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Journal of Technological Development

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Presentation of the Content

In Issue 13 is presented an article *Design of a single-acting ammonia-water solar absorption cooling system for food preservation, by* HERNÁNDEZ-GÓMEZ, Víctor Hugo, OLVERA-GARCÍA, Omar, DE LA ROSA-FLORES, Yarabi and SÁNCHEZ-BARRERA, Iveth, with adscription at Universidad Nacional Autónoma de México, in the next article *Design and development of an electronic card of radio control for adapt it to a system of irrigation conventional with activation of radio frequency*, by GONZÁLEZ-GALINDO, Edgar Alfredo, DOMÍNGUEZ-ROMERO, Francisco Javier, BIBIANO-MEJÍA, Isabel and PÉREZ-GARCÍA, Jorge, with adscription at Universidad Nacional Autónoma de México, in the next section *Design, construction and automation of an axial sieve, for use and management in the chemical plants laboratory of the UTSV*, by GONZÁLEZ-TOTO, Jorge, CRUZ-ANTONIO, William, FLORES-NARCIO, Higino and AGUIRRE-GARCIA, María Luisa, with adscription at Universidad Tecnológica del Sureste de Veracruz, in the next section *Design and construction of a prototype for the analysis of vibrations in an induction motor for the detection of faults*, by GARRIDO, Javier, ESCOBEDO-TRUJILLO, Beatris, MARTÍNEZ-RODRÍGUEZ, Guillermo Miguel and SILVA-AGUILAR, Oscar Fernando, with adscription at Universidad Veracruzana.

Content

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Design of a single-acting ammonia-water solar absorption cooling system for food preservation

Diseño de un sistema de refrigeración por absorción solar amoniaco-agua de simple efecto para la conservación de alimentos

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Abstract

The increase in the use of non-renewable energy sources and the strong dependence of the energy sector on these sources, encourage the study of applications that use renewable energy sources. In this scenario, there has been an increase in the number of jobs related to refrigeration systems that use other sources of energy in addition to electricity, such as absorption cooling systems, which can produce a cooling effect using mainly heat. residual or other sources such as solar thermal energy. This article presents the design of a cooling system that will operate with solar energy, using the principle of absorption with the ammonia-water working torque in continuous function, to contribute to a cold production alternative in food preservation.

Absorption cooling, Ammonia-water, Thermal load

Resumen

El creciente aumento en el uso de fuentes de energía no renovables y la fuerte dependencia del sector energético a dichas fuentes, incentivan el estudio de aplicaciones que utilizan fuentes de energía renovables. En ese escenario, se ha observado en los últimos años un aumento en el número de trabajos relacionados con sistemas de refrigeración que utilizan otras fuentes de energía además de la eléctrica como los sistemas de refrigeración por absorción, los cuales pueden producir efecto frigorífico usando principalmente calor residual o de otras fuentes como la energía solar térmica. En el presente artículo se presenta el diseño de un sistema de refrigeración que operará con energía solar, empleando el principio de absorción con el par de trabajo amoníaco-agua en función continua, para contribuir con una alternativa de producción de frio en la conservación de alimentos.

Refrigeración por absorción, Amoniaco-agua, Carga térmica

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Introduction

In recent years, the global elimination of CFC, HCFC and HFC refrigerant gases has been negotiated, due to their potential impact on the degradation of the ozone layer and global warming. However, these substances are essential in current refrigeration systems, being an extremely important process in modern society, as it is essential for the preservation of food, industrial processes and in air conditioning. Faced with this scenario, an increase in the number of jobs related to refrigeration systems that use other sources of energy in addition to electricity, such as absorption refrigeration systems (Pérez, 2014), has been observed in recent years, which can produce refrigeration effect using mainly residual heat or other sources such as solar thermal energy (Ruíz, 2011; Moreno, 2018).

Absorption cooling is presented as an option for refrigeration systems for product preservation purposes, since low temperatures allow the effects of chemical and enzymatic reactions to be slower, and the growth of some bacteria is limited (López, J. 2012). The Ammonia-Water (NH3-H2O) absorption cycle is a technology in extensive development and experience during the early years of the refrigeration industry, particularly for ice making. Likewise, the low to moderate temperatures necessary for its operation and the independence of electrical energy sources, make the absorption cycle a good candidate to be used in conjunction with solar energy (Esquivel, 2006).

In this work, each stage that involves the design of an adsorption cooling system for the NH3-H2O pair is shown and described, which will produce the cooling effect by taking advantage of the thermal energy from the sun and will be used for food preservation.

Absorption is a process in which two fluids that enter different states, such as a gas or liquid, combine to exit in a single state, either as a gas or liquid (Dincer, 2016). The mixtures used in these machines are composed of a solvent and a refrigerant fluid that, at a certain point in the cycle, is absorbed by the solvent (hence the name), and at another point is separated from the solvent.

In order to obtain this result, it is necessary that the solvent, when cold, has an affinity for the refrigerant fluid; when the temperature of the mixture rises, this affinity decreases, releasing the refrigerant fluid from the solvent (Rapin, 1976).

A basic absorption refrigeration system consists of a generator, absorber, condenser, evaporator, pump, and expansion valves. Figure 1 shows the operation of a basic refrigeration system.

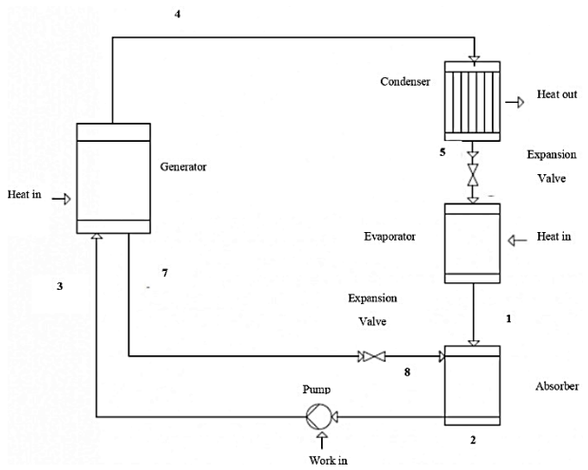

Figure 1 Ciclo de refrigeración por absorción
Source: Modified from Dincer, 2016

In Figure 1 it is observed that, in the evaporator, the saturated refrigerant mixture gains heat from the cooled space and leaves (1) to enter the absorber. The weak solution that returns from the generator passes through an expansion valve where its pressure drops to exit (8) and enter the absorber. The weak solution and the refrigerant mix in the absorbent and reject the heat of the cooling fluid to leave it as a strong solution in liquid form (2). The strong solution exiting the absorber (2), first passes through the pump, where the pressure of the strong solution increases before it enters the generator (3). The heat is supplied to the generator where the strong solution is heated (3) to separate the refrigerant. The vaporized refrigerant leaves the generator (4) and enters the condenser where it rejects the heat to the refrigerant fluid to leave it (5) as a saturated mixture, while the weak solution leaves the generator to enter the absorber (7). The saturated mixture then passes through the expansion valve where its pressure drops suddenly to increase the vapor content in the saturated mixture where it enters the evaporator (6). (Dincer, 2016).

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The selected working pair is a mixture of ammonia in water, the combinations in different proportions still retain their individual characteristics, that is, components of this mixture can be physically separated, without the need to break any chemical bonds (Church & Dwight Co. Inc. ., 2007), and its TEWI value (Total Equivalent Heating Impact) of ammonia is very low, due to its favorable thermodynamic characteristics and that less energy is used than other refrigerants (Sans, 1989; Ruíz, 2011; Miranda, 2012) .

It is also called aqueous ammonia (concentrated aqueous dilution of ammonia), these dilutions can be prepared at different concentrations. The advantage of its use compared to anhydrous ammonia (100% ammonia) is the simplicity of handling and the elimination of most of the dangers that the gaseous form presents (Navarro, 2014).

The absorption system is based on the fact that the vapors of some refrigerants can be absorbed in large quantities by certain liquids. The refrigerant can be separated from the solution resulting from the absorption by heating. Therefore, the absorption cycle replaces the compressor with the generator-absorber assembly and the pump, while the evaporator, the condenser and the expansion valve work in the same way as in the compression cycle.

Background

Progress and work on absorption refrigeration systems in recent years are presented in order to present the progress that has been made:

Francisco et. to the. (2002) developed and tested a prototype of absorption refrigeration using ammonia-water, powered by solar energy to operate in rural areas with a refrigeration capacity of 2 kW (7.2 MJ). This small-scale prototype is designed for continuous operation and the necessary energy is obtained from a parabolic cylindrical collector that reaches temperatures above 150 ° C. Mauricio Canadas. et al (2010), made a design of an absorption refrigerator for educational use, deducing that an absorption cycle operated by solar energy is technically feasible by conventionally modifying the cycle, with regard to operating temperatures, especially in the generator. , with the aim of using flat plate solar collectors as a heat source.

Labus M. J. (2013) developed a prototype of an NH3-H2O absorption heat pump designed to operate with a parabolic solar collector, the inlet temperature of the generator is 90 ºC. Typical COP values for the cooling mode were in the range of 0.58-0.8 and 1.5-1.8 for the heating mode. Due to the minimum temperature reached in the evaporator of 3 ° C, the authors recommended the use of the system for food preservation and for air conditioning.

Catota, P. & Tonato, W. (2015). They designed and implemented a prototype of intermittent ammonia-water absorption solar cooling, in which it was possible to obtain temperatures between 10 - 16 ° C for a short operating time, using an electrical resistance of 120 W that allows Take advantage of the solar energy converted by photovoltaic panels. They determined that the concentration of ammonia in the working solution is the most important factor that must be taken into account, because in a solution poor in ammonia the temperatures required for steam generation are higher to reach the working pressure in the system.

Prototype design

The system was designed using ammonia-water as a working pair in one stage and continuous operation, employing a parabolic trough concentrator with which the thermal energy (solar radiation) necessary to achieve cooling was supplied. The project is being developed at the Cuautitlán School of Higher Studies, field 4, of the National Autonomous University of Mexico.

A load of 22 lb of product was considered, which will enter at a temperature of 77 ° F and decrease until the storage temperature of 32 ° F, estimating an operating period of 8 h.

For the design conditions, the food that provides the highest amount of heat, the highest heat capacity (Cp) and the lowest storage temperature was considered, since in this way it is ensured that the other products will be close to their storage temperature.

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To calculate the heat that must be removed or eliminated from the chamber and thereby maintain the interior design temperature, the method developed by the American Association of Refrigeration, Heating and Air Conditioning Engineers "American Society of Heating, Refrigeration and Air-Conditioning Engineers ", (ASHRAE) based on the conditions in table 1.

Initial conditions Application	Value	Units
Refrigerated zone size	8.4	ft^2
Air volume	1.59	ft^3
Storage quantity	22.04	lb
Chamber temperature	23	°F
Storage temperature	32	°F
Temperature at which the product is	77	°F
Room temperature	77	°F
Temperature difference	77	°F
Working hours (storage)	8	h
Condensing temperature	86	°F

Table 1 Initial design conditions
Source: ASHRAE

Thus, obtaining the total thermal load with the following balance:

$$Q_{evaporator} = Qstructure + QProduct + Qleakages + Qlighting \quad (1)$$

Table 2 summarizes the total load per day and hour of work, in addition, 10% was considered as a safety factor added to the total refrigeration load, to consider the minimum omission or inaccuracy (Dossat, 2002).

