO of the series one of Digi. The Galileo Gen 2 card, whose functions are that of a server with HTTP in the Linux operating system, and that of a personal server where data collection, processing and storage tasks are executed.

Description of the Methodology

In this work, the WBAN was implemented using a point-to-point topology where the sensors obtain the signals of the body in the form of voltage, electrical pulses, etc. according to the type of sensor and they are collected by the BCU that coordinates the operation of the sensors and later they are sent to the personal server, that is to say to the Intel Galileo Gen 2 card for later consultation by the end user. Figure 3 shows the block diagram of the methodology used to implement this work.

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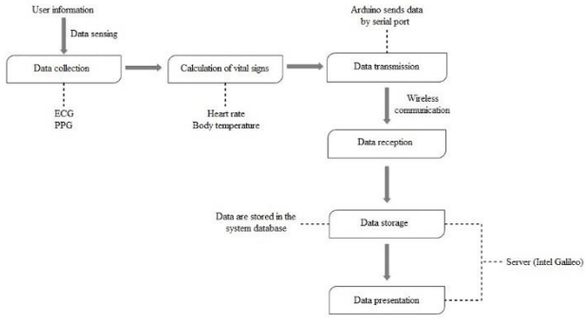

Figure 3 Block diagram for the WBAN

Analysis of results

An important feature in the development of this project is that the information will be evaluated in real time, so that the physical characteristics of the network that can influence the results are presented below.

The module to implement the network in the IEEE 802.15.4 standard, transmits data at a speed of 250 Kbps with a power of 18 dBm and have a reception sensitivity of -100 dBm which allows transmitting at maximum distances ranging from 10 at 300 m. The calculation of the end-to-end delay (End-to-End Delay, E2ED) was carried out according to Eq. one:

$$E2ED = T_R - T_S \quad (1)$$

Where T_R is the time at which the packet is received at the receiver and T_s the time at which the packet is sent from the transmitter. In table 1, the results obtained from the tests are shown. In this implementation the distance in which the data was transmitted was 3 meters and the average calculation of the delay was 22.6 s.

Test	T_R(s)	T_s(s)	E2ED (s)
1	108	73	35
2	98	77	21
3	61	42	19
4	52	33	19
5	46	27	19

Table 1 Delay in the transmission of data in the WBAN

The tests were conducted in an indoor environment where there was presence of other devices working in the same band as a modem in IEEE 802.11n which caused interference. A factor in the delay was the processing of the received information, which caused the buffer to saturate and result in a waiting time, which caused the delay to increase.

For the 2.4 GHz band, the latency is 4.25 ms for most of the monitoring applications, for this reason a waiting time of 1 second was programmed to receive the information of the final node and thus better process the information at the moment.

For the development of this work it was fundamental the analysis of the frame received in the Intel card, because this frame was decapsulated and thus the data of the sensors was obtained. In this way the data was sorted in the database in the corresponding column for analysis as shown in Figure 4.

ID	Name	Age	PPG	Temperature	Fc	Date
1	Lucero	24	483	35.16	84.27	2018-05-13
1	Lucero	24	370	35.16	84.27	2018-05-13
1	Lucero	24	360	35.16	84.27	2018-05-13
1	Lucero	24	394	35.16	84.27	2018-05-13
1	Lucero	24	431	35.16	84.27	2018-05-13
1	Lucero	24	460	35.16	84.27	2018-05-13
1	Lucero	24	476	35.16	84.27	2018-05-13
1	Lucero	24	482	35.16	84.27	2018-05-13
1	Lucero	24	480	35.16	84.27	2018-05-13
1	Lucero	24	473	35.16	84.27	2018-05-13
1	Lucero	24	459	35.16	84.27	2018-05-13
1	Lucero	24	446	35.16	84.27	2018-05-13
1	Lucero	24	432	35.16	84.27	2018-05-13
1	Lucero	24	420	35.16	84.27	2018-05-13
1	Lucero	24	410	35.16	84.27	2018-05-13
1	Lucero	24	404	35.16	84.27	2018-05-13

Figure 4 Estructura de la base de datos para el sensor de pulso

The size of the database varied according to the amount of data that was stored. The amount of information to be stored depends on the execution time, that is, if the system monitors the user's vital signs around 3 minutes, the average size of the database is 495 KB, so if the size of the database is monitored in a shorter time the BD is decremented.

A woman of 24 years of age was considered for the tests, so we will refer to her as u1. The tests were performed in a resting state and without prior physical activity.

Figures 5 and 6 show the graphic interface of the values measured in the patient by means of the AD8232 sensor and the pulse sensor respectively, in both tests the body temperature was also measured. Based on the reading of the data from each sensor is how the electrocardiogram or ECG and the photoplethysmogram or PPG were generated.

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Figure 5 Graphic ECG interface and temperature measured with AD8232 and LM35 sensors

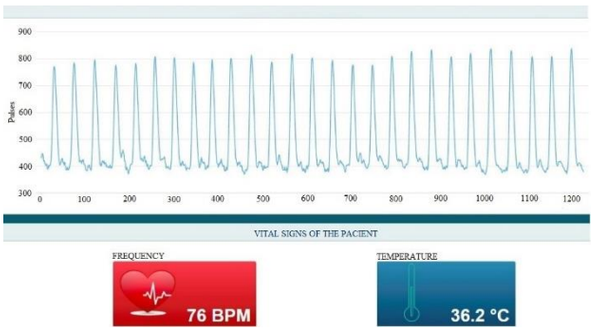

Figure 6 Graphic PPG interface and temperature measured with the pulse sensor and LM35

In Figure 5, a heart rate of 81 BPM is shown, which is in the normal range because the beats per minute of an adult range from 60 to 100 BPM. With respect to the body temperature, a value of 36.8 ° C is obtained, being acpetable because in adults the normal value goes from 36 ° C to 37 ° C. According to Figure 6, a frequency of 76 BPM and a body temperature of 36.2 ° C were measured, resulting in acceptable values.

Conclusions

The development of this work served to define potential applications in the area of health and thus perform a non-invasive and remote monitoring of the patient's vital signs. It also highlights the use of a database for the storage and processing of data, which when configured on the Intel Galileo Gen 2 card was applicable only for projects that do not require extensive use of resources for real time, for this Dedicated storage servers can be used.

