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Journal of Innovative Engineering

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The works must be unpublished and refer to topics of Production systems design, product quality management, operations research, computer simulation, supply chains, quality certification, hydrometeorology and other topics related to Engineering and Technology.

Presentation of Content

In the first article we present, *Device and method to control turn time in board games*, by ROJAS-SANDOVAL, Daniel, VELASCO-CASTILLO, Miguel Ángel, GIL-VELASCO, Alfredo and HERNÁNDEZ-BÁEZ, Irma Yazmín, with adscription in Universidad Politécnica del Estado de Morelos, as the netx article we present, *Presence of antinutritional factors in legumes*, by MARCOS-MÉNDEZ, Dora Alicia, CANSECO-NAVA, Helena, OLIART-ROS, Rosa María and RAMÍREZ-HIGUERA, Abril with adscription in Unidad de Investigación y Desarrollo de Alimentos, Tecnológico Nacional de México/ I.T. Veracruz and Universidad Veracruzana, as the netx article we present, *Phytoextraction of mercury (Hg) in soils contaminated by button batteries using Bamboo "Bamnusoideae"*, by SECUNDINO-LÓPEZ, Mitzi Gabriela, GALICIA-LUIS, Laura and LOZANO-CAMARGO, Maria Luisa, with adscription in Tecnológico de Estudios Superiores del Oriente del Estado de México and Universidad Autónoma Metropolitana-Iztapalapa, as the netx article we present, *Modeling compressor blades gas turbine in a marine environment to determine of the stress and possible damages*, by VILLAGRÁN-VILLEGAS, Luz Yazmín, PATIÑO-ORTIZ, Miguel, HERNÁNDEZ-GÓMEZ, Luis Héctor and PATIÑO-ORTIZ, Julián, with adscription in Instituto Politécnico Nacional and Universidad Veracruzana.

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Article **Journal of Innovative Engineering**
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Device and method to control turn time in board games

Dispositivo y método para controlar el tiempo de turnos en juegos de mesa

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Abstract

This invention refers to a time controller for up to six users for board games. The device uses a microcontroller and bluetooth module by means of which the number of players and the time of the turns can be configured. This controller indicates by audible and visual signals the current turn, the last seconds and the turn change. The method for counting the turn time guarantees to perform actions by interruptions, generated by the different buttons of the device, using a single microcontroller and with sequential programming.

Timers, Bluetooth, Consumer electronics, Board games

Resumen

Esta invención hace referencia a un controlador del tiempo de hasta seis usuarios para juegos de mesa. El dispositivo utiliza un microcontrolador y módulo bluetooth por medio del cual se puede configurar el número de jugadores y el tiempo de los turnos. Este controlador indica por medio de señales audibles y visuales el turno actual, los últimos segundos y el cambio de turno. El método para contabilizar el tiempo de turno garantiza realizar acciones por interrupciones, generados por los diferentes botones del dispositivo, utilizando un solo microcontrolador y con programación secuencial.

Temporizadores, Bluetooth, Electrónica de consumo, Juegos de mesa

Citation: ROJAS-SANDOVAL, Daniel, VELASCO-CASTILLO, Miguel Ángel, GIL-VELASCO, Alfredo and HERNÁNDEZ-BÁEZ, Irma Yazmín. Device and method to control turn time in board games. Journal of Innovative Engineering. 2021. 5-17: 1-5

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Introduction

Board games represent one of the oldest recreational activities in humanity. Some of them, which are played around a board and in which chance is not present, require some time to develop the different game options. As a result, too long turns are generated that generate distraction, boredom and even aversion to this type of game. Using a timer to help add dynamism to board games is an option that has proven valuable in games like chess. They have been developed from mechanical, analog to digital timers to control the time that each player has.

Currently, there are different variants for timers, mainly for games that involve two players with different types or modes of play. Among them are those of chess as in patent US4884255 (A) "Digital chess clock" by Fischer Robert J. In 1988, US4062180 (A) "Electronic chess clock" by Joseph Meshi and Jeffrey R. Ponsor in 1975 or even application; JPS60202381 (A) “Electronic timepiece for game” by Hiroyuki Ishijima in 1984. Although these models allow to control the time (ascending or descending), it is important to note that to start each player has a total time established at the beginning and also, by its application, it is only for two-user games.

Other board game timers developments can be found, only they are for specific games and with limited options. There are for example the application US20140269226 (A1) "Pressure actuated timing apparatus for use with games and the like" by Lowrance Arlen in 2013 [1]. We also find the patent (A) "Games timer" by Ping Wing William Yau in 1996 [2], which shows us a device that controls time in turns with the great disadvantage of having to use a module for each player who is playing. they will have to connect in a wired way and with this, not only occupy most of the space for the dimensions of the average board game, but also; raise costs. Another disadvantage is the configuration of the device, which is currently confusing and slow.

Methodology

The proposed methodology for the development of the project is shown in Figure 1, which is described below.

1. Research, various sources of information are investigated about the issues related to the project.
2. Design of the electronic system. Once the project requirements have been analyzed, the electronic circuit is designed and the microcontroller is programmed.
3. Design of an application in Android. Develop an application that is easy to interact with the user, integrating the data required by the user to run the device, such as the number of players and the time of the game.
4. Implementation and execution of tests. Verification of the correct functioning of the electronic system with the application.
5. PCB board layout. Once the operation of the electronic system has been verified, the PCB board is made.
6. 3D modeling of the prototype. The prototype is modeled in Solidworks.
7. Implementation of the PCB in the prototype. The necessary PCB board connections are made in the 3D Model.
8. User manual. A user manual will be developed.

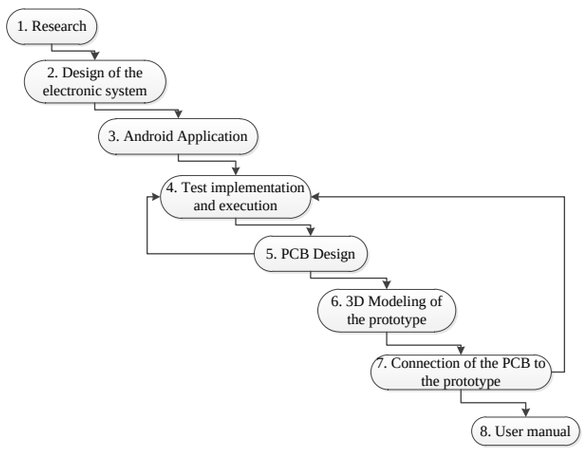

Figure 1 Work methodology
Source: Own Elaboration

For the design of the prototype, a logical structure of the solution is developed as shown in figure 2.

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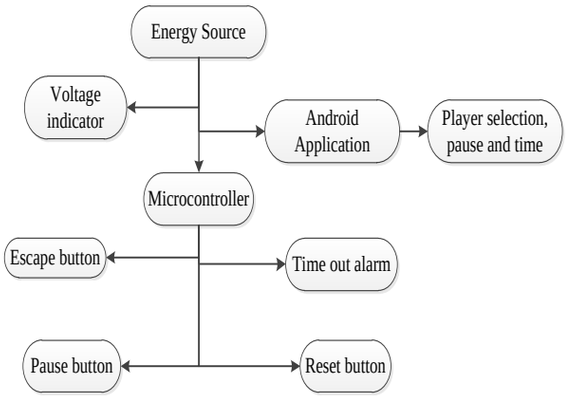

Figure 2 Logical structure of the timer
Source: Own Elaboration

As can be seen, it is necessary to differentiate two systems, the electronic system and the 3D model. For the electronic system, a block diagram is designed that is shown in Figure 3, where the different components that make it up are appreciated.

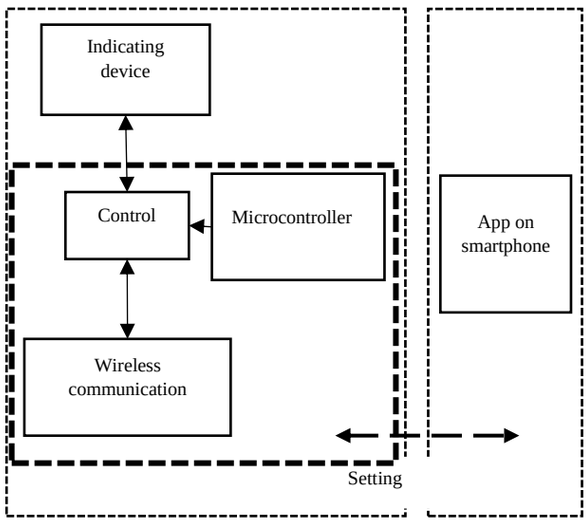

Figure 3 System block diagram
Source: Own Elaboration

For the 3D structure, the design shown in Figure 4 is developed, where it can be seen that the timer can control the time of up to six players.

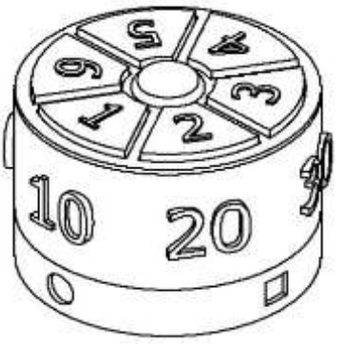

Figure 4 Timer housing
Source: Own Elaboration

The electronic design of the control and communication system is carried out as shown in Figure 5, where an ATMEGA328P-PU microcontroller and an HC-05 Bluetooth module are used. You can also see the indicator LEDs as well as the buzzer for the audible signal for shift changes.