Calculation of system flows and heats

For the prototype design, six main components were considered: evaporator, absorber, recirculating pump, rectifier, condenser and expansion valve. Its distribution and conformation is represented in Figure 2.

Loads	Q	Units
Thermal load of the structure	388.643	BTU / day
Thermal load by the product	2350.566	BTU / day
Thermal load due to infiltration	1.347	BTU / day
Charge for lighting	68.243	BTU / day
Sum of loads	2808.799	BTU / day
Q + 10%	3089.678	BTU / day
Q total (Q + 10% / working hours)	386.211	BTU / h
	0.032	TR
	112	W

Table 2 Summary of thermal loads and total load
Source: Own elaboration

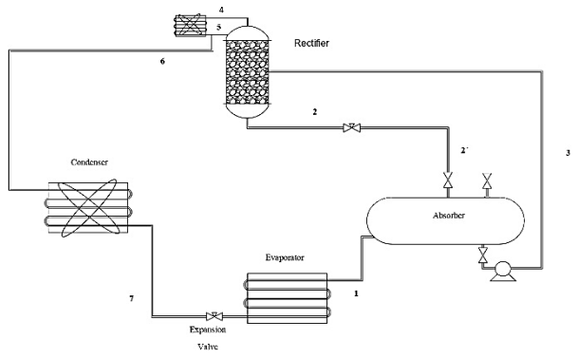

Figure 2 Simple effect ammonia-water absorption cooling system
Source: Own, AutoCAD 2018

Figure 2 represents the proposed design for this refrigeration system, where the process conditions are presented to establish the flows of each component.

Starting from the heat flow equation, the material and energy balances were carried out starting with the evaporator.

$$Q = \dot{m}\Delta h \quad (2)$$

Considering an analysis of the first law of thermodynamics, the mass flows of each component were calculated.

$$Input = Output \quad (3)$$
$$M_7 = M_1$$

Calculating the mass flow in the evaporator:

$$\dot{m} = \frac{Q}{\Delta h} = \frac{Q}{(h_1 - h_7)} \, lb/_h \quad (4)$$

To determine the mass flows that are not known, the mass balances were carried out in the different components according to the design conditions (Figure 2).

Balance in absorber

$$M_1 + M_{2'} = M_3 \quad (5)$$

By fractions:

$$M_1 X_1 + M_{2'} X_{2'} = M_3 X_3 \quad (6)$$

$$M_3 = \frac{M_1 X_1 - M_1 X_{2'}}{(X_3 - X_{2'})} \quad (7)$$

$$M_{2"} = M_3 - M_1 \quad (8)$$

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It is further considered that:

$$M_{2'} = M_2 \quad (9)$$

Balance in Condenser

$$M_6 = M_7 \quad (10)$$

$$\text{Y } M_7 = M_1 \quad (11)$$

Balance in the Generator-Rectifier

$$M_3 + M_5 = M_2 + M_4 \quad (12)$$

For M_5, a reflux ratio of 0.341 is considered, therefore:

$$M_5 = 0.341 * M_6 \quad (13)$$

Therefore:

$$M_{4=}M_5 + M_2 \quad (14)$$

To carry out the energy balance, it was necessary to determine the enthalpies of each point of the system, using the enthalpy-concentration diagram of the ammonia-water mixture originally presented by Merkel and Bosnjakovic, which allows direct reading of the enthalpy difference.

It includes in its lower part, isobar and isotherm networks, as well as liquid vapor equilibrium curves in equal concentrations. In the upper part, the reference curves allow to establish the characteristics of the vapor phase, starting from a certain equilibrium point in the lower part (Kherris, S., 2013). To determine the enthalpy, we enter with the concentrations obtained from the mass balance on the "x" axis, we enter with a vertical line up to the pressure at which it is being evaluated and finally with a horizontal line up to the "y" axis where the enthalpy can be read, this can be seen in Figure 3.

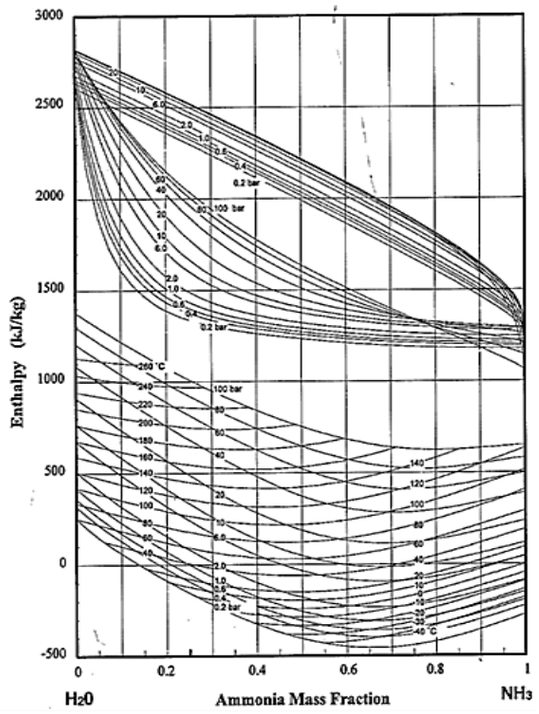

Figure 3 Enthalpy-concentration diagram of the ammonia-water mixture
Source: Herold, 1996

Table 3 presents the results of the balances.

Component	m (lb/h)	Fraction	Value	Q (BTU/h)
M1 (Evaporator)	0.761	$X_{1(NH3)}$	0.987	386.2098
		$X_{1(H2O)}$	0.013	
M2 (Return to absorber)	1.142	$X_{2(NH3)}$	0.259	1302.8723
		$X_{2(H2O)}$	0.741	
M3 (Power)	1.904	$X_{3(NH3)}$	0.55	---
		$X_{3(H2O)}$	0.45	
M4 (Distilled)	1.021	$X_{4(NH3)}$	0.987	1141.4688
		$X_{4(H2O)}$	0.013	
M5 (Reflux)	0.260	$X_{5(NH3)}$	0.987	---
		$X_{5(H2O)}$	0.013	
M6 = M7 (Capacitor)	0.761	$X_{6(NH3)}$	0.987	333.8320
		$X_{6(H2O)}$	0.013	

Table 3 Results of the balance of matter and energy
Source: Own elaboration

Design of the components of the absorption system

From the material and energy balances carried out, the transfer area was calculated to determine the dimensions, finally the designs for the evaporator, condenser, absorber and rectifier were proposed, which are described below.

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Evaporator

Features:

Length: 98.75ft

Pipe Diameter: 3/8 ", 3003 Flexible Aluminum.

Pressure: 3.64 bar.

Cold Chamber: 19.69 x 11.81 x 14.22 i

Interior: 22 gauge aluminum foil.

Insulator: 6.3 in. Expanded polystyrene.

Figure 4 shows the evaporator.

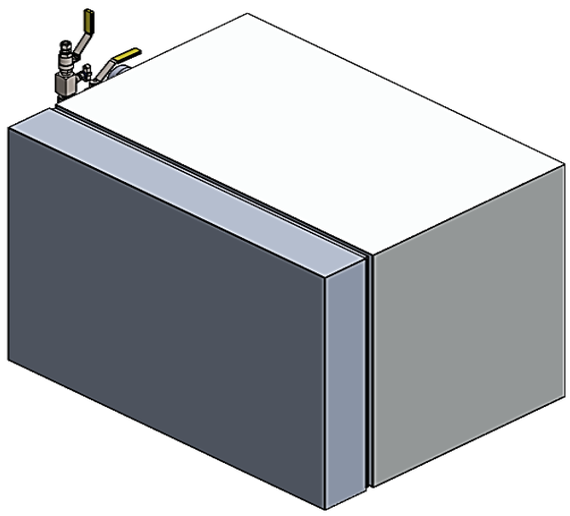

Figure 4. Evaporator proposal
Source: Own source, SolidWorks 2017

Condenser

Features:
Length: 4,265 ft.
Tubing: 3/8 ", 316 stainless steel.
Fins: Aluminum.
Pressure: 11.67 bar.
Figure 5 shows the capacitor.

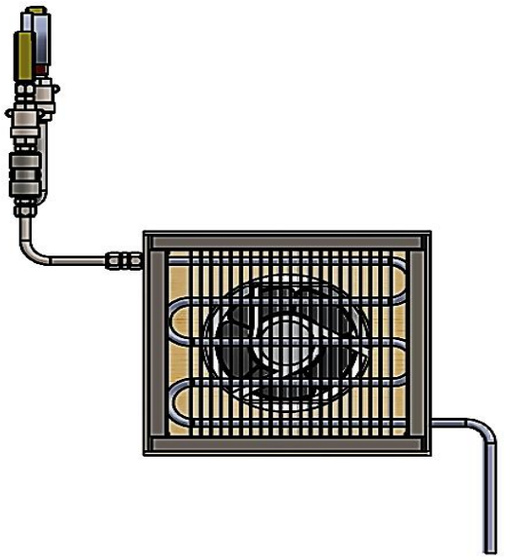

Figure 5 Condenser proposal
Source: Own source, SolidWorks 2017

Absorber

Features:
vtotal + 20%: 0.37 ft^3 / day.
Length: 1.067ft.
Body: 304 stainless steel, 9 in.
Pressure: 3.64 bar.
Mixing volume (NH3-H2O): 0.309 ft3 / day.
Accessory: 304 stainless steel sprinkler, ¼ in
The absorber is shown in Figure 6.

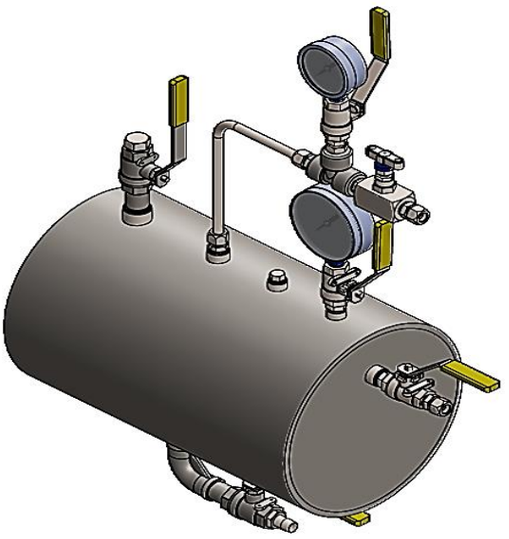

Figure 6 Absorber proposal
Source: Own source, SolidWorks 2017

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Rectifier

Features:
Body: 316 stainless steel, 4 in.
Pot: 3/8 in, 316 stainless steel.
Length: 1.6404 ft.
Condenser: 3/8 ", 316 stainless steel.
Pressure: 11.67 bar.
Packaging: glass.
Stages: 1 and a boiler.
Figure 7 shows the rectifier.