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Prosthetic needs in patients attending dental services in Clinics I, II of the Faculty of Dentistry of the Autonomous University of Campeche 2016

Necesidades protésicas en pacientes que asisten a servicios odontológicos en Clínicas I, II de la Facultad de Odontología de la Universidad Autónoma de Campeche 2016

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Abstract

Oral health is considered an inseparable part of health in general. The loss of teeth, complete or partial, substantially reduces the quality of life of an individual. The needs of prosthetic treatment are the consequence of tooth loss, a problem of oral health, and when not treated in time. When prosthetic rehabilitation is performed, the patient recovers his quality of life since edentulism is the cause of multiple diseases. Besides recovering the masticatory function rehabilitation treatment promotes phonation, masticatory function, and esthetic purposes. In this way they recover social and emotional well-being that is diminished due to deterioration of oral health. General Objective. - What are the prosthetic needs of patients that require dental service in clinics I, and II of the Faculty of Dentistry of the Autonomous University of Campeche 2016?. Methodology. - The entirety of the sample consisted of 260 adult patients who attended the dental clinic at clinics I and II of the Faculty of Dentistry of the Autonomous University of Campeche. Result: 260 patients were studied in terms of prosthetic need. By means of a classification, 21.9% (57) do not need any dental prosthesis, 40.4% (105) need fixed prosthesis 1,2,3, the 7.7% (20) need total prostodontics 4, removable prosthesis 11.5% (30) and with 18.5% (48) need a prosthesis combination. According to the variable dental arches, the highest frequency observed in relation to the need of prosthetics in both dental arches is 44.6% (116), with 22.3% (58) in the upper dental arch, with 11.2% (29) in the lower dental arch and without any prosthetic need in any dental arch with 21.9% (57). According to the type of prosthesis, the most frequent type of prosthesis presented by the patient was identified, it was observed that 60.8% (158) did not present any type of prosthesis, 28.1% (73) had a fixed prosthesis, 6.5% (17) present a removable prosthesis, 2.7% (7) use total prosthesis and 1.9% (5) have a combined prosthesis. Conclusion: The most frequent need for dental service is fixed prosthesis. Patients in this population mostly have never had prosthetic treatment, despite requiring these services they say they do not have these assets due to the economic factors. The most affected population in need of prosthesis was in patients with the age range of 40 to 50. With regard to sex, it was observed that the population that went to dental treatment the most was the feminine one. The recommendation that we can give to the patient is important, since this could serve as orientation and preventive means for their treatment decisions, so they can be carried out in the precise moment.

Dental Prosthesis, Oral Health, Dental Loss

Resumen

La salud oral es considerada como una parte inseparable de la salud en general. La pérdida de dientes, completa o parcial reduce sustancialmente la calidad de vida del individuo. Las necesidades de tratamiento protésico son la consecuencia de la perdida dentaria, por un problema de salud bucal, no tratado a tiempo, cuando se realiza la rehabilitación protésica, el paciente recupera su calidad de vida ya que el edentulismo es causante de múltiples enfermedades además de recuperar la función masticatoria el tratamiento rehabilitador favorece la fonación, función masticatoria y fines estéticos de este modo recuperan el bienestar social y emocional que se encuentra disminuido debido al deterioro de la salud bucal.Objetivo General.- ¿Cuáles son las necesidades protésicas de los pacientes que requieren servicio odontológico en las clínicas I, y II de la Facultad de Odontología de la Universidad Autónoma de Campeche 2016?. Metodología.- El universo de la muestra fueron 260 pacientes adultos que acudieron a consulta dental a las clínicas I y II de la Facultad de Odontología, correspondiente a todas las asignaturas impartidas en las clínicas Odontológicas de la Facultad de Odontología de la Universidad Autónoma de Campeche.Resultado De los 260 pacientes estudiados, en cuanto a la necesidad protésica se consideró por medio de una clasificación en la cual 21.9% (57) no necesita ninguna prótesis dental, 40.4% (105) necesita prótesis fija 1,2,3, el 7.7% (20) necesitan prostodoncia total 4, prótesis removible 11.5% (30) y con el 18.5% (48) necesitan una combinación de prótesis. De acuerdo a la variable de los arcos dentarios en donde se observó la mayor frecuencia en relación a la necesidad protética fue en ambos arcos dentarios con 44.6% (116), con el 22.3% (58) en el arco dentario superior, con el 11.2% (29) en el arco dentario inferior y sin alguna necesidad protética en ningún arco dentario con el 21.9% (57). De acuerdo con el tipo de prótesis se identificó el tipo de prótesis más frecuente que presenta en boca el paciente, se observó que el 60.8% (158) no presenta ningún tipo de prótesis, 28.1% (73) presenta prótesis fija, 6.5% (17) presenta prótesis removible, el 2.7% (7) utilizan prótesis total y con el 1.9% (5) tiene prótesis combinada.Conclusión La necesidad de servicio odontológico más frecuente es la prótesis fija.Los pacientes en esta población en su mayoría nunca se les habían realizado ningún tratamiento protésico, a pesar de requerir estos servicios, ellos dicen no tener estos bienes por cuestiones del factor económico.La población más afectada fue en los pacientes con el rango de edad de 40 a 50 años presentan mayor necesidad protésica. Con respecto al sexo, se observó que la población que más acudió a tratamiento odontológico fue el femenino.Es importante la recomendación que podemos darle al paciente, ya que esto podría servirle de orientación y medio preventivo para sus decisiones de tratamiento, se lleven a cabo en el momento preciso.

Protesis Dental, Salud Oral, Pérdida Dentaria

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1. Introduction

Oral health is considered an inseparable part of general health. The loss of teeth, complete or partial, substantially reduces the quality of life of the individual, since the teeth help in the process of digestion of nutrients and by not being able to properly crush the food, they are not absorbed correctly.

The needs of prosthetic treatment are the consequence of tooth loss, a problem of oral health, not treated in time, when prosthetic rehabilitation is performed, the patient recovers his quality of life since edentulism is the cause of multiple diseases besides recovering the masticatory function the rehabilitative treatment favors the phonation, masticatory function and esthetic ends in this way recover the social and emotional well-being that is diminished due to the deterioration of the oral health.

There are different types of prosthesis to rehabilitate the patient, and determine the prosthesis indicated will depend on the need for treatment of the patient, the socioeconomic status and oral status of the individual or cemented.