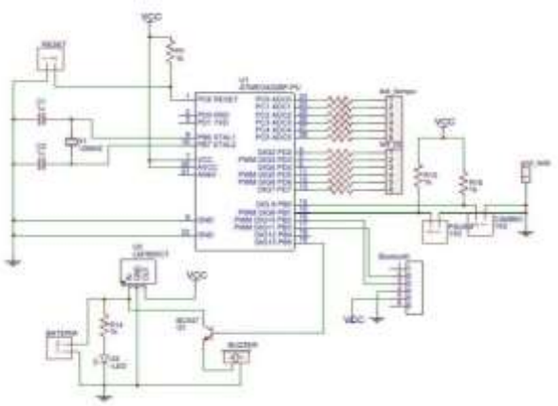

Figure 5 Electronic diagram of the control and communication system

It is important to note that the timer requires three interruptions and the microcontroller only has one, which is used for the Reset function of the system. Therefore, programming, of a sequential type, must be able to identify and perform the interruption at the requested time, namely, for shift change and to pause the system. Figure 6 shows the logic diagram of the microcontroller programming

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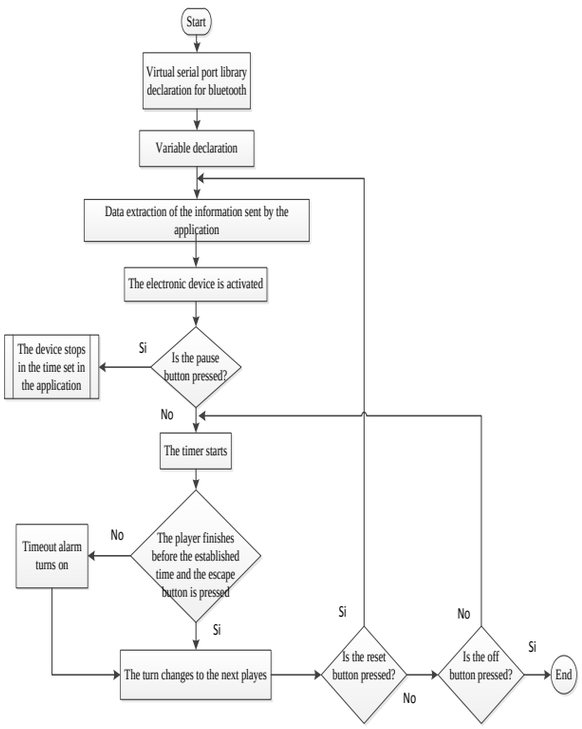

Figure 6 Microcontroller programming flow chart
Source: Own Elaboration

For the application on the smartphone, App Inventor is used following the logic shown in Figure 7.

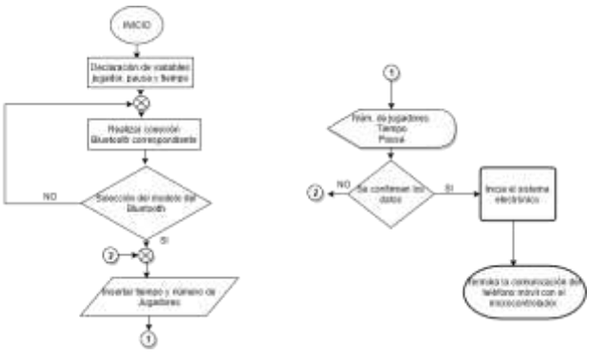

Figure 7 Programming diagram in App Inventor
Source: Own Elaboration

The application interface on the smartphone is also shown in Figure 8.

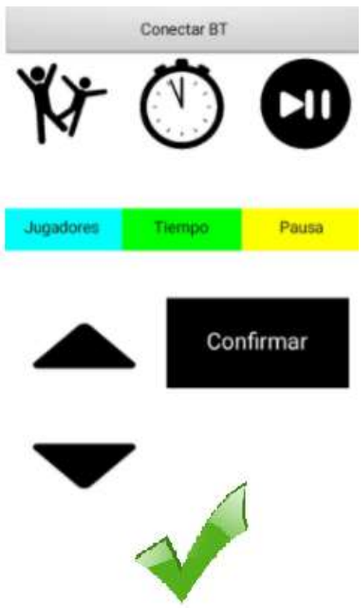

Figure 8 Interface designed in App Inventor
Source: Own Elaboration

Results

It is determined to carry out sensitivity tests of the Bluetooth module within the timer, in order to guarantee connectivity with the smartphone. This is done by setting the spectrum analyzer to a center frequency of 2.4 GHz and the SPAN: 80-100 MHz. During this pairing process, the spectrum analyzer detects a signal at -53.3dBm as shown in Figure 8.

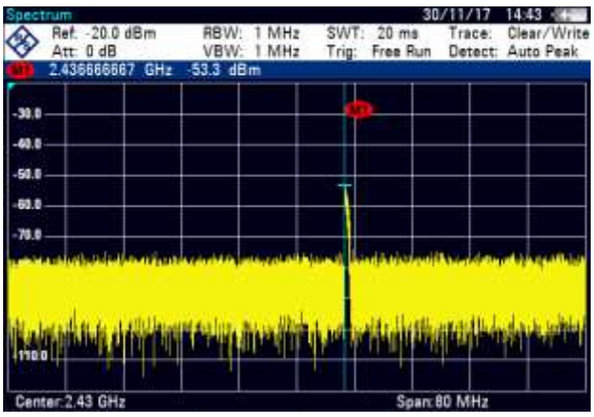

Figure 9 Connection between mobile phone and bluetooth within the prototype
Source: Own Elaboration

This proves that the power is within the stated range and the losses through the filament of the 3D casing of the timer are not significant.

By making the correct configuration of the number of players (from 1 to 6), the duration of the turn and the pause time, the device begins the count of the first player's turn.

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The device has light indicators to indicate the player in turn (Figure 10), it has an audible and light signal for the last three seconds of his turn (Figure 12).

Figure 11 Light signal on player number 2's turn
Source: Own Elaboration

Figure 12 Light signal in the last three seconds of the shift
Source: Own Elaboration

In order to measure the level of acceptance of the product, an online form was developed where a non-probabilistic sampling was carried out, since the people who responded to this form were selected through Facebook to 70 residents of the state of Morelos, Chiapas , Chihuahua and the State of Mexico. 85.7% of respondents find the timer an interesting idea, as shown in Figure 13.

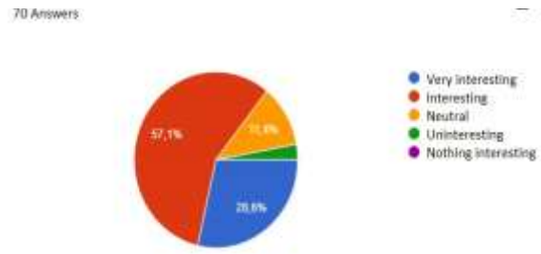

Figure 13 Acceptance of the prototype
Source: Own Elaboration

Information was also obtained about aspects of the device, such as ease of use and attractive design, as shown in Figure 14.

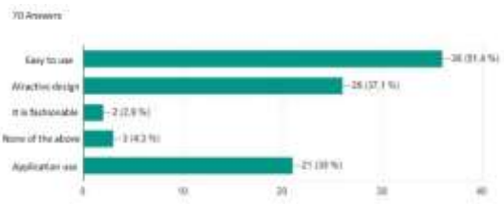

Figure 14 Attractive aspects of the prototype
Source: Own Elaboration

77.1% of those surveyed state that they would buy the timer in a short time, and 85.5% consider that by implementing the timer in their board games they would enjoy them more.

Conclusions

There is a wide variety of board games where this timer can be implemented, such as; domino, scrabble, connect 4, jenga, rummy, etc; all those where originally the user in turn has free time to make his move. This has negative consequences on the dynamics of these games and they tend to become boring or tedious. On the other hand, by implementing this solution, the game unfolds more dynamic and fun as seen in the responses to the applied survey. As part of future work, it is expected to reduce the size, expand the capacity of players, modify the application interface and design for iOS, use new materials with greater resistance as well as lithium-ion batteries to recharge the product and reduce contamination. to the environment.

References

L. Arlen, «Pressure actuated timing apparatus for use with games and the like». Patente US20140269226 (A1), 2013.

W. Y. Ping Wing, «Games timer». Patente GB2319637 (A), 1996

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Presence of antinutritional factors in legumes

Presencia de factores antinutricionales en legumbres

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Abstract

Legumes are one of the main sources of vegetable protein, and it has also been shown that, after consumption, beneficial effects can be obtained for human health, since they can help reduce blood glucose levels, as they are considered a low glycemic index food, promote bone health, and contain bioactive compounds with different biological activities such as hypotensive or hypocholesterolemic, among others. This group of foods are considered complete foods since they contain proteins, carbohydrates, minerals, vitamins, among other nutritional components; however, they also have antinutritional factors (ANF), which are defined as non-fibrous natural substances that can cause a negative effect on the nutritional value of some foods, as well as on health since they hinder or inhibit the assimilation of some nutrients. For this reason, it is of great importance to apply processing methods to reduce or eliminate the presence of these ANF in legumes.

Legumes, Antinutritional factors, Processing methods

Resumen

Las legumbres son una de las principales fuentes de proteína de origen vegetal; además se ha demostrado que, tras su consumo, se pueden obtener efectos benéficos para la salud humana, debido a que ayudan a reducir los niveles de glucosa en sangre, al ser consideradas un alimento de bajo índice glicémico, promueven la salud ósea, y contienen compuestos bioactivos con distintas actividades biológicas como hipotensora o hipocolesterolémica, entre otras. Este grupo de alimentos se consideran alimentos completos ya que contienen proteínas, carbohidratos, minerales, vitaminas, entre otros componentes nutricionales; sin embargo, también presentan en su composición factores antinutricionales (FAN), que se definen como aquellas sustancias naturales no fibrosas que pueden causar un efecto negativo en el valor nutricional de algunos alimentos, así como en la salud, ya que dificultan o inhiben la asimilación de algunos nutrientes. Es por esto que resulta de gran importancia utilizar métodos de procesamiento adecuados para reducir o eliminar los FAN presentes en las legumbres.

Legumbres, Factores antinutricionales, Métodos de procesamiento

Citation: MARCOS-MÉNDEZ, Dora Alicia, CANSECO-NAVA, Helena, OLIART-ROS, Rosa María and RAMÍREZ-HIGUERA, Abril. Presence of antinutritional factors in legumes. Journal of Innovative Engineering. 2021. 5-17: 6-13

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1. Introduction

Legumes are considered complete foods since they contain proteins, carbohydrates, minerals, vitamins, among other nutritional components (Elizalde, *et al.,* 2009). They are an excellent complementary food for infants and young children to meet their daily energy needs and are also very important in women of childbearing age (FAO, 2016).

However, legumes have antinutritional factors (ANF) in their composition (Elizalde, *et al.,* 2009); examples are tannins, phytic acid, trypsin inhibitors, and flatulence-causing oligosaccharides (Khattab and Arntfield, 2009). ANF are defined as non-fibrous natural substances that are generated by the secondary metabolism of plants as a defense mechanism, which can cause a negative effect on the nutritional value of this food group, as well as on health, since they hinder or inhibit the assimilation of some nutrients (Elizalde, *et al.,* 2009).

Among the main ANF present in legumes are tannins, which are versatile, astringent and water-soluble phenolic compounds that reduce the bioavailability of food in the intestine (Idate, *et al.,* 2021); saponins, which are compounds that have a complex structure made up of a hydrophobic steroidal nucleus and a hydrophilic part made up of monosaccharide units. Saponins cannot be absorbed in the intestine, thus affecting the absorption of zinc and iron (Elizalde, *et al.,* 2009).

