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AUTOMATION MACHINE DOSING AND PACKING YOGURT BRAND THIMONNIER EN LA INDUSTRIA LECHERA CARCHI S.A

TECHNICAL REPORT

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"AUTOMATION MACHINE DOSING AND PACKING YOGURT BRAND THIMONNIER EN LA INDUSTRIA LECHERA CARCHI S.A "

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Abstract. This study is the description of machine automation dosing and packing yogurt brand Thimonnier, carried out in order to increase the efficiency of the machine, to improve the production and quality of the process, solving existing problems, the biggest of them an obsolete control system.

The objective of this work is to modernize the machine to increase the production of yogurt covers in the company.

The main work was the design and implementation of the new control system, using the PLC range low brand Siemens that controls all outputs used for the operation of the dispenser, such as pistons, valves, sensors, date. The production capacity is 23 bags of 100ml of yogurt per minute.

1. INTRODUCTION

La Industria Lechera Carchi S.A. is dedicated to the production of dairy products such as milk, cream, milk, yogurt, cheeses, delicacies, etc. Therefore it uses machines to different processes starting in the pasteurization of milk and ending in the packaging and preservation of the product. Dosing machine brand Thimonnier type 04-0 USR of French, is responsible for dispensing yogurt and pack it in bags of 100 ml, in a home machine used a mechanical system which included with a cam shaft which they triggering to the different microswitch and thus obtain the sequence of the machine process. Due to the deterioration of mechanical parts machine was losing efficiency, obtaining the following problems:

- Cam shaft unbalance
- Desynchronization of the filling, sealing, and packaged by wear of the cams
- Absence of controls for manipulation of certain parameters, such as the current control in the niquelinas, changing the time of dosing, JAWS activation control.
- Slow, whose production is 10 bags per minute
- Lack of a reviser in the machine for printing the date on the cover.

2. DESCRIPTION OF THE PROCESS

The machine is composed of several parts that are responsible for correctly completing the process of dosing and packaging, these are: a tree of camshaft, microswitch, pneumatic cylinders, electric motor, gearbox and jaws.

2.1. DOSAGE

For filling of yogurt in the sleeves have a dispenser by gravity, a hopper located in the upper part of the machine sends the yogurt down for their respective

packaging; a mechanism closes the passage of the yoghurt depending on the position of the cam that is. In Figure 1 you can see that hopper and cam mechanism.

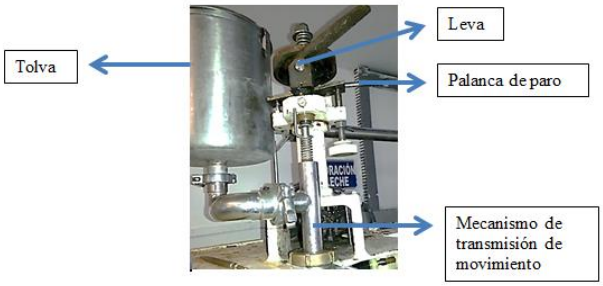

Figure 1. Doser
Source: Author

When the operator needs to stop the dispensing machine lifting lever stop doing raise swivel shaft cam, so the yogurt leaves descend. For the placement of the yogurt into the hopper the operator should position the product with the help of a ladder.

2.2. SEALING AND CUTTING

The entry of the plastic to the machine starts in roll, where joined by a stainless steel neck obtaining a cylindrical plastic. Figure 2 shows how taking cover when entering to the neck.

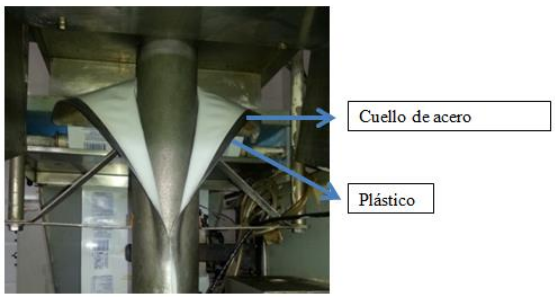

Figure 2. Stainless steel collar
Source: Author

A vertical vise is located after the neck of stainless steel, which is intended to seal the ends of the plastic, as seen in Figure 3. It has a resistance which remains at a constant temperature (80° C approximately), to make contact with the cover it melts and is sealed. To decrease the temperature in the jaws, there is a channel within them where water circulates constantly, because that machine does not have any kind of electronic temperature control.