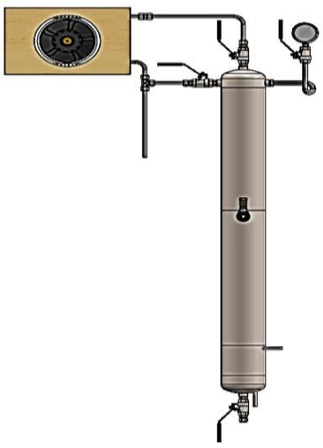

Figure 7 Rectifier proposal
Source: Own source, SolidWorks 2017

To drive the saturated mixture from the absorber to the rectification tower, a centrifugal pump for corrosive liquids brand Little Giant, model 1-MD of 1/70 HP and RPM 2450-2250 is used.

Instrumentation

The distribution of each connection and instrument is shown in Figure 8 and the specifications in a summarized way are shown in Table 4.

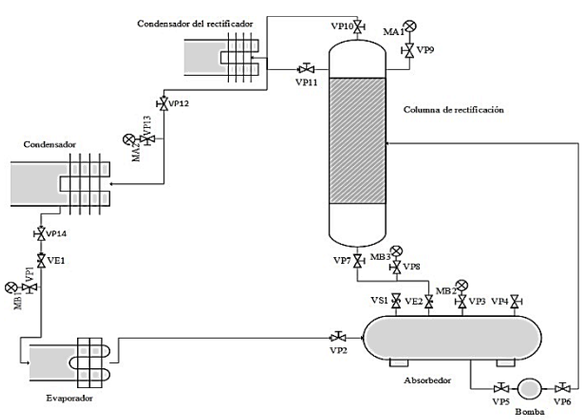

Figure 8 Connection and instrumentation of the prototype
Source: Own source. Microsoft Visio, 2019

Code	Name	Quantity	Specs
VP	Gate valve	13	Connection: 3/8 and ¼ in Material: Stainless steel, 316 Pressure: 1000 WOG
VE	Expansion valve	2	Connection: 3/8 in Material: Stainless Steel, 316 Pressure: 6000 PSI Pressure Range: -30 inHg to 150 PSI
MA	High pressure gauge	2	Connection: ¼ in Material: 316 Stainless Steel Pressure Range: -30 inHg to 300 PSI
MB	Low pressure gauge	3	Connection: ¼ in Material: 316 stainless steel

Table 4 Specifications of the connections and instrumentation of the prototype
Source: Own elaboration

Advance

The prototype design is in place and is currently under construction. After that, hydrostatic tests will be carried out on components such as the absorber and rectifier to determine whether or not they present leaks. Finally, each component of the system will be assembled using pipes and the necessary connections, with this, the designed prototype will finally be obtained, which will once again be carried out the same test to identify leaks within the entire system before starting it up.

Once it is ensured that the prototype does not have leaks, the equipment will be tested, for which, enough refrigerant (Ammonia) has already been purchased to start it up. During these tests, the temperature inside the cold chamber is monitored during the 8 hours of operation for which it was designed and the temperature of the water vapor that will feed the rectifier (boiler). With these results, the thermal history will be obtained that will allow us to determine what are the operating conditions under which the system can operate so that it is suitable for preserving food.

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It is expected that with the results obtained from this project, it will be possible to have a functional alternative of an environmentally-friendly refrigeration system, which uses solar energy that works with a natural refrigerant that does not generate any environmental impact, but that it considers in the future be totally independent of electrical energy consumption.

Acknowledgment

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Conclusions

Absorption systems are technology that boomed again in recent years because it can work by taking advantage of residual energy and mainly solar energy. These systems, unlike compression equipment, require less maintenance, lower energy consumption, lower noise generation, but above all they have less environmental impact. The prototype was designed to be used in the conservation of food at a temperature of 32º F which is considered to use the materials with which they are available in the research laboratory in renewable energies and has the characteristic of being fed with different sources of heat. It will not limit its operation since it is independent of any solar energy collection equipment.

It is intended to be part of the transition in the refrigeration industry towards the use of clean energy and natural refrigerants.

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Design and development of an electronic card of radio control for adapt it to a system of irrigation conventional with activation of radio frequency

Diseño y desarrollo de una tarjeta de radiocontrol para adaptarlo a un sistema de riego convencional con activación de radiofrecuencia

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Abstract

A radio control card was designed and developed to adapt to a conventional irrigation system with radio frequency activation for the State of Puebla, Mexico. In the design of the double-layer printed circuit board, the modules of decode of dual tone multi frequency and two of record and playing of audio were employed. The control functions were carried out with a microcontroller, the power stage was adapted using two triodes of alternating current to activate two contactors, in addition, three relays were placed; the first has the function of regulating the temperature, the second activates the radio transmitter and the third turns on the lighting in the cabinet, temperature control is carried out through a sensor. An electronic radio control card was obtained with the ability to connect to a radio transmitter to activate and deactivate loads of high demand for electrical energy at a distance of 2 linear km, allowing to reduce the times in the irrigation system and to confirm the audio messages on the mobile radio, the card is low cost compared to the market and its operation is simple.

Radio frequency, Irrigation system, Radio control

Resumen

Se diseñó y se desarrolló una tarjeta de radiocontrol para adaptarse a un sistema de riego convencional con activación de radiofrecuencia para el Estado de Puebla, México. En el diseño de la tarjeta de circuito impreso de doble capa, se emplearon los módulos de decodificación de doble tono multi-frecuencia y dos de grabación y reproducción de audio. Las funciones de control se llevaron a cabo con un microcontrolador, se adaptó la etapa de potencia utilizando dos triodos de corriente alterna para activar dos contactores, además se colocaron tres relevadores; el primero tiene la función de regular la temperatura, el segundo activa al radiotransmisor y el tercero enciende la iluminación en el gabinete, el control de temperatura se lleva a cabo a través de un sensor. Se obtuvo una tarjeta electrónica de radiocontrol con la capacidad de conectarse a un radiotransmisor para activar y desactivar cargas de alta demanda de energía eléctrica a una distancia de 2 Km lineales, permitiendo reducir los tiempos en el sistema de riego y confirmar los mensajes de audio en el radio móvil, la tarjeta es de bajo costo en comparación al mercado y su operación es simple.

Radiofrecuencia, Sistema de riego, Radiocontrol

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Introduction

Technological advancement has allowed the economic development of countries since an advance in the development of science began, but today more than ever the global situation of confinements due to severe acute respiratory syndrome (SARS CoV2 for its acronym in English) , and the disease it causes is called COVID-19. It is essential not to neglect the crops. This is why the use and implementation of electronic communication and radio frequency cards can control sprinkler irrigation systems remotely, to have control without the user being present and in this way there is no shortage in crop production. agricultural.

The municipality of Libres is located in the north-central part of the State of Puebla, an approximate distance from the City of Puebla of 165 km, the approximate number of inhabitants is 11,283. The name of the municipality comes from the Nahua roots that signify "big land". It has an area of 275.48 square km. Topographically they are perfectly defined in two zones; the east of the municipality is a plain, and the west presents a quite mountainous relief.

The municipality does not have important surface currents; however, a large number of streams originate in the mountain complexes. The municipality has a temperate semi-dry climate with rains in summer and little throughout the year. Its main economic activity is commerce and agriculture (H. Ayuntamiento de Libres, 2014).

In the State of Puebla, there are two systems of agricultural production; 1) the irrigation infrastructure with filtering galleries, irrigation channels, ditches or ditches to take advantage of the rainwater from the ravines, springs and other minor works, and 2) the temporary mountain range is production from the orchards where they cultivate the following seeds: Beans, wheat, capulín (seed), broad bean, corn, pochote and pine nut. The condiments that are generally harvested in the State of Puebla are: Epazote, peppermint, holy leaf, parsley, thyme, avocado leaf, bay leaf and oregano.

The production of fruits are the following: Chirimilla, guaje, apricot, sugar apple, polochocos, capulín, mamey sapote, mango, guava, white sapote, apple, pomegranate, tejocote, chico sapote, pear, quince, banana, chayote, black sapote, Granadilla, pitaya, fig, cuajilote, xoconostle, pitahaya, avocado, tamarind, tomato, yellow sapote, tilapo, guaje, peach, coyol, halaches, chupandilla, jiotilla, mesquite (pod), pitaya, guaje and nopal-tuna (Granados Sánchez, 2004). In other regions such as the northern highlands of Puebla, coffee plantations are the main harvest, these plantations incorporate various trees for shade. Producers have applied novel techniques such as the development of organic production systems, making them sites with potential for the development of new crops that can contribute to the economy of the region (Martínez et al., 2007). The State of Puebla is characterized by the cultivation of chili peppers due to its cultural-gastronomic tradition such as: The 'Poblano chile' or 'Mulato' for being a basic ingredient of traditional dishes such as "mole poblano" and "chiles en nogada" (Rodríguez *et al*., 2007). It is also characterized by being a region of fertile soil for the harvest of corn on the cob, the genetic diversity in Latin America is 50 races and in Mexico there are only 12 of them that are equivalent to 23% and 77% of diversity is present in the rest of America (Gil-Muñoz *et al*., 2004).

Irrigation provides crops with essential water for their growth and development. The implementation in irrigation systems through automatic control programming ensures optimal water supply (Espinosa *et al*., 2011).

Irrigation is defined as the artificial application of water to the ground in order to supply plant species with the moisture necessary for their development (Orson W. Israelsen, 1952). The forms of irrigation are Irrigation by laying or by flooding, Irrigation by platforms or borders, Irrigation by Furrows, Irrigation by sprinkling, Drip irrigation and Irrigation by Microjet (Quispe Tapara, 2018). At the global level, agricultural food production activity requires; among many aspects, the supply of basic resources such as water and constant electricity.

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The growth of the harvest will depend on the obtaining and distribution of resources, in some developing countries the supply of electrical energy to the cultivation areas is not profitable for the electricity supply companies, for these cases, technified irrigation can be implemented where diesel-based electric power generators are used, or some renewable energy such as wind or photovoltaic energy (Moreno Flor García, & col, 2013). Currently, electronic circuits, microcontrollers and development cards have been used to incorporate them into technified irrigation systems. In addition to using sensors that are a type of transducer that are responsible for transforming an analog electrical signal at the input, they generally convert physical variables to an electrical signal at the output that can be voltage or current, their purpose is to obtain the parameters in real time of measurements, by using sensors capable of measuring (reacting) to pH, soil moisture sensors, temperature sensors, solar radiation sensors and anemometers as variables of interest. Once the signal has been acquired through the sensors, the actuators are devices that transform an electrical signal at the input into another type of signal or amplitude (electrical, pneumatic, hydraulic, etc.) capable of modifying or altering the conditions of the crop.

The actuators receive the control order through the microcontroller and gives a necessary output (Cruz J., 2009). Systems have been developed with the implementation of remote activation, as in the region of Murcia a Spanish community, it is characterized by being dry and arid, it makes the development of efficient agriculture complicated, due to this problem they have implemented data acquisition and control systems through Modbus communication using ArduPLC for measurement and control, is a device that comes from the family of Arduino development boards that foresees its implementation in agricultural technology systems in the future, using "internet" as a means of communication so that the The user has control of the wireless transmission in real time of the remote system, using the LabView program as a graphic interface, so that the end user can use it intuitively (Belmonte Martínez, 2020).