Another ANF are phytates, present in small amounts in legumes and other food groups; due to their negative charge they bind to minerals such as iron, zinc, calcium, and magnesium, giving rise to an insoluble complex (Idate, *et al.,* 2021). Phytates have been widely shown to inhibit the biological functions of trace elements (calcium, magnesium, zinc, iron, etc.), food proteins, and digestive enzymes, causing potential digestive problems. (Kumar, *et al.,* 2010, Muzquiz, *et al.,* 2012).

Protease inhibitors are thermolabile compounds that cause alterations in the digestion of proteins (Elizalde, *et al.,* 2009 Lectins can bind to carbohydrate chains of glycoproteins and glycolipids,both glycoconjugates bound to the glycocalyx membrane and free glycoconjugates in mucus (Lagarda, *et al.,* 2017).

These reduce the surface of the villi, which diminishes the gastric secretion for the absorption of nutrients (Idate, *et al.,* 2021).

There are different processing methods and treatments that improve the nutritional quality of legumes by reducing the content of ANF. These methods are adapted to each specific legume; some examples are milling, soaking, cooking, germination, and dehulling.

2. Legumes

Legumes (*Leguminosae* family) are plants, which are a fruit formed by a pod that encloses a seed or a row of seeds inside, which are consumed dry. Legumes usually contain about twice the amount of protein found in whole grain cereals, so they are an excellent complementary food for infants and young children to meet their daily energy needs (FAO, 2016).

When combined with foods rich in vitamin C, the high iron content of legumes can make them an important food to replenish iron stores, especially for women of childbearing age, who are more vulnerable to iron deficiency anemia (FAO, 2016).

In Mexico, about 1.93 million hectares are allocated to the cultivation of legumes: beans (91.7% of the area), chickpea (6.4%), broad bean (1.4%), lentils (0.4%), and peas (0.1 percent); being 12.3% of the area destined to cyclical crops in the country.

The most consumed legume is bean, with more than 70 varieties (black, yellow, white, purple, bay, pinto, and mottled) (Ministry of Agriculture and Rural Development, 2015). It has been demonstrated that including legumes in the human diet is beneficial, Table 1 mentions some examples of these vantages (FAO, 2016):

Healthy benefits	Mechanism of action
Due to their low glycemic index, low-fat content, and high fiber content, they are ideal for diabetic people.	Legumes' fiber increases satiety and helps stabilize blood glucose and insulin levels, reducing postprandial peaks and improving insulin sensitivity. All this makes legumes ideal foods for weight control.
They can help reduce the risk of heart disease.	Dietary fiber is known for its participation in regulating LDL cholesterol levels, a recognized risk factor for coronary heart disease.

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They are a good source of vitamins.	The folate considerably reduces the risk of congenital anomalies of the neural tube, such as spina bifida in newborns.
Protein content.	The quality of proteins in vegetarian and plant-based diets improves considerably when legumes are combined with cereals.
They promote bone health.	Phytoestrogens can also prevent cognitive decline and reduce menopausal symptoms.
Legumes are gluten-free.	
They are rich in bioactive compounds.	Phytochemicals and antioxidants may contain antineoplastic properties.

Table 1 Benefits of legume consumption
Source Consulted: Own Elaboration

According to the 2020 National Health and Nutrition Survey on Covid-19, the distribution of the average per capita expenditure on foods such as cereals, legumes and tubers, was 21.4% of the average expenditure on food. The average per capita expenditure for legumes is around 68.7 Mexican pesos (3.38 US dollars). During pandemia confinement, legumes were one of the food groups with greater consumption stability; 74.3% of the population maintained their consumption, while 14% increased and 11% decreased their consumption.

3. Antinutritional Factors

As mentioned earlier, legumes are considered whole foods since they contain proteins, carbohydrates, minerals, vitamins, among other nutritional components. However, they also present antinutritional factors (ANF) in their composition (Elizalde, *et al.,* 2009) such as tannins, phytic acid, trypsin inhibitors, and flatulence-causing oligosaccharides (Khattab and Arntfield, 2009).

The term "antinutrients" is used to describe those compounds that can affect or cause a negative effect on the nutritional value of some foods, as well as on health because they hinder or inhibit the assimilation of some nutrients. ANF are considered non-fibrous natural substances, generated by the secondary metabolism of plants as a defense mechanism against stressful situations or the attack of molds, bacteria and birds (Elizalde, *et al.,* 2009).

However, some ANF, due to their biological activities and when consumed in small amounts, have shown to be beneficial in the prevention of diseases (Rochfort and Panozzo 2007).

4. Types of antinutritional factors

4.1 Tannins

They are defined as versatile, astringent, and water-soluble phenolic compounds of high molecular weight ranging from 500 Da to 3000 Da (Hassanpour, *et al.,* 2011). It has been reported that tannins reduce the bioavailability of nutrients in the intestine (Idate, *et al.,* 2021). Among the antinutritional effects of these compounds are reduced digestibility, mutagenic and carcinogenic effects, and the induction of hepatotoxic activity. The accumulation of tannins in legumes makes the protein unavailable and decreases the digestibility of the protein and most carbohydrates since amylases, lipases, trypsin, and chymotrypsin enzymes are inhibited by tannins (Idate, *et al.,* 2021). The absorption of iron from the intestine can also be affected (Khattab and Arntfield, 2009).

4.2 Saponins

Saponins are compounds with a complex structure made of a hydrophobic steroidal nucleus and a hydrophilic part made of monosaccharide units. They largely determine the bitter taste of some foods (Elizalde, *et al.,* 2009). Saponins are a category of steroidal glycosides that get their name from their ability to form stable, soap-like foams in aqueous solutions. Its intake through plant-based foods has been associated with both harmful and beneficial effects (Muzquiz, *et al.,* 2012).

Saponins cannot be absorbed in the intestine, thus affecting the absorption of zinc and iron (Elizalde, *et al.,* 2009). They have been found to reduce nutritional supply and the production of some digestive enzymes such as amylase, glucosidase, trypsin,chymotrypsin and lipase, which can cause indigestion-related health disorders,and the inhibition of bodily growth in animals (Idate, *et al.,* 2021).

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These compounds decrease the intestinal uptake of some nutrients, such as glucose and cholesterol, through an intraluminal physicochemical interaction, for which it has been determined that they have a hypocholesterolemic activitydue to the formation of an insoluble complex with cholesterol, thus preventing its absorption in the intestine; in addition, they increase bile acid excretion, an indirect method of lowering cholesterol (Rochfort and Panozzo 2007). Its biochemical effects are due to the structural differences of its sapogenin fractions (Idate, *et al.,* 2021).They also have anti-cancer properties, inhibit dental cavities, and have been shown to have an inverse relationship with the incidence of kidney stones (Muzquiz, *et al.*, 2012).

4.3 Phytates

Phytate is formed during the maturation of the plant's seeds; in dormant seeds it represents 60-90% of the total phosphate (Muzquiz, *et al.,* 2012). Phytic acid hinders the activity ofenzymes, which are necessary for protein degradation in the small intestine and stomach also affect the bioavailability of minerals and has a strong effect on infants, pregnant and lactating women when large portions of cereal-based foods are consumed (Khattab and Arntfield, 2009).

It is present in small amounts in legumes and other food groups; its negative charge allows it to bind to some minerals such as iron, zinc, calcium, and magnesium, giving rise to an insoluble complex (Idate, *et al.,* 2021). Phytate forms a strong complex with some proteins and resists their proteolysis. In general, the interaction of phytate with protein is dependent on pH and affect the protein structures that can hamper enzymatic activity, protein solubility and digestibility (Kumar, *et al.*, 2010), modifies enzymatic activity with negative effects on the main digestive enzymes (lipase, α-amylase, pepsin, trypsin and chymotrypsin) (Muzquiz, *et al.,* 2012).

Phytate is the main form of phosphorus storage in legumes and other foods; it is known as a food inhibitor that chelates the micronutrient and prevents it from being bioavailable to monogastric animals, including humans because they lack the enzyme phytase in their digestive tract (Gupta, *et al.,* 2015).

On the other side, a protective effect against a variety of cancers has been associated with phytate, mediated by antioxidant properties, interruption of cellular signal transduction and inhibition of the cell cycle. A therapeutic use against diabetes, atherosclerosis and coronary heart disease and the reduction of the formation of kidney stones has also been reported (Kumar, *et al.,* 2010).

4.4 Protease Inhibitors

Protease inhibitors are thermolabile compounds that are present in legumes that inhibit the action of proteolytic enzymes (trypsin and chymotrypsin) causing alterations in the digestion (Elizalde, *et al*., 2009).

These compounds in research with animal models have been found to have negative health effects(Idate, *et al*., 2021), for example, some protease inhibitors have been associated with increased hypertrophy and hyperplasia of the pancreas, as well as with the hypersecretion of digestive enzymes (proteins rich in sulfur); causing a slowdown in growth, since the proteins of the seeds of legumes, are usually deficient in sulfur amino acids (Muzquiz, *et al*., 2012; Idate, *et al*., 2021).

However, these protease inhibitors have also been found to have tumor cell growth inhibitory activity and are considered a strategy in cancer therapy (Kim, et al., 2009; Clemente, et al., 2004).

4.5 Lectines

Lectines are considered as antinutritional factors since they are carbohydrate-binding proteins of non-immune origin that can recognize and bind simple or complex carbohydrates in a reversible and highly specific way (Lagarda, *et al.,* 2017).

The main effect caused by lectins is related to the fact that they adhere to carbohydrates on the surface of the small intestine and cause damage to the intestinal wall in such a way that they affect the absorption and transport of some nutrients (Elizalde, *et al.,* 2009).

In addition, the continuous secretion of gastric enzymes generates adverse health effects (gastric ulcers) that could cause a pathological disorder in the intestine (Idate, *et al.,* 2021).

