UNIVERSIDAD RICARDO PALMA

ENGINEERING FACULTY

PROFESSIONAL SCHOOL OF INDUSTRIAL ENGINEERING

INDUSTRIAL AUTOMATION RESEARCH WORK

"Design and development of an automatic sealing system."

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INTRODUCTION

The packaging process is one of the most important stages of the production flow in various industries because it is responsible for containing the product (wheat grain), preserving its quality and providing protection during transportation and storage. Therefore, it is essential to have a processing that meets the fundamental requirements to provide a quality product.

Currently, there are many packaging techniques that allow achieving the same objective. Automatic packaging has been able to develop over the years, becoming a vitally important equipment in the operations of large industries as it provides several benefits such as higher productivity, agility, adaptability, lower costs and errors.

In this work, an automatic packaging machine will be designed and manufactured in order to increase the productivity and efficiency of bag filling and sealing activities.

In Chapter 1, the general problem and the specific problems were presented, together with the objectives to be achieved and the justification for the project.

Then in chapter 2 the theoretical framework was developed, where the background of the research was reviewed, as well as the theoretical bases related to the terms used in this project.

Chapter 3 explained in more detail what the project consisted of and the stages that were planned and carried out in order to achieve the proposed objectives.

Chapter 4 presents the explanation of each stage developed, starting with the preliminary design and ending with the testing of the machine. Also, the techniques, parts and instruments used during the project and the results obtained are defined.

Finally, the conclusions and bibliographic sources consulted are presented.

1. PROBLEM STATEMENT

1.1 Description of the

problem Main problems

Currently, there are still rudimentary techniques in some production processes in micro and small companies (MSEs) in Peru, such as the packaging of food products in plastic bags, which are often sealed with staples or by tying a knot in the bag itself. This not only represents a danger to the preservation of the product, but also wastes resources.

Within the market there are other alternatives for sealing bags such as manual heat sealers, however many times the operator who manipulates the sealer takes days and sometimes weeks to learn to do it correctly, during this period time and raw material is lost because the operator is used to seal a certain size of bag at a fixed temperature, the problem begins when you have to seal a caliber by changing the temperature, if the caliber of the bag to be sealed is thicker, it is likely that the bag will not seal at the first attempt because it needs a little more temperature and exposure to sealing, this leads the operator to make a second attempt by increasing the temperature (if the machine has a temperature regulator) and the exposure time to sealing, causing this time, probably, that the bag breaks in two or melts and deforms due to excessive exposure to sealing and temperature: This happens because the machine does not have an operating manual and it takes a long time for the operator to learn how to seal correctly.

In a market as competitive as the current one, polypropylene bags have positioned themselves as one of the big players in the food and cosmetic industry. Today, there are many companies that request polypropylene bags, usually for wrapping, packaging or storing their products.(Martinez, Martinez & Ortiz, 2018, p.9)

Table 01: Main problems of the manual sealing process of plastic bags. Source: Own elaboration

Problems identified in the plastic bag sealing process					
N°	**Problem**	**Frequency**	**%**	**Accumulated**	**Accumulated**
1	Errors in manual sealing of plastic bags	45	52.94	45	52.94
2	Waste of resources (plastic bags)	20	23.53	65	76.47
3	Delays in the sealing process	15	17.65	80	94.12
4	Products expired before their expiration date	5	5.88	85	100
Total		85			

As shown in Table 01, the following main problems were identified in the manual process of sealing plastic bags:

- Errors in manual sealing of plastic bags
- Waste of resources (plastic bags)
- Delays in the sealing process

Possible root causes

The causes of the main problems described above are shown in the following Ishikawa diagrams (see Figure 1-3).

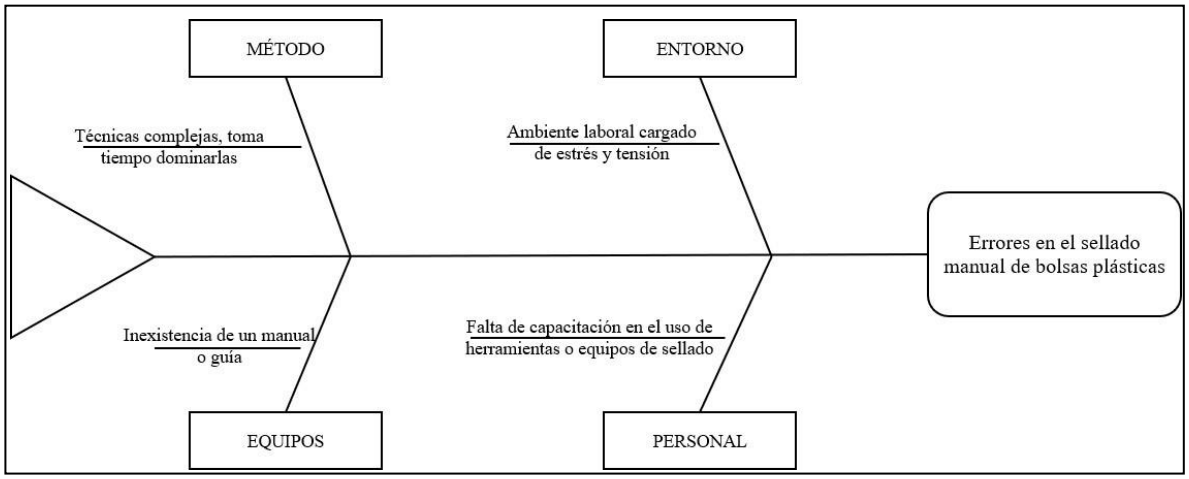


Figure 01: Ishikawa diagram with the possible causes of errors in the manual sealing of plastic bags.