The development boards mainly Nanoarduino, Arduino, Arduino Mega, Galileo Intel and Launchpad TI, have been incorporated in the control and automation systems as well as in the process for the treatment of seeds that the farmers carry out, for example in the maceration and germination in the treatment of barley, to avoid loss of seeds (Herrera Jiménez *et al*., 2020).

Water is the fundamental element for the development of agricultural activity, agriculture consumes more than 70 percent of the water available at the level. In Mexico 77% is used, with 6.3 million ha. under irrigation with global efficiencies less than 50%. Irrigation is the best option for food production Despite its enormous importance, poor distribution and contamination make this resource more scarce and expensive every day (Servín Palestina, 2017).

In this work an electronic radio frequency control card is presented as a prototype to integrate it into a sprinkler irrigation system using a microcontroller to operate it by radio control using a radio station that allows remote devices to be activated such as: the electric pump, displacement motor linear, lamps, fan and contactors. Its placement for the start-up located in the municipality of the city of Libres in the State of Puebla, to carry out the cultivation of potatoes, broccoli, radishes and carrots.

Hypothesis

The severe acute respiratory syndrome has generated a new way of human interaction. If you have an electronic radio control card that adapts to a conventional irrigation system with radio frequency activation that allows remote on / off, then there will be no need for staff to move, avoiding contact with other people to the place operation, for activating the actuators connected to the pumping system that allows the passage of the water flow.

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Objectives

Develop a radio control card to adapt it to a conventional irrigation system with radio frequency activation, efficiently using the start-up of a sprinkler irrigation system, activated by a radio station with a range of 2 km, taking advantage of the use correct electricity and natural resource such as water, for the benefit of the environment, and avoiding contact with other people during the transfer in this syndicate confinement generated by SARS CoV2.

Methodology

In this work for the development of the electronic card, three modules were integrated into the system, one of them is a DTMF decoder and two are for audio recording and reproduction that allow two-way Half Duplex communication and are capable of activating / deactivating connected peripherals. to the ATMEGA328P-PU microcontroller through remote commands from a Motorola EP450 mobile radio, it also sends audible on / off alarms indicating the status of the system. A Motorola EM200 brand radio station was attached, the model LAM50QNC9AA1AN specifies the frequency range of 403-440MHz with a power level of 25W, UHF, 4 channels with the ability to program burst sending adapted to an RF connection and Mini UHF, there are two models with UHF ranges of 438-470 MHz and 465-495MHz, in addition a Motorola EP450 brand mobile radio was used with a frequency range: 438-470 MHz and consumes 4W with 64 channels, in addition It has a maximum range of 5 km, using two Brand contactors: Siemens model 3RH1122-1AK60 with four internal relays and a 10A coil; 2-NO 2-NC, 120 / 110V 60 / 50Hz.

The DTMF technique represents 16 alphanumeric characters of the phone (0-9, AD, *, #), see Table 1. The signal generated by the DTMF encoder is the algebraic sum, in real time, of the amplitudes of two sinusoidal waveforms of different frequencies as represented in Equation (1).

$$x(t)=A\sin(\omega_L t) + B\sin(\omega_H t+\varphi) \quad (1)$$

where ω_L and ω_H correspond to the low and high frequency$\omega = 2\pi f$), A and B are the amplitude of the signals and φ is the initial phase shift (Artal et al., n.d.).

Frequency	1209Hz	1336Hz	1477Hz	1633Hz
697Hz	1	2	3	A
770 Hz	4	5	6	B
852 Hz	7	8	9	C
941 Hz	*	0	#	D

Table 1. *Set of frequencies applied by DTMF*.

Figure 1 shows the schematic circuit of the electronic card used for the sprinkler irrigation system, in this image the different connections of the peripheral devices that are coupled to the microcontroller that allow remote operation can be observed.

Power activation devices are had; relays and TRIACs. The ISD1820 audio recording and playback modules, coupled to an LM386 audio amplifier that controls the gain of the signal to be transmitted to the radio station so that the audio signal is not saturated, in addition to the MT8870 DTMF decoding module, finally , the DS18B20 sensor for sensing the system temperature.

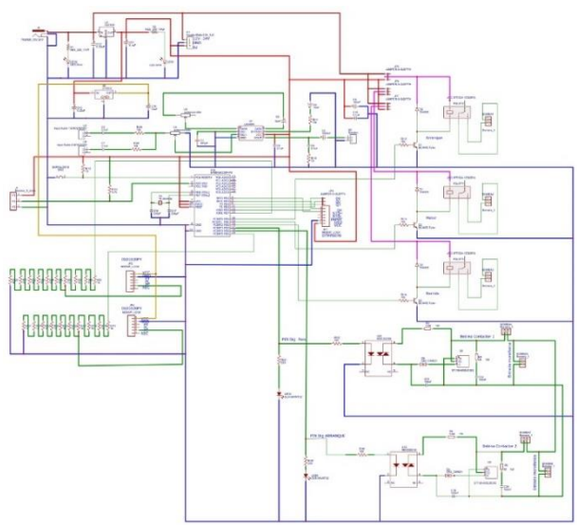

Figure 1 Schematic circuit corresponding to the electronic board

The connections in the prototype of the schematic circuit designed for assembly using a protoboard as shown in Figure 2, allows to visualize and detect errors in the connections and, to join each section of the circuit to be able to have the total system working.

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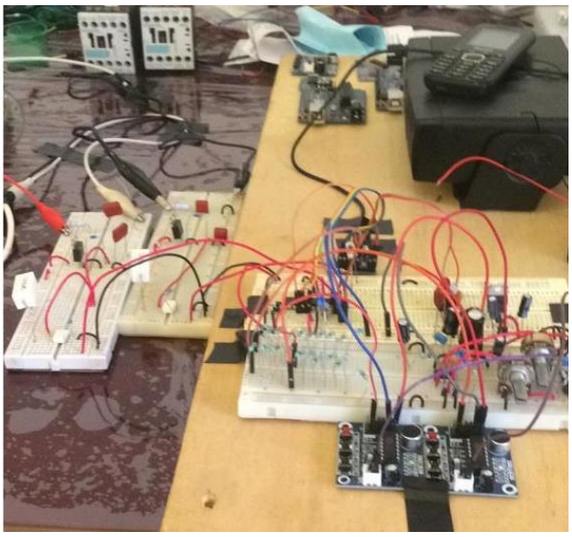

Figure 2 Mounting of electronic components and modules on the system breadboard

The PCB (for its acronym in English Printed Circuit Board) (E-Alfredo, & col., 2019) designed double layer corresponding to the electronic card used in the sprinkler irrigation system in Figure 3, a microcontroller is shown as the main programmable control device, which waits for the output of the DTMF decoder to start the different routines depending on the byte of characters sent by the EP450 mobile radio.

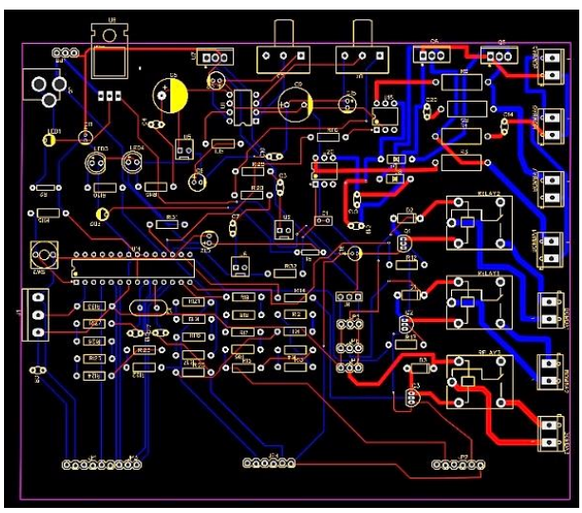

Figure 3 Design of the PCB prototype corresponding to the electronic circuit board for the irrigation system
Source: (Part, 2018).

The design of the electronic card in its first version for the sprinkler irrigation system shown in Figure 4 is connected to the Motorola radio station, where you can see the power devices connected to activate the on / off operation of high voltage loads, that is, the 10A SIEMENS brand contactors to operate the pump that acts as the main pumping device, the contactors being connected as a self-interlocking system, this allows that when the contactor is instantly activated, the entire high power system.

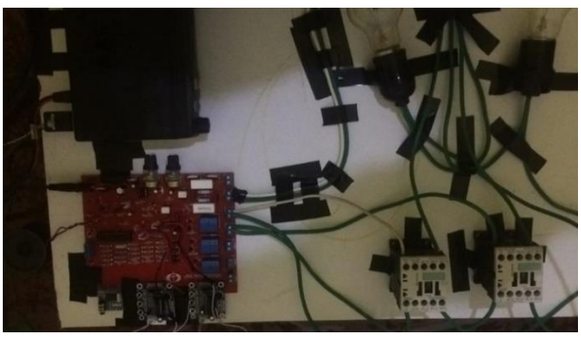

Figure 4 Experimental setup using the electronic card designed for the sprinkler irrigation system

The electronic card finished with the electronic elements and the DTMF and audio recording and reproduction modules that are coupled to the radio station to observe the operation as shown in Figure 5.

Figure 5 Modules incorporated into the electronic card connected to the radio station for transmission with Motorola EP450 equipment

Program for the control of the irrigation system in the ATMEGA328P-PU microcontroller, the declaration of the character arrangements assigned for the password and for the data received in the radio we use the following instructions (Arduino_Genuino, 2017):