The removable partial prosthodontics is aimed at replacing missing teeth and the bony structures that are atrophied over time after the loss of teeth organ, through oral devices that are the carriers of artificial teeth; and the total prosthodontics are those that include both the replacement of the lost natural dentition, as well as the associated structures of the maxilla and mandible in patients who have a total demand for their dental organs.

The fixed prosthesis is the art of restoring the damaged teeth with cast metal or porcelain and replacing the missing ones with fixed or cemented prostheses.

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1.1 Problem Statement

Oral health is the expression of living conditions and these in turn express the difference between the various social groups, the loss of teeth is equivalent to losing oral health and its treatment is aimed at solving various problems caused by said dental absence.

The treatment of tooth loss has been one of the fundamental pillars of dentistry since ancient times, currently the treatment of edentulism is the placement of dental prostheses whether fixed type, removable or prosthodontics, in order to restore functions lost due to the lack of a dental organ.

The realization of epidemiological studies on the needs of prosthetic treatment is of great importance to obtain information on the real need of the population in question, and be able to establish a comparative pattern between different populations.

To identify the most frequent type of prosthesis, in patients that attend the dental service in the Faculty of Dentistry of the Autonomous University of Campeche. The type of prosthesis that the patient brings.

As well as establishing the need for a fixed prosthesis: crown, bridge, incrustations and endoposts, removable bilateral or unilateral partial prosthesis, total superior, inferior or bimaxillary prosthodontics, related to schooling in patients attending the dental service in the Faculty of Dentistry of the Autonomous University of Campeche.

The age range is studied according to the need of the fixed prosthesis to determine the appropriate use of a crown, bridge, incrustations and endoposts, bilateral or unilateral partial removable prosthesis and total superior, inferior or bimaxillary prosthodontics of the patients who attend to the dental service in the Faculty of Dentistry of the Autonomous University of Campeche, where it is worth mentioning that these prosthetic services are provided to the population within the institution, presenting needs in the patients of this dental treatment to support their rehabilitation.

The following research question is made by carrying out the following approach:

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What are the prosthetic needs of patients who require dental service in clinics I, and II of the Faculty of Dentistry of the Autonomous University of Campeche?

1.2 Justification

Currently the need for prosthetic treatment has been increasing due to the loss of dental organs as a result of multiple factors: among the main ones are dental caries which is a multifactorial disease with a very high prevalence according to the WHO, periodontitis is also determinant in this problem because it is the result of poor oral hygiene and exaggerated oversight of oral health.

The dental loss leads us to have different consequences such as the lack of different functions that are necessary for the correct nutrition of the organism, for the phonetics, the aesthetics is also affected the lost tooth will obviously leave an empty space inside the patient's oral cavity that in the future will affect the physiognomy of the patient. But beyond having a negative effect on your face, it allows the adjacent teeth to leave their correct positions within the oral cavity. This problem over time can lead to misalignment of the smile and even be the culprit of temporomandibular problems.

When losing a dental organ and not placing a dental prosthesis in due time, they usually suffer from loss of mandibular bone, which changes the appearance of the face over a long period of time. The ability to speak can be affected, especially if a dental organ or more is lost. It goes without saying that this can cause a loss of important confidence and self-esteem, affecting the social life of the person.

The placement of a dental prosthesis will solve this loss of the different functions that are affected by the lack of dental organs. The dental prosthesis will return the masticatory function, this means that it will be able to eat normally, thus improving the tone of the muscles, reducing problems at the level of the joint and improving gastric health.

The phonetic and aesthetic function are greatly improved with the presence of teeth restored by a prosthesis, the pronunciation of the words will be much clearer and better understood, as well as the recovery of smile and confidence.

The patient recovers the vertical dimension that is from the tip of the nose to the chin, which had been lost due to the absence of teeth; this manifests itself in the form of wrinkles in the peri-labial area and depressions in the lips, giving the impression of premature aging. When we recover it, we not only recover the vertical dimension, but also recover the tonicity of the labial and labial muscles, making the appearance recover.

The functionality of the prosthesis means a good quality of life and therefore enjoy good health in all aspects for the patient, it will also allow to preserve the structures of the masticatory system avoiding its possible deterioration; the self-esteem of the patient is recovered with the definitive placement of the prosthesis achieving a better quality of life.

The following study allows us to recognize what are the prosthetic needs of patients and allows to apply certain actions for the motivation of the use of prostheses. There are studies that show that one of the most frequent treatment needs is dental prostheses with different results to the type of prosthesis that requires.

The results obtained from this study present diversity according to the variables included, where data are provided that are used for the prevention and timely treatment of this dental problem, to serve as a basis for more in-depth studies on the needs of prosthetic treatment within the Clinics of the Faculty of Dentistry of the Autonomous University of Campeche.

2 Theoretical Framework

Health is a condition that refers to a state of well-being in the person, and is the absence of disease in the body; according to the WHO "Health is a state of complete physical, mental and social well-being, and not only the absence of diseases or illnesses". The quotation comes from the preamble of the Constitution of the World Health Organization, which was adopted by the International Sanitary Conference, held in New York from June 19 to July 22, 1946, signed on July 22, 1946 by the representatives of 61 states (Official Records of the World Health Organization, No. 2, p.100), and entered into force on April 7, 1948. The definition has not been modified since 19831.

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Following this definition, we can identify two major aspects of health, physical and mental. As in the first one, the conservation of the organs is given, and the preservation of the organic functions; in the case of the second, it is about the preservation of the mental faculties. Within these are: the ability to discern, to behave in an appropriate way, to control emotions and behaviors. In conclusion, mental health would be the psychological, and therefore emotional, well-being of the subject.

For health to be preserved, there must be a combination of certain factors that contribute to the balance of the human being, the relationship between oral health and the impact on the organism, numerous studies have already shown their close relationship, because in the mouth they are present different bacteria, including those related to dental caries, periodontal diseases and systemic diseases that affect overall health.

The close bi-directional relationship between oral health and general health, as well as its impact on individual health and quality of life, provide a solid conceptual basis for an approach to the integration of oral health in general health.

The World Health Organization (WHO) defines oral health as "the absence of oral or facial pain, oral or throat cancer, infections or ulcers, periodontal diseases, tooth decay, tooth loss, as well as other diseases and alterations that limit the individual capacity to bite, chew, laugh, talk or compromise psychosocial well-being ".