Source: Own elaboration

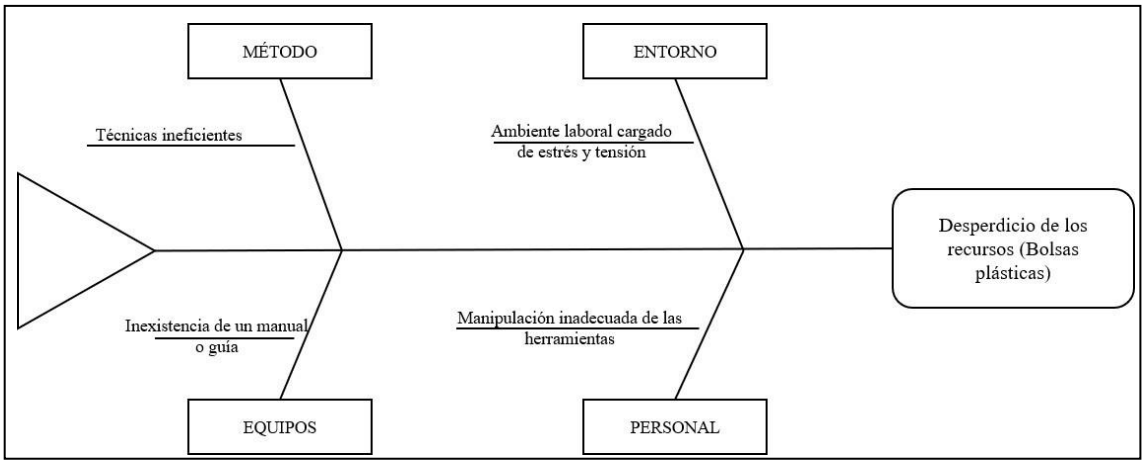


Figure 02: Ishikawa diagram with possible causes of resource wastage (plastic bags)

Source: Own elaboration

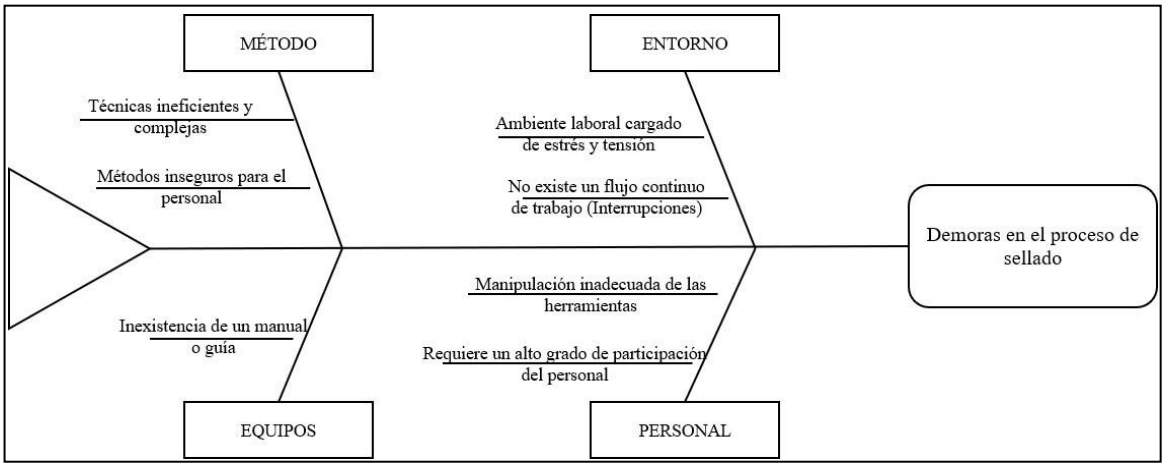


Figure 03: Ishikawa diagram with possible causes of delays in the sealing process.

Source: Own elaboration

Environmental impact

Table 02 shows the amount of the consumption tax on plastic bags (ICBP) over five years. It is a tax levied on the purchase or acquisition of free plastic bags offered in commercial stores or service providers. As an individual or legal entity, you are obliged to pay it when you purchase these plastic bags to carry your purchases.

Table 02: Amount of consumption tax on plastic bags (ICBP) Source: Gob.pe

Year	Price
2019	0.10
2020	0.20
2021	0.30
2022	0.40
2023	0.50

The table reflects an increase in the price of plastic bags in the last five years, we can deduce that this is due to the negative environmental impact that plastics have on the planet, despite this they are still used to package candy products, varied, among others. The sealing of bags can contribute to the reduction of pollution caused by plastics, a proper sealing makes better use of the plastic bag, wastes less, facilitates the task of opening the bags of our favorite treats, providing a practical opening system and generates that the bag can be reused.

1.2 Problem formulation

1.2.1 General problem

How to design and manufacture an automation system to improve efficiency in the plastic bag sealing process?

1.2.2 Specific problems

a. By what measures is bag sealing time reduced with an automation system?

b. To what extent does the production capacity of sealed bags increase with an automation system?

1.3 Objectives

1.3.1 Main objectives

Design and manufacture an automation system to improve the efficiency of the plastic bag sealing process.

1.3.2 Secondary objectives

a. Reduce bag sealing time with an automation system.

b. Increase the production capacity of sealed bags with an automation system.

1.4 Justification

1.4.1. Theoretical justification

We use industrial automation concepts, manage information about components, parts and PLC programming, to automate the manual process of sealing plastic bags.

In addition to using the RPA evaluation method (See Appendix, *Figure 04*), to determine if the process is a good candidate for automation,

1.4.2. Practical justification

The main reason for automation of the plastic bag sealing process is to improve the efficiency of the process. To create a continuous workflow in the manufacturing process.

1.4.3. Methodological justification

The increased efficiency of the plastic bag sealing process, once tested and proven to be valid and reliable, will provide input for further research.

1.4.4. Social justification

The automation work will serve as a guide and a reference for small and medium-sized entrepreneurs to innovate in their manufacturing processes and become more competitive in the market.

2. THEORETICAL FRAMEWORK

A plastic bag is a type of container made of thin, flexible plastic sheeting. Plastic bags are used to contain and transport goods such as food, products, powders, ice, magazines, chemicals and waste. It is a common form of packaging.

Currently, most goods industries have packaged or bagged their products before or after selling them; storage in bags has become very common over the years. As it happens at a national level, the products that are most commercialized in our society are packed manually by the informal sector, which represents the majority of the economic circulation in our country.

This is because they are inexpensive to purchase and easy to seal. However, in recent years, industries have found it necessary to automate their processes, due to the high demand for products.

The higher demand results in insufficient production, one of the main factors being the lack of automation of processes that take time to perform, such as, in this case, sealing the bags. For this reason, to implement a continuous improvement regarding the efficiency of the production of a packaging company, it is essential to implement and develop a mechanism to reduce packaging times, acquiring greater production capacity and therefore greater profits for a company.

In this paper we will discuss a specific type of sealer. As described by Javier Molano & Iván Mendoza (2020):

> For this reason, in response to the request of Mr. William Mendoza, who seeks to automate the blackberry packing process in his sales stand to improve his sales, it was decided to design and build a machine capable of improving packing times, hygiene, accuracy of the final product, packing quality and presentation, and reducing dependence on manual labor, since there is no operating personnel to do this work. (p.11)

An attempt will be made to manufacture this automatic bag sealer to solve the demand fulfillment problem.