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4.6 Cyanogenic Glucosides

Cyanogenic glycosides have been found in more than 100 species in nature including legumes such as beans and chickpeas (Gleadow and Woodrow, 2002). They are derived from amino acids and are stored in vacuoles as inactive glycosylated precursors. The thermal processing of beans has been found to reduce total hydrogen cyanide content by 54-82% (Cressey, *et al*., 2013). Cyanogenic glycosides are not toxic by themselves, but cyanide is, acting at the level of cytochrome oxidase, a powerful inhibitor of the respiratory chain (Valle, 2000). In addition, after enzymatic hydrolysis by endogenous β-glucosidases they act as deterrents to feeding or oviposition (Shlichta, *et al*., 2014), and hydrogen cyanide is produced resulting in cyanide poisoning which causes rapid breathing, headache, dizziness and seizures, symptoms (Cressey, *et al*., 2013),

4.7 Oxalates

Oxalic acid is a strong organic acid that binds to minerals and forms insoluble salts of calcium and magnesium, reducing their intestinal absorption; in children it can lead to kidney damage after ingestion (Lluís, 1996). Oxalate is normally excreted in the urine, and can cause the formation of kidney stones due to its slow elimination (Valle, 2000). The ingestion of large amounts of oxalate can induce hyperoxaluria, which is a risk factor in the development of calcium oxalate stones (Siener, *et al*., 2020). Oxalate is present in different foods, and the normal dietary intake ranges from 80-10mg / day (Williams and Wandzilak, 1989). Its content in cooked legumes varies between 4-80 mg / 100 g; in beans, 50 mg of oxalates are found per serving (1 cup), while lentils and chickpeas present contain 8 and 9mg / 100g, respectively (Chai and Liebman, 2005).

5. Treatments for the reduction of antinutritional factors

There are different processing methods and treatments that improve the nutritional quality of legumes by reducing the FAN content. It is important to mention that these compounds have beneficial functions in the plant, so genetic modification is not feasible (Khattab and Arntfield, 2009). Some technologies that reduce or eliminate ANF in legumes are explained below.

5.1 Milling

This is a traditional method used to remove the outer layer of the seeds (Nikmaram, *et al.,* 2017). In this process the grains are ground into flour, and some ANF are eliminated (Samtiya, *et al.*, 2020). However, it also removes important minerals present in food (Gupta, *et al.,* 2015). Milling is used as a pretreatment, however, due to cellular degradation and the rearrangement of minerals, ANF and enzymes, the bioaccessibility of minerals is affected (Raes, *et al.*, 2014).

One of the ANF eliminated through this method are phytates, since these are found in the aleurone, which is the outer coating of the endosperm (Nikmaram, *et al.*, 2017).

5.2 Soaking

This technique, in addition to eliminating the ANF content, also reduces the cooking time of the legumes (Samtiya, *et al.*, 2020). This process consists of placing the seeds in a solution of preferably acidified water at a certain temperature and for a period of time (Raes, *et al.*, 2014). This processing method has been shown to reduce tannin and phytate content. Soaking caused a reduction of 42.82-48.91% in phytic acid content, a reduction of trypsin inhibitory activity of 10.22-19.85% and of oligosaccharides of 40% in legumes (Khattab and Arntfield, 2009). Specifically, in lentils, this method eliminated most of the oligosaccharides of the raffinose family (Valverde, e*t al.*, 1992).

5.3 Cooking

This is a method characterized by heat treatment of legumes in boiling water. This process elicits physicochemical changes as starch gelatinization, protein denaturation, polysaccharide solubilization, among others (Djabali, *et al.,* 2020). Using this method in legumes has been shown to improve nutritional value due to the reduction of tannins, trypsin inhibitors, phytates, among others (Samtiya, *et al.*, 2020; Wang, *et al.,* 2009).

For example, cooking inactivates trypsin inhibitors by denaturation; previous research has shown that cooking beans for 60 minutes completely removes trypsin inhibitors (Khattab and Arntfield, 2009).

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A reduction in tannins has also been observed in beans (Idate, *et al.,* 2021). Boiling removes oligosaccharides that cause flatulence; when this is carried out without a previous soaking of the seeds, the level of total soluble sugars increases (Valverde, *et al.,* 1992). In lentils, as well as in beans, broad beans, chickpeas, cooking eliminates or reduces the trypsin inhibitory activity, as well as the phytic acid content (Wang, *et al.,* 2009; Ma, *et al.,* 2011).

5.4 Germination

This method, like the previous ones, also improves the nutritional quality of legumes; it consists of soaking the seeds in water, which will activate the sequence of biochemical reactions that involves the germination process, until the elongation of the embryonic axes. The process includes soaking, draining, and leaving the seeds until they germinate and begin to sprout (Raes, *et al.,* 2014).

Germination activates the phytase, an enzyme that degrades phytate leading to a decrease in phytic acid concentrations (Samtiya, *et al.,* 2020). This process is considered one of the best options for the preparation of chickpea because it also increases the number of phenolic compounds (Idate, *et al.,* 2021).

5.5 Dehulling

This technique consists of the removal of the outer layers of the seeds and is often used as a pretreatment for other methods (Raes, *et al.,* 2014). Dehulling reduces the cooking time of legumes by eliminating the impermeable layer of the seed, which prevents water absorption (Wang, *et al.,* 2009).

This method has a great impact on the elimination of fibers, tannins and other phenolic compounds that fix iron (Raes, *et al.,* 2014). It also decreases trypsin inhibitory activity in different varieties of lentils, although to a lesser extent than cooking (Wang, *et al.,* 2009), and removes minerals as well (Raes, *et al.,* 2014).

6. Conclusions

Legumes are complete foods that are characterized by their high protein content, in addition to other nutrients such as carbohydrates, minerals, vitamins, among others; however, they contain ANF, which cause a negative effect on the nutritional value of this food group, as well as on health because they hinder or inhibit the assimilation of some nutrients. For this reason, it is necessary to increase the knowledge on processing methods or techniques that might reduce or eliminate these components in each legume, without affecting the nutritional quality of the food.

References

Chai, W., & Liebman, M. (2005). Oxalate content of legumes, nuts, and grain-based flours. Journal of Food Composition and Analysis, 18(7), 723–729. doi:10.1016/j.jfca.2004.07.001.

Clemente A, Mackenzie DA, Johnson IT, Domoney C (2004). Investigation of legume seed protease inhibitors as potential anti-carcinogenic proteins. In: Muzquiz M, Hill GD, Pedrosa MM, Burbano C (eds) Proceedings of the fourth international workshop on antinutritional factors in legume seeds and oilseeds. EAAP publication No. 110, Wageningen, pp 137–142.

Cressey, P., Saunders, D., & Goodman, J. (2013). Cyanogenic glycosides in plant-based foods available in New Zealand. Food Additives & Contaminants: Part A, 30(11), 1946–1953. doi:10.1080/19440049.2013.825819.

Djabali, S. & Makhlouf, F.Z. & Ertaş, Abdulselam & Barkat, Makeesha. (2020). Effect of heat treatment on polyphenolic compounds and antioxidant activity of lentils (Lens culinaris). Acta Scientifica Naturalis. 7. 58-71. 10.2478/asn-2020-0033.

Elizalde, A., Pismag, Y., & Chaparro, D. (2009). FACTORES ANTINUTRICIONALES EN SEMILLAS. Biotecnología en el Sector Agropecuario y Agroindustrial, 7(1), 45-54.

Gleadow RM, Woodrow IE (2002) Constraints on effectiveness of cyanogenic glycosides in herbivore defense. J Chem Ecol 28:1301–1313.

ISSN 2523-6873

Gupta, RK, Gangoliya, SS & Singh, NK Reducción del ácido fítico y mejora de los micronutrientes biodisponibles en los cereales alimentarios. J Food Sci Technol 52, 676–684 (2015). https://doi.org/10.1007/s13197-013-0978-y.

Hassanpour, S., MaheriSis, N., & Eshratkhah, B. (2011). Plants and secondary metabolites (Tannins): A Review. Int. J. Forest, Soil and Erosion, 1 (1), 47-53.

Idate, A., Shah, R., Gaikwad, V., Kumathekar, S., & Temgire, S. (2021). A comprehensive review on antinutritional factors of chickpea (Cicer arietinum L.). The Pharma Innovation Journal, 10(5), 816-823.

Khattab, R. Y., & Arntfield, S. D. (2009). Nutritional quality of legume seeds as affected by some physical treatments 2. Antinutritional factors. LWT - Food Science and Technology, 42(6), 1113–1118. doi:10.1016/j.lwt.2009.02.004.

Kim, J.-Y., Park, S.-C., Hwang, I., Cheong, H., Nah, J.-W., Hahm, K.-S., & Park, Y. (2009). Protease Inhibitors from Plants with Antimicrobial Activity. International Journal of Molecular Sciences, 10(6), 2860–2872. doi:10.3390/ijms10062860.

Kumar V, Sinha AK, Makkar HPS, Becker K. Dietary roles of phytate and phytase in human nutrition: A review. Food Chemistry, 2010; 120(4):945-959.

Lagarda, I., Guzman, A., & Vazquez, L. (2017). Legume Lectins: Proteins with Diverse Applications. International Journal of Molecular Sciences, 18(6), 1242. doi:10.3390/ijms18061242.

Lluís Berdonces, Josep. (1996). Toxicología alimentaria. Natura Medicatrix: Revista médica para el estudio y difusión de las medicinas alternativas, ISSN 0212-9078, Nº. 44 (Otoño), págs. 16-20.

Ma, Z., Boye, J. I., Simpson, B. K., Prasher, S. O., Monpetit, D., & Malcolmson, L. (2011). Thermal processing effects on the functional properties and microstructure of lentil, chickpea, and pea flours. Food Research International, 44(8), 2534–2544. doi:10.1016/j.foodres.2010.12.017.

Muzquiz, M., Varela, A., Burbano, C., Cuadrado, C., Guillamón, E., & Pedrosa, M. M. (2012). Bioactive compounds in legumes: pronutritive and antinutritive actions. Implications for nutrition and health. Phytochemistry Reviews, 11(2-3), 227–244. doi:10.1007/s11101-012-9233-9.

Nikmaram, N., Leong, S. Y., Koubaa, M., Zhu, Z., Barba, F. J., Greiner, R., … Roohinejad, S. (2017). Effect of extrusion on the anti-nutritional factors of food products: An overview. Food Control, 79, 62–73. doi:10.1016/j.foodcont.2017.03.02.

Organización de las Naciones Unidas para la alimentación y la Agricultura (FAO). Beneficios nutricionales de las legumbres. 2016. Disponible es: http://www.fao.org/fileadmin/user_upload/pulses2016/docs/factsheets/Nutrition_SP_PRINT.pdf.

Raes, K., Knockaert, D., Struijs, K., & Van Camp, J. (2014). Role of processing on bioaccessibility of minerals: Influence of localization of minerals and anti-nutritional factors in the plant. Trends in Food Science & Technology, 37(1), 32–41.

Rochfort, S., & Panozzo, J. (2007). Phytochemicals for Health, the Role of Pulses. Journal of Agricultural and Food Chemistry, 55(20), 7981–7994. doi:10.1021/jf071704w.

Samtiya, M., Aluko, R. E., & Dhewa, T. (2020). Plant food anti-nutritional factors and their reduction strategies: an overview. Food Production, Processing and Nutrition, 2(1). doi:10.1186/s43014-020-0020-5.

