UNIVERSIDAD RICARDO PALMA

COLLEGE OF ENGINEERING

PROFESSIONAL DEPARTMENT OF INDUSTRIAL ENGINEERING

DESIGN, PROGRAMMING AND IMPLEMENTATION OF AN ALUMINUM CAN COMPACTOR MACHINE

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Course:

Industrial Automation

2023-I

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SUMMARY

The present research work included the design, programming and implementation of an aluminum can compactor machine, which had the purpose of applying a force to reduce the initial volume of a can, thus allowing a better handling and storage.

The function of the machine was started by manually placing one can after the other and these fell in an orderly fashion into the next space where they were compacted with the help of an automatic actuator. The compacted can was then transferred to a collection container.

It was concluded that it can be strategically implemented in collection centers to promote recycling in places where there is greater use of metal containers, to facilitate and collaborate with aluminum recycling as a sustainable solution.

Keywords: aluminum, can, recycling, compacting, automation.

ABSTRACT

The present research work included the design, programming and implementation of an aluminum can compactor machine, whose purpose was to apply a force to reduce the initial volume of a can, thus allowing better handling and storage.

The function of the machine began by manually placing one can after another and these fell in an orderly manner towards the next space where they were compacted with the help of an automatic actuator. Subsequently, the compacted can went into a collection container.

It was concluded that it can be implemented strategically in collection centers, to promote recycling in places where there is greater use of metal containers, to facilitate and collaborate with aluminum recycling, as a sustainable solution.

Keywords: aluminum, can, recycling, compact, automation.

INTRODUCTION

Nowadays, aluminum can recycling is important, since it promotes the preservation of the environment, besides committing to sustainability in society; It is estimated that aluminum cans are very valuable materials for recycling, since their recycling process allows reducing the amount of waste in landfills, as well as saving energy and natural resources by producing new products from recycled materials, thus reducing the high use of energy used to obtain primary aluminum, where aluminum is considered a 100% recoverable material and the re-melting process only requires 5% of the energy needed to obtain primary aluminum. Worldwide, many countries are concerned about aluminum recycling, such as the United States, Japan, Brazil and European countries; where in Peru, due to the little initiative of the authorities, aluminum recycling is not promoted. Our country has a practically non-existent aluminum recycling system, so in recent years aluminum recycling has grown rapidly in foreign countries such as Brazil, and with this growth, there is an increasing innovation in articles related to this practice, such as the invention of machines to compact the cans to reduce the volume and be more transportable to the recycling centers.

Likewise, previous research that was conducted on can recycling; where research by Auburn University(2017) in the United States, examined the effects of compacting on the quality of recycled aluminum and found that compacting does not significantly affect the quality of the recycled material, another recent research is the one promoted by the University of Alicante(2022) in Spain, where it rewards people for recycling aluminum cans, In summary, foreign research on aluminum can compaction has shown that it is an efficient and cost-effective technique for reducing transportation and storage costs, thus improving recycling efficiency and reducing the environmental impact of the recycling process.

In this research work, we will develop a proposal of "Design, Programming and implementation of an aluminum can compactor machine", which seeks to encourage and teach the recycling of metal cans for the preservation of the environment, thus promoting the reduction of contamination of cans in garbage cans and in turn raise awareness of recycling in society.

Chapter 1: The theoretical framework is developed, where the theoretical foundations used and the objective of the project are explained.

Chapter 2: explains the detailed description of the current process, where the description of the process is made; in addition to the description and detail of the production indicators before automation.

Chapter 3 presents the current design of the process, where the 3D CAD plan of the current situation is plotted.

Chapter 4 presents the design proposal to automate the process, where the description of the proposed process, 3D CAD drawings of the proposed situation chosen, the analysis diagram of the proposed process, description of the materials, design of the electro-pneumatic circuit of the proposed process, programming of the process in LADDER language, as well as the description and detail of the production indicators after automation.

Chapter 5 presents the investment and operating costs, detailing the cash flow and economic viability (NPV, IRR) of the project.

The conclusions and recommendations of the project conclude the report.

Chapter 1: Theoretical Framework

1.1. Theoretical basis

1.1.1. Circular economy

Journal of Cleaner Production (2020), with its publication "Circular economy: A critical review"; the circular economy is vital to be developed between the public and private sectors, as this allows the promotion of environmental and economic sustainability among states; in addition to adopting a comprehensive approach that addresses social problems with sustainable production, generation and consumption.

In addition, Almeida, M., Diaz. (2020), with its publication "Circular economy, a strategy for sustainable development", where it is considered to be a topic of progressive interest, because the management of resources throughout the entire cycle must be reconsidered, to mitigate the impact on the environment and enabling the welfare of people and the environment.

Figure N°1: Circular economy transition

Source: Prometheo,2021

1.1.2. Metal Recycling

Some articles such as Quispe, A., Quispe, V. (2021), metal recycling is necessary for efficient metal recovery and must be promoted in collaboration between the public and private sectors, in addition to being a daily challenge, with limitations, adding the lack of access to resources and the environmental and social problems they face.

Figure N°2: Recycling metals: what to consider?

Source: DondeReciclo.org, 2016.

1.1.3. Environmental Impact

Journal of Cleaner Production (2020), where for the mitigation of environmental impact, the identification and evaluation of the environmental impacts of projects should be carried out, to improve transparency and public participation in the environmental impact assessment process. In addition, that the challenges and limitations of environmental impact assessment, should apply evaluation criteria, to address social and ethical issues related to environmental decision making.

Figure N°3: Environmental Impact

Source: RSS.2022

1.1.4. Industrial Automation

Saravanan, G., Karthikeyan, R. & Sivakumar, P. (2018), industrial automation, allows the improvement of productivity efficiency, for cost reduction and thus improve product quality. Also, that when applying industrial automation in a process it requires investment in technology, but the advantage is that it allows you to reduce operator intervention in the process.

Figure N°4: Application of industrial automation

Source: EDS Robotics, 2022

1.1.5. Programming of logic controllers

Fernandez, F., Fabero, J. (2019), The programming of logic controllers, is a technology that is present as an alternative more used in automation industries for its minimum cost, parallel processing capacity, allowing higher processing speed.

1.1.6. Process innovation

Corso,M.Prencipe, A., & Barnabé,F.(2018) process innovation allows you to improve efficiency, quality and makes production processes more flexible. In addition, that more investment in research and development is needed, so a culture of innovation in companies is necessary for a process innovation management.

Figure N° 5: Innovation, where and when does it originate?

Source: Universidad Anáhuac,2022

1.1. Objectives

1.1.1. General Objective:

Design, program and implement an aluminum can compactor machine throughthe theoretical and practical application of industrial automation.