2.1 Automated project definition

The bag sealing machine is a machine whose function is to seal plastic bags by pressure and heat, which has PLC automated system and this machine will be satisfactory its application in packaging industry.

This sealing technology consists of generating an artificial atmosphere inside the bag, in which up to 99% of oxygen is removed before sealing. The machine used for this type of sealing is the vacuum sealer. It is normally used for the food industry, because food can be kept fresh and in good quality for a prolonged period of time (Mendoza, 2020, p.27).

2.2 Planning of activities

The Gantt chart was a great support during the realization of the automatic sealing system. Being a project management tool, it allowed us to plan the activities and tasks with their respective dates, quickly and easily, generating an order and sequences throughout the project, allowing us to meet the objectives expected by the working group.

	INICIO DEL PROYECTO	**22 días?**	**lun 12/09/22**	**vie 7/10/22**		
	INICIO DEL PROYECTO	0 días?	lun 12/09/22	lun 12/09/22		
	Inicio	0 días	lun 12/09/22	lun 12/09/22		
	Avance de Semana 4	**6 días?**	**lun 12/09/22**	**sáb 17/09/22**	**3**	
	Avance de Semana 4	0 días?	lun 12/09/22	lun 12/09/22		
	Avance de Semana 4	0 días?	sáb 17/09/22	sáb 17/09/22		
	Informacion sobre el proyecto	1 día	lun 12/09/22	lun 12/09/22		Marcelo Bashi
	Cotizacion del proyecto	1 día	mié 14/09/22	mié 14/09/22	7	Juan Morales
	Presentacion y consulta al profesor	1 día	sáb 17/09/22	sáb 17/09/22	8	Adriana Ruiz;Alexandro Co
	Avance semana 5	**6 días?**	**lun 19/09/22**	**sáb 24/09/22**	**9;4**	
	Avance semana 5	0 días?	lun 19/09/22	lun 19/09/22		
	Avance semana 5	0 días?	sáb 24/09/22	sáb 24/09/22		
	Progreso del diseño CAD	4 días	lun 19/09/22	jue 22/09/22	9	Miguel Mejia;Celso Jimene
	Primer aporte economico	3 días	lun 19/09/22	mié 21/09/22	9	Adriana Ruiz;Alexandro Co
	Compra de los componentes	1 día	jue 22/09/22	jue 22/09/22	9;14	Cuadros;Marcelo Bashi;Seb
	Avance grupal	1 día	vie 23/09/22	vie 23/09/22	15	Adriana Ruiz;Alexandro Co
	Presentación del avance	1 día	sáb 24/09/22	sáb 24/09/22	16	Adriana Ruiz;Alexandro Co
	Avance semana 6	**6 días?**	**lun 26/09/22**	**sáb 1/10/22**	**17;10**	
	Avance semana 6	0 días?	lun 26/09/22	lun 26/09/22		
	Avance semana 6	0 días?	sáb 1/10/22	sáb 1/10/22		
	Medicion de Proyecto modelo	1 día	lun 26/09/22	lun 26/09/22	17	Camila Cristina;Celso Jimer
	Verificacion de componentes faltantes	0.5 días	mar 27/09/22	mar 27/09/22	17	Adriana Ruiz; Alexandro Coaguila;Celso
	Segundo aporte economico	3 días	mar 27/09/22	jue 29/09/22	22CC	Adriana Ruiz;Alexandro Co
	Compra de componentes faltantes	1 día	vie 30/09/22	vie 30/09/22	23	Alexandro Coaguila;Camila

	Avance semana 7	**4 días?**	**lun 3/10/22**	**vie 7/10/22**	**24;18**	
	Avance semana 7	0 días?	lun 3/10/22	lun 3/10/22		
	Avance semana 7	0 días?	vie 7/10/22	vie 7/10/22		
	Desarrollo del diseño final	1 día	lun 3/10/22	lun 3/10/22	21	Celso Jimenez
	Verificacion de diseño final	1 día	mar 4/10/22	mar 4/10/22	28	Adriana Ruiz;Alexandro Co
	Cotización de estructura	1 día	mar 4/10/22	mar 4/10/22	29CC	Celso Jimenez;Juan Morale
	Elaboración de la estructura	1 día	mié 5/10/22	mié 5/10/22	30	Celso Jimenez
	Avance semana 8	**6 días?**	**lun 10/10/22**	**sáb 15/10/22**	**31**	
	Avance semana 8	0 días?	lun 10/10/22	lun 10/10/22		
	Avance semana 8	0 días?	sáb 15/10/22	sáb 15/10/22		
	Parciales	6 días	lun 10/10/22	sáb 15/10/22		
	Avance de la elaboracion de estructura	1 día	mié 12/10/22	mié 12/10/22	31	Celso Jimenez
	Avance semana 9	**6 días?**	**lun 17/10/22**	**sáb 22/10/22**	**32**	
	Avance semana 9	0 días?	lun 17/10/22	lun 17/10/22		
	Avance semana 9	0 días?	sáb 22/10/22	sáb 22/10/22		
	Desarrollo e implementacion de los componentes	1 día?	lun 17/10/22	lun 17/10/22	36	Celso Jimenez; Juan Morales;Miguel Mejia
	Implementacion dela parte electrica	1 día?	mar 18/10/22	mar 18/10/22	40	Alexandro Coaguila;Celso J
	Cotizacion de pieza adicional en L	1 día?	lun 17/10/22	lun 17/10/22	36	Sebastian Palma
	Avance semana 10	**6 días?**	**lun 24/10/22**	**sáb 29/10/22**	**37**	
	Avance semana 10	0 días?	lun 24/10/22	lun 24/10/22		
	Avance semana 10	0 días?	sáb 29/10/22	sáb 29/10/22		
	Implementacion de la pieza en L	1 día?	lun 24/10/22	lun 24/10/22	42	Celso Jimenez;Juan Morale
	Desmontaje del sellador manual	1 día?	lun 24/10/22	lun 24/10/22	37	Cuadros;Diego Medina;Mig
	Verificacion de la parte electrica del sellador	1 día?	mar 25/10/22	mar 25/10/22	46	Celso Jimenez;Cuadros; Juan Morales
	Desarrollo de la programacion	1 día?	lun 24/10/22	lun 24/10/22	37	Adriana Ruiz
	Implementacion de la programacion	1 día?	mar 25/10/22	mar 25/10/22	49	Adriana Ruiz
	Avance semana 11	**4 días?**	**jue 3/11/22**	**lun 7/11/22**	**43**	
	Avance semana 11	0 días?	jue 3/11/22	jue 3/11/22		
	Montaje completo de los componentes del sellador automatico	1 día?	jue 3/11/22	jue 3/11/22	48	Celso Jimenez;Cuadros; Juan Morales
	Prueba y error de cada funcionamiento	1 día?	vie 4/11/22	vie 4/11/22	53	Adriana Ruiz; Alexandro Coaguila;Celso
	Verificacion y medida de tiempo de la programacion	1 día?	sáb 5/11/22	sáb 5/11/22	54	Adriana Ruiz; Celso Jimenez;Juan
	Grabacion del funcionamiento	1 día?	lun 7/11/22	lun 7/11/22	55	Adriana Ruiz;Alexandro Co
	Compra de componentes deteriorados	1 día?	sáb 5/11/22	sáb 5/11/22	53;54	Cuadros;Marcelo Bashi
	Avance semana 12	**6 días?**	**lun 7/11/22**	**sáb 12/11/22**	**51**	
	Avance semana 12	0 días?	lun 7/11/22	lun 7/11/22		
	Avance semana 12	0 días?	sáb 12/11/22	sáb 12/11/22		
	Pruebas del sellador	1 día?	mar 8/11/22	mar 8/11/22	55	Alexandro Coaguila;Celso J
	Verificacion de la parte electrica	1 día?	mié 9/11/22	mié 9/11/22	61	Celso Jimenez;Juan Morale
	Perfilamiento de los componentes del sellador	1 día?	jue 10/11/22	jue 10/11/22	62	Marcelo Bashi; Miguel Mejia;Sebastian
	Demostracion del funcionamiento al profesor	1 día?	sáb 12/11/22	sáb 12/11/22		Adriana Ruiz; Alexandro Coaguila;Celso