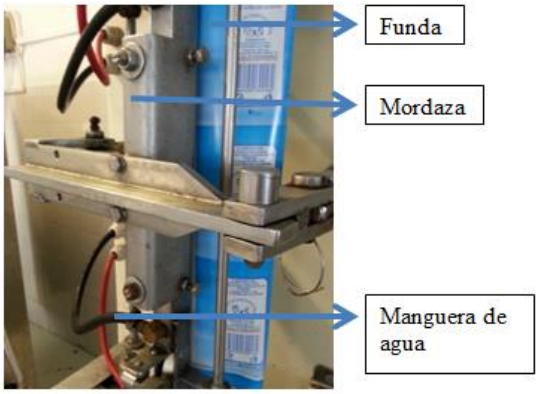

Figure 3. Vertical vise
Source: Author

Vertical cover trawling is done by means of a horizontal jaw that goes together with a pneumatic cylinder, where cylinder pushes the sheath to the preset length while gag press the cover to be dragged.

The horizontal vise has two functions, one of which is to press the case for the drag through the cylinder; and the second function is to seal and cut the cover using a niquelina at constant temperature. For that gag decrease temperature circulates water through a canal, since there is no temperature controller.

Because of the regular operation of the machine, each operation is performed at a specific point in the cycle of the machine. The element that performs this operation is a set of cams and switches type limit bar also called micro-switch, as shown in Figure 4. A motor with reduction attached to the camshaft box is responsible for turning them to the respective activation of each of the switches.

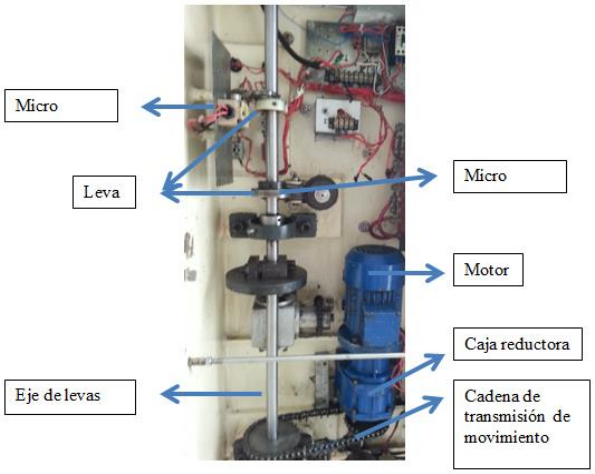

Figure 4. Camshaft
Source: Author

2.3. AUTOMATION

The automated system consists of two main parts:

- Operative part
- Part of command

2.3.1. OPERATIVE PART

This part acts directly on the machine. They are the elements that make the machine move and perform the desired operation. The elements that form the operational part are pneumatic actuators, electric pump, date, and registration mark sensor.

Pneumatic actuators that possessed the machine were not in good condition, therefore held the respective maintenance consisting of the replacement of the gaskets or seals that go on the ends of the rod, seals of the plunger, as also the lubrication of the shirt. Once the maintenance of cylinders, the respective elements for vertical and horizontal seal is counted as shown in Figure 5 and 6