1.1.2. Specific Objectives:

- Apply automation to improve the traditional process of an aluminumcan compacting machine.
- Build a structure that will allow the circulation of the cans to be crushed.

Chapter 2: Detailed description of the current process

2.1. Description of the process

The process of the aluminum can compacting machine consists of 3 stages. The first one is to manually position the empty cans in the feeding system, which consists of a 26° inclined ramp for the cans to move.

Two actuators, actuator A and actuator B, are located on the ramp.
B. Where the actuator A, placed at the end of the ramp, is activated to hold the first can. Actuator B limits the passage of the following aluminum cans, so that order is maintained and they do not fall one on top of the other, hindering the process.

Actuator A is deactivated and by gravity the first can falls into the second stage of the process where actuator C is located, which generates the force to compact the can and thus reduce its initial volume.

The third stage of the process consists of ejecting the compacted can that falls through the hole, and then transferring the metal to the recycling center.

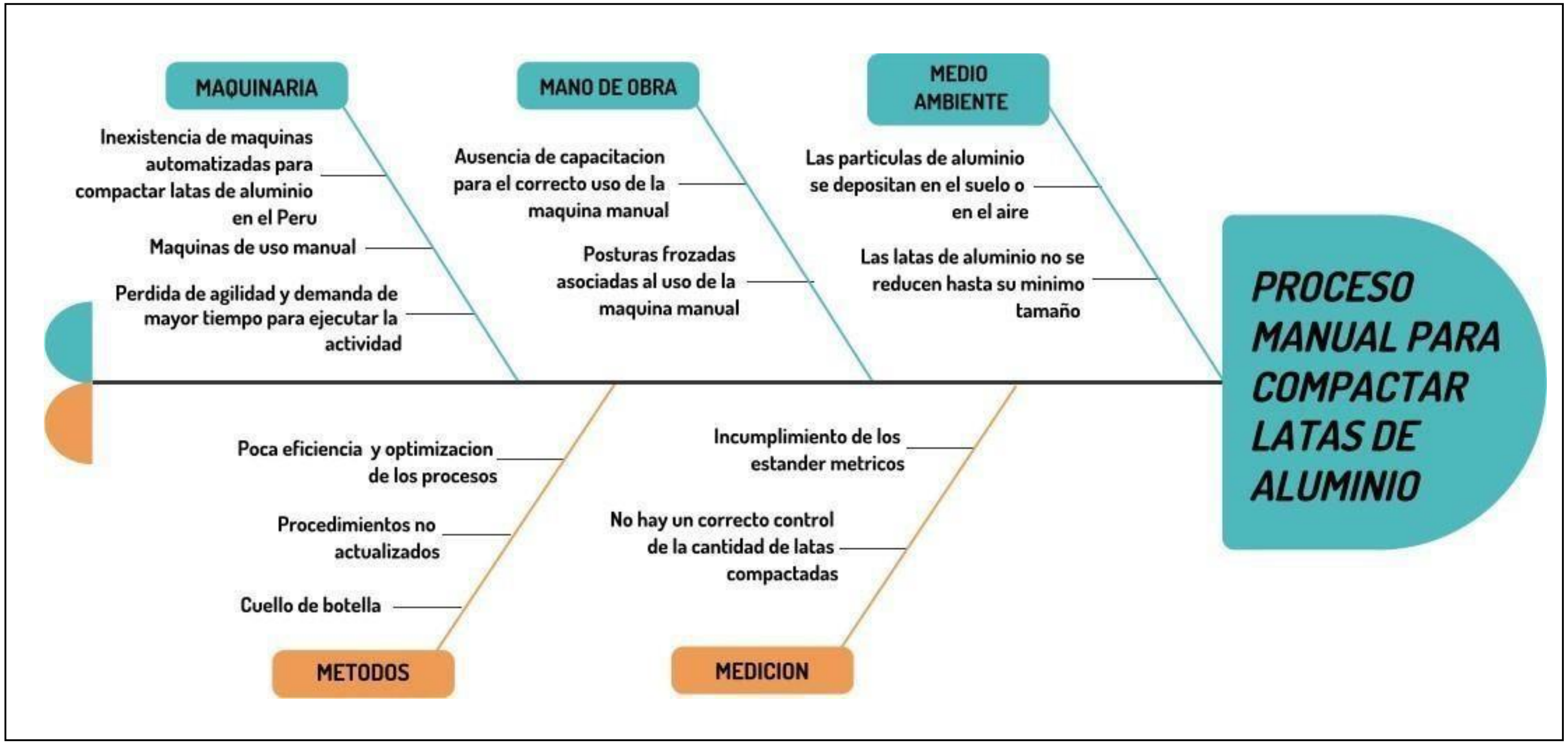

Figure N°6: Ishikawa Diagram

Source:Own elaboration

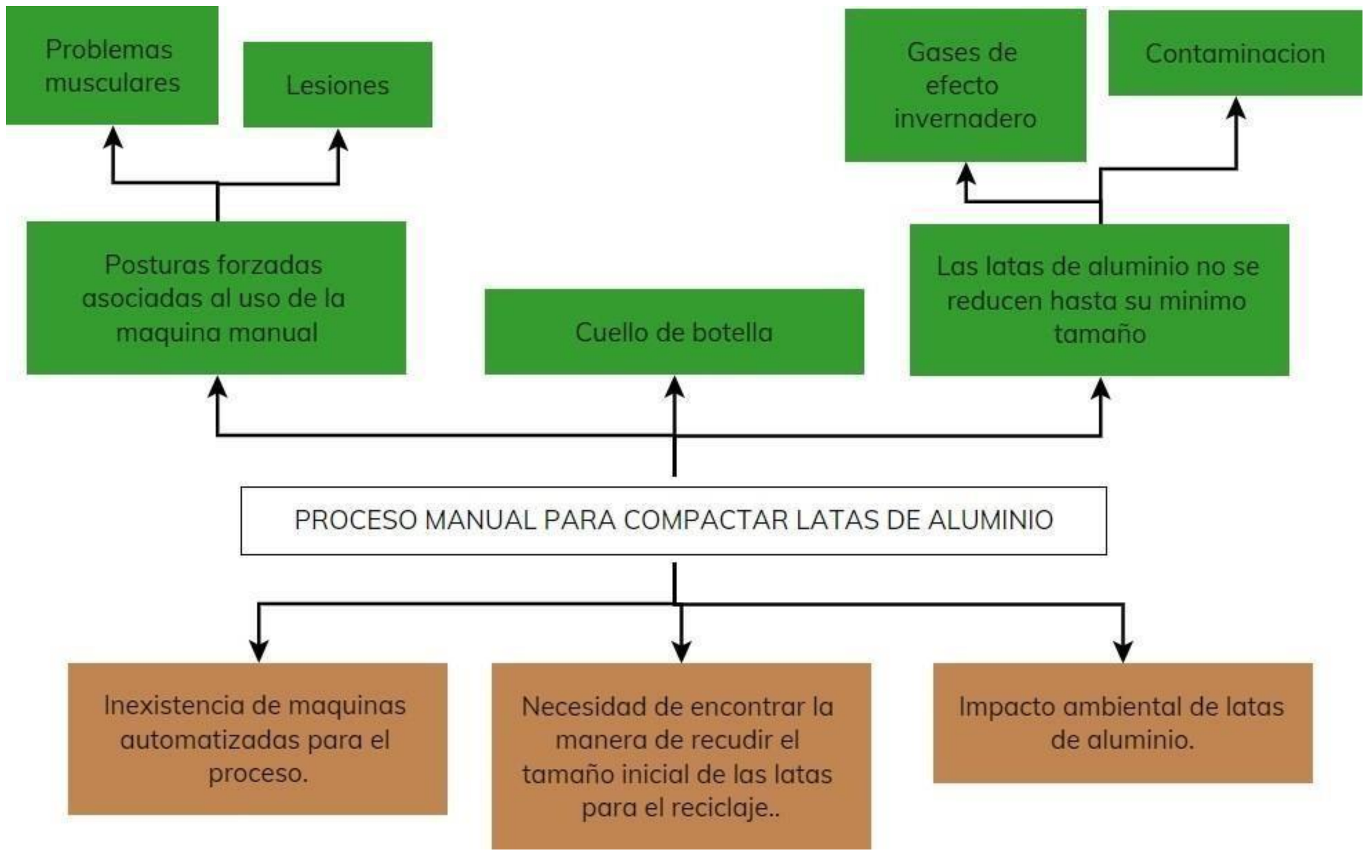

Figure N° 7: Problem tree

Source:Own elaboration

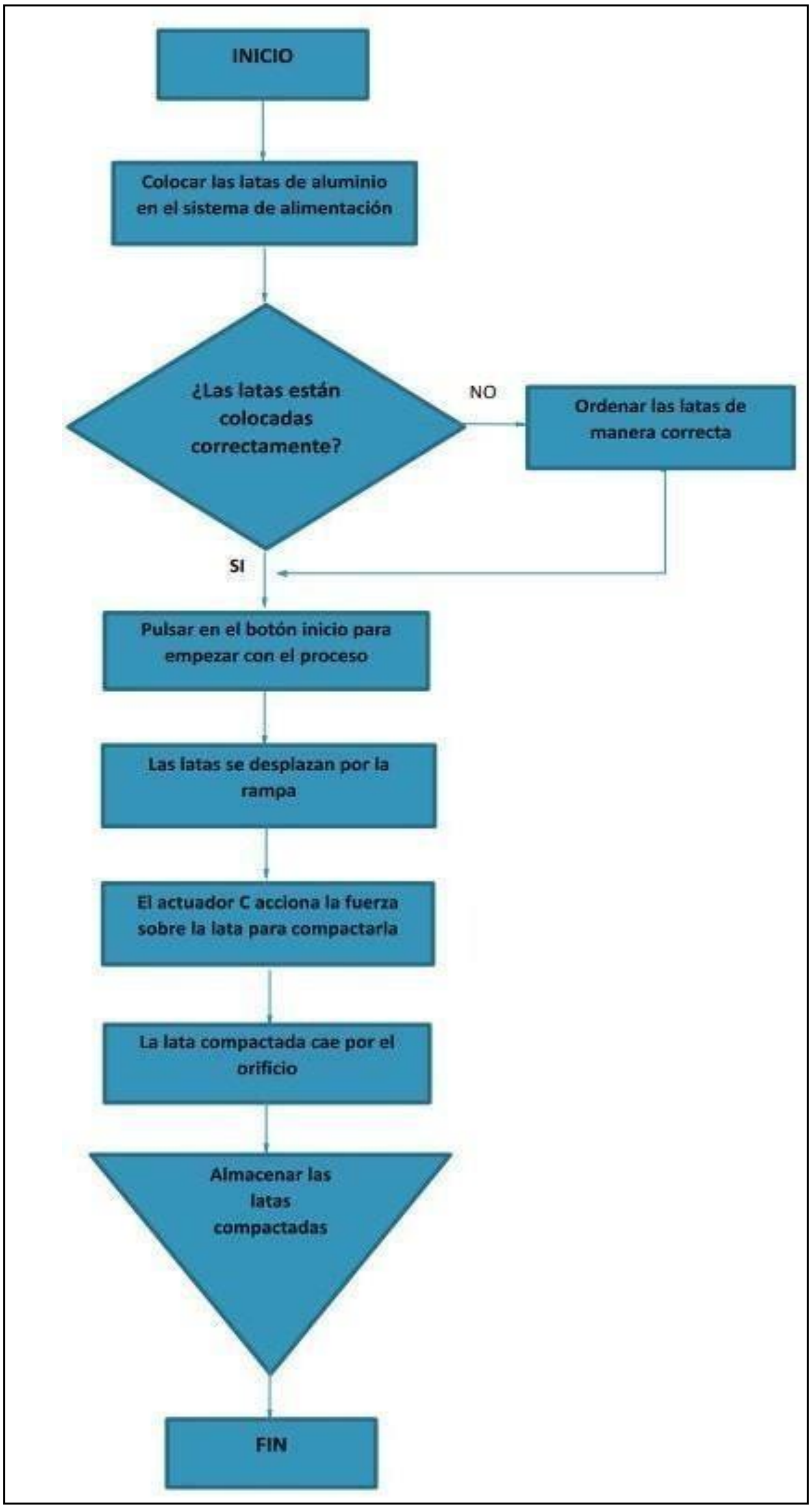

Figure N° 8: Flow Diagram

Source:Own elaboration

2.2. Description and detail of production indicators before automation

2.2.1. Number of products produced

The amount of cans compacted with the help of a manual compacting machine does not achieve the expected production. Therefore, an automated compacting machine was designed for higher productivity, higher throughput and thus reduced operating costs.

2.2.2. Productivity man/hour

It is applied by measuring the number of cans compacted per employee in an hour worked, by implementing an automated machine allows to measure the productivity of the employees who control the equipment. Productivity increases and gives the company the option to reduce the number of operators and only have supervisors.