Oral health is the result of the intervention of all economic, social, biological and cultural factors that promote a longer stay of dental organs in the individual and that is also supported by an attitude of prevention, nutrition, hygiene and physiological harmony that allow the best function with the organs involved in digestion.

Oral health is one of the aspects that affect perceptions about quality of life. The Canadian Dental Association points out that oral health "is a state of the tissues of the mouth and related structures that positively contributes to physical, mental and social well-being, to the well-being and enjoyment of life's possibilities, allowing the individual to speak , eat and socialize unhindered by pain, discomfort or embarrassment".

Sheiham shares this when she affirms that oral health affects people physically and psychologically, influencing their growth, the enjoyment of life, looking, speaking, chewing, tasting food and enjoying social life, as well as their own feelings about their social welfare.

Having a healthy and functional dentition is important in all phases of life to allow essential human functions such as speech, smile, socialization or eating, to maintain these, and the general health of the individual is maintained there must be a oral hygiene.

Among the risk factors of increased indication of exodontia as definitive treatment we find: difficult access to dental care, poor oral hygiene, low educational level, living in rural sector, and age, the latter factor considered by the special conditions of prevalent care and diseases as the years increase.

The loss of teeth alters the functions of the stomatognathic system, such as chewing, phonetics and aesthetics. In the case of chewing function can lead to a change in diet by the person, forcing new dietary practices determined with a greater consumption of soft foods and easy to chew, causing dietary restrictions and compromising the nutritional status of the person.

Edentulism is considered a chronic, irreversible and incapacitating disease, in all partial edentulous, the loss of dental pieces adversely affects the stomatognathic system, reflected in an alteration of the occlusion, the neuromuscular component and often with serious repercussions in the temporomandibular joint. Likewise, the remaining oral structures undergo changes in position and contour and even the formation of a new anatomical component, the edentulous ridge.

Edentulism is preventable, irreversible and constitutes mutilation, a loss of physical integrity and is the result of systemic diseases such as diabetes and prevalent oral diseases, such as dental caries and periodontal disease (PD), or it can be secondary to orthodontic, aesthetic, prosthetic needs, traumatisms, and generated by socioeconomic, cultural and public policy factors that favor inequalities and inequalities in health.

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The loss of dental pieces brings with it a series of mechanical, functional, aesthetic and emotional alterations for the patient, the prosthesis allows us to return the oral health and at the same time the general health is recovered, since they are closely related to one another; the usual therapy to recover the loss of a dental organ is necessary the placement of a dental prosthesis, be it a fixed prosthesis, removable partial prosthesis or total prosthodontics.

With the dental prosthesis the dental aesthetics, the smile, volume and shape of the face are recovered, without forgetting the masticatory function that is fundamental for the maintenance of the health in general.

Dental prostheses prevent the adjacent dental organs from being distalized in the place where a tooth has been lost. Dental prostheses prevent possible interferences and the appearance of cavities, solving many problems of the articulation of the jaw. It is essential to replace lost teeth with dental prostheses as soon as possible, in order to prevent the different problems that the absence of a dental piece entails. According to the latest research, prosthetic needs are increasing due to the loss of teeth caused by multiple factors. The replacement of missing teeth is the common need of patients, especially elderly.

For this reason, rehabilitation dentistry specializes in performing treatments in patients with alterations of any level of complexity, returning the function, aesthetics and harmony of the stomatognathic system through the use of fixed, removable and / or total dentures. Replacement of lost teeth, always seeking correct occlusion.

However, there may be poorly adapted or damaged prostheses due to their prolonged time in the mouth, which can prevent the intake of food in a satisfactory manner, causing stomatological damage.

A prosthesis can be made to replace a tooth, two teeth, three teeth, and so on up to all the dental organs. For each situation there is a recommended type, or several types of possible prostheses.

Fixed prosthesis

The treatment with fixed prosthesis consists of the replacement or restoration of the natural teeth by means of the placement of artificial analogs that are going to be fixed in the mouth. The fixed prosthesis ranges from the restoration of a single tooth to the rehabilitation of the entire occlusion, this depends on the patient's treatment needs.

Missing teeth can be replaced with fixed prostheses that improve comfort, the masticatory capacity of the patient in many cases, the concept he has of himself. It is also possible, through fixed restorations, to make the basic and extensive corrections needed to treat problems related to the temporomandibular joint and the neuromuscular components.

At the moment of the placement of a fixed prosthesis, the chewing function is recovered, the aesthetic for it influences some factors such as color, shape, size, texture of the tooth, middle line, dark background of the mouth, oral corridor, degree of opening of the incisal embrasures, height of the occlusal plane, gingival tissue and the need or not of artificial gingiva and phonation.

Among the fixed prostheses we can find various treatment options such as individual crowns, which are cemented restorations that reconstruct the morphology, function and contour of the damaged coronal portion of a tooth, it must protect the remaining structures of the tooth from further damage, if it covers the entire clinical crown, it is a complete crown; if only part of it is covered, it is called a partial crown, a crown can be made of some metal free of corrosion, porcelain fused to metal, porcelain only, resin or resin only.

The incrustations are intracoronal cast restorations that are used for the repair of proximal occlusal lesions, or moderate or minimal gingival lesions. If the occlusal face is covered, the intracoronal restoration is called onlay and is very useful for repairing extensively damaged teeth and those that require a mesio-occlusal-distal restoration.

A bridge is a prosthesis that replaces one or several missing teeth, permanently fixed to the remaining pieces.

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There are some indications that must be taken into account when making a fixed prosthesis. The realization of crowns will represent an intervention of difficult equilibrium for the integrity of the functional and biological principles of the masticatory organ, for this reason it is advisable to choose a conservative therapeutic procedure that protects as much as possible both the pulp and the marginal periodontium and the hard tissues.

General indications for the placement of a crown: extensive caries, morphological defects, crown trauma, discoloration, position anomalies, abrasions, erosions, vertical corrections.

Anchorage of bridges

The socioeconomic aspects also influence the placement and the material to choose in the development of a fixed prosthesis, this is because prosthetic restorations of fixed crowns and bridges are usually high cost treatments. They require a great investment of time for the previous treatment as for their definitive insertion. The same oral hygiene is a factor for the placement of fixed prostheses since the main cause of caries and periodontopathies is bacterial plaque, for this reason it is unpredictable to determine the plaque index when starting a treatment, the assessment should be simple, as accurate as possible.