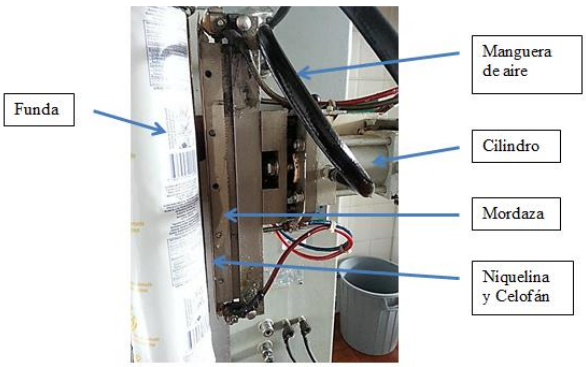

Figure 5. Elements of sealing vertical
Source: Author

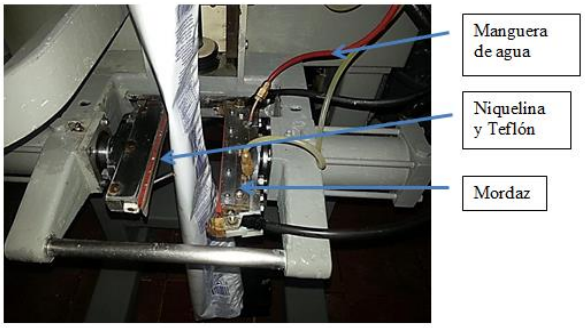

Figure 6. The Horizontal sealing elements
Source: Author

Solenoid valves were placed on the inside back of the machine as shown in Figure 7, this location is prevented its deterioration when in contact with water.

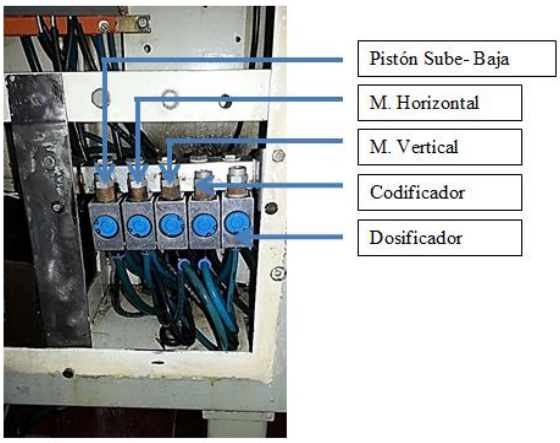

Figure 7. Solenoid valves
Source: Author

The dispensing cylinder used is shown in Figure 48. You can see being attached using splints of stainless steel pipe that comes from the hopper. Its function is to allow the passage of the yoghurt

through a plug that is attached to a rod and this to the stem of the cylinder as shown in Figure 8.

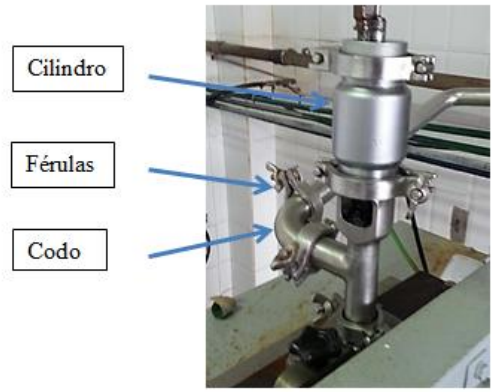

Figure 1. Cylinder feeder
Source: Author

2.3.2. PART OF COMMAND

According to the operation of the machine and to the requirements of the company, the type of the process control system is open-loop, where there is no feedback to adjust the variables to control. Figure 9 shows the block diagram of the system in general. This type of control is a PLC-controlled automatic being responsible for of all functions of the machine having sequence to obtain the final product.

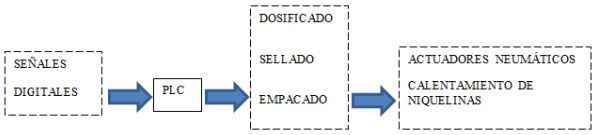

Figure 9. Block diagram of the general system
Source: Author

2.3.3. CONTROL BOARD

It contains devices of connection, maneuver, command, measurement, protection, and signage, with their covers and corresponding supports, to perform a specific function within the electrical system.

Since in the back of the machine retired mechanical elements in a home space for Board mounting profited as shown in Figure 10.

Figure 2. Mounting Control Board
Source: Author

Sealing and cutting of the yogurt case needs a thermal process, in which the cover must be completely sealed and cut. To accomplish this, a system was used from sealed by electrical impulse.