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char master_Irrigation_Open_0[Password_Lenght]= “Contraseña”
char master_Irrigation_Close_0[Password_Lenght]= “Contraseña”, es char Data[Password_Lenght]

```
#define Password_Lenght 4
#include <DallasTemperature.h>
#include <OneWire.h>
byte data_count = 0;
byte master_count = 0;
volatile bool toneLoc = false;
const byte pinDatosDQ = 0;
float temperatura = 0;
OneWire oneWireObjeto(pinDatosDQ);
DallasTemperature
sensorDS18B20(&oneWireObjeto);
void setup() {
  sensorDS18B20.begin();
  pinMode(2,INPUT);  //StQ (Interrupt for
data available)
  pinMode(3,INPUT);  // Q4
  pinMode(4,INPUT);  //Q3
  pinMode(5,INPUT);  //Q2
  pinMode(6,INPUT);  //Q1
  pinMode(7,OUTPUT); //speaker
  pinMode(13,OUTPUT); //speaker
  pinMode(10,OUTPUT); //Relay
  pinMode(11,OUTPUT); //Relay
  pinMode(12,OUTPUT); //Relay
  pinMode(8,OUTPUT); //Relay
  pinMode(9,OUTPUT); //Relay
  attachInterrupt(digitalPinToInterrupt(2)
, newDTMF, RISING);
  sensorDS18B20.requestTemperatures();
  delay(500);
  temperatura =
sensorDS18B20.getTempCByIndex(0);
    if (temperatura >= 30 )
      {
      digitalWrite(8, HIGH);
      }
    else if(temperatura < 25)
      {
      digitalWrite(8, LOW);
      }
}
void loop() {
  if(toneLoc == true){
    char keySymbol;
    bool Q1 = digitalRead(6);
    bool Q2 = digitalRead(5);
    bool Q3 = digitalRead(4);
    bool Q4 = digitalRead(3);
byte toneData = (0x00 | Q1 | (Q2 << 1) |
(Q3 << 2) | (Q4 << 3));
    keySymbol = dtmf_decode(toneData);
    if(keySymbol){
      Data[data_count] = keySymbol;
      data_count++;
    }
    if(data_count == Password_Lenght-1){
if(!strcmp(Data,Master_Irrigation_Open_0))
{
      digitalWrite(8, HIGH);
      digitalWrite(11, HIGH);
      digitalWrite(9,HIGH);
      digitalWrite(13,HIGH);
      digitalWrite(13,LOW);
      delay(2500);
      digitalWrite(9,LOW);
sensorDS18B20.requestTemperatures();
      delay(500);
      temperatura =
sensorDS18B20.getTempCByIndex(0);
          if (temperatura >= 6 )
           {
            digitalWrite(8, HIGH);
           }
             else if(temperatura <5)
          {
            digitalWrite(8, LOW);
          }
     }
       else
if(!strcmp(Data,Master_Irrigation_Close_0)
){
     digitalWrite(8, HIGH);
     digitalWrite(11, LOW);
     digitalWrite(9,HIGH);
     digitalWrite(7,HIGH);
     digitalWrite(7,LOW);
     delay(2500);
     digitalWrite(9,LOW);



     sensorDS18B20.requestTemperatures();
     delay(500);
     temperatura =
sensorDS18B20.getTempCByIndex(0);
     if (temperatura >= 30 )
          {
          digitalWrite(8, HIGH);
          delay(10000);
          digitalWrite(8, LOW);
          }

          else if(temperatura < 25)
         {
           digitalWrite(8, LOW);
         }
     }
     else
if(!strcmp(Data,Master_Irrigation_Open_1))
{
     digitalWrite(8, HIGH);
     digitalWrite(12, HIGH);
     digitalWrite(9,HIGH);
     digitalWrite(13,HIGH);
     digitalWrite(13,LOW);
     delay(2500);
     digitalWrite(9,LOW);
    sensorDS18B20.requestTemperatures();
     delay(500);
     temperatura =
sensorDS18B20.getTempCByIndex(0);
     if (temperatura >= 6 )
          {
           digitalWrite(8, HIGH);
          }

          else if(temperatura < 5)
         {
           digitalWrite(8, LOW);
         }
     }
     else
if(!strcmp(Data,Master_Irrigation_Close_1)
){
     digitalWrite(8, HIGH);
     digitalWrite(12, LOW);
     digitalWrite(9,HIGH);
     digitalWrite(7,HIGH);
     digitalWrite(7,LOW);
     delay(2500);
     digitalWrite(9,LOW);
sensorDS18B20.requestTemperatures();
     delay(500);
     temperatura =
sensorDS18B20.getTempCByIndex(0);
     if (temperatura >= 30 )
```

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```
          {
          digitalWrite(8, HIGH);
          delay(10000);
          digitalWrite(8, LOW);
          }
     else if(temperatura < 25)
         {
           digitalWrite(8, LOW);
         }
     }
     clearData();
    }
    toneLoc = false;
  }
}
void clearData(){
  while(data_count != 0){
    Data[data_count--] = 0;
  }
  return;
}
void newDTMF(){
  toneLoc = true;
}
char dtmf_decode(byte recv_data){
  switch(recv_data){
    case  1: return '1';
    case  2: return '2';
    case  3: return '3';
    case  4: return '4';
    case  5: return '5';
    case  6: return '6';
    case  7: return '7';
    case  8: return '8';
    case  9: return '9';
    case  10: return '0';
    case  11: return '*';
    case  12: return '#';
    case  13: return 'A';
    case  14: return 'B';
    case  15: return 'C';
    case  0: return 'D';
    default : return '?';
  }
}
```

Results

The development of the electronic system has the ability to control and measure the operation of a sprinkler irrigation system, continuous use operation tests were carried out lasting 56 hours a week, with a transmission range between 0.1 and 2 linear kilometers. maintaining control of the system without any interference, ensuring the proper operation of the contactors, which allow the rational use of water and electrical energy, a fundamental part so that there is no waste, being a strategic point for crop production, due to Since a percentage greater than 50% is assigned to the consumption of water used in the irrigation of crops, the use of technology in this region is of great importance, since due to the confinement during the next months production will be reduced food.

Therefore, it is of great importance to use these electronic cards for remote irrigation systems without affecting production in the agricultural sector that influences the region's economy.

The secondary section of the pipe where pressurized water is released through the sprinklers to generate artificial rain with the ability to cover the surface of the irrigation land as shown in Figure 6, through the electronic card that controls the radio control system can activate and deactivate artificial rain and in this way the amount of water supplied to the crop is administered.

Figure 6 Bypass of secondary piping to the sprinklers operated with the use of the electronic card

The sprinklers and their connection to the main pipeline are embedded in a concrete slab to supply the flow of water as seen in Figure 7, in addition to the electrical panel to obtain the electrical energy necessary to operate the actuators to move the sprinklers. across the surface of the farmland.

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Figure 7 Structure of main pipe for water supply with control board

The stopcock that allows the water flow to be directed towards the sprinklers is shown in Figure 8 this turns on / off through the relays controlled by the microcontroller, selecting the surface that will be sprayed by the sprinklers.

Figure 8 Main pipe and stopcock

Conclusions

An electronic card was designed and developed to adapt it to a radio control system and have the ability to control a remote sprinkler irrigation system in the Municipality of Libres, Puebla, Mexico, in order to face the situation that is occurring in Mexico and in worldwide, confinement due to severe acute respiratory syndrome (SARS CoV2).

The electronic card was left working daily, 56 hours a week continuously showing the operator having control of the effective water supply for the crop and executing the control instructions that make the irrigation system work correctly. The transmission and sending of the passwords by DTMF to the microcontroller, performs a correct response to execute the control routines and obtaining an auditory response on the Motorola EP450 mobile radio. This radio control system can activate and deactivate more than 2 linear kilometers from the receiver without any problem for the main pump actuators to carry out the water supply. This electronic card, compared to some existing on the market, reduces its cost up to three times, allowing farmers to incorporate technified irrigation systems, reducing the consumption of water and electricity, resulting in an economic retribution in production.

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Design, construction and automation of an axial sieve, for use and management in the chemical plants laboratory of the UTSV

Diseño, construcción y automatización de un tamizador axial, para el uso y manejo en el laboratorio de plantas químicas de la UTSV

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Abstract

Objectives. The present project allows an axial sieve to be put into operation, whose purpose is to determine the efficiency in the grinding of solids, in the screening of particles of different sizes from Tyler sieves, whose purpose is to characterize solid raw materials, by dry method, applied to chemical engineering. Methodologic. This research work describes the design of the physical structure as a design based on a CAD environment, computer-aided design, as well as the electronic design and programming that is carried out to configure the time sequence that must be developed in the horizontal linear motion sieve, which is defined as a prototype that is functional to screen and characterize solid raw materials. Contribution. Acquiring a sieve for technical use is very expensive, its movements are shaky and noisy, in addition its control systems do not allow the user to modify variables such as time, that is why it is decided to innovate and start up an axial sieve from a mechanical system, with speed and timing control which will allow the user to regulate said variables in relation to the material to be sieved. With C + programming tools, use of LABVIEW software, ARDUINO. Uniting two areas, Chemical and Mechatronic engineering, of the UTSV

Engineering, Processes, Prototypes

Resumen

Objetivos. El presente proyecto permite poner en operación un tamizador axial, cuyo propósito es determinar la eficiencia en la molienda de sólidos, en el cribado de partículas de diferentes tamaños a partir de tamices Tyler, cuyo propósito es caracterizar materias primas sólidas, por vía seca, aplicados a la ingeniería química. Metodología. El presente trabajo de investigación describe el diseño de la estructura física como un diseño basado en un entorno de CAD diseño asistido por computadora, así como el diseño electrónico y la programación que se lleva acabo para configurar la secuencia de tiempo que se debe de desarrollar en el tamizador de movimiento lineal horizontal, el cual se define como un prototipo que es funcional para cribar y caracterizar materias primas solidas. Contribución. Adquirir un tamizador de uso técnico es muy costoso, sus movimientos con trepitatorio y ruidosos, además sus sistemas de control no permiten al usuario modificar variables como el tiempo, es por ello, que se decide innovar y poner en marcha un tamizador axial a partir de un sistema mecánico, con control de velocidad y de temporizado el cual permitirá al usuario regular dichas variables en relación con el material a tamizar. Con las herramientas de programación en C+, el uso del software LABVIEW, ARDUINO. Uniendo dos áreas, la ingeniería Química y Mecatrónica, de la UTSV.

Ingeniería, Procesos, Prototipos

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Introduction

This research work describes the design of the physical structure as a design based on a CAD environment, computer-aided design, as well as the electronic design and programming that is carried out to configure the time sequence that must be developed in the horizontal linear motion sieve, which is defined as a prototype that is functional to screen and characterize the particle diameters.

It is important because it allows to characterize solids and calculate the efficiency of the grinding of raw materials

It is a functional prototype, it is not expensive, its movements are not trepidant and noisy, like those in common use, its control system allows the user to modify variables such as time, adjust it according to their needs.

Description of the design and construction method of the prototype

Design and construction of the prototype

In the first instance, the decision is made to design the prototype in the SolidWorks program, the construction and commissioning of the sieve, for this, we base ourselves on the already existing structure of a commercial team and in this way propose the design of the same.

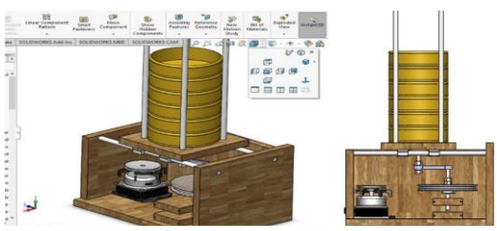

Figure 1 SolidWorks Illustration of the Sifter
Source: (Chryssis, G. C, 1989)

The design is made where a space is left, for the installation of a touch screen for them, wood is used for convenience, costs and according to the 7 "Nextion HMI LCD touch screen model and a switch that would be placed for power on and off it.

Figure 2 strainer housing
Source: (Chryssis, G. C,1989)

A gear reduction train with pinion is installed that fits and seals the entire mechanical system, inside a wooden base, with the electronic circuitry, from a switched Source with enough force to be able to activate the motor and the circuit.

It was decided to use a direct current motor, with physical characteristics such as: similar speed to the alternating current motor, good torque to support the loads during the tests, as well as greater control in power setting and greater stability during the operation of the same.

The idea of using a gear reduction train is presented, which allows a reduction in motor speed and further increasing the torque force, to make the change from rotary to linear movement, a modification is made to the shaft in such a way that allow the gear base to fit with the shaft base in order to make the full movement of the mechanism (Mohan, 2003).

In the main gear, a reduction train is located, this consideration was taken at the time of making the design, so the gear box is easy to disassemble.

Figure 3 Mechanic system
Source*: (own elaboration,2020)*

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When observing that the motor together with the mechanism complied with the required specifications as indicated in Figure 3, the electronic stage begins which consists of the motor control, it is carried out by means of programming in ARDUINO, proceeds in the part electronics according to (Borbor & lapo, 2013).

When consulting Moreno (2001), we took on the task of making a diagram in PROTEUS for the development of the PCB that will be mounted two ARDUINOS nano, which will be communicated in series, an ARDUINO will have the function of performing all the ignition actions of the motor and the other ARDUINO will carry the actions that the touch screen will have which will be mounted on the structure of the sieve.

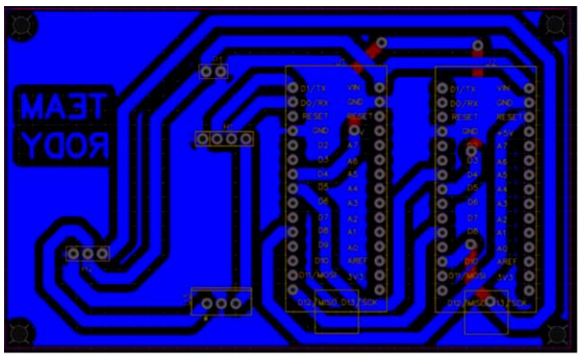

Figure 4 Connection plate
Source: *(Pazmiño Piedra, J. P., & Quintuña Padilla, W. P, 2004)*

a) With the development of the PCB, it continues with the elaboration of it in a physical way to carry out the physical assembly, once assembled, the testing stage begins which is governed by two fundamental parts:

b) The test of the operation of the board is activated without any load, that is, only by activating a relay that is what gives us the guideline towards the power stage of the same, it is carried out several times to verify that it works correctly.

c) Once recognizing that the requested signal is correct, the circuit is assembled to the prototype, to work in conjunction with the power stage and engine ignition, when testing only the engine is turned on forcing the start of the circuit, this is done with a 5v pulse to input port to drive mechanism.

d) Subsequently, the power stage starts the control and electronic circuit, an adaptation will be made in the Source, so that the relay acts as a switch to turn on the power, for this a 5v Source is taken which feeds the entire circuit.

The 5v Source is taken as positive and is connected to the relay and the negative is connected to the direct current motor, at the other end of the motor it is connected to the relay, in order to close the power circuit, which will be start and stop the motor.

Once the control and the power stage have been developed, we proceed to make the assembly of the touch screen, which will be mounted on the structure shown in Figure, which must be adjusted to the board by placing a frame, as well as placing the switch of on / off on the right side of the screen (Billings, 1989).

Figure 5 Shield connection to connector module
Source: (Own elaboration, 2020)

To connect to the switch power supply, one of the two wires of the switched Source cable that goes to the power outlet is cut with the idea of passing that wire through the switch and making the interruption, to have an on and off the sieve directly.

The screen is connected directly to the ARDUINO to give it the power it requires, as on the board there is a circuit for protection in case of a short, not to damage the screen, it is connected to the ARDUINO to turn on the screen

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Figure 6 In-dash touch screen installation
Source: (own elaboration,2020)

Analysis of the method and programming of the prototype

Programming the start control and touch screen of the Axial sieve

According to Pazmiño Piedra, J. P., & Quintuña Padilla, W. P, (2004). It is necessary for the programming to be handled with two different codes, due to the fact that it handles two ARDUINOS that work together, one for the control and the other for the visualization that will be shown on the touch screen, with the following algorithms:

Algorithm designed as a second operating module function for sieve control.

Configuration for second serial port.