Secretaría de Agricultura y Desarrollo Rural. (13 de Octubre de 2015). *GOBIERNO DE MÉXICO*. Obtenido de Leguminosas, el alimento de todos: https://www.gob.mx/agricultura/es/articulos/leguminosas-el-alimento-de-todos.

Shamah-Levy T, Romero-Martínez M, Barrientos-Gutiérrez T, Cuevas-Nasu L, Bautista-Arredondo S, Colchero MA, Gaona-Pineda EB, Lazcano-Ponce E, Martínez-Barnetche J, Alpuche-Arana C, Rivera-Dommarco J. Encuesta Nacional de Salud y Nutrición 2020 sobre Covid-19. Resultados nacionales. Cuernavaca, México: Instituto Nacional de Salud Pública, 2021.

ISSN 2523-6873

Shlichta, J. G., Glauser, G., & Benrey, B. (2014). Variation in Cyanogenic Glycosides Across Populations of Wild Lima Beans (Phaseolus lunatus) Has No Apparent Effect on Bruchid Beetle Performance. Journal of Chemical Ecology, 40(5), 468–475. doi:10.1007/s10886-014-0434-0.

Siener, R., Seidler, A., & Hönow, R. (2020). Oxalate-rich foods. Food Science and Technology, 41, 169-173.

Valle-Vega, P., & Lucas-Florentino, B. (2000). Toxicología de alimentos. México, DF: Instituto Nacional de Salud Pública. Centro Nacional de Salud Ambiental. Retrieved from http://cetis59.com/biblioteca/toxicologia.pdf.

Valverde, C., Frías, J., & Valverde, S. (1992). Effect of Processing on the Soluble Carbohydrate Content of Lentils. Journal of Food Protection, 55(4), 301–303. doi:10.4315/0362-028x-55.4.301.

Wang, N., Hatcher, D. W., Toews, R., & Gawalko, E. J. (2009). Influence of cooking and dehulling on nutritional composition of several varieties of lentils (Lens culinaris). LWT - Food Science and Technology, 42(4), 842–848. doi:10.1016/j.lwt.2008.10.007.

Williams, H.E., Wandzilak, T.R., 1989. Oxalate synthesis, transport and the hyperoxaluricsyndromes. Journal of Urology 141, 742–747.

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Phytoextraction of mercury (Hg) in soils contaminated by button batteries using Bamboo "*Bamnusoideae*"

Fitoextracción de mercurio (Hg) en suelos contaminados por pilas botón empleando Bambú "*Bamnusoideae*"

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Abstract

The pollution of the planet has generated a series of problems for the environment and human health, such as the case of soils contaminated by heavy metals from batteries that are improperly disposed of in domestic garbage and sanitary landfills; Button batteries (HgO) pollute the soil, since mercury is very persistent in the environment due to its biomagnification and its great capacity to accumulate in organisms causing diseases in humans at the skin level, respiratory tract, digestive system, etc. . this being a highly toxic metal worldwide. The accumulation of Hg in soils depends on physicochemical factors such as pH, redox potential, organic matter, and clay. The main objective of this research work is to implement mercury phytoextraction in soils contaminated by button cells, using "*Bamnusoideae*" Bamboo, a UV-Vis spectroscopic study was carried out to determine the desorption of Hg from the contaminated soil, images of the stem were obtained, leaves and roots of bamboo without contamination and contaminated with Hg with a VE-B6 microscope, rating: 85V to 265V 50/60 Hz, Halogen Lamp: 12V 30W, and the pH of the contaminated soil was measured.

Phytoextraction, Button batteries, Bamboo "*Bamnusoideae*"

Resumen

La contaminación del planeta ha generado una serie de problemas al medio ambiente y salud humana, tal es el caso de los suelos contaminados por metales pesados provenientes de las pilas descartadas inadecuadamente en la basura doméstica y rellenos sanitarios; las pilas botón (HgO) contaminan el suelo, ya que el mercurio, es muy persistente en el medio ambiente por su biomagnificación y su gran capacidad de acumularse en los organismos causando enfermedades en el ser humano a nivel cutáneo, vías respiratorias, aparato digestivo etc. siendo este un metal altamente tóxico a nivel mundial. La acumulación del Hg en los suelos depende de los factores fisicoquímicos como pH, potencial redox, materia orgánica y arcilla. Este trabajo de investigación tiene como objetivo principal implementar la fitoextracción de mercurio en suelos contaminados por pilas botón, empleando Bambú "*Bamnusoideae*", se realizó un estudio espectroscópico UV-Vis para determinar la desorción de Hg de la tierra contaminada, se obtuvieron imágenes del tallo, hojas y raíz del bambú sin contaminar y contaminado con Hg con un microscopio VE-B6, rating: 85V a to 265V 50/60 Hz, Halogen Lamp: 12V 30W, y se midió el pH de la tierra contaminada.

Fitoextracción, Pilas botón, Bambú "*Bamnusoideae*"

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Introduction

In recent decades, technological-industrial development has increased worldwide, offering a better quality of life to the population, however, energy expenditure, food production, etc., have caused environmental pollution (Bertheau, 2011). The contamination and degradation of natural resources, such as the soil, represents a great problem due to the serious impacts that are had on the environment and human health by heavy metals, which are highly toxic such is the case of mercury, although it has various uses to industrial level either for electricity, chemical mining, metallurgy and electrical.

In the electrical and electronic industry, it is used for its great ability to conduct electricity, the manufacture of button cells and/or mercury oxide (HgO) batteries, presents a long-term energy storage stability, for which they are used in portable devices (radios, toys, headphones, watches) (Weinberg, 2010). However, at the end of their useful life cycle, they are irrationally discarded to the common garbage dump and sanitary landfills were when they meet climatic factors (air, temperature, and water), their internal components begin to react, which are highly damaging to the environment. environment and human health, the accumulation of mercury in soils depends on the physical-chemical factors such as pH, Eh, organic matter, chlorine ions, and oxides of Fe and Mn (Lindsay 1979, Andersson 1979, Schuster 1991)

So scientists have been given the task in recent years of looking for viable and environmentally friendly alternatives to eliminate the mercury present in soils some of the in situ thermal desorption treatment techniques that physically separate pollutants from the soil by increase the temperature from 600 to 800 ° C obtaining gaseous mercury for purification and recovery (Kucharski et al., 2005); soil washing that involves the extraction of contaminants from the soil; Vitrification performs a heating of the pollutants until reaching the melting point and cools to have a solidified chemically inert glassy mass and immobilize the pollutants (Dermont, G., et al., 2008);

Solidification / Stabilization reduces the mobility of pollutants, encapsulating them in a matrix (solidification) is used when there are mercury concentrations lower than 260 mg/kg (Mahbub, 2017); Nanotechnology uses iron sulfate (FeS) particles with a nanoparticle size of 1-1nm, thus reducing the mobility, toxicity and bioavailability of pollutants (Carbrejo at. el., 2010); Phytoremediation which includes emerging techniques using different species of plants, in figure 1, a scheme of the three types of remediation that exist for mercury contamination is shown when using phytoremediation, which are: Phytostability where the roots of the plants immobilize and reduce the bioavailability of the pollutant through biochemical processes that take place in the roots or their surroundings (Dermont et. al., 2008);

Phytoextraction allows the pollutants to be captured by the roots and transported to the organs of the plant (stem and leaves), for their subsequent extraction and destruction or recycling, removing the metal from the soil (Wang, 2012);

Phytovolatization transfers pollutants from the soil to the atmosphere, using plants as intermediaries where metals are absorbed by the roots, transporting them through the xylem and subsequently released from cell tissues to the atmosphere, the most efficient of these processes is phytoextraction by remove the contaminant from the soil (Lázaro, 2008).

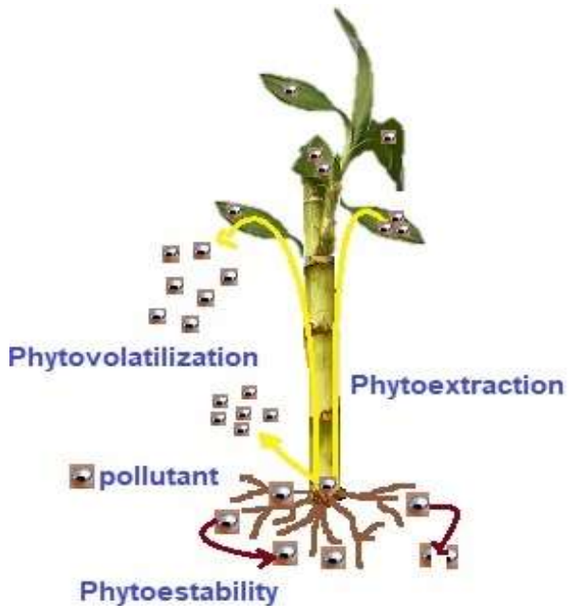

Figure 1 Scheme of the three processes of Phytoremediation of soils contaminated
Source: Own Elaboration

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SECUNDINO-LÓPEZ, Mitzi Gabriela, GALICIA-LUIS, Laura and LOZANO-CAMARGO, Maria Luisa. Phytoextraction of mercury (Hg) in soils contaminated by button batteries using Bamboo "*Bamnusoideae*". Journal of Innovative Engineering. 2021.

Methodology

Two "Bambusoideae" bamboo plants were planted, one was placed in a pot without Hg and the other in a pot contaminated with Hg from button cells, as shown in figure 2.

Figure 2 Image of the pots with bamboo, a) soil contaminated with Hg from button batteries, b) without Hg
Source: Own Elaboration

Subsequently, 1 gram of soil contaminated with Hg was collected for 65 days, samples of soil contaminated with Hg, and it was placed in a sterilized bottle containing 5 mL of water, these were perfectly closed and covered with aluminum.

UV-vis spectroscopic study

The spectroscopic studies were performed using a Perkin-Elmer Lambda 25 UV/Vis spectrometer, which has a tungsten and deuterium lamp, the spectra were obtained from 200 to 500 nm with a scanning speed of 240 nm/min

Bamboo images

Bamboo images were obtained using a VE-B6 microscope, rating: 85V to 265V 50/60 Hz, Halogen Lamp: 12V 30W, Delay-action Fuse: 1A.

Results

UV-Vis spectroscopic study and pH values

Table 1 shows the results obtained from the absorbance of Hg at the wavelength of 253.56 nm as a function of the time of the contaminated soil samples, as well as the obtained pH values.

