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"DESIGN AND IMPLEMENTATION OF AN AUTOMATIC SYSTEM FOR THE PROCESS OF DOSAGE, MOLDING AND PRESSURE OF CURD"

TECHNICAL REPORT

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"DESIGN AND IMPLEMENTATION OF AN AUTOMATIC SYSTEM FOR THE PROCESS OF DOSAGE, MOLDING AND PRESSURE OF CURD"

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Summary. *The present project describes the development of an automatic system coupled with a series of mechanisms to control the flow of curd, in cheese processing, which support the artisan industry, which has low resources and therefore this Thesis project is aimed at small industry. This project seeks to create development with the fulfillment of sanitary norms for the elaboration of the cheese with materials of the stories as the stainless steel, and the semiautomatic processes, to create added value in the products without the necessity to change the traditions and the methods of the elaboration. Currently, 90% of all artisanal industries manufacture all of their products manually, it is believed that this process is eliminated, the product ceases to be artisanal and passes through an industrialized being, but the objective is not that, the objective is to follow the same Manufacturing method alone than with automated processes for safety factors for consumers, apart from other benefits offer shorter manufacturing times and accelerate the production of cheeses.*

The control systems are configured in such a way that the understanding about the operation of the machine is simple and can be used by anyone after two-hour training. The result of the work is the design and implementation of an automatic system for the dosage molding and pressing of the curd which aims to produce cheeses for sale, raising the quality and production of this product, without affecting its selling price.

Keywords: *Automation, processes, dosing, molding, pressing, curd, cheese, milk, production.*

I. INTRODUCTION

The study and application of automation requires experience and knowledge in different branches of engineering such as: mechanics, electricity, electronics, communication, computing, etc. [1] This has achieved a revolution in the manufacture of products of any type, reducing production times, raising quality standards, reducing the risk of accidents and human intervention in most processes, leaving alone and eliminating unnecessary labor. One of the factors that impede industrial growth within any industry is the initial investment, because this is very high and many managers and managers do not risk making such investments because the recovery of capital is long Term, and can not raise the cost of final products, because it would affect the sale of the same reducing the profit margin for the factory or company. For these and many other reasons the process automation is discarded in many cases [2].

Therefore, this project proposes the implementation of an automatic system for the dosage, molding and pressing processes of the curd, in the manufacture of handmade cheeses, reducing the cost of automation by implementing elements and mechanisms manufactured nationally, providing an option for those companies Which do not have large capital, but wish to raise their quality standards and improve production.

AUTOMATION

The word automation comes from the ancient Greek 'self' (self-guided) and refers to the use of electronic, mechanical and computer systems or elements to control processes within the industry, which ultimately or partially replace human operators and transfer tasks of production to a set of technological mechanisms [2] (see Fig. 1).

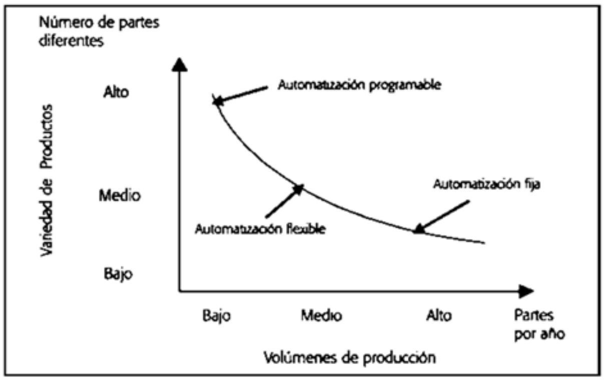

Fig. 1 Type of automation suitable for the production level of the company.

The automation of industrial processes is based on the ability to use the necessary information generated in the production process, through mechanisms of measurement and control of the methods that each process has. Through controlled instruments ordered by the computer, previously programmed for the required action, the operation of machines or other elements involved in the production process is regulated [2].

Parameters to perform an automation.

- The first factor that justifies an automation is the implementation, this refers to knowing all the processes that involve elaborating a final product and considering the mechanisms, production times, among others, in this case we analyzed the relevant processes within the manufacturing Of cheeses, from the curd, the following processes were determined: dosing, molding and pressing.

  The verification of the dosage is performed by the weight of the product that varies according to a calibration of the weighing module that is initially performed, and varies from 100gr to 1500 [gr] [3].