This type of sealed used an electrical resistance in the form of small thick blade calls niquelinas, same to be in contact and with some pressure warm instantly to make the seal. For both vertical and horizontal electric impulse sealing, designed two postcards of power as shown in figures 11.

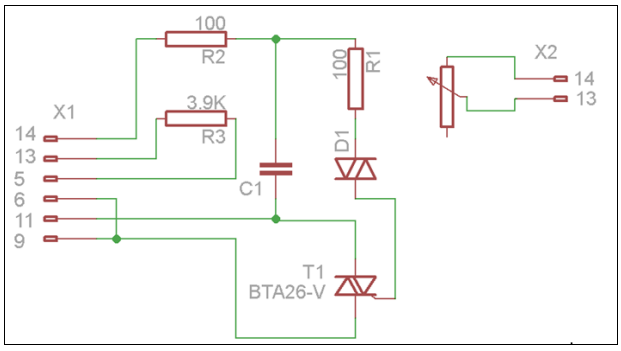

Figure 11. Horizontal sealing Power Board
Source: Author

The function performed card is to vary the current in the niquelinas by means of pulse, where the operator can adjust the value of current through a potentiometer until the Court and wanted the cover seal.

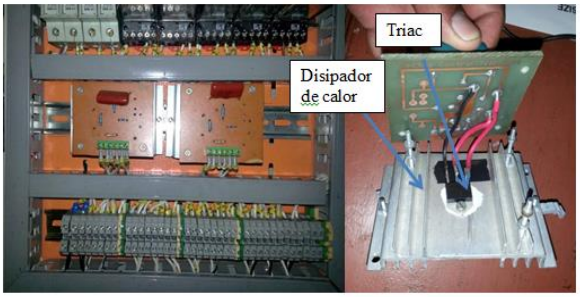

Figure 12. Horizontal sealing Power Board
Source: Author

The simulation of the performance of the card is with software Matlab Simulink tool. In Figure 13 you can see different pulses generated by the card whose entrance are pulses that simulate the functioning of resistance with capacitor.

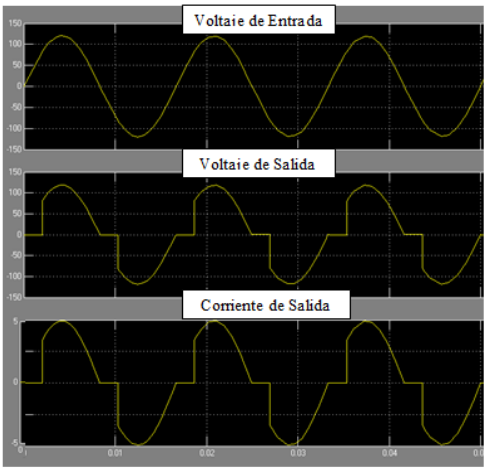

Figure 13. Response of the power card
Source: Author

Output wave shape is due to the loading and discharge of the capacitor of the card which varies depending on the value of the potentiometer, but software is a value that depends on the response time of the capacitor with the resistance which is obtained from the equation 1.

Equation 1. Response time

$$\tau = RC$$

(Serway, 2005)

Where:

τ= Response time

R= The variable resistance value

C= Capacitance of the capacitor

The greater the value of the potentiometer, the lower the value of the current, thus the niquelinas heat up less

2.3.4. EXTERNAL CONTROL PANEL ELEMENTS

The selectors were placed on the right side, while the Logo! TD on the front. Sensor record mark was placed at the front of the machine to power sensing sleeve. Figure 14 shows the position of the elements mentioned.