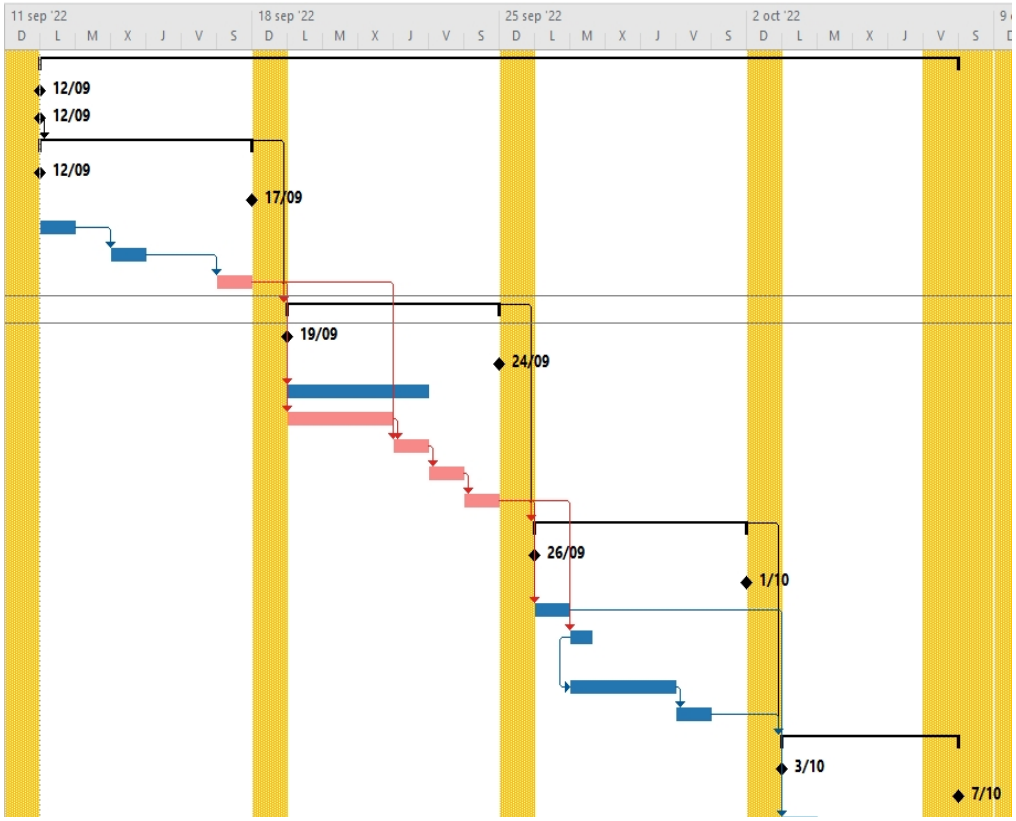


Figure 04: Gantt Chart Source: Own elaboration

2.3 Preliminary machine design

2.3.1 Freehand sketch

In our first sketch that could be generated on paper, as we have in the figure above, we can see that the measurements of the frame were still waiting for their respective manufacture based on cast iron.

. And as part of the "Bag Sealing Machine" project team, the decision was made to use two tubes for the final structure, a square tube and a rectangular tube to give the frame a unique coupling since it will internally work with and include fragile grade components.

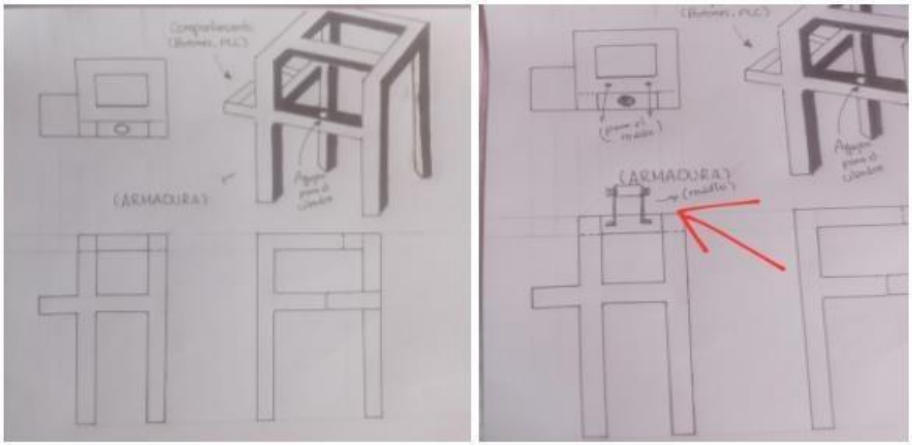


Figure 05: Freehand sketch of the framework
Source: Own elaboration

2.3.2 Frame sketch (Solidworks)

For our second sketch, both the piston design and the sketch frame were generated in Solidworks for subsequent fabrication in the metalworking shop. SolidWorks is a CAD (computer-aided design) program that helps us in the design and mechanical modeling of the elements of a system. This program allows the designer to translate their ideas into real products and subject them to real-world conditions. Offering better quality products, guaranteeing manufacturing and reducing costs in the manufacture of prototypes (Manzano & Rodriguez, 2013, p.134).