There are contraindications that should be taken into account for the procedure of the fixed prosthesis, should be considered as relative, since usually from the relevant previous treatment can create the necessary conditions for the placement of a crown or a bridge, for restorations fixed. However, tooth cutting should be avoided, especially in the placement of full crowns, in young people, due to the amplitude of the pulp cavity, the relative contraindications are: teeth with necrotic pulp without root treatment, with periapical lesions, oral hygiene deficiency, gingivitis, periodontitis, obstacles and obscure occlusal conditions, insufficient retention and socioeconomic aspects.

Intraradicular restorations

Another of the prosthetic restorations of the fixed prosthesis is those that go intraradicular. When performing the pulpectomy to a tooth, it loses resistance, so it is essential that the dental treatment returns to the piece of resistance lost, objective that can be achieved with the application of intraradicular posts, is that they provide support to the teeth with endodontic treatment, and reduce excessive loads helping to distribute them between the post and the remaining dental tissue.

The endoposts, serve to give resistance to the dental organ, but they are also the structure for the placement of the dental prosthesis (crown) have qualities that should be used to meet the objectives of a restoration in the tooth, likewise the preparation of the teeth. ducts must have different characteristics to ensure stability resistance and especially longevity of the post and the tooth. These possess several characteristics such as, shape and size of the endo post, are made of different materials, there are individualized posts can be made of materials such as: gold, steel, stainless, titanium, semiprecious metal and not precious.

The prefabricated posts can be: a) metallic, gold alloys, titanium, stainless steel, chrome, cobalt b) non-metallic: composed of 36% resin and 64% glass fiber, quartz, carbon and combined. They arose due to the evolution of the adhesion, since they can be united with the dentin by means of the cement of the resin, in this way it is possible to support the functional loads improving the resistance of the tooth.

Removable partial prosthesis

The removable partial prosthesis has the purpose of conserving the remaining teeth and the secondary tissues that can be substituted when they are not, it also helps to improve the phonetics, chewing and aesthetics of the patient. The main purpose of the removable prosthesis should always be the preservation of the remaining teeth and tissues and not their replacement when they are already lost, which is a secondary purpose.

Once the main purpose of the removable prosthesis has been achieved, we can begin to improve the phonetics, increase the masticatory efficiency and aesthetics.

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There are several factors that must be considered to achieve the success of a removable partial denture and determine the specific indications for its placement: a) balance the retention of the abutment teeth, b) eliminate interferences, c) establish an optimal aesthetics and d) prepare plans of guide.

The indications that must be followed for the placement of the removable partial denture are the following:

When due to lack of health of the periodontal tissue, the residual ridge should help the support of the masticatory forces.

The edentulous space does not have posterior remanent teeth, except in those cases in which it is not advisable to replace the second and third molars.

In the remaining teeth there is little support tissue and needs splinting through the arch, the PPR can act as a splint stabilizing the teeth weakened by the underlying periodontal disease. The patient's metal or physical conditions do not allow carrying out the necessary procedures for the adaptation, implantation and action of the fixed prosthesis.

There is excessive bone loss in the edentula area and a base in the prosthesis is required, in order to obtain a correct position of the teeth and at the same time give support to the lips and cheeks.

There is a long prosthetic gap, it is necessary to place a PPR that achieves the retention, support and stability of that from the pillars of the opposite side. To serve as cover, support or both in the treatment of cleft palate in maxillofacial prosthesis.

The contraindications of this type of prosthesis are minimal:

- A fixed partial denture can succeed.
- When there is no adequate oral hygiene.
- There is no cooperation on the part of the patient.

There is a classification of partially edentulous arches, and different methods of classifying arcs or partially edentulous spaces are still being applied and are being proposed.

Kennedy Classification

This classification is the most accepted, because it precisely defines the areas of the partially edentulous arch.

When making the modifications applied to classes I, II, III, and IV, the number of edentula zones in the original classification must be taken into account. Dr. Oliver C. proposed several rules to properly use the original classification of Dr. Kennedy, without which such classification is difficult to apply in each case, namely:

First rule. More than precede, the classification must follow all dental extraction that may alter the original classification.

Second rule. If the third molar is missing and it will not recover, it is not considered within the classification.

Third rule. If there is a third molar and it is going to be used as a pillar, then it is considered within the classification.

Fourth rule. If a second molar is absent and will not be replaced, it is not considered within the classification.

Fifth rule. The more posterior edentulous zones or zones always determine the classification.

Sixth rule. The edentulous zones that do not determine the classification are only indicated as modifications and are designated by their number.

Seventh rule. The size or extension of the modification is not considered, but only the number of additional edentulous areas.

Eighth rule. Modifying zones can not exist in class IV (any edentula zone after the bilateral zone that crosses the middle line, determines the classification in turn). Total Prosthodontics

The total prosthodontics is the total rehabilitation of the natural teeth or remnants that have already been lost for different reasons, from the general clinical point of view, partial or total edentulous patients are classified considering their anatomical structures, psychological, pathological, geriatric characters, etc.

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They usually occur in mono-maxillary, or inferior and bimaxillary form, separated into three categories:

Edentulous patients pos partial or total extraction.

Edentulous patients not rehabilitated with partial or total prosthesis.

Patients with partial or total defective prostheses.

The edentation means, at the same time, the loss of security in itself, confessed or not, consent or acting from the planes of the subconsciousness.

The prosthetic rehabilitation of the total indentation focused on the human plane is a difficult purpose and presupposes to achieve, in addition to the good biomechanical functioning, other factors that include phonetics, this will allow to communicate psychically with others, and the comfort that involves physical relaxation or psychic of the stomatognathic musculature, which will favor its calm and harmonic relationship with said functional environment.

There are different types of edentulism, prosthetic and calcification treatments for this oral health problem; The American College of Prosthodontics developed a classification method to establish a better level in the diagnosis and complexity of treatments in patients with varying degrees of partial edentulism. This system offers the following benefits: it is an objective method to analyze patients in dental schools and establish normed criteria to measure results of treatments and research, among others. The system establishes four classes according to the degree of complexity, established with the following diagnostic criteria: location and extension of the edentulous areas, conditions of the abutment teeth, occlusion and characteristics of the residual alveolar rims.14

Classification system of partial edentulism according to the degree of complexity:

Grade I: Minimum compromise in the location and extension of the edentulous areas (limited to an arch), of the abutment teeth (without pre-prosthetic treatments), occlusal characteristics and conditions of the residual ridge.