  The molding is performed by filling a cylindrical container with a defined volume of 1130 [cm^3] this process is called injection molding [4].

  The pressing of the curd is performed by means of a pneumatic cylinder coupled to a piston at the end exerting a pressure of approximately 29 [PSI] [4].

  The second factor is human resources, because they have to adapt to the change that the company presents, after being automated.

  From a humanistic point of view the first factors to be taken into account are:

  - Reduction of unskilled personnel.
  - Dangerous and harmful work.
  - Simplification of administration.
  - Perform complex and impossible processes.

- The third factor is economic resources, which intervene directly in the development and implementation phase of any project. In this process, a cost benefit analysis must be carried out to determine whether or not the project is feasible and the recovery time of the project. Investment, to have complete control over all aspects that influence automation [5].

- [6] The degree of automation is the fourth factor within a technological modernization, for which there are five levels:

  - Level 1 per operation.
  - Level 2 per machine.
  - Level 3 by process.
  - Level 4 integrated level.

- The fifth factor is the technology used, it mentions the options that can be used today. The first is the wired technique that uses only components connected to each other. The second technique is programming that influences or includes control systems with programmable electronic devices such as: Microcontrollers, PLCs among others [7].

- The sixth factor is productivity, which is related to current competition, due to the rapid technological development and the new financial opportunities offered, the great alternative in mechanisms and devices for automation has made this type Of processes, not only find the solution to a problem but also do it optimally, taking into account the resources and needs that are created during the upgrade process.

II. DESIGN OF THE AUTOMATIC CONTROL SYSTEM

For the design of the control system will take into account four branches of engineering that influence all this process, and in the different phases for the creation and implementation of each of the elements that lead to the automation of cheese manufacturing.

PRE DESIGN

In the pre-design stage, an analysis is performed to establish or determine all the physical and non-measurable physical factors to make a prior sizing of all the mechanisms that go from the accumulations to the mechanical structure, to make possible the control of all the processes They help to make the final product, in this case the cheese (see Fig. 2).

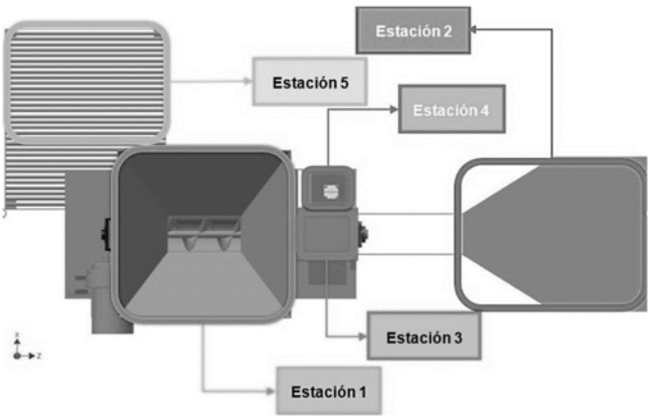

Fig. 2 Graphical assignment of the stations from a virtual prototype.

In this stage, each of the assigned elements is verified and divided into stations in order to reach the target. In this case, the automatic system is divided into five stations, and analyzed in Figure 2 and Table 1.

Table. 1 Division in cheese processing stations and processes.

Stations	Stations´name	Processes
1	Container 1	Curd storage
2	Container 2	Storage of empty molds
3	Dosage	Transfer the mold from station 2 to station 3.
		Fill the molds
4	Compressed	Transfer the mold from station 3 to station 4.
		Compaction of the curd.
5	Container 3	Transfer the mold from station 4 to station 5.
		Accumulation of filled molds

Once the processes are divided by station, a flowchart can be established to help with programming, through analysis (see Fig. 3).

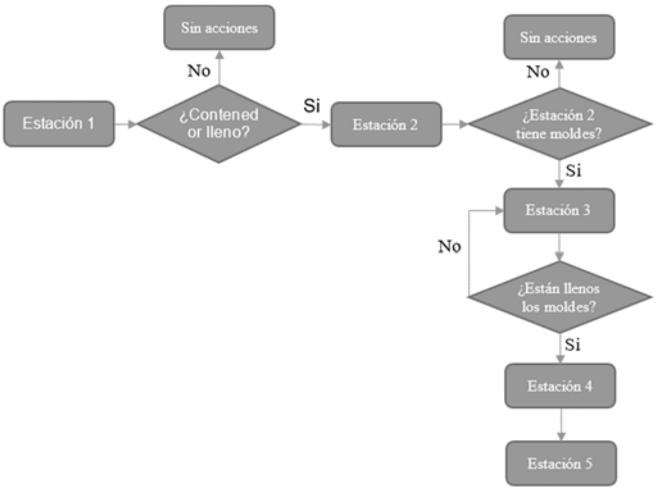

Fig. 3 Flow diagram the interaction of the stations by automation.