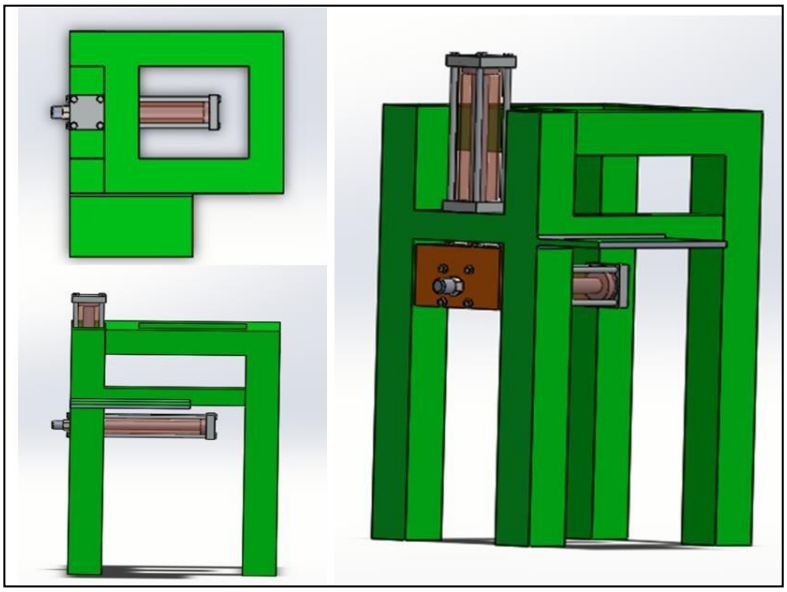


Figure 06: Frame capture in solidworks

Source: Own elaboration

2.4. Packaging machine operations planning

2.4.1 Operations Diagram

Figure 4 shows the steps performed during the sealing process in an automated system. The process starts by placing the bags in the hopper and filling it manually with cereal, then the sealing process starts by pressing the green button, the solenoid valves receive the signal to activate the pistons, the sealing time is waited and the sealed bag is removed. It should be noted that the bag sealing finish must be inspected, once approved, the product can be used.

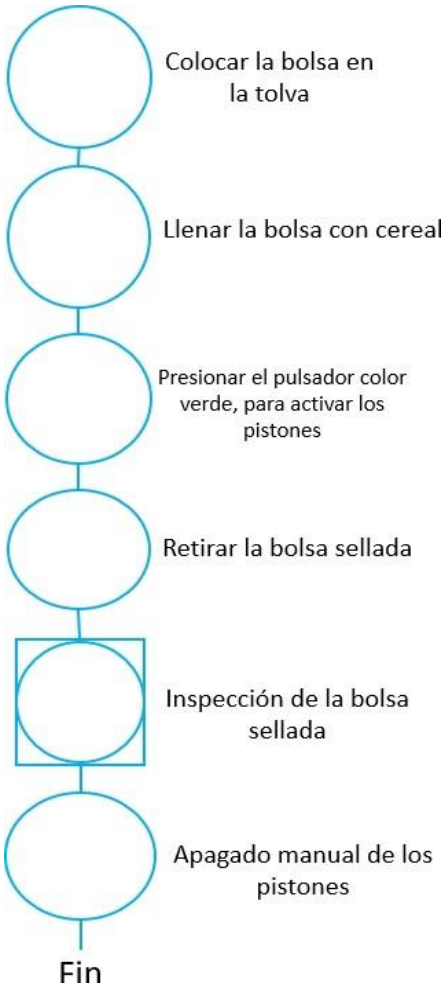


Figure 07: Diagram of operations of the automatic sealing process

Source: Own elaboration

3. PROJECT DEVELOPMENT

3.1 Parts or components

In this section, a list is presented with all the parts necessary to carry out the project of the automatic sealing system, indicating the required quantity of each part and its dimensions or characteristics.

Parts list:

a. 1 square piston (Scaf brand 40x100 mm).
   Double-acting piston through which pressurized air enters to drive the shaft.

Figure 08: Double-acting square piston Scaf

Source: Own elaboration

b. 1 cylindrical piston (Scaf brand 15 x 50 mm)
   Double-acting piston through which pressurized air enters to drive the shaft. It has a regulator to control the pressure and has a shorter stroke than the square piston.

Figure 09: Double-acting cylindrical piston

Source: Own elaboration

c. 2 solenoid valves (Scaf 220 V brand)

Electromechanical valves are used to regulate the passage of air discharged through hoses with a compressor.

For the operation of the 5/2-way valve, Konda (2017) expresses that it is as follows:

In the first position of the 5/2 valve, compressed air flows from P to A and B to E1 and this flow is through the flow control valve, where it is controlled by the piston where it slowly extends and the cut is completed. In addition, compressed air also flows from P to B and A to E2 and then the piston retracts at a higher speed to save time (p. 20-22).

Figure 10: Solenoid valve 5/2

Source: Own elaboration

d. 1 hose (5m)

Hose through which the compressed air flows for the operation of the valves that redirect it to the pistons.

Figure 11: 8 mm hose. Source:

Own elaboration

e. Pushbuttons (green red and emergency stop)

Button panel with three functions, start, shutdown and emergency, all of which are programmable.

Figure 12: Button panel

Source: Own elaboration

f. Manual sealer components (bar heating element and temperature regulator)

Regular sealing machine which allows the sealing of plastic materials by means of heat and compression resistance.

Figure 13: Manual sealer Source:

Own elaboration

g. Air compressor (8 1/4" output)

Compressor that allows by means of air flow, the operation of mechanical parts with the power generated by containing stored air and compressing it in its respective tank.