2.2.3. Turnover rate

Turnover rate is an essential productivity metric used by professionals to measure employee retention. This indicator had not been taken into account and operators were being kept in a single area performing a single function. With machine automation, worker turnover is implemented leading to lower recruitment and training costs

Chapter 3: Current process design

3.1. 3D CAD drawings of the current situation

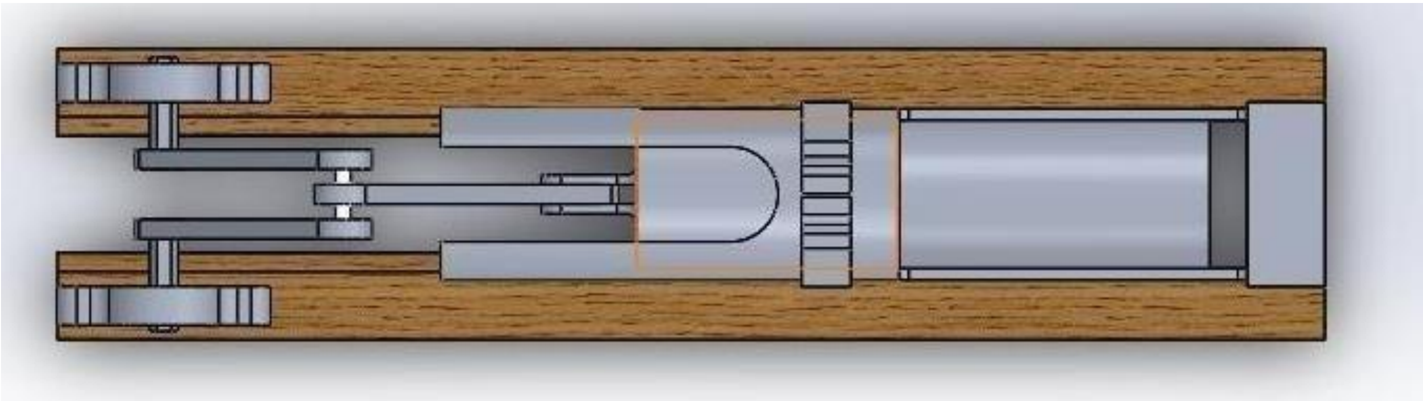

Figure N° 9: Plan view

Source:Own

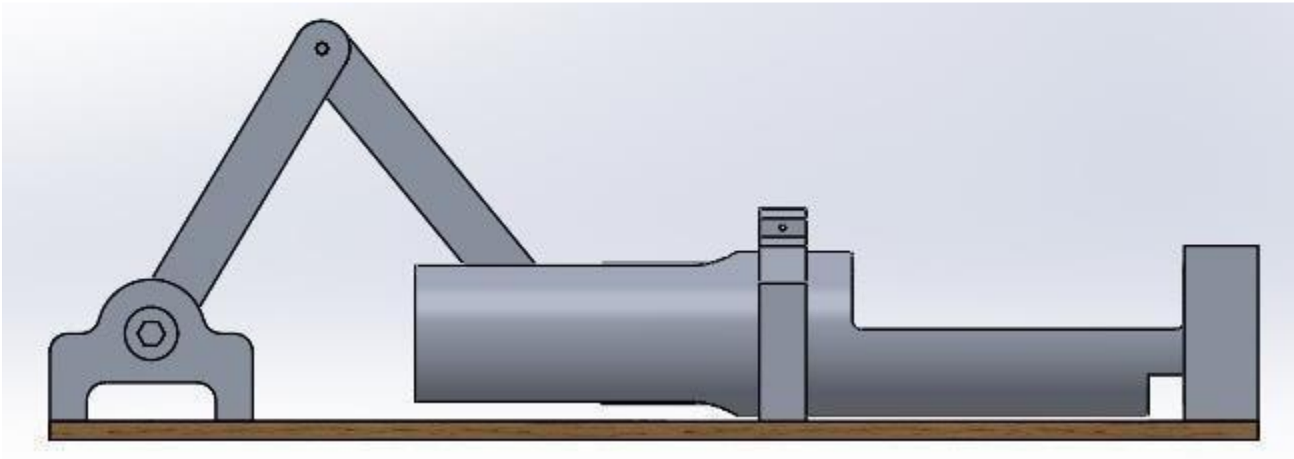

Figure N° 10: Left lateral view

Source:Own

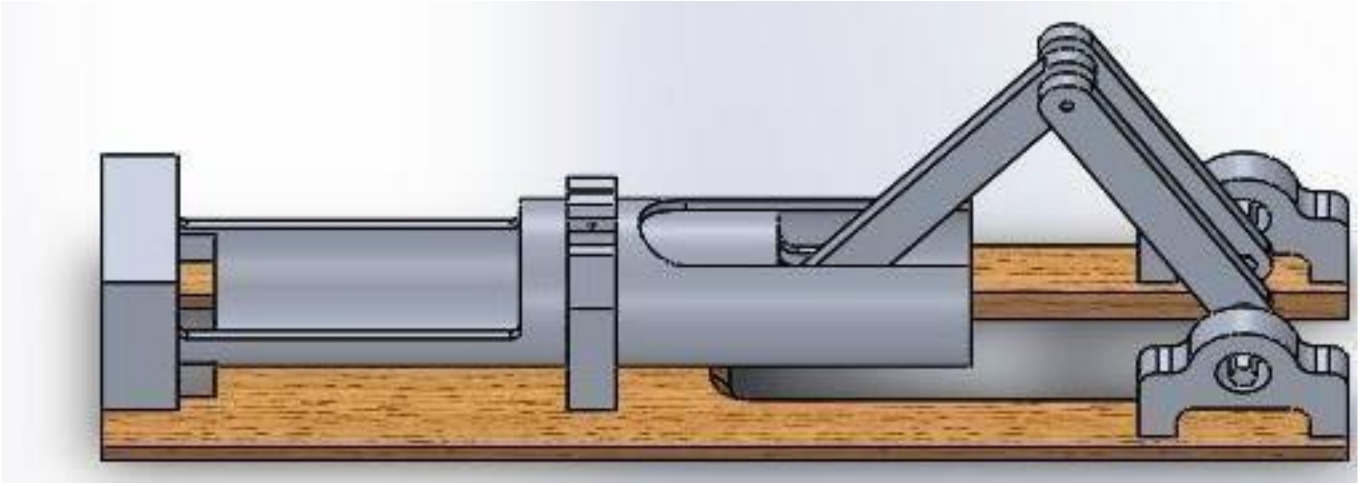

Figure N° 11: Right side view

Source:Own

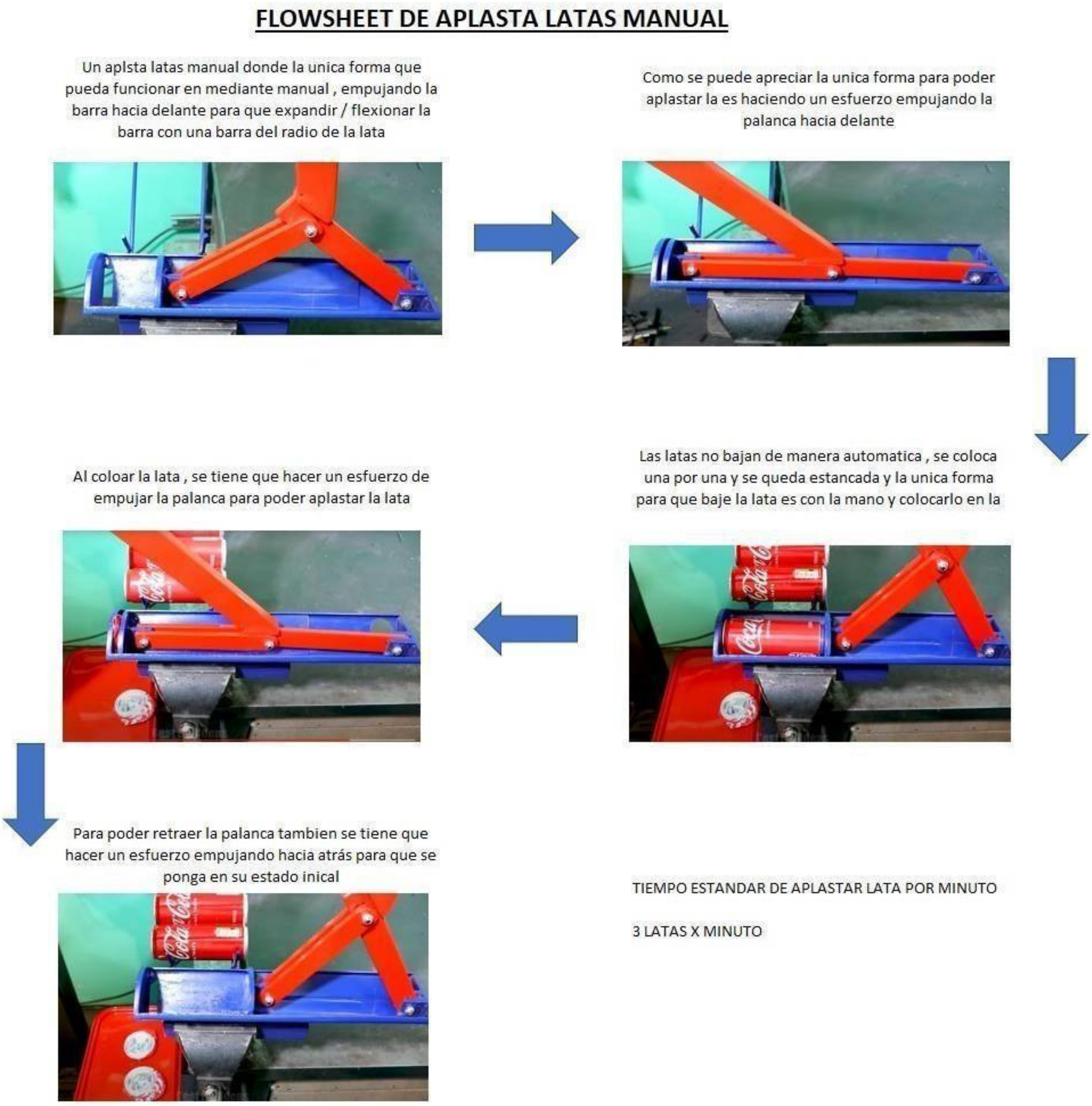

Figure N° 12: Manual Can Crusher Flowsheet
Source: Own

Chapter 4: Design of a proposal to automate the process

4.1. Detailed description of the proposed process

It is proposed that the aluminum can compacting machine will consist of 3 stages; where the first stage will manually position the empty cans in the feeding system, which consists of a 26° inclined ramp to move the cans.

Where the ramp is located two actuators, Actuator A and Actuator B. In which actuator A is placed at the end of the ramp, where it is activated to hold the first can. For which actuator B limits the passage of the following aluminum cans, so that an order is maintained and does not fall one on top of the other, hindering the process.

Then the actuator A is deactivated and the first can falls by gravity to the second stage of the process where the actuator C is located, which generates the force to compact the can and thus reduce its initial volume.

At the end of the third stage of the process, the compacted can is ejected from the can, which falls through the hole, and the metal is then transferred to the recycling center.

4.2. 3D CAD drawings of the proposed scenario chosen (must show each component in a different color) or video of the improved scenario