Finally, a pre-selection of alternatives for the design is carried out, for which a series of alternatives are proposed that help to solve the different problems that occur in each station.

Next, a series of criteria for the selection of components that conform the automatic system is described.

- Geometry of the container, in this case the container that houses the curd under two geometric concepts, which proposes the design, is chosen from the structure in this case cubic or cylindrical (see Fig. 4).

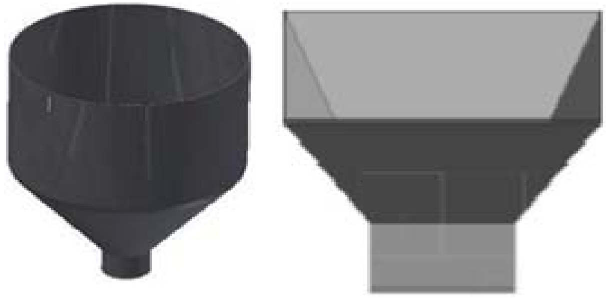

Fig. 4 Geometry of containers.

- Helical feeder selection, are designed to regulate the flow of a material stored in a hopper or tank. The feed is usually flooded with material (95% of trough load). One or more tapered or conical pitch coils transport the material to the required capacity (see Fig. 5) [8].

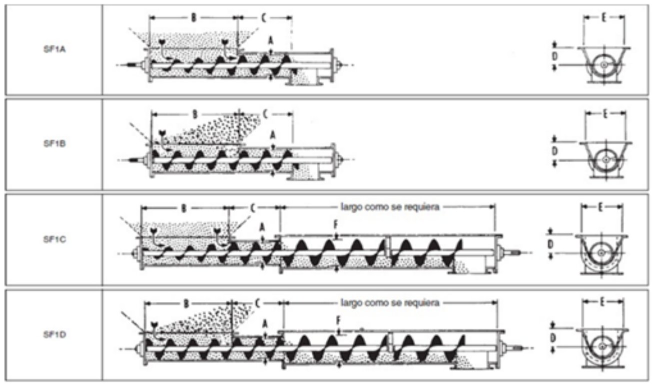

Fig. 5 Selection criterion for helical feeder

- Stainless steel this criterion allows to comply with the sanitary standard of the equipment manufacturing chemical, naval, pharmaceutical and food industries [9].
- Electromechanical equipment, Electromechanical equipment refers to all those electrical devices that are in charge of the control inside the machine being designed, in this case it has been divided into two phases; The sensors (sensors) and the actuators (actuators), which will enable automation.
- The control devices are those that allow linking the sensors with the actuators, to make possible the automatic control in this case two elements have been considered; Micro controllers and PLC's.
- Maintenance and operation, the operation of the machine is estimated, at least for daily use, after which a complete washing of the whole machine must be done especially the parts that are in direct contact with the raw material to eliminate residues that can Be housed in corners and may cause a partial or total contamination of the new raw material; For this reason it has been chosen to build the machine with steel AISI 304 for its ease of cleaning thanks to its constitution of materials, does not allow any type of waste to adhere.

- Sizing, Based on these considerations, it is possible to start the design of elements, but before starting to design we must do a dimensioning process within the same chapter, this serves to define the size of the elements that will form the automation.

III. DESIGN

The design process begins with a mechanical structuring that is the basis of all the additional systems, since in this is supported all the elements that make up the automation.

For this case, it starts with the control system since the thesis is based on an automation. In order to develop the mechanical system, it is necessary to make a selection of electrical and electronic components, of which the size of the components must be taken into account for dimensioning in the mechanical structuring.

CONTROL SYSTEM

To design a control system, the first step is to set the number of variables to be controlled. Variables are all devices connected to the machine control objects, (sensors or actuators).