When electricity supply is less than demand, compressed air is discharged, mixed and burned with gaseous fuels to run electric power generators, subsequently exporting electricity (Zhou, Xia & Zhou, 2020, 2070-2093).

Figure 14: Compressed air compressor Source:
Own elaboration

h. 6 fittings (8 1/8)

Quick coupling fittings for the valves through the 8 mm hoses and allow the flow of compressed air, ensuring its continuous passage.

Figure 15: Fittings
Source: Own elaboration

i. Customized metallic structure (robust design that withstands vibrations)

Main body of the project assembly previously designed through solidworks for the previous visualization of the parts to be implemented.

Figure 16: Galvanized iron structure
Source: Own elaboration

j. 1 PLC (SIEMENS LOGO!)

It is the main memory, which allows the programming of the mechanical components for their respective operation.

For the operation of this system, "A PLC Programmable Logic Controller is a digital device used for the control of machines and operation of industrial processes; it can also be programmed by the user" (Villavicencio, 2009, p.109).

Figure 17: PLC

Source: Own elaboration

k. 1 Power supply (220 V)

Adjustable power supply from 110 V to 220 V, allows the operation of the mechanical and automatic parts of the project.

Figure 18: Power supply Source: Own elaboration

l. Cables for electrical connection

i. THW 14 AWG Blue
ii. Cable THW 16 AWG Blue
iii. Cable #18 monopolar - blue
iv. Cable #20 multi-core - red

Figure 19: Connection cables

Source: Own elaboration

Figures 16 and 17 show an image of the "Sofia" automatic sealing system in different positions, showing each of the parts described above.

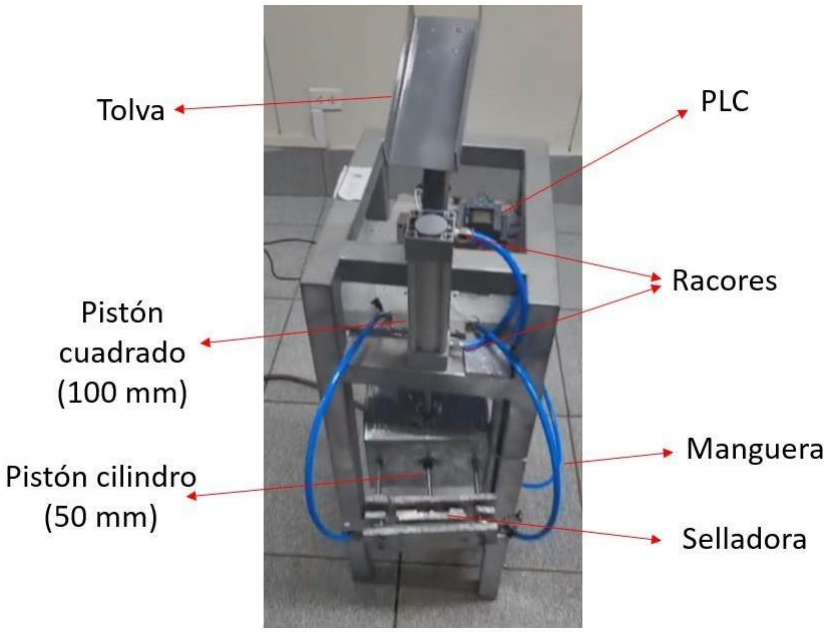


Figure 20: Front view of the automatic sealing system

Source: Own elaboration

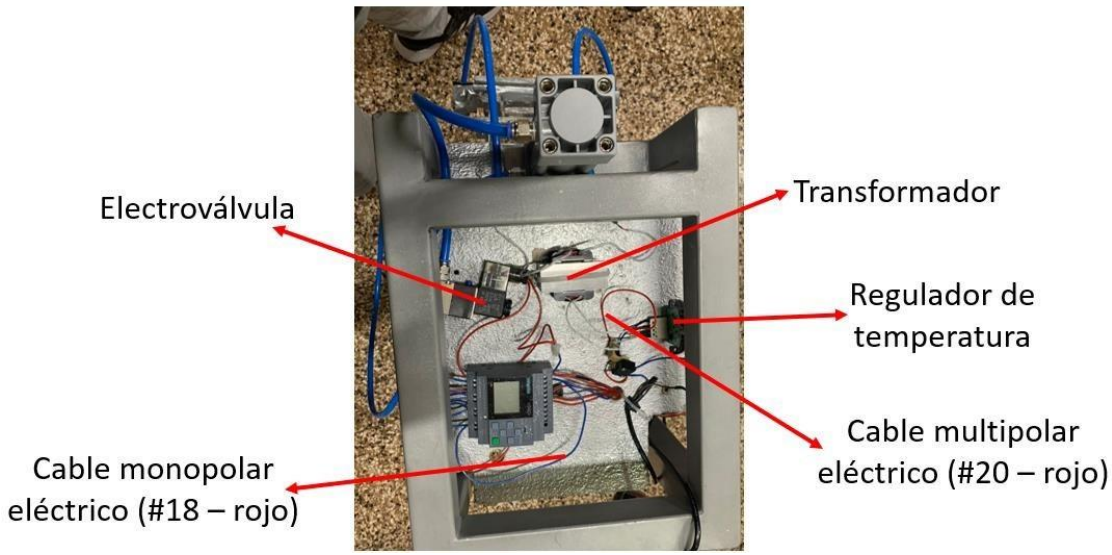


Figure 21: Horizontal view of the automatic sealing system Source: Own elaboration

3.2 Manufacturing

Our galvanized iron frame according to the plans made in SolidWorks was simulated and finished in the second week of the cycle. Now, in the first week of the cycle, the construction was made based on cutting, joining and intersection of iron pieces, which as a second instance were taken to a flat welding as vertical. Then the prototype of the "L-shaped piece" (figure 18) was elaborated using wood that gave us a coupling contribution, to assemble it to such a magnitude that it approaches a solid iron box.

Figure 22: Elaboration of the "L" piece

Source: Own elaboration

Figure 23: Measurement of the "L" shaped part

Source: Own elaboration

Observations are made to be able to make decisions about the measurements, and center the cylindrical piston (5mm), so with this we move to the next step of assembling the piece "L", where in this mounted could make the new measurement to calculate the new center of the square piston (10mm).

Taking into account a thesis referring to the sealing system with an assembly.