Figure N° 13 Plan View

Source:Own

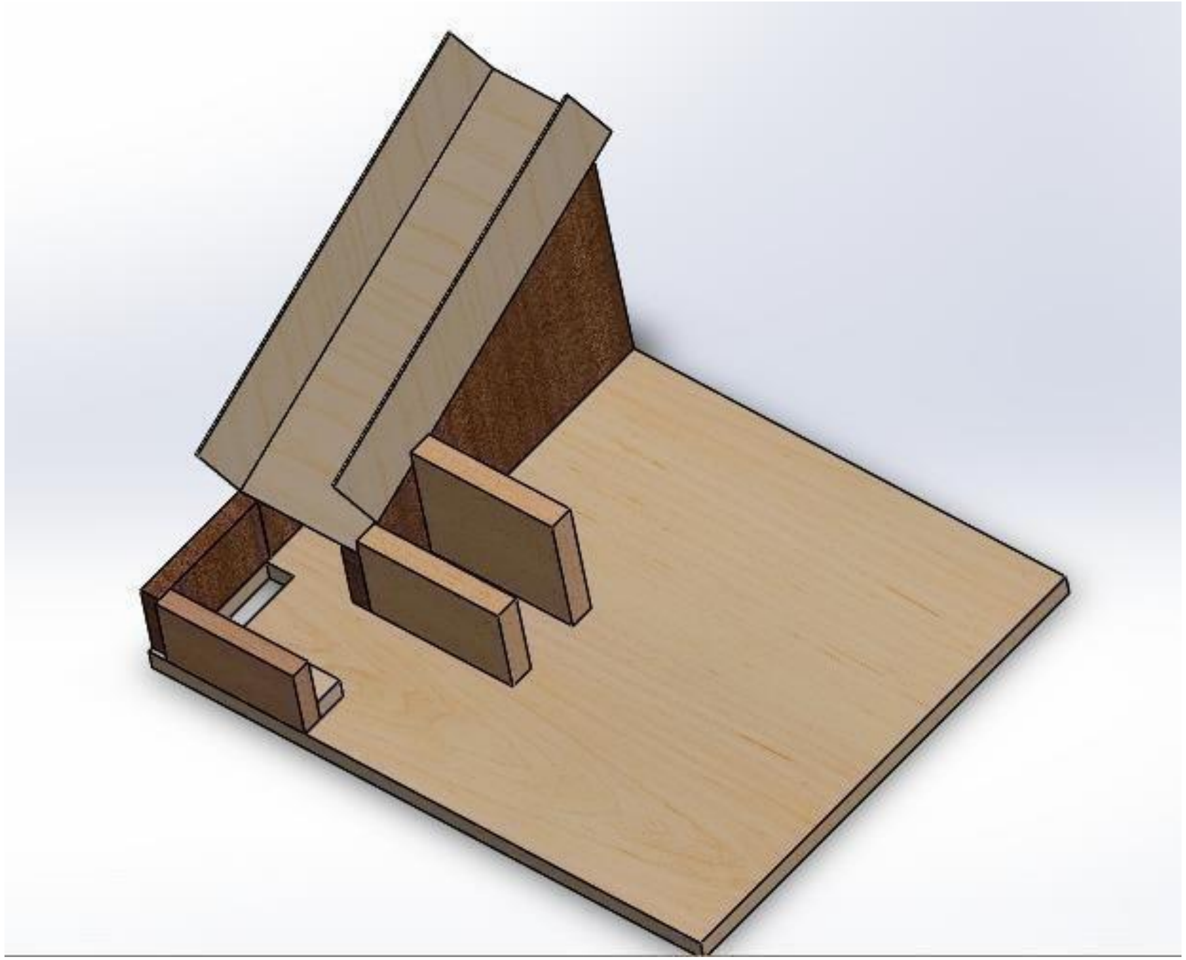

Figure N° 14 Elevation View
Source: Own

Figure N° 15 Rear View
Source: Own

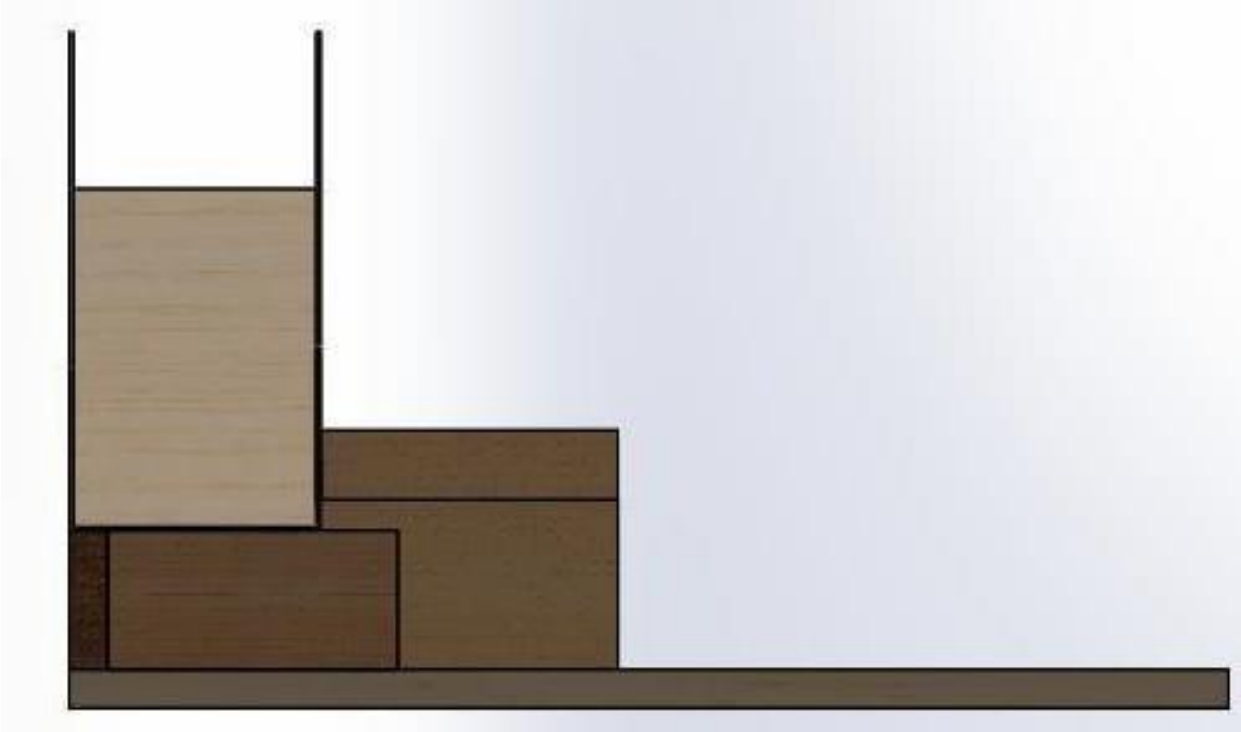

Figure N° 16 Profile View
Source: Own

4.3. Analysis diagram of the proposed process

DESCRIPCCIÓN	Cantidad	Tiempo (min)	ACITIVIDAD						OBSERVACIONES
			●	■	◗	➡	▼	○	
PRIMERA ETAPA									
Colocar latas de alumnio a la rampa.	6	1.00	•						Se ingresan latas de forma cilindricas , en la rampa de la estructura.
Verificar que las latas esten colocadas correctamente.	1	0.75		•					Se debe de verificar que las latas de alumnio esten colocada en la posicion adecuada en la rampa.
La primera lata de alumnio baja por la rampa.	1	0.03				•			La lata de alumnio desciende hasta el final de la rampa.
Actuador A , se activa para sotener la primera lata.	1	0.05			•				El actuador A esta colocado al final de la rampa.
Las latas de alumnio restantes bajan por la rampa.	5	0.03				•			La demás latas desciende por la rampa , pero son limitadas.
Actuador B , se activa para limita el pase de las siguientes latas de aluminio.	1	0.05			•				El actuador B limita el pase ,para que se mantenga un orden y no caiga una sobre otra.
SEGUNDA ETAPA									
El actuador A se desactiva y por gravedad cae la primera lata de alumnio.	1	0.03			•				La lata de alumnio pasa a la segunda etapa del proceso.
La lata de alumnio se posiciona.	1	0.02				•			La primera lata se posiciona para ser aplastada
El actuador C, se activa y compacta la lata de aluminio.	1	0.17	•						El actuador C , se activa y aplasta la lata de alumnio y reduce su volumen inicial.
TERCERA ETAPA									
La lata de alumnio es expulsada.	1	0.03				•			La lata de alumnio es explusada.
La lata de alumnio compactada que cae por el orificio, para su almacenaje.	1	0.05					•		La lata de alumnio compactada , pasa a alamcenaje
TOTAL	20	2.21							