Second step is to establish if the devices are input (sensors) or output (actuators), once this parameter is identified, the signal emitted by the devices, these can be: analog or digital.

Third step is to select the device that will be in charge of performing the control according to the type of programming of the device to make the set of elements responsible for controlling the processes is stable in the machine and fulfill their individual tasks so Correct.

ELEMENTS OF CONTROL AND POWER.

This section analyzes the selection of electrical, mechanical and electronic elements that will help to carry out the automation of the processes being treated (dosing, molding and pressing).

- Electric motor with clutch, this function serves to turn the helical worm screw to bring the curd of the container to each of the molds and when they have acquired the initially calibrated weight, the engine stops uncoupling the clutch that Has built-in, no longer producing movement without the engine turning off or turning. [8] This is selected based on the power required and the rpm needed to move the defined volume of the material.
- Linear actuators, also known as pneumatic cylinders, are selected based on three essential parameters: the force in [N], the pressure in Bar and the diameter of the internal piston. In the present case, in order to perform the automation processes, a diameter of 30 [mm] has been selected for the piston, a pressure of 2 [bar]. The actuator manufacturer recommends a maximum force of 100 [N][10].
- Solenoid valves allow you to control the pneumatic actuators by means of an electric impulse that allows the passage of air in one direction or another to push the pneumatic cylinder stem out or in. This is selected based on the air flow to be handled and the number of ways the valve has, the double acting actuators require a 5/2 configuration which means 5 ways and 2 positions, which allow movement, Speed of the piston, regulation and air venting in the different chambers.
- IFM position sensors help detect the position of objects by interrupting the magnetic field, these are swich type, which activates or deactivates an electrical signal indicating that the object is in that position, there are two configurations for this type of switches NO (normally open), NC (normally closed). For the development of the present work has been used to detect whether or not the cylinder is displaced and also to census the molds in the filling station that allows the opening of a valve to prevent spillage of material while the molds are not in said station.

CURD CONTAINER

Within the corresponding design, there are factors that must be taken into account in the design of the container, such as: The amount of material to be processed on a daily basis, losses when transforming raw material into processed product, volumes and spaces occupied by materials And materials at the time of processing among others.

For the design in this phase the cheese performance is taken into account, which refers to the analysis of the milk before and after processing during the production of finished product, in order to be able to determine the dimensions in this case volumetric that will define size and shape of the container [11]. 100 [l] of cow's milk equivalent to 22.75 [kg] of fresh cheese and 76.8 [kg] of whey.

MECHANICAL DOSING SYSTEM

For the design in this phase five steps should be followed which will be named below which will make easier the criteria for an optimum design in terms of helical feeders [8].

Step 1 Set the known factors:

- Material to Transport.
- Maximum particle size.
- Volume in percentage of particle sizes.
- Required capacity in cubic feet per hour.

- Required capacity in pounds per hour.
- Distance to which the material must be transported.
- Any additional factors that may a.

Step 2 classification of the material, this phase establishes known factors of the material such as:

- Material size.
- Fluidity.
- Abrasiveness.
- Other features.

Step 3 determine the capacity of the design, to establish the capacity of the design, it is necessary to determine factors such as: rpm of the system and the type of helical to be used, in this case was determined according to Fig. 5 a helical step Standard for the SF1B series [8].

Once this parameter is established, the selection catalog provides an equation for calculating system capacity [8].

$$N = \frac{Capacidad\ requerida\ (pie^3 / \ h)}{pies\ cubicos\ por\ hora\ a\ 1\ RPM}$$

Equation 1. Capacity System [8].

Step 4 Determine the speed and diameter of the helicoidal, using the required capacity in cubic feet per hour, the material classification and the percentage of trough load determine the diameter and speed.

Step 5 Check the Minimum Helical Diameter for Particle Size Limitations, using the known helical diameter and particle size percentage, check the minimum helical diameter.

Step 6 Determine the power [Hp], this calculation is performed in three stages with three equations according to the selection catalog [8].

$$HP_f = \frac{L \cdot N \cdot F_d \cdot F_b}{1000000}$$

Equation 2 Power to move the empty conveyor [8].

$$HP_m = \frac{C \cdot L \cdot W \cdot F_f \cdot F_m \cdot F_p}{1000000}$$

Equation 3 Power to move the material in the trough [8].

$$HP_{total} = \frac{(HP_m + HP_f)F_o}{e}$$

Equation 4 Total power to move the conveyor and materials [8].