To seal the bag, in the rectangular piece that serves as a stopper, a small sealer was assembled in the wooden piece, using an insulator and an electrical resistance of 10 cm, which adapts to the wooden piece of the mechanical system, and thus with the open-close movement it will perform the process of sealing the plastic bag. (Molina & Farias, 2017, p.14)

Figure 24: "L" piece Source:

Own elaboration

The L-shaped piece of wood is used as a test, once it works, a new L-shaped piece of galvanized iron is made and placed, and once the alignment of the square and cylindrical piston is completed, the wiring process can begin.

We continue with the wiring process, for which we will need: THW cable 14 AWG Blue, THW 16 AWG Blue Cable, Pushbuttons, PLC, Power Supply, Solenoid Valves and the 10 mm square piston. To place these elements it is necessary to build a platform that can support them. The material chosen for this is wood. With the elements well placed, the wiring between the pushbuttons, the PLC, the power supply and the solenoid valves is done.

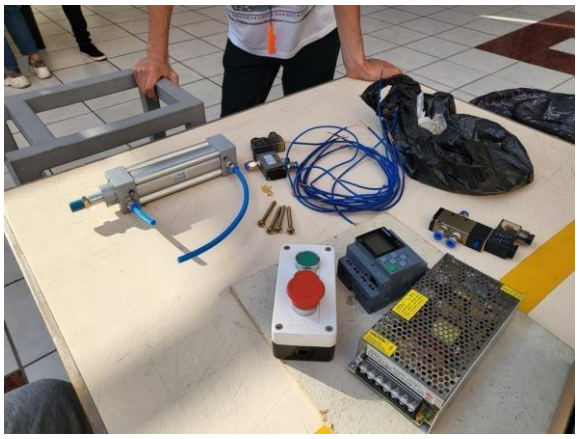


Figure 25: Components for the elaboration of the project: PLC, Piston, Power supply, pushbutton panel and solenoid valves.

Source: Own elaboration

Figure 26: Control panel wiring

Source: Own elaboration

In the next part, a correction was made to the previous wiring, since a single platform was not sufficient to cover all the elements that needed to be placed. Therefore, an additional wooden platform was built. As for the wiring itself, there were also some changes, the main one being the type of cables we used. The new cables are: Cable #18 monopolar - blue and Cable #20 multipolar - red.

Figure 27: Wiring Correction Source: Own elaboration

Figure 28: Placement of the second platform with components Source: Own elaboration

In the final form of the project, the aforementioned elements can be seen distributed on the two wooden platforms, now in a silver color made with spray paint. In addition, you can see plastic bands that hold the cables to the structure to prevent them from getting tangled and interrupting the machine when activated.

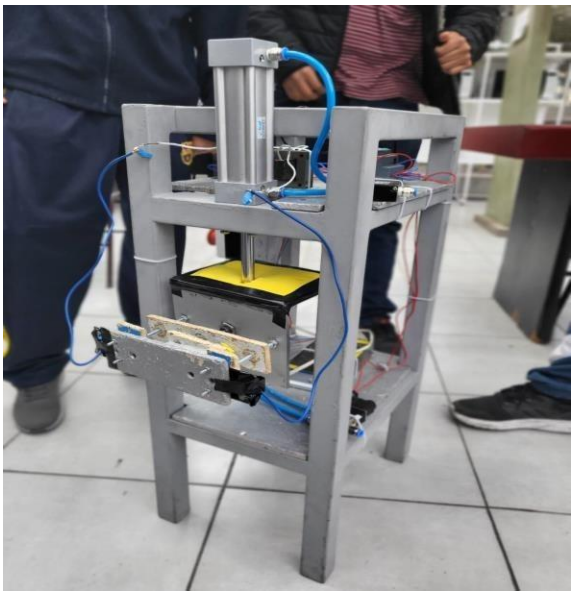


Figure 29: Final project

Source: Own elaboration

The only thing missing would be the resistor, the part of the project that performs the sealing. A manual sealer was purchased for the project, with the intention of disassembling and using its parts in the designed prototype. The resistor is installed in the front part of the project, with a wooden structure around it to fasten and join it to the frame by means of screws. Taking into account the fragility of the resistor, 2 components were needed, since one was a replacement of the first one due to tests and errors during the programming and operation of the same.

"It is important to emphasize that the basis for the proper functioning of almost any machine is in the cleanliness of the machine and the lubrication of the components that require it. These two tasks are the basic pillars for the optimal operation of the machine" (Frany & Ramos , 2018, p.156).

Once the sealer is installed on the frame, the electrical connections of the sealer are made.

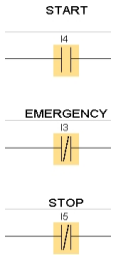
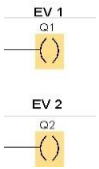
3.3 Programming

The programming was carried out using LOGOSoft Comfort software, using the Contact Schematic Diagram type or also known by its acronym KOP.

First, we set up the Logo configuration, parameterizing some features such as hardware type, I/O Names, I/O Password, Program Password, etc. In our case, we defined the hardware type as Logo! 8.1 & 8.2 (LOGO! 8.FS4).

To start with the programming, we determined the inputs and outputs of our project. Our machine needs two solenoid valves, which require air to be moved and converted into energy to allow the pistons to operate. However, this order must be directed by the PLC programming. Likewise, the same happens with the push button, our machine has a push button with three buttons (on, off, emergency), which will indicate the order of the activation of each solenoid valve. The inputs were established, which will be the buttons of the push button, depending on which button is pressed the order will be exercised. The Start button will have a normally open contact, the Stop and Emergency buttons will have a normally closed contact. The same procedure was done with the outputs, the solenoid valves will be our outputs and will be considered as coils.

Table 03: Inputs and outputs involved in programming

Tickets	Exits
	

Source: Own elaboration

Among the other instructions we used, there is the autoclave relay that allowed us to define the start and deactivation of the outputs by means of the signal sent by input I4 (start) and by inputs I3 and I5 (stop, emergency) respectively; also, we used a timer with an edge-triggered sweep relay that helped us to specify the duration of the time to start the impulse sent by the order and the duration of the impulse. We used this timer in both solenoid valves, taking into account that "the control of the temperature of the pulse jaws is achieved by regulating the period of the current pulse by means of an electronic timer and by regulating the voltage supplied to the resistor" (Quinga, 2010, p.9).