```
#include <softwareSerial.h> // Library declaration for serial port
softwareSerial SerialN2 (4,5); // Declaration of transmit and receive pins
Configuration of pins and variables to occupy.

int led = 13; // Indicator pin declaration
int relay = 10; // Output pin declaration
int data = 0; // Declaration of time variable
int output = 8; // Pin declaration for output data, process finished
```

The program initialization function is executed

```
void setud () {// the program start function is executed
serialN2.begin (9600); // the transmission speed of the second serial port is declared
serialN2.begin (9600); // the transmission speed of the first serial port is declared
pinMode (led, output); // the indicator is set as output
pinMode (relay, output); // set the data to control as output
pinMode (output, output); // the confirmation data is set as output
digitalwrite (output, low); // start commit as 0
digitalwrite (relay, low); // start the output data as 0
```

Execution of the reset subroutine and the ARDUINO restarts

```
void (* resetFunc) (void) = 0 // the reset subroutine is executed and the ARDUINO is restarted
// ---
void timer () {// the time subroutine starts
if (data> 0) {// A statement of the data obtained by the second serial port is declared, if it is greater than 0 the following is executed:
while (1) {// a loop is executed that will be based on the data statement
serial. println | string (data) |; // send the data on the 1st. serial port
fact--
digitalwrite (led, HIGH); // the indicator that the sieve is already operating is activated
digitalwrite (relay, HIGH); // the relay is activated to start the sieving
delay (1000);

if (data <= - 1) {// If the value of the data is = 1 0 <-1, the following is executed
data = 0; // the data value remains at 0

digitalwrite (led, LOW); // The indicator turns off as a sign that the process has finished
digitalwrite (relay, LOW); // The relay turns off

digitalwrite (output, HIGH); // The confirmation pin is activated
delay (200); // a delay of 200 milliseconds is set
digitalwrite (output, LOW); // Confirmation Pink turns off
resetFunc (); // command to execute the reset subroutine to reset the ARDUINO}}}}
```

The serial data is configured as the delay for the response delay.

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```
void loop () {// the main function is executed
data = serialN2.parseINT (); // the information obtained by the second serial port is recorded in the data variable
delay (700); // a delay of 700 milliseconds is executed
timer (); // the subroutine of the time for the start of the process is executed.
}
```

With this programming, the operation and operation of the same is started as indicated in Figure 7.

Figure 7 Axial type sieve
Source: (own elaboration,2020)

Methodology to be developed

Technical characteristics and operation of the sieve

In this section the methodology to be developed for the construction and automation of the axial sieve is mentioned.

The user can program the prototype at 5, 10, 15 up to 60 min of operation, according to the needs of the process.

The equipment can operate up to 60 min with a
20 min rest, to avoid engine overheating.

According to Téllez (2018), he mentions that lubrication of the mechanical system is necessary for a better displacement, in the same way in the horizontal rods and to work with solids by dry means.

Tyler sieves must be cleaned after each laboratory practice.

With the design, construction and automation of this prototype it will allow the realization of solid particle characterizations from laboratory practices, of the subjects related to the chemical engineering career.

In table 1, table 2 and graph 1, the efficiency and operation time of the Axial sieve are observed.

% mechanical system efficiencies		
Weeks	**Desired state**	**Estimated status**
1	100	100
2	100	99
3	100	85
4	100	82
5	100	80
6	100	80
7	100	78
8	100	75

Table 1 Minutes of Axial Sieve Operation
Source: (Own elaboration, 2020)

We proceed to measure and carry out the time operation tests of the sieve.

Operating time table in min		
Scheduled time	**Real time**	**Minutes of operation**
5	5	5
8	8	10
15	15	15
20	20	20
22	10	25
25	25	30
30	30	35
35	35	40

Table 2 Minutes of Axial Sieve Operation
Source: (Own elaboration, 2020)

From the data in Table 2, we obtain the behavior of the sifter in real time.

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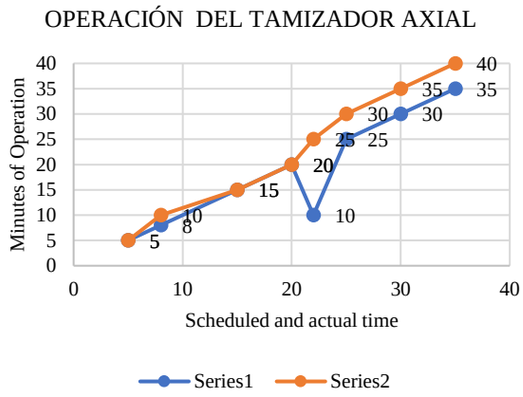
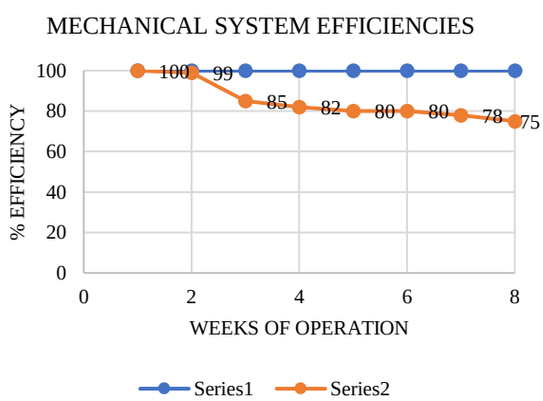


Graphic 1 Sieve operation
Source: (Own elaboration, 2020)

This graph indicates the continuous working time that the sieve must have and the rest that the motor should have to work optimally.

The period through which preventive maintenance must be carried out, the gear system, which is why it must be operated at a time of 60 min, maximum, with a rest of 20 min. The sieve is functional according to Table 2 and graph 1, preventive maintenance is necessary every 8 weeks of operation, that is, every 2 months. It should be noted that it depends on the use and handling that it is given, in the same way it is necessary that after 50 hours of work it is preferable to lubricate the gear system and the horizontal rods. For optimal team performance.

From the data in Table 1, we obtain the efficiency of the mechanical system.



Graphic 2 Sifter efficiencies
Source: (Own elaboration, 2020)

This efficiency is reducible to 75% in an operation time of 8 weeks. That is, in 2 months, preventive maintenance is preferable

Results

According to Retsch (2012), laboratory tests were developed. Next, the results obtained from the particle distribution of marble stone in a 60-minute grinding operation are indicated. Where the weight of sample A, fraction A and% Retained A, represents the raw material before being crushed and / or ground by a ball mill and the weight of sample B, fraction B and% Retained B, represents the finished and sieved product, by this prototype, of this research work (Perry, 2012)

Next, it is indicated in Table 3. The laboratory analysis of the distribution of the grinding and sieving particle of the marble stone and in graph 3, the graphic interpretation is observed, obtaining an efficiency of 69.76% of grinding, as a product in the 200 mesh specification given by the client, or according to the need in the process, using a ball mill and an axial sieve, designed by UTSV labor.

No. Of Mesh	D (in)	D (mm)	Mesh weight (gr)	Sample weight (gr) A	Sample weight (gr) B	Fraction A	Fraction B	% Retained A	% Retained B
4	0.18	4.76	465	698	0	0.70	0.00	69.8	0.00
8	0.09	2.38	449	271	0	0.27	0.00	27.1	0.00
10	0.06	1.68	463	21.8	8.6	0.02	0.01	2.18	0.96
50	0.01	0.29	362	3.6	10.8	0.00	0.01	0.36	1.21
60	0.09	0.25	380	2	40.2	0.00	0.05	0.20	4.52
80	0.007	0.17	379	1.5	209	0.00	0.24	0.15	23.5
200	0.002	0.07	347	0.9	621	0.00	0.70	0.09	69.7
TRA			400	999	891	1	1	0	0

Table 3 Particle distribution of raw material and product
Source: (Own elaboration, 2020)

On the Table. 3. The main product is presented in mesh No. 200, obtaining an efficiency of 70% according to Graphic 3, from the grinding of marble stone, it is decided on this raw material, due to its availability and hardness 3 on the Mosh scale, this being a specification of the prototype design, according to Smith (1998), of the ball mill design of the UTSV chemical plants laboratory. The Graphic indicates that it is preferable to carry out other runs in the grinding to increase the efficiency in the grinding of the solid, in the case of this test we worked with 1 Kg of sample.