Step 7 Check the torsional and / or power capacity of the components of the conveyors, use the required power calculated in step 6 [8].

$$Torque = \frac{63.025\ x\ HP}{RPM}$$

Equation 5Calculation of the torque in lb-pulg] [8].

Step 8 select the components, at this point we analyze all the elements that make up the helical feeder as the catalog proposes from this point onwards with all known factors, simply select from the tables proposed [8].

Step 9 Transmission distribution of the conveyors, to make the reduction of rpm it has been decided to make a direct coupling of the motor shaft with the input in gearbox and output of the gearbox shaft of the endless, for Calculation the reduction of speed between the reduction box and the electric motor it is only necessary of the data: original rpm in the engine, relation of the box reduction.

IV. IMPLEMENTATION Y RESULTS

Automatic manufacturing processes are most often summarized in the construction of one or several mechanisms that make up a machine, for the case of this degree work is summarized in a dosage of curd, for which there are some in the market with Purchase prices in excess of twenty thousand dollars, therefore the acquisition of these machines for micro-enterprises or craft enterprises is almost impossible because their capital investment does not exceed five thousand dollars, for this reason is sought to reduce costs With implementation of low cost technology and Ecuadorian manufacturing processes, which end up reducing in cost by 75% compared to any commercial machine.

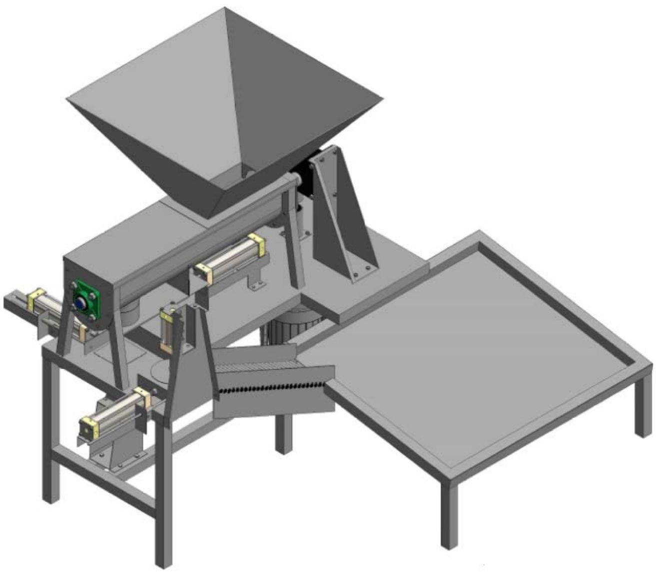

Fig. 6. Isometric view 1 of the system.

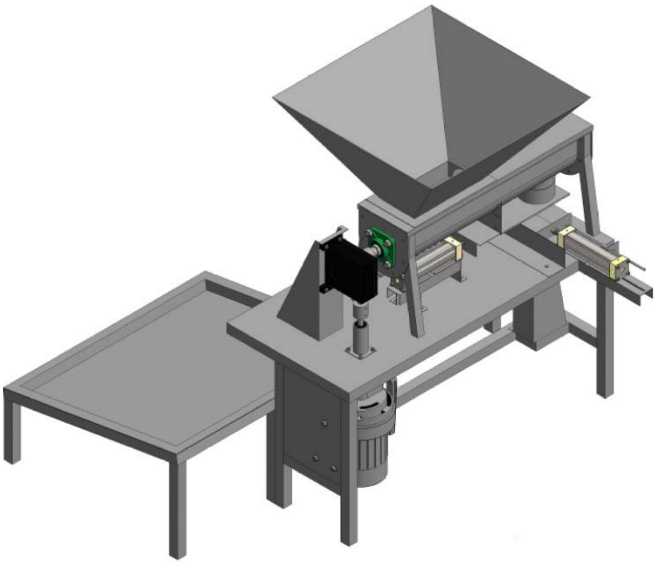

Fig. 7. Isometric view 2 of the system.

The implementation of the automation was achieved after some tests performed with materials similar to the curd because it is very expensive to see figs. 8 and 9.

Fig. 8. Substitute material for the curd.