Time/ days	Abs	[Hg]/ppm	pH± 0.05
1	0.54129	0.217	6.51
2	0.51321	0.206	6.36
4	0.49185	0.197	6.22
6	0.48630	0195	7.12
8	0.47872	0.192	6.25
10	0.46917	0.188	6.22
12	0.45597	0.183	6.22
14	0.45320	0.181	6.29
21	0.35991	0.144	6.36
28	0.30836	0.124	6.14
35	0.30617	0.123	6.22
49	0.28579	0.115	6.04
56	0.22570	0.091	6.00
65	0.21511	0.086	6.25

Table 1 The concentrations, and pH values of the samples taken from the contaminated substrate are shown
Source: Own Elaboration

As can be seen in table 1, it is clearly shown that there is a decrease in the concentration of Hg in the contaminated land as a function of time, with mercury concentrations higher than the permissible limits established by the Official Mexican Standard **NOM-147-SEMARNAT/SSA1-2004** regarding the concentration of soluble pollutants (CRs) that indicates that for mercury it is 0.020 ppm, which gives a clear indication of the serious contamination that is had in the soil by button batteries at the end of their life cycle of an inappropriate way.

In graph 1, the absorbances are shown as a function of time for the samples extracted from the substrate, where it is clearly observed that there is desorption of Hg as the days pass, it is important to clarify that these are the first studies carried out.

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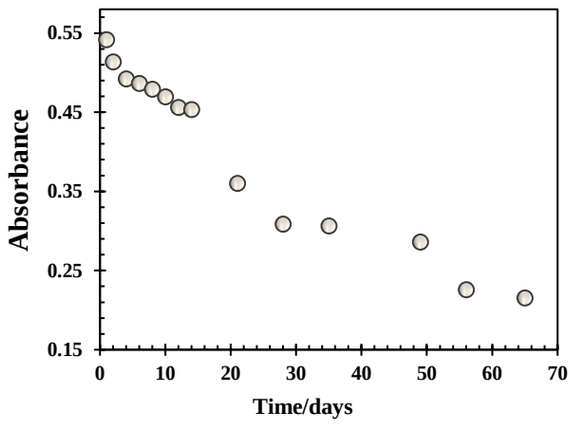


Graphic 1 Hg desorption graph in contaminated soil vs time in days
Source: Own Elaboration

The pH values obtained in this work indicate that there is a reduction of the Hg salts to Hg°, favorably increasing the loss of Hg by volatilization since, as reported in the literature by Frear at. the. when the pH rises from 5.3 to 6.4 there is less volatilization to the environment, according to the analyzes carried out so far it can be established that on earth the predominant species is mercury (II) hydroxide ($Hg(OH)_2$), which is a short-lived transitory intermediate in the formation of mercury oxide (HgO) in the alkaline aqueous medium, it has been determined that $Hg(OH)_2$ is a weak base and that it may be accompanied by $HgOH^+$ and Hg^{2+}, as shown in figure 3, distribution diagram of Hg (II) species as a function of pH in soils (Adriano, 1986).

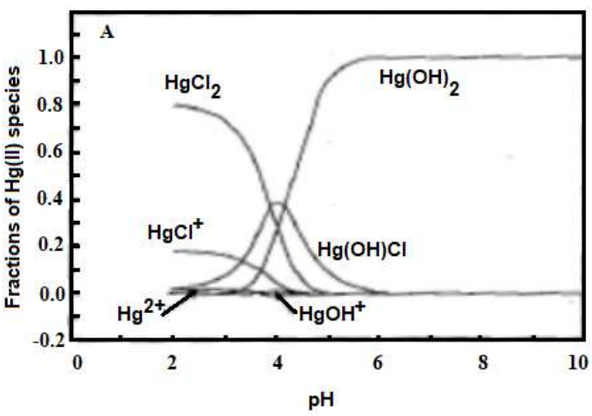
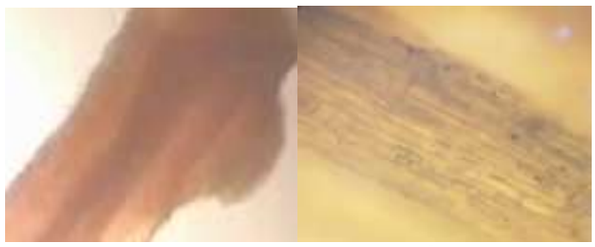


Figure 3 Hg (II) speciation as a function of pH (*Adriano, 1986*).

Leaf, stem and root images

Images of the leaves, stem and root of the bamboo were obtained without and with Hg, using a VE-B6 microscope, in figure 4.

The images obtained from the roots of the bamboo are shown, 4a without mercury and 4b with mercury as it can be Observe there is a great difference in the structure of the vascular cylinders found in the stela along with the xylem and phloem in the contaminated root, small clusters are observed changing the structure of the root, which gives evidence of the adhesion of Hg in it.



a **b**

Figure 4 Images of the bamboo root a) without Hg and b) with Hg
Source: Own Elaboration

In figure 5, the images of the stem are shown, 5 a) without Hg and 5 b) with Hg, as can be seen, there is a clear alteration in the structure of the metaxylem vessel and of the protoxylem vessel in the stem structure when absorbing the Hg.

a **b**

Figure 5, Images of the bamboo root a) without Hg and b) with Hg
Source: Own Elaboration

In figure 6, the images of the leaves are shown, 6 a) without Hg and 6 b) with Hg, in figure 5a no change is shown in the structure of the bamboo leaf, only small drops of water are distinguished, in figure 6b, it can be seen that there is actually an absorption of Hg in the structure of the sheath and trichomes in the cross-section, observing metallic clusters.

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a **b**

Figure 6 Images of bamboo leaves a) without Hg and b) with Hg
Source: Own Elaboration

In order to corroborate the presence of mercury in the stem, leaves, and root of the bamboo, a UV-vis spectroscopic study was carried out, for this, acid digestion was carried out on the samples to extract the amount of Hg contained, the spectrum It was the neighborhood in a wavelength of 200 to 500 nm, observing at 253.56 nm the absorbance of Hg in the contaminated samples, in the samples without mercury no absorbance was detected at that length, in table 2 the concentrations of Hg in the stem, leaves, and root of bamboo.

samples	Abs	[Hg]/ppm	pH± 0.05
Leaf	3.1033	$3.09x10^{-5}$	5.32
Stem	1.0706	$5.94x10^{-6}$	5.65
Root	1.2037	$6.68x10^{-6}$	5.45

Table 2 Hg concentrations, absorbance and pH value of leaves, stem, and root
Source: Own Elaboration

The data obtained show that in the stem there is a lower concentration of Hg than in the root and there is a higher concentration in the leaves, the Bamboo is capable of concentrating and precipitating the Hg of the soil in the biomass due to its high potential as a phytoremediator being This is a good candidate to capture metal ions through the roots and accumulate these in their stems and leaves in a friendly and economical way without altering the environment and human health, according to the literature the wavelength in UV- Vis at 253.65 nm there is the presence of inorganic Hg ° this is not susceptible to any of the main mechanisms of dry deposition and has very low solubility in water, elemental mercury is deposited through a series of chemical reactions in the drops of water of the clouds as expressed in the following equations.

$$\mathrm{Hg}^{\circ}_{(g)} \rightarrow \mathrm{Hg}^{\circ}_{(aq)} \quad (1)$$

$$\mathrm{Hg}^{\circ}_{(aq)} + O_3 \rightarrow Hg(II)_{(aq)} \quad (2)$$

$$\mathrm{Hg(II)}_{(aq)} + \text{polvo/evaporación} \rightarrow \mathrm{Hg}_{(II)(p)} \quad (3)$$

$$\mathrm{Hg}_{(II)(aq)} + \mathrm{SO}_3^{2-} \rightarrow \mathrm{Hg}^{\circ}_{(a)} \quad (4)$$

This type of mechanism opens a possible deposition path for elemental mercury present in the atmosphere.

Acknowledgments

Thanks to the Tecnológico de Estudios Superiores del Oriente del Estado de México and the Universidad Autónoma Metropolitana-Iztapalapa for the support received to carry out this project.

Conclusions

The spectroscopic UV-Vis study allowed identifying that the bamboo “Bamnusoideae” is a good candidate to be used as a phytoremediator of soils contaminated with mercury from discarded button cells, obtaining Hg concentrations in the root of 6.68x10-6 ppm, in the stem 5.9x10-6 ppm and in the leaves 3.09x10-5 ppm and having an average desorption concentration of Hg in the soil of 14.07 ppm. The images obtained in the microscope give clear evidence of the presence of mercury in the root, stem and leaves by changing their morphological structure.

References

Adriano D. C. 1986. Trace Elements in the Terrestrial Enviroment. Springer-Verlag. 298-324. New York (USA).

Andersson, A (1979) Mercury in Soil. In: Nriagu, J.O (Ed.) The Biogeochemistry of Mercury in the Environment. Elsevier, Amsterdam, 79-112.

Cabrejo, E. y Philips E. 2010. In situ remediation and stabilization technologies for mercury in clay soils. Student summer internship technical report

Dermont G., Bergeron M., Mercier G., Richer-Lafleche M. 2008. Soil Washing for Metal Removal: a Review of Physical/Chemical Technologies and Field Applications, J. Hazard. Mater. 152: 1–31.

ISSN 2523-6873

Frear, D., y Dills, L. (1967). Mechanism of the Insecticidal Action of Mercury and Mercury Salts. Journal of Economic Entomology, 60(4), 570-574.

Kucharski, R., Sas-Nowosielska, A., Małkowski, E., Japenga, J., Kuperberg, J. M., Pogrzeba, M., Krzyzak, J. 2005. The use of indigenous plant species and calcium phosphate for the stabilization of highly metal-polluted sites in southern Poland. Plant and Soil. 273: 291- 305.

Lázaro, J. 2008. Fitorremediación de suelos contaminados con metales pesados: Evaluación de plantas tolerantes y optimización del proceso mediante prácticas agronómicas. Tesis de la Universidad Santiago de Compostela. Dpto. de Edafología y Química agrícola.

Lindsay, W.L. (1979) Chemical Equilibria in Soils. John Wiley and Sons, New York, 449.
Mahbub, K., Bahar, M., Labbate, M., Krishnan, K., Andrews, S., Naidu, R., Megharaj, M. 2017. Bioremediation of mercury: not properly exploited in contaminated soils. Appl Microbiol Biotechnol 101:963–976

Wang, J., Feng, X., Anderson, C., Xing, Y., Shang L. 2012. Remediation of Mercury Contaminated Sites. Journal of Hazardous Materials. 221-222: 1-18.

Weinberg, J. (2010). Introducción a la Contaminación por Mercurio para las ONG. Red Internacional de Eliminación de los Contaminantes Orgánicos Persistentes (IPEN), 166.