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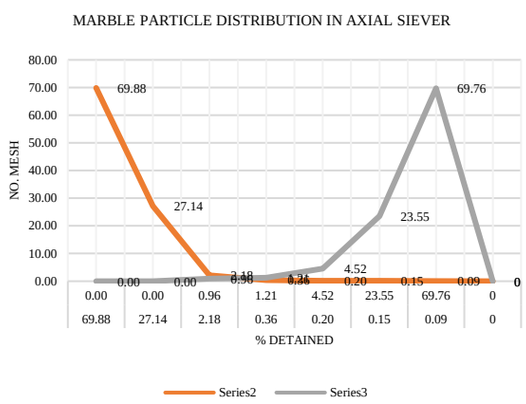

Graphic 3 Marble distribution in Axial sieve
Source: (Own elaboration, 2020)

Annexes

Annexed. To

1. Lock screen

To start working with the equipment, an interface is displayed on the screen, to operate it.

1. Slide the middle button to the right to unlock and enter the main page

2. If you press the image located in the lower right, it will give access to another screen where the credits will be displayed

2. Main screen

The boot instructions are placed as follows:

1. Select the time to set

2. After setting the time, it must be accepted by pressing the button at the top right of the screen.

3. If the lower right button is pressed, the system will lock again

3. Run screen

1. In the sieving analysis, the remaining time, set time and motor speed will be observed (By having the appropriate speed it will always be at 100%)

2. 1. You will enter this section when the set time has been confirmed.

3. 2. The section will be visible until the time reaches zero or the exit button located at the bottom right is pressed.

Observations

1. After operating the sieve system for more than one hour, allow 20 minutes for the engine not to overheat

2. Press the buttons well, since being a capacitive screen it will not respond correctly if it is not used properly.

Suggestions

1. Maintain the mechanical system, once a year

2. If there is excessive noise from the sieve, locate the source of the noise:

A) If it is the motor, stop using the sieve for 1 hour

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B) If it is the mechanical system, disassemble the screen and lubricate all the parts

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Conclusions

The project in general, is functional for the purposes for which it was created, however, it can have continuous improvement, to have higher performance in terms of the pretreatment of solid raw materials, not only for the University laboratories, even for the Chemical industry, it is advisable to improve the time per material, in order to obtain a specific pattern which can help you when looking for a granulometric analysis.

As we now know there are improvements and innovations in control, which are coming to the market in the field of technology that provides instruments, which help us in our daily or specific activities, that is why we seek to make the grinding process more efficient and sieving, from its automated control, with a low economic cost for the purposes and specifications by which it was designed.

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Design and construction of a prototype for the analysis of vibrations in an induction motor for the detection of faults

Diseño y construcción de un prototipo para el análisis de vibraciones en un motor de inducción para la detección de fallas

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Abstract

The contribution of this work is to present the design of a prototype integrated by an induction motor, a data acquisition system, accelerometers and control devices for stop and start, to generate and identify different types of faults by means of vibration analysis. in the domain: time, frequency or frequency-time, through the use of the Fourier Transform, Fast Fourier Transform or Wavelet Transforms (wavelet transform). In this prototype, failures can be generated in the induction motor such as: unbalance, different types of misalignment, mechanical looseness, and electrical failures such as broken bars or short-circuited rings, an example of a misalignment failure is presented to show the process of analysis and detection.

Motor, Vibrations, Faults to motor

Resumen

La contribución de este trabajo es presentar el diseño de un prototipo integrado por un motor de inducción, un sistema de adquisición de datos, acelerómetros y dispositivos de control para el paro y arranque, para generar e identificar diferentes tipos de fallas mediante el análisis de vibraciones en el dominio: del tiempo, de la frecuencia o frecuencia-tiempo, mediante el uso de la transformada de Fourier, Transformada rápida de Fourier o la transformadas de onduletas (transformada wavelet). En este prototipo se pueden generar fallas en el motor de inducción como: desbalance, diferentes tipos de desalineamiento, soltura mecánica, y fallas eléctricas como barras rotas o anillos en corto circuito, se presenta un ejemplo de una falla de desalineamiento para mostrar el proceso de análisis y detección.

Motor, Vibraciones, Fallas en motores

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Introduction

Electric motors demand 45% of electricity consumption worldwide, activating pumps, fans, compressors and mechanical traction in industrial facilities, infrastructure plants and large buildings (Motor Summit, 2014). Motors that work under normal operating conditions suffer wear and tear and over time they come to present failures that can lead to: unscheduled stoppages in production, environmental problems or safety problems that could cause deaths. To prevent these problems, solutions such as corrective, preventive and predictive maintenance arise.

Motors generally do not fail instantaneously, the failure occurs gradually, that is, different characteristics of a healthy engine begin to be noticed.These characteristics are: vibrations, heat and noise, if after a while the failure is not attended to, it can cause that the computer stops. One of the strategies to detect when a failure is initiating is preventive maintenance.

Predictive maintenance offers the advantage of detecting a failure, there are different types of analysis that can be carried out in predictive maintenance such as: Vibration analysis, oil analysis, temperature monitoring, etc., the most used in industries are monitoring from vibrations to rotating equipment. Mechanical vibration is the harmonic movement of a machine, or element of it, in any direction of space from its position of equilibrium. (Moreno-García, Becerra-Vargas, & Rendón-Echeverri, 2015). In motor, vibration can be generated by:

- Degradation due to exceeding the useful life of the motor.
- Failures in the mechanical part: failure in the bearings, misalignment of the rotor shaft.
- Worn or damaged gears.
- Stator Failures: Open circuits or short circuits in the stator windings.
- Human errors when performing poor engine maintenance.
- Severe work environments (dust, humidity, water).

Prototypes for vibration analysis have been developed by Zhaoxia et al. (2009) where applying an analysis with the Wavelet Transform, synchronously comparing signals in the time and frequency domain. The work presented by (Hua. 2011), performs a design for the acquisition of data and processing of mechanical vibration signals using LabVIEW software. The presented prototype has the advantage of being able to do different tests at different load values, and apart from being able to do a vibration analysis, an analysis of current signatures can be done.

The main objective of this work is to present the design of a prototype for the analysis of vibrations in induction motors where different types of failures can be detected using techniques in the time domain, frequency or frequency-time and the severity of this This prototype was developed in the laboratory of the Faculty of Engineering of the Universidad Veracruzana, Coatzacoalcos campus.

This work is organized as described below. In section 2 motor failures are presented and because they can be detected using vibration analysis, in section 3 the programming of the data acquisition system is explained, in section 4 the prototype for vibration analysis and the results when simulating a misalignment fault in a motor, the last section contains the conclusions.

Induction motor failures

The question Why do engines fail? To answer the previous question, the main causes can be listed:

- Components in engines degrade over time and stress from the length of time they are in operation.
- Electrical insulators degrade over time due to imbalances in voltage, humidity, and temperature within the motor.
- Contact between moving surfaces causes wear, wear is affected by dirt, moisture, corrosive vapors, and wear is accelerated by lack of lubrication.
- Apply a mechanical overload to the motor.

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The types of failures in a motor are classified as: Mechanical and Electrical, to detect this type of failure it is necessary to know that by design and construction the motors have an electrical and mechanical symmetry for the coupling of the stator and the rotor. Vibration monitoring is based on detecting faults in this symmetry which produces changes in normal engine operations such as:

- Vibrations.
- Increase in temperature.
- Variations in torque.
- Acoustic noise.
- Speed variations.

These changes have to be identified by a pattern in order to detect the type of failure and the severity of the failure. These patterns can be in frequency, duration, amplitude and phase shift. The most common engine failures in the industry are:

- Degradation due to exceeding the useful life of the motor.
- Failures in the mechanical part.

Failures are usually related to the environment or work cycle and occur during some transitory process, which is when the mechanical and electrical stresses to which it is subjected are greater (Cabanas, 1998).

Failures can be measured based on the factors that cause them: bearing failures account for 40%, related stator failures equal 38%, rotor related failures 10%, and other failures are within than 12% of engine failures (Toliyat, Nandi, Choi, & Meshgin-Kelk)

Cryo programming

The data acquisition system consists of a Compact Rio (CRio) system, which is programmed through LabVIEW software, the CRio controller is programmed in the Real time and FPGA interface, depending on the sampling frequency is the mode of programming, if the sampling frequency is greater than 1 kHz, it is programmed in FPGA mode, Before programming the CRio, the first step is to create a project within which the cards installed in the controller are organized as shown in Figure 1.

FPGA Interface Programming

In Figure 2, the FPGA interface programming is shown, this program stores the measurements of three sensors which were mounted on the motor to measure mechanical vibrations, the program creates a vector of n readings and stores the data in a memory FIFO, the memory size depends on the sample time and sample rate, the stored data is sent to the Host interface.

Host interface programming.

The Host interface program is shown in Fig. 3, this program receives the data from the FIFO memory of the FPGA program, which is plotted in the time domain, for the vibration analysis the Transform tool is used. Fourier (TF), which graphs the aromonics of the vibration signal, finally the data is stored in TDMS format, to be able to analyze it in Excel or Matlab.

The stored data can be analyzed using the Fast Fourier Transform or the Waveform Transform, using Matlab software to analyze other types of faults.

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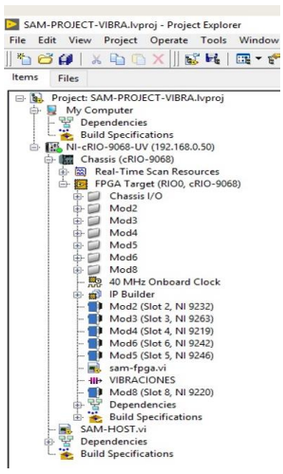

Figure 1 Compac Rio Project

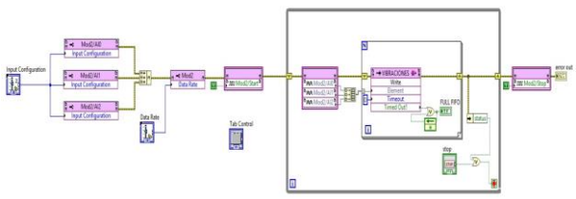

Figure 1 FPGA programming

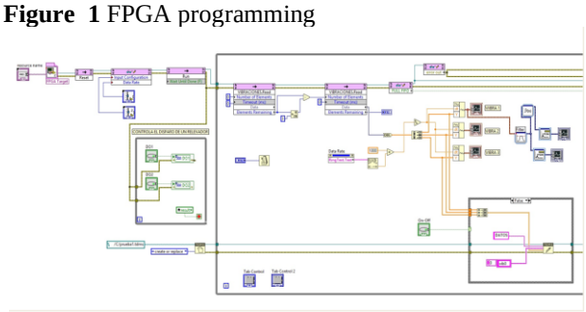

Figure 2 Host programming

In Fig. 4, the Human-Machine Interface (HMI) of the vibration monitoring system is shown.