Grade II: Moderate commitment in the location and extension of the edentulous areas in both arches, the abutment teeth and the occlusal conditions require additional treatments and moderate compromise of the residual ridges.

Grade III: Substantial commitment in the location and extension of the edentulous areas in both arches, abutment teeth that require substantial additional treatments, occlusal characteristics that require re-establishment without modification in the vertical occlusal dimension and residual rims that compromise the stability of the bases.

Grade IV: Severe compromise and reserved prognosis in the location and extension of the edentulous areas, abutment teeth that require excessive additional treatment, occlusal characteristics that require re-establishment of the occlusion with modifications in the vertical occlusal dimension and residual ridges that do not provide support and stability.

Dinia Isabel Rodríguez and Cols. In order to determine the need for stomatological prosthesis in patients aged 15 and over from September to December 2014, a descriptive cross-sectional observational research was conducted at the David Moreno Domínguez Polyclinic in Santa Rita, Jiguaní municipality, Granma, since September to December 2014. The study universe consisted of 9622 people aged 15 and over, from which a sample of 1078 people was determined.

A form created by the authors and validated by a committee of experts was used; an oral examination was performed in the patients' home; the data were emptied and processed by descriptive statistics. The variables studied were: need dentistry prosthesis, age, sex, type of prosthesis needed and type of need, and the results is the need for stomatological prosthesis in the area of health studied was 75.60%; the female sex and the age group of 60 and over were the most in need of stomatological prostheses, with 80.92% and 99.29% respectively; the type of dental prosthesis most needed was the partial lower removable with 21.59% and the felt need prevailed over the unfelt, with 88.59%, the need for denture prosthesis in the area under study was high. The female sex and the group of 60 and over were the most needy.

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The lower removable partial denture was the most needed and the felt need prevailed over the non-felt.

Gutiérrez, Vanessa and Cols. They determined the frequency of edentulism and the need for prosthetic treatment in adult population between 18 and 64 years of age in the marginal urban area of the Human Settlement El Golfo de Ventanilla, district of Ventanilla, Callao - Lima, 2014, cross-sectional, descriptive, observational study, the population consisted of 1350 people and the calculated sample was 168 adults, who were evaluated by means of a data collection sheet, structured from a questionnaire of the World Health Organization (WHO) for edentulous people., and it was determined that there was a frequency of edentulism in the population of 121 (72%) and the need for partial and total prosthetic treatment present for the upper jaw was 100 (59.6%) and in the lower jaw of 113 (67.3%); the majority of the population had edentulism and need for prosthetic treatment.

San María Abel with the objective of determining the need for prosthetic rehabilitation in a population corresponding to the Hermanos Cruz health area assigned to the stomatological department of the General Teaching Hospital "Abel Santamaría Cuadrado" from September 2013 to August 2014, a descriptive study was carried out , retrospective and transversal to determine the need for prosthetic rehabilitation of patients treated in the stomatological department of the selected hospital from a health area, in the period September 2013 to August 2014.

The Health Situation Analysis corresponding to the clinics involved in that population and the individual clinical histories of each patient were reviewed, the data of interest were emptied into a model prepared for this purpose. The universe was 10 238 patients and the sample of 6 680 patients met the inclusion and exclusion criteria; it was found that only 26.7% of the sample needed rehabilitation, the group of 60 years and more was the most needed, the upper jaw was the most affected and a greater number of patients with partial rehabilitation was detected.

The need for rehabilitation was determined in the population corresponding to the health area of the stomatological department of the General Teaching Hospital "Abel Santamaría Cuadrado" during the period from September 2013 to August 201416

Bermúdez, S., and Cols. They did a research work where the objective was to determine the prosthetic needs of the patients of the population of Río Chico-Edo. Miranda; being a descriptive and transversal study. The data collection instrument was the Clinical History used by both centers, 701 patients were studied between male and female who came to request dental treatment to the urban ambulatory type III Center for Special Medical Dentistry (CEMO) and the outpatient urban type II Association Ladies Salesian (ADS) during the August-November 2010 period.

A data matrix was developed in the Excel program for the organization of the data. Throwing the following results: 72% of the sample were women and 28% were men. The most affected age was between 21 and 30 years (28%). According to the prosthetic needs, 71% required one or more fixed prostheses, 26% required removable partial dentures, both dented-supported and dented-muco-supported and 3% required total prostheses. The importance of this study to provide information to the State entities responsible for providing resources to rehabilitate this population at the oral level is ratified.

Ángel P. and Cols. In 2010, they published a research paper where the objective of this cross-sectional study was to assess oral health status and quantify the prevalence of dental caries, tooth loss and the need for treatment in the Mapuche-Huilliche adult population. that inhabits the Huapi Island. A representative sample of 64 adult inhabitants of Huapi Island, consisting of 31 men and 33 women between 25 and 82 years old, who had at least one surname of Mapuche-Huilliche origin, was examined. The average of the COPD index of the sample was 14.59. All the individuals had a history of cavities. Of those who kept teeth, 71.43% had untreated caries, with an average of 1.25. The 98.43% of the individuals in the sample presented some degree of demerit, 12.5% were edentulous. 100% of the population needed dental care, whether for surgery or prosthesis.

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This population presents a great damage in terms of oral health, especially due to loss of teeth. The magnitude of the damage and the importance of the social environment as a determining factor in the generation of this, forces to face the problem and seek solutions developing and applying governmental programs of promotion and attention in oral health to the entire population.

Felix José Amarista Rojas y Cols. They analyzed the prosthetic needs of 51 subjects who attended the Center of Specialties Dentistry of Petare in the period April-May 2011, 60.8% of the Female sex and 39.8% of the Male sex, 56.9% of the subjects are within the age group of 45-64 years and 19% are 65 or older. 94% of the subjects came from the Miranda state, of these 86% came from the Sucre municipality and of these 76% from the Petare parish. The highest percentage of subjects required multiple unit prosthesis followed by the total prosthesis and in a smaller proportion the prosthesis of a unit.

The 53.7% of the subjects that require multiple unit prosthesis corresponds to situations with degree III and IV complexity, it was evidenced relationship between the degree of complexity with age ($p = 0.037$). The results coincide with previous work carried out by Sánchez and Vieira, so it is considered that the table of prosthetic needs corresponds to what has been observed in other services in the Metropolitan Area.