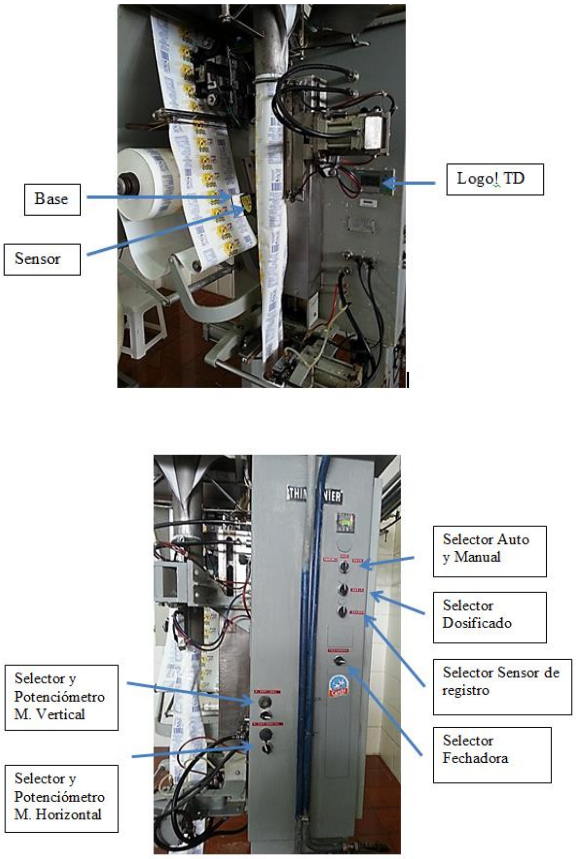

Figure 14. Elements external
Source: Author

2.4. PROCESS OF OPERATION

2.4.1. SEQUENCE OF TIMES

The main element of the machine was the set of cams which according to the geometry of the cams

and the angular velocity of the shaft running the machine with an established sequence. Since you replaced that system with an electronic system, it is necessary to obtain the times of each cam that running the machine with the old system.

Path that describes the profile of cam follower can be seen in the diagram of displacement of the cam's rotation and translation follower y = f(θ) in Figure 15

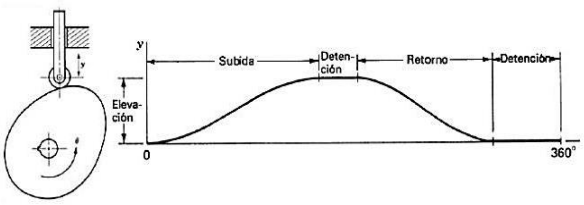

Figure 15. Displacement diagram of cam and follower
Source: (Northon, 2004)

For this path is used a cycloidal motion, since it has zero acceleration at the beginning and at the end, corresponding null accelerations of the arrests.

Equations 2 and 3 define the curve of the diagram of displacement with cycloidal motion of ascent and descent respectively.

Equation 2. Displacement of ascent

$$s = S[\frac{t}{T} - \frac{1}{2\pi} sen(\frac{2\pi}{T} t)]$$

Equation 3. Displacement of slope

$$s = S[1 - \frac{t}{T} + \frac{1}{2\pi} sen(\frac{2\pi}{T} t)]$$

Source: (Northon, 2004)

Where:

s= Instant displacement of the follower at any time given [cm]

S= Maximum displacement of the follower [cm]

T= Period of time for departure and approach of the follower sequences [seg]

t= Time intervals in which divides the working time of the cam [seg]

Used Matlab software to enter equations 2 and 3 and so look at your behavior for the times. A fact important to consider is the angular velocity of the shaft which is of? = 4.18 rad/s, already that this speed was obtained it taking the time in which a cam is delayed in one full turn of 360 degrees, which was 1.5 seconds, being in this case the value of T. Figure 16 shows the sequence of the camshaft for each of the elements.

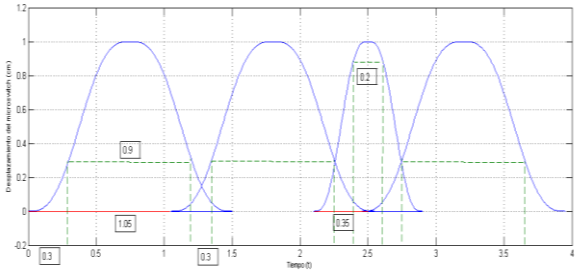

Figure 16. Sequence of the cams
Source: Author

Gag dosed, vertical and horizontal vise, activation must be followed one after another, without any waiting time between her. Therefore, that is observed in the curves of the cams cuts of intersections just in the activation of the microswitch. With all of these criteria was the time of activation, deactivation, and gap between the cams for its previous PLC programming. Table 1 shows the results of the times for each of the cams.