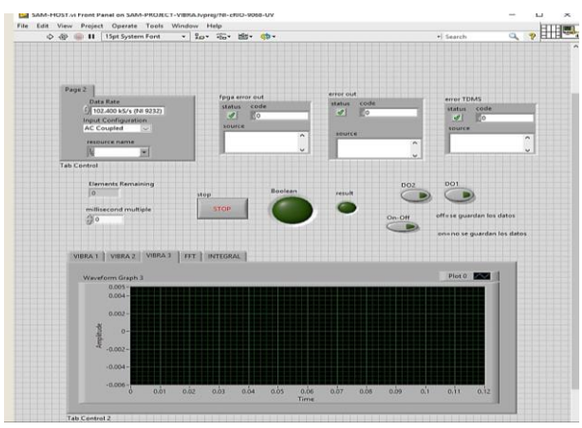

Figure 4 HMI for vibration analysis

Platform for vibration analysis

The prototype architecture is shown in Figure 5, where you can see the CRio data acquisition system, the accelerometer type sensors, the control module for turning the engine on or off and the HMI to monitor vibrations. The data of the equipment to be used is shown in Table 1.

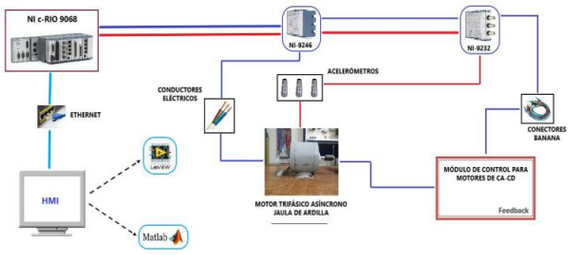

Figure 5 Prototype architecture to measure vibrations

In Fig. 6 the induction motor coupled to a prony brake is shown, with which different load levels can be generated and the changes in the amplitude of mechanical vibrations can be analyzed.

Figure 6 Induction motor and prony brake

To perform the vibration analysis, the sensors were installed in three positions: Axial, Radial, Tangential and Axial, Axial is the direction that is parallel to the arrow, Radial is the direction that goes from the sensor to the center of the arrow and Tangential is 90 degrees from the radial and tangent to the arrow as shown in Fig 8

In Fig. 7, the module of the feedbak brand Contactor Panel 65 -123 is shown, which is used to control the stop and start manually or remotely through the HMI.

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Figure 7 Feedback control modules

Results

Different types of failures can be generated in the prototype, for this work only an angular misalignment failure of the shaft is presented as an example, which generates vibrations, noise, temperature increase and premature damage to the bearings, depending on the severity of the failure is the magnitude of the previous variables.

Equipment	Description
Induction motor	Brand: Labvolt, 4 Poles, 60 Hz, ¼ hp, 1670rpm, 208V, 1.2 A, 3 phases.
CRIO-9068	Brand: National Instrument, 667 MHz Dual-Core CPU, 512 MB DRAM, 1 GB, Zynq-7020.
NI-9232	Brand: National Instrument, 3 AI, ± 30 V, 24 Bit, 102.4 kS / s / ch Simultaneous.
NI-9375	Brand: National Instrument, 16 DI / 16 DO, 30 VDC, 7 µs DI sink, 500 µs, DO Source.
Power supply 60-105	Brand: Feedback, Power Source, 0-220 Vac.
Panel Contactor 65-123	Brand: Feedback, 3 24 Vac power control for contacts
Accelerometers	Brand: IMI, 2-Pin Accelerometers, 100mV / g, ICP® (IEPE), 15kHz.

Table 1 Equipment characteristics

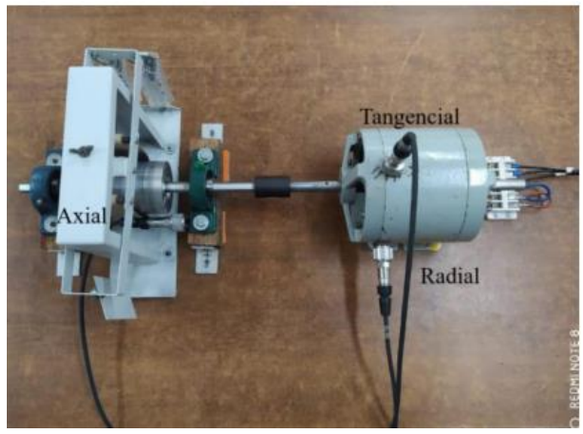

Figure 8 Vibration sensors

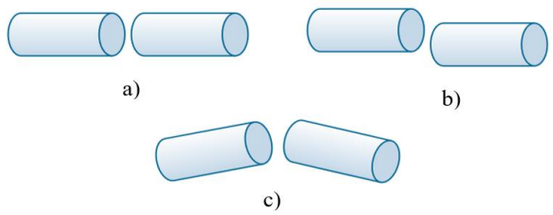

Figure 9 Types of misalignment A) ideal, b) parallel c) angular (Luedeking)

Shaft misalignment failure (angular), characterized by high axial vibration 180 ° out of phase through the coupling will typically have an axial vibration of 1xRPM (abbreviated as 1x) where RPM is the revolutions per minute and 2x. However, it is not unusual for both 1x, 2x, or 3x to dominate in frequency domain analysis. Different types of motor shaft misalignment are shown in Fig. 9

The first step to perform the vibration analysis is to observe the signal in the time domain and in the frequency domain, but the conditions of the place must be taken into account, such as the base where the equipment is mounted and the force with the screws are tight, because these conditions cause abnormal vibration conditions.

To check the misalignment, the healthy motor is compared against the faulty motor, so the vibrations of the healthy motor are measured as shown in Fig. 11, to determine the frequency of the harmonics the nominal motor speed is used (1800 RPM) and are converted to cycles per second (cps) so that 1x = 30 cps, 2x = 60 cps and 3x = 90. In Fig. 12 the motor with misalignment is shown in which it can be observed that the 1x harmonics and 2x, and 3x are those that dominate the spectrum so it can be verified that there is a misalignment problem.

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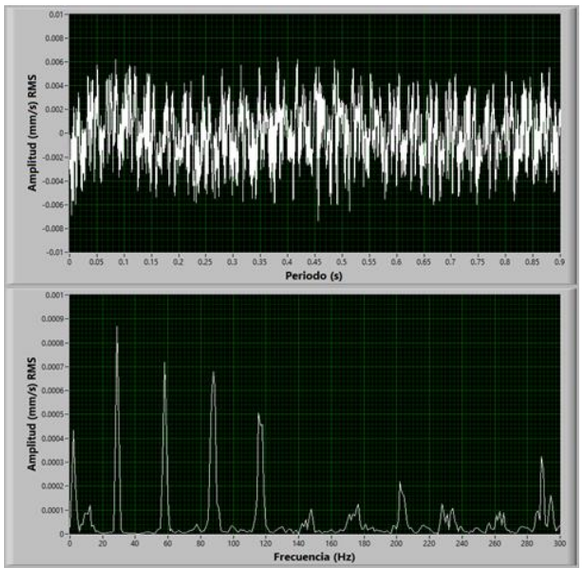

Figure 11 Frequency and time domain speed spectrum of radial accelerometer (healthy motor)

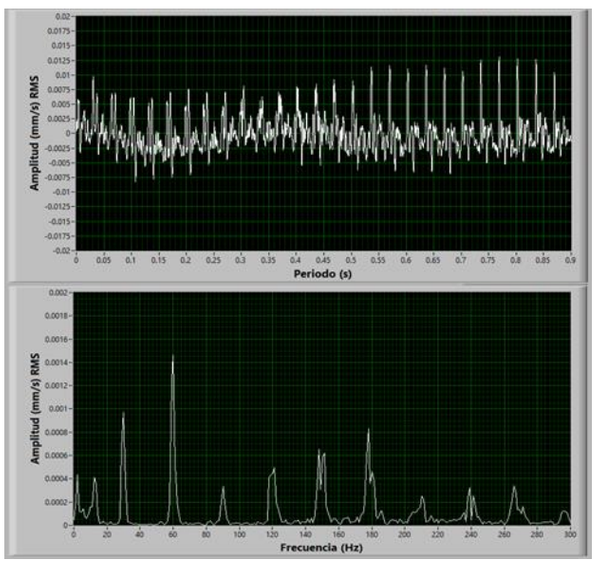

Figure 12 Axial accelerometer frequency and time domain velocity spectrum (misaligned motor)

Table 2 compares the peaks of the 1x, 2x and 3x harmonics of the healthy motor and the motor with misalignment.

Motor without fault		
Sensor position	Rotor frequency (Hz)	Amplitude (mm / s) RMS
Axial	28.18	$0.975x10^{-3}$
	56.36	$1.45x10^{-3}$
	84.54	$0.35x10^{-3}$
Misaligned motor		
Sensor position	Rotor frequency (Hz)	Amplitude (mm / s) RMS
Axial	28.18	$0.88x10^{-3}$
	56.36	$0.72x10^{-3}$
	84.54	$0.68x10^{-3}$

Table 2 Comparative table of motor harmonics

From Table 2, the absolute difference in percentage of the 1x, 2x and 3x harmonics of the healthy motor and the faulty motor is calculated, remaining as:

- The 1X axial harmonic (28.18 Hz) presents a difference of 9.74%.
- The 2X axial harmonic (56.36 Hz) presents a difference of 50.34%.
- The axial harmonic 3X (84.54 Hz) presents a difference of 94.28%.

Conclusions

The monitoring of rotating equipment is of utmost importance within industries and mechanical vibration analysis is one of the most important techniques used.

In this work, a prototype was designed and built to perform vibration analysis tests in which the Fourier transform was used to detect different types of faults, in this work only this technique is shown but the prototype is open to use other tools of analysis as current signatures.

In this work, an angular unbalance fault was generated in the motor, which could be detected using the LabVIEW software in real time.

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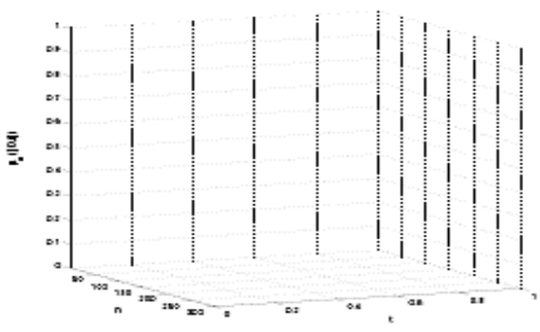

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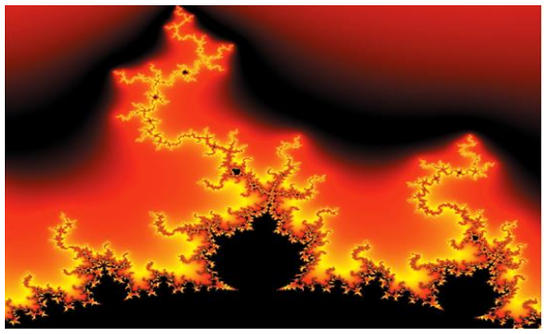

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