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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

GONZÁLEZ-TOTO, Jorge†*, CRUZ-ANTONIO, William, FLORES-NARCIO, Higino and AGUIRRE-GARCIA, María Luisa

Universidad Tecnológica del Sureste de Veracruz, Mexico.

ID 1st Author: *Jorge, González-Toto* / **ORC ID:** 0000-0002-2960-4831, **Researcher ID Thomson:** F-8045-2019, **CVU CONACYT ID:** 947343

ID 1st Co-author: *William, Cruz-Antonio* / **ORC ID:** 0000-0001-9578-6891, **Researcher ID Thomson:** F-7391-2019, **CVU CONACYT ID:** 543122

ID 2nd Co-author: *Higino, Flores-Narcio* / **Researcher ID Thomson:** G-7410-2019, **arXiv Author ID:** OLD3AQ-JFYYGQ

ID 3rd Co-author: *María Luisa, Aguirre-García*

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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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* Correspondence to the author (Email: jorge.gonzalez@utsv.edu.mx).
† Researcher contributing as first author.

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.

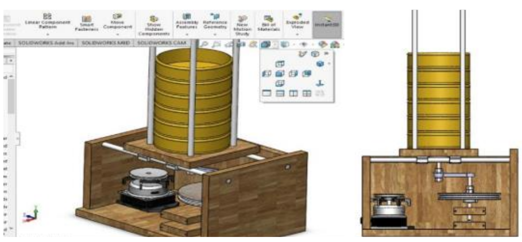

Figure 1 SolidWorks Illustration of the Sifter
Source: (Chryssis, G. C, 1989)

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.

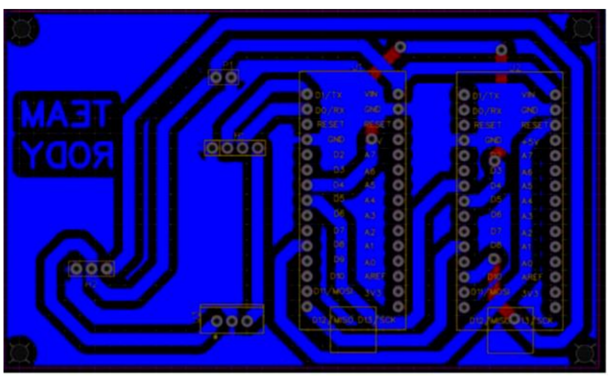


Figure 4 Connection plate
Source: *(Pazmiño Piedra, J. P., & Quintuña Padilla, W. P, 2004)*

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

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.

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

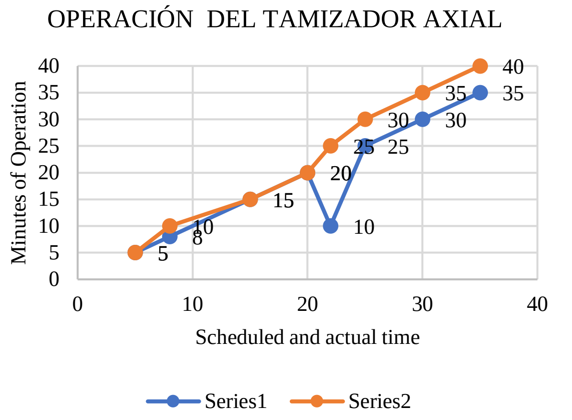
Table 1 Minutes of Axial Sieve Operation
Source: (Own elaboration, 2020)

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.

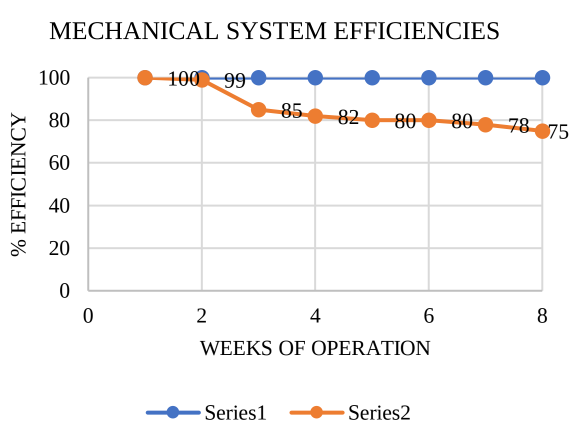


Graphic 1 Sieve operation
Source: (Own elaboration, 2020)

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

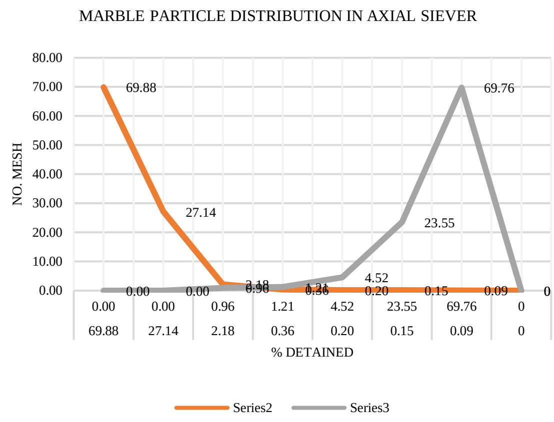
According to Retsch (2012), laboratory tests were developed. Next, the results obtained from the particle distribution of marble stone in a 60-minute grinding operation are indicated. Where the weight of sample A, fraction A and% Retained A, represents the raw material before being crushed and / or ground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



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

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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