Table 1. Time of activation and waiting for the systems of cams

Precedencia	Leva para:	Tiempo de activación (s)	Tiempo de espera (s)	Desfase (s) con respecto a la leva 1
1	Arrastre	0.9	0.6	0
2	M. Horizontal	0.9	0.6	1.05
3	Dosificado	0.2	0.6	2.1
4	M. Vertical	0.9	0.6	2.45

Source: Author

2.5. PROGRAMMING OF THE SYSTEM

The programming of the PLC Logo made in software LOGO!Soft comfort of Siemens, with the programming software programs are can create, simulate, modify, save and print directly on the PC.

The sequence of each of the elements involved in the process outlined in table 2.

Table 2. Sequence of the elements that are involved in the process of the machine

Precedencia	Elementos
1	Cilindro de arrastre
2	Niquelina Mordaza Horizontal
2	Cilindros Mordaza Horizontal
3	Cilindro para Dosificación
4	Niquelina Mordaza Vertical
4	Cilindro Mordaza Vertical
4	Cilindros del Codificador

Source: Author

Manipulation of some parameters in the machine makes this greater versatility for the operator. One of the advantages of doing this is that when you change the values of the variables the machine can be adjusted to the desired requirements without having to modify mechanical parts, since everything depends on the times programmed into the PLC.

The screen Logo! TD allows you to view and modify the desired variables. To see enough block-programmed variables by pressing the arrow keys to locate in the parameter desired.

2.5.1. FLOWCHART OF THE AUTOMATIC SYSTEM

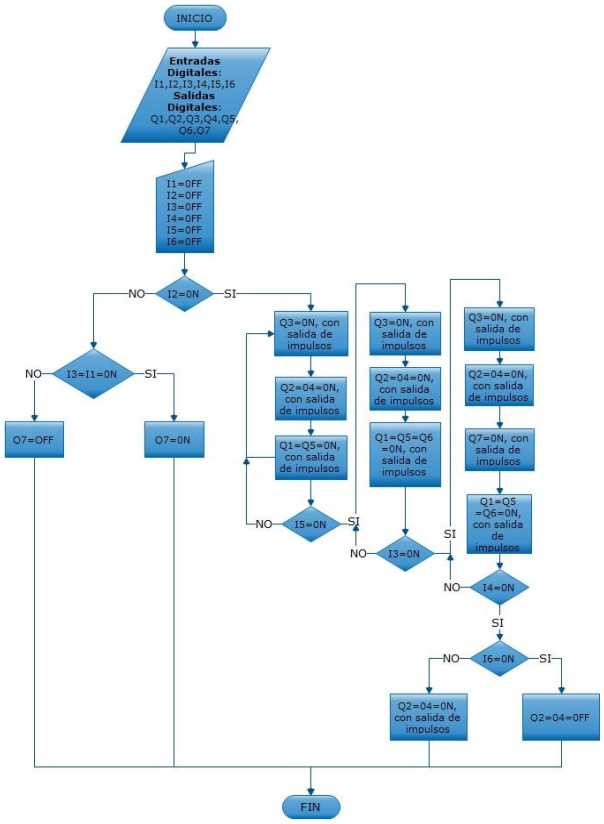

Figure 17. Flowchart of the automatic system of the machine
Source: Author

2.6. LEVEL CONTROL

One of the drawbacks in the process of the machine is the placement of the yogurt into the hopper carried out manually with the aid of a ladder. For the verification of the level of the yogurt into the hopper used a transparent hose whose principle was that of a glass communicating, where the operator observed through this when had to put more yogurt.