Miguel Á. Fernández-Barrera and Cols. They undertook a research work where the loss of teeth has become a public health problem, determining the prevalence and distribution of edentulism, as well as the associated sociodemographicic and socioeconomic variables in individuals aged 35 years and over. A cross-sectional study was carried out in 656 randomly selected subjects. The dependent variable was edentulism. The average age was 49.06 ± 10.33. The individuals were mainly women (63.3%). The general prevalence of edentulism was 15.7% (95% CI: 12.9-18.5); among women it was 17.6% and in men it was 12.5% ($p = 0.081$). The prevalence of edentulism was higher among the older subjects ($p <0.001$). It was observed that the higher the level of schooling ($p <0.001$), the better the socioeconomic level ($p <0.001$) and those who had a car at home ($p <0.05$), the lower the prevalence of edentulism.

There was a difference in the prevalence of edentulism by age, but not by sex. Socioeconomic differences were observed, suggesting certain inequalities in oral health.

María del Carmen Jiménez Malagóna and Cols. They carried out with the objective of describing the oral epidemiological profile and the needs of dental treatment in HIV / AIDS patients attended in an institution. Design. Transversal descriptive study. Site. School of Dentistry University of Cartagena. Participants. Patients diagnosed with HIV / AIDS and under antiretroviral treatment. Main measurements. Sociodemographicic variables, Oral Hygiene status, history of Caries, Periodontal Disease, oral manifestations associated with HIV / AIDS, need for dental treatment were evaluated. Of the 53 subjects of the study, 59.9% presented regular oral hygiene, 66% showed supragingival calculus and 15.1% gingival bleeding.

The caries was observed in 92.5% of the participants and the absence of teeth in 73.6%. The prevalence of oral manifestations of HIV / AIDS was 45.3%, highlighting those of infectious origin with 28.3%. The presence of lesions not associated with HIV was 81.1%, with oral pigmentation associated with antiretroviral drugs standing out with 28.3%. 100% of the subjects required dental care, requiring 4 different types of treatment, 60.4% of them. The promotion and prevention stand out in 98.1% of the cases, followed by the elimination of calculus in 73.6% and the prosthetic need in 81.2% of the individuals. It becomes evident the lack of attention and the need for treatment of this population. Which presents a state of regular oral health, affirming the right to comprehensive care that this type of patients deserves.

José Francisco Medina-Castro et al. They studied the prevalence of dental caries and the need for treatment. 200 individuals between the ages of 20 and 64 were examined from the San Isidro Welfare and Social Service Center in Lima, Peru, dividing them by gender and ethereal groups, evaluating their status with the DMFT index and the need for treatment. It was found that 95.5% of the individuals were affected by caries. The results obtained were from a population CPOD index of 14.05.

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The average of dental pieces for each treatment required for Sealing 14.66% of the pieces; Sealing with an area 13.94%; sealing with more than two surfaces 3.47%; crowns 9.02; pulp treatment 0.23%; extraction 1.47%, removable partial dentures with 3% and complete prosthesis 1%. The general CPOD index was 14.05, being considered as serious according to WHO parameters. The greatest need for treatment was for the need for sealant in the group of 20 to 24 and the lowest (zero) for pulp treatment in the groups of 45 to 54 and 55 to 64. The greatest need for removable prosthetic treatment was for removable partial dentures with 3%.

Rosa Isabel Esquivel Hernández y Cols. In 2010, they published an article in which the Geriatric Oral Health Assessment Index (GOHAI) was designed to detect oral health care needs in the geriatric population and is characterized by high sensitivity and ease of application, which allows timely attention. The objective was to determine the relationship between the self-perception of oral problems and the clinical evaluation of a group of older adults, through the application of GOHAI. It was a cross-sectional, prospective and associative study in a group of 96 elderly volunteers, attending a Rest House in the municipality of Tlalnepantla, Edo. from Mexico.

Two instruments were applied, the GOHAI and the WHO Oral Health Survey. The average age of the group is 67 years, 84.4% are women. The CPOD index is 20.2 (higher in women), and increases with age, At the age of 65 they have an average of 20 teeth. Edentulism was 18.75%. Due to the presence of caries, 37.5% requires dental care, while 79.2% requires repair or new prostheses, whether partial or total. 92.7% obtained values below the established cutoff point that is 57 in the GOHAI, however, those who received dental consultation within the last 12 months or had higher educational level obtained higher score. Those who had a lower CPOD index and a larger number of teeth present in the mouth obtained a significantly higher GOHAI score. The GOHAI has proven to be an instrument with high sensitivity to clinical variables allowing to detect care needs more easily, besides that it does not require qualified personnel for its application.

Carlos Campodónico Reátegui and Cols, with the main objective of this study was to determine the health profile-oral disease of elderly people (AM) of urban Lima, a descriptive-cross-sectional study was conducted in 120 adults over 60 years, living in Lima fenced and districts. The data collection was performed through the method of clinical observation and interview using the WHO indexes and procedures, the average age 71 years, with prevalence of females (70%) and secondary education, presence of hypertension 33 % and diabetes mellitus 10.8%, disorders of the mucosa in 10.8%, being of the ulceration type located on the palate and alveolar ridges. Presence of stones and periodontal bleeding, in 52% of the population. 23.3% needed prophylaxis and only 11% needed root scaling. Of the teeth present in the mouth 23% have lost fixation in 4-5 mm. Only 5.82% of the teeth are healthy, with an average caries 4.43, teeth lost 14.77 of 53%. The CPO had an average of 19.71. DS. 6.74. The 31.7% use total removable upper prosthesis and fixed prosthesis in 19.2%. In the lower maxilla 20% use PPR and 13.3% use total prosthesis and 9.27% fixed. Meeting a high need for removable prosthesis in upper and lower jaw.

Results

Of the 260 patients studied, in terms of prosthetic need was considered by means of a classification in which 21.9% (57) do not need any dental prosthesis, 40.4% (105) need fixed prosthesis 1, 2.3, 7.7% (20) need total prostodontics 4, removable prosthesis 11.5% (30) and with 18.5% (48) need a prosthesis combination. (Table 1, graphic 1).