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Modeling compressor blades gas turbine in a marine environment to determine of the stress and possible damages

Modelado de álabes de compresor de una turbinas de gas en un ambiente marino para determinar el esfuerzo y posibles daños

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Abstract

In this paper, the static simulation carried out on the blades of the seventh stage of the compressor of a gas turbine installed in an offshore oil platform is reported, the objective of this simulation is to have a means of analysis that confirms and complements the tests visual inspection (boroscopy), as well as non-destructive tests. In specific case of this compressor, the results of boroscopy were available, as well as the scanning electron microscope (SEM), with which it was possible to measure the roughness and evaluate the degradation of the blade surfaces after 30,000 hours of service operating in Cantarell, Mexico, in a very aggressive marine environment conditions, where the entry of solid particles is highly possible. The model of seventh stage's blade was obtained with a cloud of points. A finite element analysis was carried out with ANSYS software. Results showed wear modes were originated by a severe stinging action. Also, large craters, similar to those observed in solid particle erosion, were developed by at normal impact. The points, where peak stresses were calculated, correspond to those places in which corrosion and some irregular scratches similar to plowing action, was observed. These are the points in which failures take place. Results showed wear modes were originated by a severe stinging action.

Blades, Gas turbine, Optical 3DScanner, Finite element

Resumen

En este trabajo se reporta la simulación estática realizada en los álabes de la séptima etapa del compresor de una turbina de gas instalada en una plataforma petrolera costa afuera, el objetivo de esta simulación es contar con un medio de análisis que confirme y complemente las pruebas de inspección visual (boroscopia), así como pruebas no destructivas. En el caso específico de este compresor, se empleraron los resultados de boroscopia, así como del microscopio electrónico de barrido (SEM), con el que se pudo medir la rugosidad y evaluar la degradación de las superficies de los álabes tras 30.000 horas de servicio operando en Cantarell, México, en un entorno marino muy agresivo, donde la entrada de partículas sólidas esta presente. El modelo de la álabe de la séptima etapa se obtuvo con una nube de puntos. Se realizó un análisis de elemento finitos con el software ANSYS. Los resultados mostraron que los modos de desgaste se originaron por una acción severa. Además, se desarrollaron grandes cráteres, similares a los observados en la erosión de partículas sólidas, con un impacto normal. Los puntos, donde se calcularon los esfuerzos máximos, corresponden a aquellos lugares en los que se observó corrosión y algunos rayones irregulares similares a la acción del arado. Los puntos analizados, son los puntos en los que se producen las fallas severas.

Alabes, Turbina de gas, Escanner 3D, Análisis de elemento finito

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Introduction

Gas turbines operating in offshore oil installations are subject to the presence of solid pollutants, as well as the corrosive effect of sea salts, as is the case with this turbine, Solar Centaur 40 gas turbine, for this reason, special care must be taken in routine maintenance inspections in order to detect faults such as opening of blade clearances and leading and trailing edge erosion (caused by solid and liquid impacts on blades), airfoil (blade) fouling and pitting (caused by corrosion and surface deposits);

The Centaur 40 gas turbine has 11 stages in axial type air compressor, pressure ratio is 10.3: 1 and air flow inlet is 18.7 kg / sec (41.3 lb / sec). Variable blades begin to open when the Pcd (Pressure compressor discharge) reaches approximately 32 psi (gp) and fully open when Pcd reaches approximately 76.5 lb / in2 (gauge) [1].

Figure 1 Blade rotor of compressor gas turbine
Note. Adapted of Compressor turbine disk, Villagrán-Villegas Luz Yazmin, 2017

A study of wear damage of a seventh-stage's blade of axial compressor of a gas turbine (see Figure 1) was carried out. Manufacturer recommends routine maintenance at 30,000 hours to reduce chances for shutdown of gas turbine, but the C40 gas turbine shutdown at 24,000 hours in field and out of service after 30,000 hours. In this study an analysis was made to model through computational dynamics the efforts to which it will be subjected and anticipate the operation shutdown time. [2].

As part of the inspection process carried out on the compressor, boroscopy studies and digital images were carried out, as well as scanning it with an electronic scanner. In order to carry out the dynamic simulation, the results of these inspections were used.

Methodology: Scanning electron microscopy analysis

The methodology developed where in the Emission Scanning Electron Microscopy analysis to carry out an analysis of damage caused by wear of blades of axial compressor on a gas turbine had three steps, the first chemical elements characterization, second, an inspection of both sides, trailing edge and leading edge of the blade and finally a microstructural test.

In the first step, it was obtained that blades are manufactured from a chrome-based superalloy with chemical elements such as Co, Cr, Ni, Fe, C, Nb and Mo, this analysis was necessary to define in the software.

At the second step could, the analysis showed the degradation of surfaces in areas of higher air pressure mixed with particles, that it is hoped it can be confirmed in the modelling. In this phase of scanning, two techniques to preparation of the sample were used, first one analysis in trailing edge and then leading edge of the piece (Figure 2).

In microstructural tests, wear mechanisms characterized by large craters and grooves were identified, and degradation mechanisms were presented such as corrosion damage, irregular cavities, wear debris, flattened foreign particles on surface and parallel grooves showing the trajectory of solid particle impacted on the blade during its operation. [3]

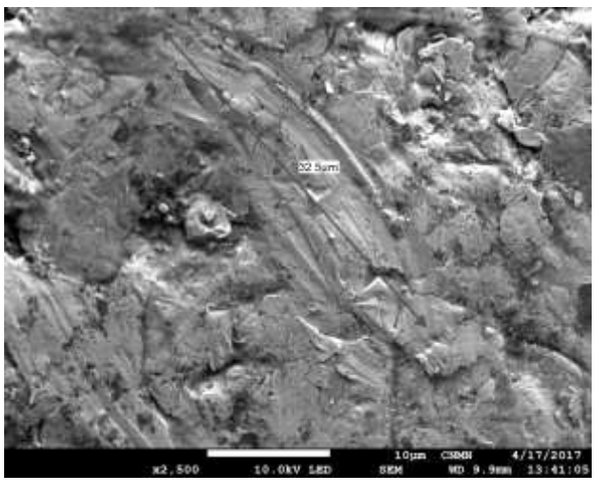

Figure 2 Irregular indentation and material piled-up (trailing edge)
Note. Adapted of Compressor turbine disk, Villagrán-Villegas Luz Yazmin, 2017

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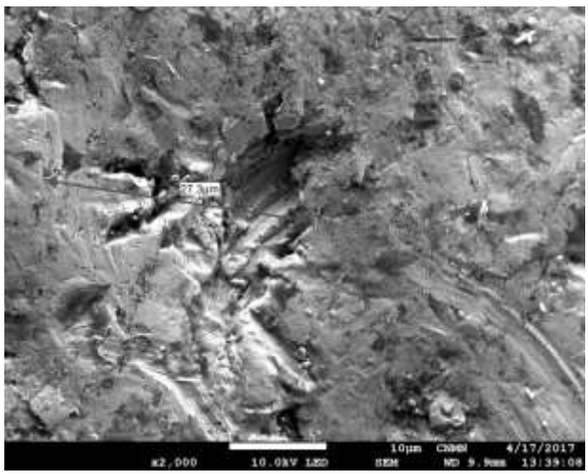

Figure 3 Trailing edge (Emission Scanning Electron Microscopy test)
Note. Adapted of Compressor turbine disk, Villagrán-Villegas Luz Yazmin, 2017

Figure 3 in trailing edge, present irregular indentations were identified on surfaces around 27.3 μm length with material piled-up (lips) at sides as the result of subsequent particle impacts, which caused detachment of lips with trajectory around 32.5 μm.

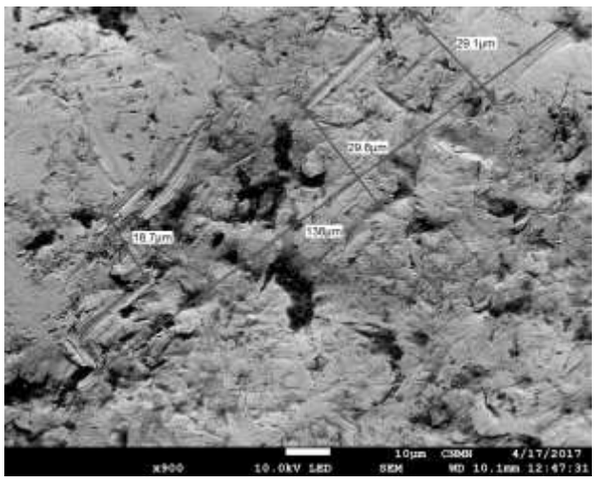

Figure 4 Leading edge (Emission Scanning Electron Microscopy test)
Note. Adapted of Compressor turbine disk, Villagrán-Villegas Luz Yazmin, 2017

Images in Figure 4 in leading edge, which are characterized by large craters and grooves (ploughing action) of around 0–138 μm length with material piled-up (lips) at sides around 4.7–15.2 μm length and in front of cavities, which is common in solid particle erosion, as specimens are impacted at oblique incident angles ($\alpha \leq 45°$)

Results: Numerical analysis

Blades operate at great vibratory forces, which requires sufficient resistance to fatigue; in particular, they must be manufactured with careful processes to support wear and resonance conditions, [4] as well as to function optimally depending on pressure, temperature and viscosity conditions of fluid.

Another question that must be considered in the maintenance inspections is the variation in the geometry of the blade, [5] either due to wear or incrustations, since it would change the natural frequency of the set, bringing it closer to the designed natural vibration frequency, with the possible damage that this would cause. [6]

ATOS ScanBox is 3D optical measuring equipment that was developed by GOM This a software package for digital image correlation (DIC) and 3D motion analysis in materials and component testing. The software is used for the determination of material properties as well as for the validation and optimization of numerical simulations. GOM Correlate is applied in basic research, product development and failure analyses; It is an optical 3D coordinate measurement system. ATOS sensors provide full field 3D coordinates for each individual measurement of up to 16 million independent measurement points and are captured from 1 to 2 seconds. ATOS captures the full-surface geometry of an object accurately in a dense dot cloud or polygon mesh; it allows detailed high resolution scans, fast data collection, advanced inspection functionality and a complete dimensional analysis.

GOM Inspect is software for analysis of 3D measurement data. Generated model is a polygonal mesh that can be smoothed, thinned and refined, and from the initial model holes in the mesh can be filled and curvatures can be extracted. Mesh is processed using algorithms based on curvature and tolerances. Software provides the user with a preview of each processing step and generates calculation of an average mesh [7]; and solving meshing by approximations under the SST model SST Turbulence model, because of the limitations of the eddy viscosity modelling, flow models have been developed to better suit the turbulent flows found in turbo compressors.