To solve this problem, used an electric pump (responsible for transporting the yogurt from the container until the hopper), and a level control for sensing the maximum level of the yogurt into the hopper.

2.6.1. PUMP SELECTION

Data to consider for the design of the pumping system is the diameter of the pipe of d = 1'½ = 0.

0381m whose material is stainless for being a food type, hopper application is 0.45 m high and 0.6 m in diameter, the time estimated to climb the yogurt is 5 min.

Properties of yogurt to help the selection of the pump are the viscosity and specific gravity values are μ = 800cp y ρ =1.025 g/cm3 respectively. Therefore, the flow rate of the system it is obtained of equation 4.

Equation 4. Flow system

$$Q = \frac{V}{t}$$

Where:

V: Hopper volume to be filled [m3]
t: Time to fill the hopper [min]

Equation 5. The base of the container area

$$A = \pi * r^2$$

Where:

A: Area of the base of the container [m2]
r: Radius of the vessel [m]

Replacing data is:

$$A = \pi * 0.3^2 = 0.282\ [m]$$

Equation 6. Volume of the container

$$V = A * h$$

Where:

A: Area of the base of the container [m2]]
h: Height of the vessel [m]

Replacing data is:

$$A = 0.282 * 0.45 = 0.127\ [m^3]$$

To replace the system in equation 4 data is obtained that:

$$Q = \frac{0.127\ [m^3]}{5\ [min]}$$

$$Q = 1.524\ [\frac{m3}{h}] = 1524\ [\frac{l}{h}]$$

Table 3. Characteristic of lobe pump

Parámetro	Valor
Tipo	Lobular 125NDAVG
Caudal m^3/h	1.8
n min	200
Diámetro en pulgadas de succión y de impulsión	1'1/2
Potencia HP	0.75
Voltaje V	Δ220/Y380 trifásica
Material	Acero Inoxidable, a excepción de la base, motovariador y del motor
Frecuencia (Hz)	60

Source: Author

The type of control for the level of the yogurt into the hopper is ON-OFF, as do not need complex control for such a system. The main function of the control is to activate the pump to transport the yogurt from the container to the hopper until it is filled, once this happens the control switches off the pump.

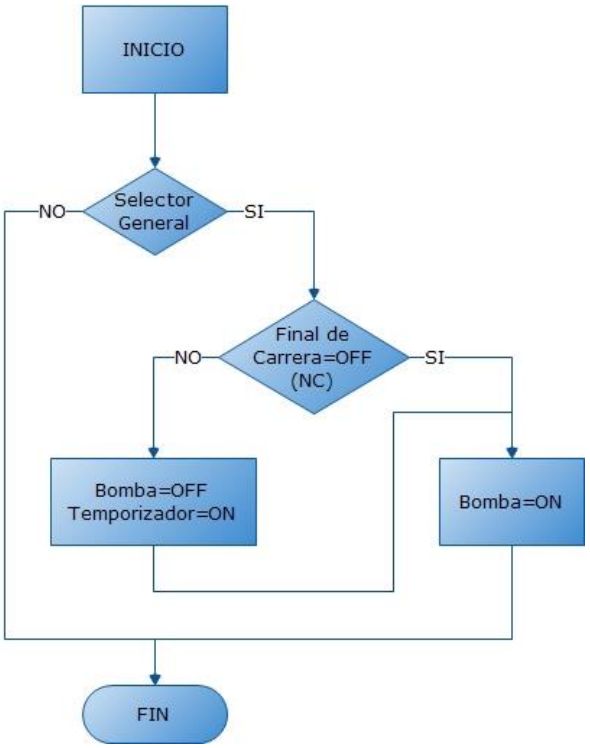

Figure 18. Flowchart of the level Control

Source: Author

The Assembly of all the elements of the control system is shown in Figure 19.