According to the variable dental arches where the highest frequency was observed in relation to the prosthetic need was in both dental arches with 44.6% (116), with 22.3% (58) in the upper dental arch, with 11.2 % (29) in the lower dental arch and without any prosthetic need in any dental arch with 21.9% (57). (Table 2, graphic 2).

According to the type of prosthesis, the most frequent type of prosthesis presented by the patient was identified, it was observed that 60.8% (158) did not present any type of prosthesis, 28.1% (73) had a fixed prosthesis, 6.5% (17) presents a removable prosthesis, 2.7% (7) use total prosthesis and 1.9% (5) have a combined prosthesis. (Table 3, graphic 3).

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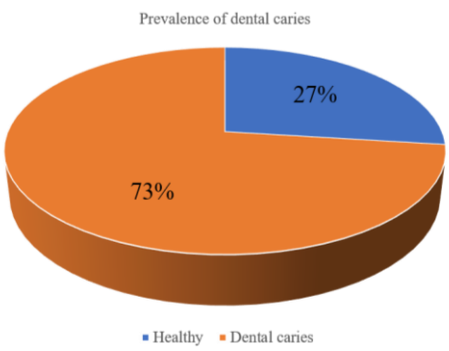
According to the mandibular arches where the most frequent type of prosthesis presented in the mouth was presented, the patient was observed more frequently in the upper dental arch with 25.4% (66), in the lower dental arch 3.8% (10), in both dental arches 8.8% (23) and without any prosthesis 61.5% (160). (Table 4, graphic 4)

Regarding schooling, it was categorized into four groups, 11.2% (29) reported having no studies, 48.1% (125) basic education, 20.8% (54) secondary education and 20.0% (52) higher education. (Table 5, graphic 5).

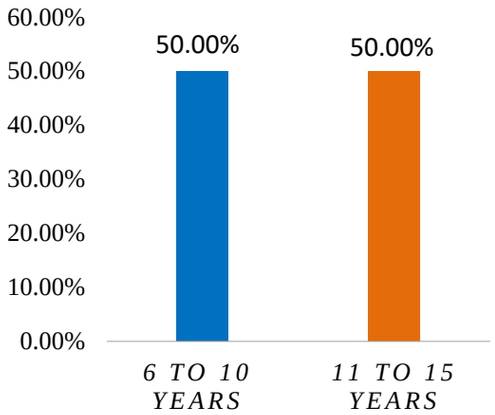
The patients attended by the female sex represent 62.7% of the studied population while the male patients represent 37.3% of said population. (Table 6, graphic 6).

Regarding the distribution by age, the average is 3.00, SD = 1.42, with a population of 260 patients, categorized into five age groups, group I from 18 to 28 years of age with 22.3% (58), group II 29 to 39 years of age corresponds to 14.2% (37), group III from 40 to 50 years of age with 23.8% (62), group IV from 51 to 60 years of age with 20.4% (53) and group V from 61 plus corresponds to 19.2% (50). (Table 7, graphic 7)

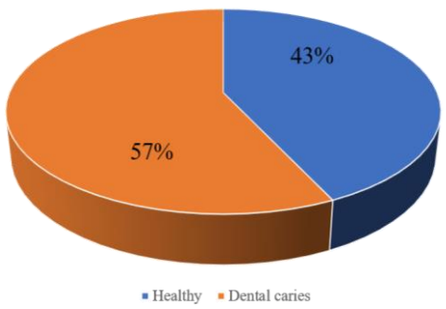
A correlation between the prosthetic need variables, age and degree of study was observed, the Pearson test gave significant to said variables, the lower the degree of studies the patients presented the higher prosthetic need required, according to the age, the higher is more frequent the prosthetic need. (Table 8).



Graphic 1 Prevalence of Dental Caries



Graphic 2 Average CPOD by Age



Graphic 3 Average CEOD with Caries

6 Conclusion

The present study determines that this population has a great prosthetic need in the patients that attend the clinics of the Faculty of Dentistry of the Autonomous University of Campeche.

The most frequent need for dental service is the fixed prosthesis. Most of the patients in this population had never undergone any prosthetic treatment, despite requiring these services, they say they do not have these goods because of the economic factor.

It is worth mentioning some indications that must be taken into account when making a fixed prosthesis. The realization of crowns will represent an intervention of difficult equilibrium for the integrity of the functional and biological principles of the masticatory organ, for this reason it is advisable to choose a conservative therapeutic procedure that protects as much as possible both the pulp and the marginal periodontium and the hard tissues.

Observing a more affected population in patients with the age range of 40 to 50 years present greater prosthetic need.

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The female sex of that population observes an attendance to the dental treatment. After having performed the statistical analyzes in this population study in the result, we observed a relationship between the variables of age, schooling and type of prosthesis that these patients require, concluding that the lower the schooling, the greater the need for prosthesis in the clinics of the Faculty of Dentistry of the Autonomous University of Campeche.

7 Recommendations

It is important to mention that timely information within the clinics of the dentistry faculty of this University of Campeche, should be necessary for the option of acquiring a dental prosthesis oriented to the patient motivating them to use it and keep it as part of their oral health, since that this could serve as a preventive means for their future decisions in oral treatment, so that the clinical intervention is carried out at the precise moment required by the patient.

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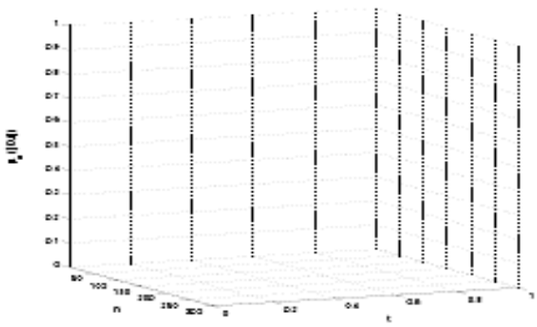

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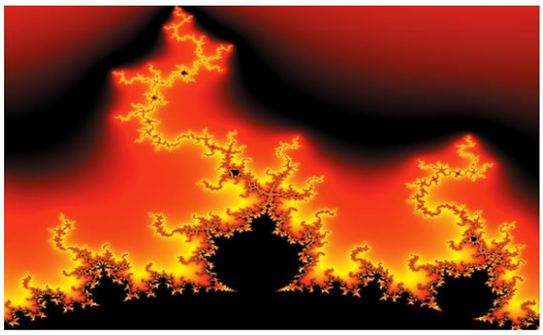

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