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One of those are the Shear Stress Transport, that shows the distortional energy failure theory which is usually called the Von Mises stress, or effective stress model that from now on will be addressed as the SST model. The SST is based on the K − ω model and is the standard turbulence used for simulations on centrifugal compressors because of its ability to predict the flow separation under unfavourable pressure gradient that are found in compressors. The model takes into account for the transport of the turbulent shear stress and take advantage of both the Wilcox and K − model. It solves both transport equation for kinetic energy as well as specific dissipation rate. This makes the SST model more sophisticated and accurate than its predecessors and is suitable for a larger range of different flows, like compressors and aerodynamics. The SST model is identical to the K −model in the free shear flows. At near walls, the prediction of separation from a smooth surface with high accuracy is difficult, especially under unfavourable pressure gradients like in the compressor.

It is recommended in the user guide to properly resolve the boundary layer with at least 10 layers (in this case, the software solved 18 positions) for the SST model to capture the flow correctly and with high accuracy at boundaries. This is especially of importance when solving for heat transfer [8]. Throughout this study, the SST model is used for simulations together with an automatic wall function.

This automatic wall function will switch from wall function to a low-Re near wall treatment when the mesh is refined. As already mentioned, SST is recommended for accurate predictions near wall, but is mathematically identical to the K − model in the free stream. By using the automatic near-wall treatment, the SST model will shift from a low-Re number form to a wall function formulation when the mesh is refined. This shift will be carried out to smoothly shift between the two formulations, so the low-Re formulation is used for y + < 2.

Therefore at least 10 layers of inflation should be used, so the wall can be resolved enough. Since the condition of y + ≤ 2 is difficult to adapt in all parts of the geometry, the SST model with automatic near-wall treatment will shift between low-Re and wall function for y + < 11.06.

By resolving the mesh by the use of inflation layer, so the mesh is below these criteria, the simulation does not have to switch between different wall functions, which may lead to an increased accuracy for the solver. Calibration process of equipment starts with selection of the type of calibration to be carried out, which depends on precision and number of calibration positions, for this case a calibration of 18 positions is chosen. At the start of calibration process, ambient temperature measurement was 21.4 ° C and ambient temperature recorded for blade scan was 27.1 ° C.

Piece evaluated with blue light of ATOS scanner is a compressor vane of 7th stage, which when mounted on turntable, a point cloud is obtained. Data acquisition procedure (Figure 5) requires that the piece is coated with a white paint film (zinc oxide), for this testing stage the piece was already evaluated in RX and SEM.

Figure 5 3D digitization process of blade. Note: Adapted "Study of wear damage in compressor turbine blades"(p. 76), Villagrán-Villegas L. , 2017

At the end of the process, a dot grid of axial compressor blade was obtained, one mesh with 93508 nodes (points). The model was optimized with GOM software and the model was reduced to 19938 nodes, which helps to optimized processing time.

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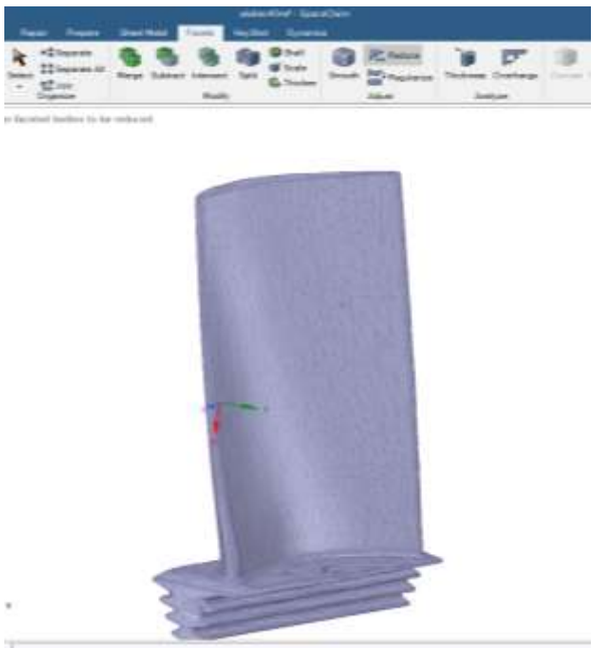

Figure 6 Model optimized with GOM software

Conclusions

After having carried out the dynamic simulation of the stresses to which the compressor blade is subjected, it was possible to verify the coincidence between the calculation developed with the evidence of the faults and wear found in the electronic scan carried out on the blade. A mesh points of axial compressor's blade was obtained, which allowed us to design a structural stress model.

With both analysis for the study of damage caused by wear in axial compressor's blades on a gas turbine will allow to characterize because the points, where pick stresses were calculated, correspond to those places in which corrosion and some irregular scratches similar to plowing action, was observed. These are the points in which failures take place. Therefore, there is now both theoretical and physical evidence of the areas where it will be necessary to inspect the compressor blades in the Solar Centaur 40 gas turbine installed in the marine weather conditions.

References

[1] Tabakoff, H. S. (1998). Blade Deterioration in a Gas Turbine Engine. (G. science, Ed.) International Journal of Rotating Machinery, 4 (4), p. 233-241.

[2] Pettit, F. S., & Goward, G. W. (1981). High temperature corrosion and use of coatings for protection. Metallurgical Treatises, 1, p. 603-619.

[3] Hutchings, I. (2003). Tribology (Vol. 1). (B. Heinemann, Ed.) London, London, UK: Elsevier Science.

[4] Kurz. (2014). Gas turbine degradation. Turbomachinery Laboratory, 1 (1), p. 36.

[5] NageswaraRao, M. (2011). Materials for Gas Turbines – An Overview, Advances in Gas Turbine Technology.Intech Europe, University Campus STePRi. Rijeka: Intech.

[6] Shilke, P. W. (2004). Advanced Gas Turbine Materials and Coatings. (Ge, Ed.) Ge Power, 1 (p. 356).

[7] R. Mendriky, Determination of measurement of accuracy of optical 3D scanner. Journal (Vol.1.) (2016), p.1565-1572.

[8] Mann BS. (1999) Solid-particle erosion and protective layers for steam turbine blading. Wear; 224: p. 8–12.

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Abstract (In English, 150-200 words)

Objectives
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Contribution

Keywords (In Spanish)

Indicate 3 keywords in Times New Roman and Bold No. 10

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* Correspondence to Author (example@example.org)
† Researcher contributing as first author.

Introduction

Text in Times New Roman No.12, single space.

General explanation of the subject and explain why it is important.

What is your added value with respect to other techniques?

Clearly focus each of its features

Clearly explain the problem to be solved and the central hypothesis.

Explanation of sections Article.

Development of headings and subheadings of the article with subsequent numbers

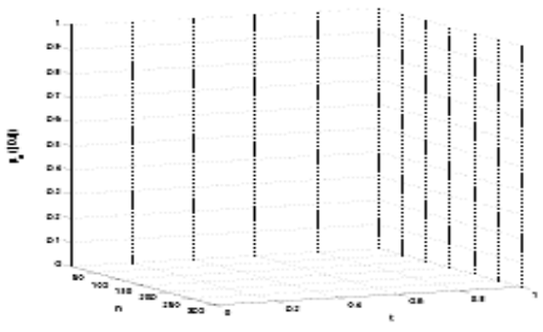
[Title No.12 in Times New Roman, single spaced and bold]

Products in development No.12 Times New Roman, single spaced.

Including graphs, figures and tables-Editable

In the article content any graphic, table and figure should be editable formats that can change size, type and number of letter, for the purposes of edition, these must be high quality, not pixelated and should be noticeable even reducing image scale.

[Indicating the title at the bottom with No.10 and Times New Roman Bold]



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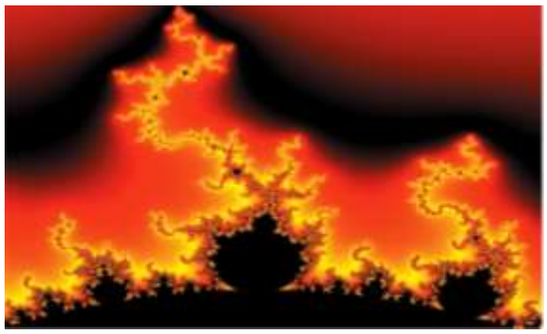

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Table 1 Title and *Source (in italics)*

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Each article shall present separately in **3 folders**: a) Figures, b) Charts and c) Tables in .JPG format, indicating the number and sequential Bold Title.

For the use of equations, noted as follows:

$$Y_{ij} = \alpha + \sum_{h=1}^{r} \beta_h X_{hij} + u_j + e_{ij} \qquad (1)$$

Must be editable and number aligned on the right side.

Methodology

Develop give the meaning of the variables in linear writing and important is the comparison of the used criteria.

Results

The results shall be by section of the article.

Annexes

Tables and adequate sources

Thanks

Indicate if they were financed by any institution, University or company.

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Conclusions

Explain clearly the results and possibilities of improvement.

References

Use APA system. Should not be numbered, nor with bullets, however if necessary numbering will be because reference or mention is made somewhere in the Article.

Use Roman Alphabet, all references you have used must be in the Roman Alphabet, even if you have quoted an Article, book in any of the official languages of the United Nations (English, French, German, Chinese, Russian, Portuguese, Italian, Spanish, Arabic), you must write the reference in Roman script and not in any of the official languages.

Technical Specifications

Each article must submit your dates into a Word document (.docx):

Journal Name
Article title
Abstract
Keywords
Article sections, for example:

1. Introduction
2. Description of the method
3. Analysis from the regression demand curve
4. Results
5. Thanks
6. Conclusions
7. References

Author Name (s)
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Universidad Politécnica del Estado de Morelos

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MARCOS-MÉNDEZ, Dora Alicia, CANSECO-NAVA, Helena, OLIART-ROS, Rosa María and RAMÍREZ-HIGUERA, Abril
Unidad de Investigación y Desarrollo de Alimentos, Tecnológico Nacional de México/ I.T. Veracruz
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SECUNDINO-LÓPEZ, Mitzi Gabriela, GALICIA-LUIS, Laura and LOZANO-CAMARGO, Maria Luisa
Tecnológico de Estudios Superiores del Oriente del Estado de México
Universidad Autónoma Metropolitana-Iztapalapa

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VILLAGRÁN-VILLEGAS, Luz Yazmín, PATIÑO-ORTIZ, Miguel, HERNÁNDEZ-GÓMEZ, Luis Héctor and PATIÑO-ORTIZ, Julián
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