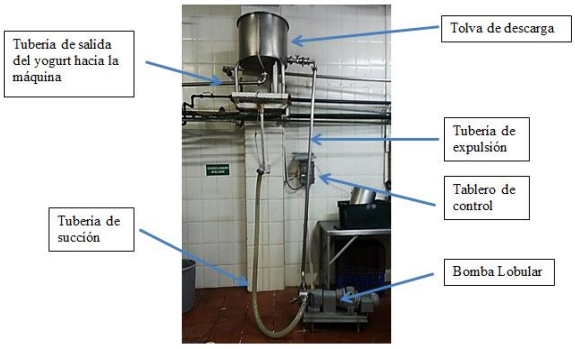

Figure 19. Assembly of the elements of the level Control System

Source: Author

The pump motor was not in good condition by what you had to rewind the stator. He was the respective maintenance of parts for proper operation. The bomb was placed on the floor as shown in Figure 20, since the yoghurt to be pumped is located in the lower part of the machine.

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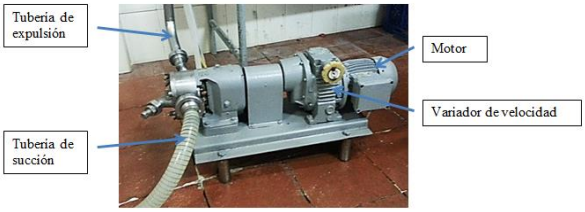

Figure 20. Implementation of the pump

Source: Author

Figure 21. Level Control dash mounting

Source: Author

3. CONCLUSIONS

- With the dosing and packing yogurt machine automation was increased the efficiency of the machine dosing 27 bags of 100ml per minute, being about three times faster, increasing the production of yoghurt in the company.
- The parameters achieved control in the process of the machine were the amount of yogurt in each case cutting and sealing the liner.
- We implemented a dosing system by gravity, which could control the flow of the yogurt in the sleeves through the cylinder control that had a plug on the stem allowing the passage and closure of the flow of yogurt.
- Implemented a system electro pneumatic according to the needs of the process of the machine, i.e. for the drive of the cylinder of JAWS, the dispenser and the encoder.
- Implemented level sensing to control the high level of the yogurt into the hopper, and a pump to transport the yogurt from the container into the hopper. It is worth mentioning that the level control system does not have any control on the operation of the machine, i.e. If there is no yogurt into the hopper the machine will not stop, because the company decided it to be so.
- It replaced the cam mechanism by a PLC, whose timing is based on time and no longer by the activation of the micro-switch through the camshaft, avoiding the desynchronization of machine wear and tear of mechanical components.
- Tests carried out on the machine were satisfactory, since it managed to obtain the final product with the desired amount.
- With the respective maintenance of certain elements of the machine and others obtained

from other machines were reused in the machine, getting better efficiency of the machine and saving of investment in the project.

4. RECOMMENDATIONS

- Calibrate daily different variables to control is in the process of the machine, and the amount of filling, sealing and cutting of the cover.
- In case of failure of any element of the machine control system, either electro tire, level and power, choose to use the recommended elements, since similarly ensure correct operation in the process.
- Place the roll of packaging before starting the machine, since there might be burns when touching the niquelinas jaws. Should be required to change when the machine has already been launched and the niquelinas are hot, take the necessary safety measures.
- If you want to upgrade the machine for increased production, it will be necessary to replace the pneumatic cylinder of the advance of the case by a mechanism of wheels by means of a motor.
- Frequently check the amount of yogurt in the covers, since there may be the possibility that a problem with pneumatic cylinders.

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6. BIOGRAFÍA DEL AUTHOR

Juan Carlos Nazate Rosero

Born in the city of Tulcán belonging to Ecuador, on April 17, 1991. He studied primary school Cristóbal Colón. High school course at the higher technological Institute Simón Bolívar in the speciality of physical mathematical. Was the best graduate of the specialty. He participated in the national competition Interuniversity LOGO!-SIEMENS. He was a speaker at the International Congress of Mechatronics in Bogotá. Currently he is a graduate of Northern technical college in Ibarra-Imbabura in engineering in Mechatronics in 2014. Area of interest: mechanical design, process automation and electronics..