Fig. 9. Machine Calibration with substitute material.

After calibrating the machine with the test materials, the experiment was performed with the curd, s figures. 10 and 11.

Fig. 10. Curd elaboration.

Fig. 11. Curd ready for performance test.

Once the curd has been poured into the container, it is ready to pass to the corresponding stations to be dosed, molded and pressed see fig. 12.

Fig. 12. Dosing and curd molding.

Once dosed and molded the curd must pass to its station together to be pressed see Fig.13.

Fig. 13. Pressing the curd.

When this process is completed, the following final result is obtained, see fig 14.

Fig. 14. Process Completion.

INVESTMENT RECOVERY

The cost-benefit analysis (CBA) is a brief detailed summary about the gains, losses and potential risks of a financial decision, anyone who is willing to do a little research and analyze information along with the relevant data is able to perform A quality ACB analysis.

Table 2. Cheese Production in units.

Cheese Production		Cheese real Production	Loss of cheeses due to handling factors
Daily Values	33	31	2
Monthly Values	990	930	60

Table 3. Cost of cheese production in units.

Cheese Production		Production Cost	Sale Cost	Real Production Cost	Real Total Cost
Daily Values	33	1,93	2,50	1,93	2,50
Monthly Values	990	1910.7	2475	1794.9	2325

Table 4. Monthly production of cheese without automation.

Item	Cost USD	Representation
Milk	1000	MPD
Curd	15	MPD
Salary workers	350	MOD
Electric power	20	GGF
Drinking water	10	GGF
Other manufacturing expenses	200	GGF

Table 5. Monthly expenditures of cheese manufacturing with automation.

Item	Value USD	Representation
Milk	1000	MPD
Curd	15	MPD
Salary workers	350	MOD
Monthly payment Machine cost	143.96	GGF
Electric power	20	GGF
Drinking water	10	GGF
Other manufacturing expenses	200	GGF

If the monthly difference between the unit selling cost and the actual total unit cost is realized, the company loses approximately $ 150 per month in cheese manufacturing in the worst cases. As can be seen in Table 3, the monthly payment in machine at 24 months is 143.96, a value that can be covered only with the optimization of production; In this case the machine is paid alone. If we establish a relation between Tables 4 and 5, we have that they are almost the same, with the only difference that in the 3 does not have the machine payment GGF.

V. CONCLUSIONS

- The optimum dosing time is 2.5 seconds to avoid hardening of the raw material.
- In an average of four hours, the waste cheese acquires a mass of 700 grams.
- For an optimal operation of the processing plant, a user manual is available
- The project is in its execution phase, after having overcome difficulties caused by the safeguards.
- Applying an average force of 40 PSI for two seconds, the compaction process speeds up the waste process.
- This processing plant ensures quality and quantity production in less time and greater performance.
- The automation of the cheese processing process, guarantees compliance with the quality standards.
- The implementation of this type of projects favors the micro enterprise.

VI. RECOMMENDATIONS

- The responsible person for this phase must verify that all the material of the hopper has been dosed.
- Avoid delays or distractions of responsible personnel for the dosage phase.
- Review operations manual in the event of any doubt or any part that is not understood within the process.
- Performing any project as soon as possible reduces the risk of small contingencies that can delay implementation.
- Accelerating the pressing not only helps the cheeses to come out faster, but also prevents the hardening of the curd in the hopper.
- Simplifying production times not only increases production but also production gains by minimizing manufacturing costs with a single investment.
- Implementing more and more quality standards guarantees a product of excellent quality.
- Encourage and motivate the students of the different engineering major to make agreements with companies and institutions so that they can carry out projects of this type to have a bipartite benefit.

VII. ACKNOLEDGEMENT

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IX. AUTOR BIOGRAPHY

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He was born in Guaranda city-Province of Bolivar - Ecuador, on February 12, 1985. His secondary studies were carried out at Teodoro Gómez de la Torre High school, Physical Mathematician specialty, He gave classes at Provincial Government of Imbabura in the areas of: Computer science, Macros, CAD design in CATIA programs, Inventor, AutoCAD, Solid Works. He formed an industrial automation, design and security company called Mecatronic S.A His studies were carried out at the Universidad Técnica del Norte. He is an Engineer in the Mechatronics major. Areas of Interest: Industrial Automation, Design and Maintenance