Solenoid valve 1 will start 5 seconds after pressing the push button, then it will start the piston descent, which will last 4 seconds, but in the middle of the time, after two seconds, solenoid valve 2 will start working and its impulse will last 7 seconds. After this time and the remaining two seconds of solenoid valve 1, both will return to their initial position. This process is repeated cyclically.

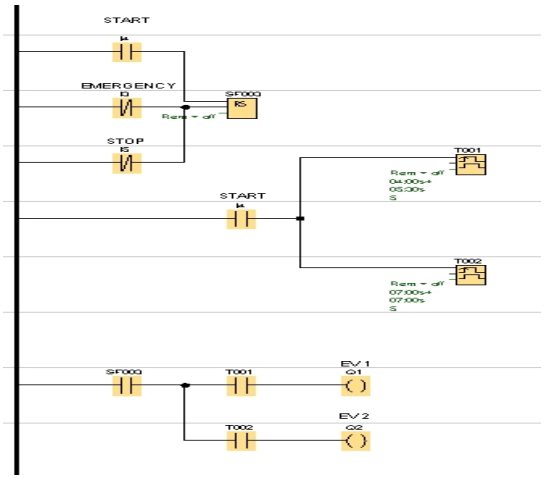


Figure 30: Capture of PLC programming Source: Own elaboration

4. CONCLUSIONS

How to design and manufacture a bag sealer to reduce bag sealing time and increase production capacity?

Basically it is designed from a sketch that will be represented and calculated in the SolidWorks application, where the drawing is made to scale, so that after the dimensioning of the galvanized iron frame that can be seen to measure to have a precision at the time of assembly of our components for automation.

How can we apply engineering knowledge to the development of the project?

- With the automation of the machine, it was possible to improve its operation from 70% to 100% in the sealing process in relation to the handling of the machine, reducing the ergonomic effort that the operator made with the previous process. The great advantage of selecting a pneumatic piston or actuator and not an electric motor is that the pneumatic actuators are very fast in their movements and they can be easily adjusted and take advantage of the air network of the factory and for its ease of adaptation and connection of the different parts that make up the pneumatic assembly.
- With the automation of the sealer, the plastic achieved a stronger bond and a more homogeneous appearance.
- As a result of the above, it was possible to reduce the sealing time and therefore increase the production of cereal bags.
- In closing we will say that automation is of great help to the industry, since it reduces time that can be invested in the production of more goods, which could increase the income of the companies if the demands are high.
- By means of the tests carried out it was possible to observe that the process of form manually the time and the pressure used was a disadvantage for what was very continuous to observe lost, with this implementation it is diminished and these two factors were found to obtain a better quality of the product.

5. ANNEX

Table 04: RPA evaluation of the manual sealing process of plastic bags Source: Own elaboration

ROBOTIC PROCESS AUTOMATION (RPA)

Nombre del Proceso	Sellado manual de bolsas plásticas
Descripción del proceso	La automatización del proceso, comienza cuando identificamos un proceso que se realiza repetitivamente sin la necesidad de tomar deciciones por un ser humano. En nuestro caso vamos a automatizar el proceso de sellado de bolsas.
Objetivos posteriores a la automatización	1. Reducir el tiempo del sellado de bolsas con un sistema de automatización. 2. Aumentar la capacidad de producción de bolsas selladas con un sistema de automatización.

Atributos del proceso	Escala de calificación de procesos	Puntuación de 1 a 5	Notas adicionales
¿Basado en reglas primarias, o muchas excepciones que requieren juicio humano?	Califique el proceso de su organización en una escala del 1 al 5 para este atributo. Una puntuación de 5 describe un proceso que sigue reglas estrictas que a menudo no requieren un juicio humano independiente; Una puntuación de 1 describe el proceso que a menudo necesita juicio humano	5	
¿Manual y repetitivo?	Una puntuación de 5 describe el proceso de un proceso que es altamente repetitivo y manual; Una puntuación de 1 describe un proceso que no suele ser repetitivo	5	
Datos estructurados o no estructurados	Una puntuación de 5 describe el proceso donde la mayoría o todos los datos del proceso están en un formato de estructura dentro de una base de datos y son fáciles de digitalizar; Una puntuación de 1 describe un proceso en el que la mayoría de los datos de proceso no están estructurados.	1	
Las entradas ya están digitalizadas o son legibles	Una puntuación de 5 describe el proceso donde las entradas del proceso están digitalizadas y son fácilmente legibles por los sistemas informáticos; Una puntuación de 1 describe un proceso en el que muchas entradas no están digitalizadas	1	

Atributos del proceso	Escala de calificación de procesos	Puntuación de 1 a 5	Notas adicionales
¿Proceso de alto volumen/alta frecuencia?	Califique el proceso de su organización en una escala del 1 al 5 para este atributo. Una puntuación de 5 describe un proceso que es de alto volumen o alta frecuencia dentro de la organización; Una puntuación de 1 describe un proceso de bajo volumen o baja frecuencia.	5	
¿proceso estable o uno que cambia con frecuencia?	Una puntuación de 5 describe un proceso estable que ha existido durante un tiempo dentro de la organización y no cambia a menudo; Una puntuación de 1 describe un proceso más nuevo o uno que cambia con cierta frecuencia.	5	
¿Proceso actual propenso a errores?	Una puntuación de 5 describe un proceso que es propenso al error humano; Una puntuación de 1 describe un proceso que experimenta pocos errores	5	
¿Habilidades del empleado transferibles?	Una puntuación de 5 describe un proceso en el que el talento y las habilidades de los empleados que realizan el trabajo podrían transferirse fácilmente a otras tareas dentro de la organización; Una puntuación de 1 describe un proceso en el que las habilidades de esos empleados no se pueden transferir se fácilmente a otra tarea.	5	
¿Efectos medibles?	Una puntuación de 5 describe un proceso en el que los efectos positivos o negativos de la automatización serían fácilmente medibles, en términos de tiempo para completar el proceso, tasa de error, etc.; Una puntuación de 1 describe un proceso en el que los efectos serían difíciles de medir	5	
Puntuación total	36+ El proceso es un buen candidato para automatizar 27 - 35 El proceso puede ser un candidato para automatizar 0 - 26 Actualmente no es un buen candidato para automatizar	37	

Figure 31: Team photo (from left to right) Alex Coaguila, Manuel Cuadros, Juan Morales, Jose Palma, Celso Jimenez, Adriana Ruiz, Marcelo Bashi.

Source: Own elaboration

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