RESUMEN TOTAL	Tiempo (min)	●	■	◗	➡	▼	○
	2.21	2	1	3	4	1	0

CICLO POR ACTIVIDAD (min)	●	■	◗	➡	▼	○
	1.17	0.75	0.12	0.11	0.05	0

Figure N° 17: Process WTP
Source: Own

4.4. Detailed description of the materials to be used

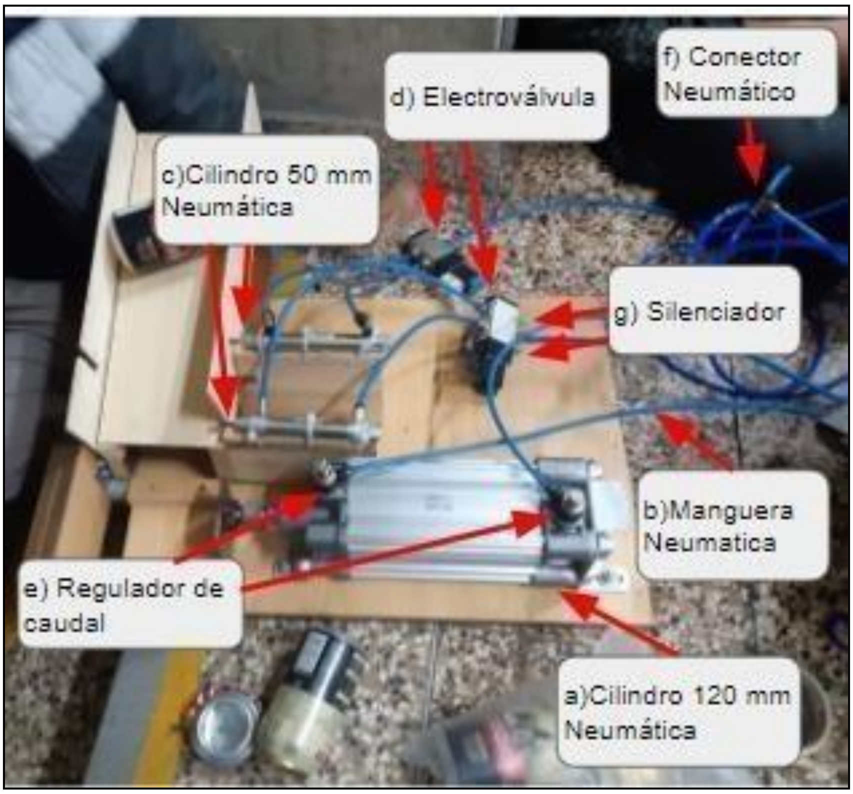

Figure N° 18: Parts and materials used Source: Own

a) Pneumatic Cylinder 80 x 125 mm

For the project, a Pneumatic Cylinder of 80 mm diameter and 125 mm stroke was purchased. The purpose of using the cylinder will be to crush or compress any type of solid up to a certain admissible force. In the project, the cylinder will play a fundamental role in the process, since it will allow us to compress the soda or beer can in an extremely small size, achieving a lower volume, less risk and less time.

b) Pneumatic Hose

For the project, about 1000 mm were purchased to be able to perform the distribution of compressed air throughout the system. This will deploy the compressed air through various actuators and electro-pneumatic valves.

c) Small Pneumatic Cylinder 50 mm

For the project, two short-range pneumatic cylinders were used at 50 mm stroke to allow the metal bottles to move in a staggered and orderly, cascading fashion. This will allow each bottle to drop periodically, making a clean and orderly process.

d) **Solenoid valve**

In order to transfer the compressed air and perform internal movements for the project to be executed, 5/2 24VDC solenoid valves will have to be used for effective distribution. Three solenoid valves will be used in the project for each different actuator.

e) **Flow Regulator**

For the project, two flow regulators were acquired, making the system more efficient and controlling the displacement of each pneumatic cylinder where these types of regulators are placed. The purpose will be that we will be able to control the movement of the piston rod along its path.

f) **Pneumatic connector 1/4 x 8mm**

Thirteen pneumatic connectors were purchased for our different types of actuators and solenoid valves, where the compressed air will move along the system. This will allow greater safety for the connection of the compressed air tubes. The type of pneumatic connector to be used is ¼ x 8 mm.

g) **1/8 bronze muffler**

As part of decompressing the noise of our actuator, two ⅛ bronze mufflers were purchased so that the radial noise levels at the time the compressed air can significantly reduce, this will allow for a less noisy and higher quality process.

4.5. Design of the electro-pneumatic circuit of the proposed process.

The sequence assigned for our project will be subject to the displacement of the aluminum sheet cans A+ B+ A- C+ C- B-. It should be noted that the sequence (+) means the extension of the pneumatic cylinder, otherwise (-) means the retraction sequence.

The design is proposed using the FluidSIM simulation tool, following the following process:

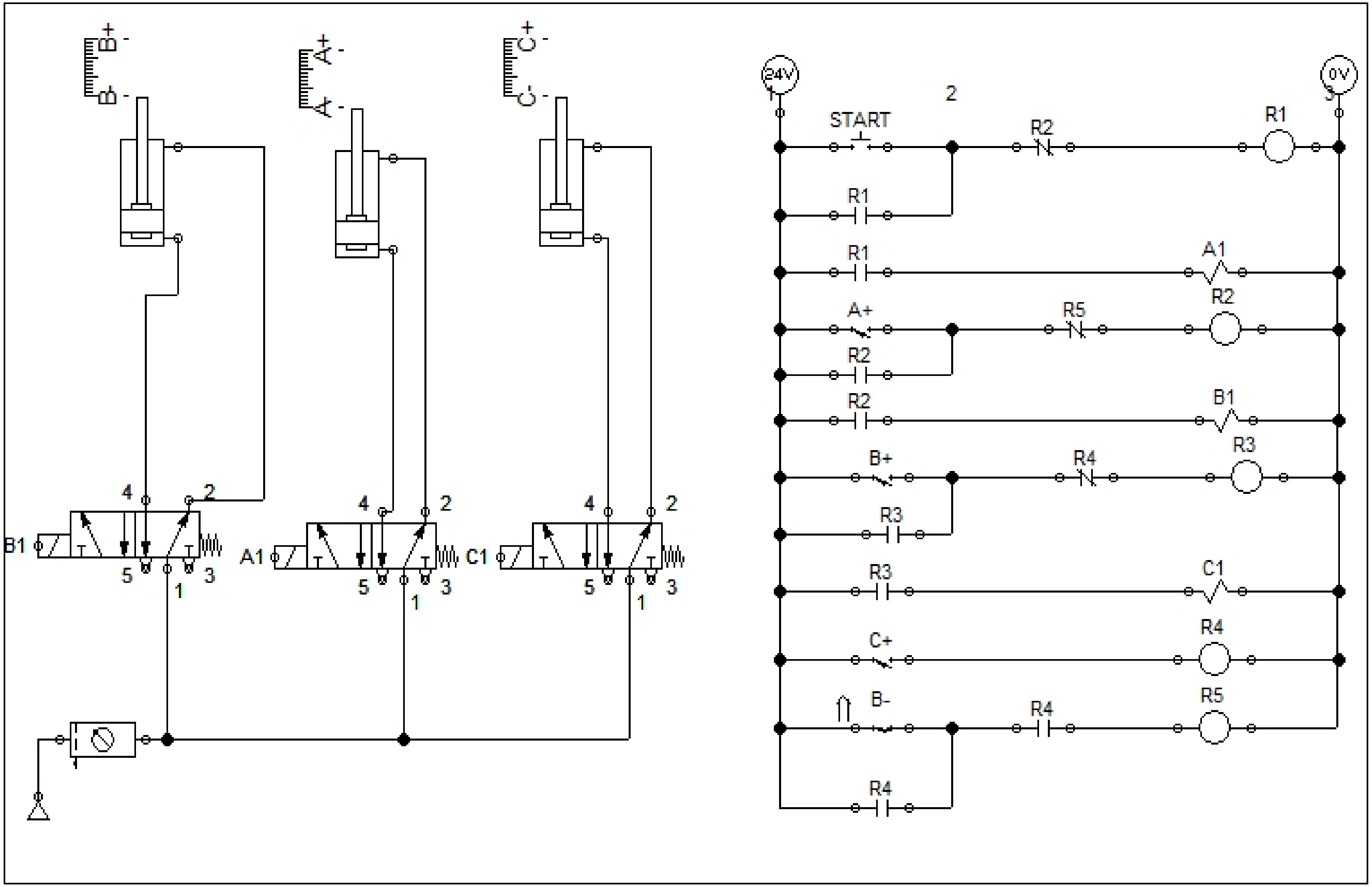

Figure N° 19: Electropneumatic circuit design of the proposed process
Source: Own.

4.6. Ladder programming of the process (comment on each of the segments used in your ladder programming).

Once the PLC has been acquired, a circuit will have to be created with ladder language in order to diagram and structure the operation of the system through the pushbuttons identified in the electro-pneumatic circuit.

In the simulation of our system, the synchronization of the three pneumatic cylinders of the project will be shown.

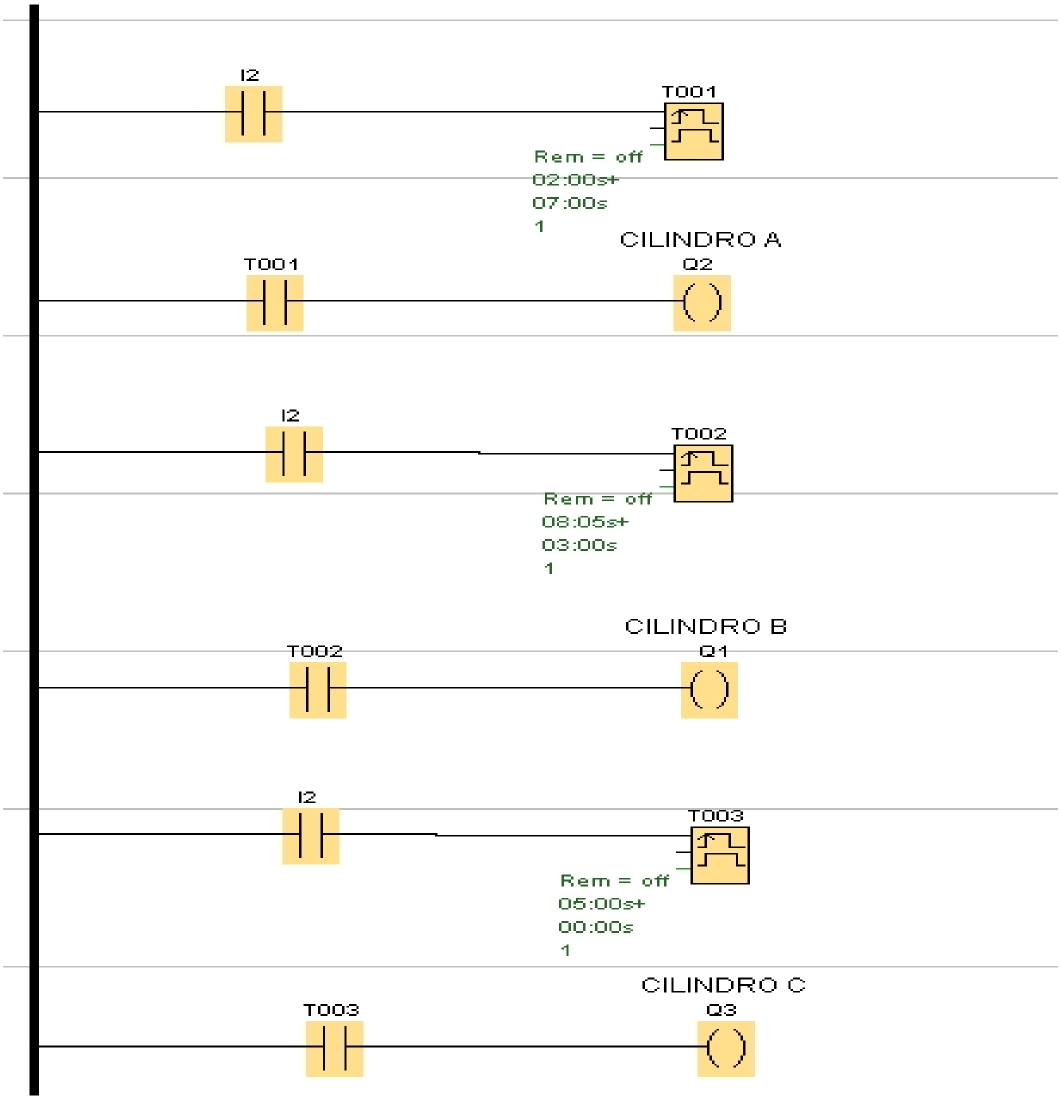

Figure N° 20 Electropneumatic circuit design in Logo
Source: Own.

4.7. Description and detail of production indicators after automation.

4.7.1. Quality Control:

An automated can crusher increases the production quantity with improved quality using fewer resources, compared to the manual method of a can crushing machine, which was a great improvement.

4.7.2. Production speed:

When comparing an automated process with a manual one it is evident that there is a difference in production speed and by using electro-pneumatics it is possible to improve process times. This will be measured by the amount of cans the machine can crush in a predetermined period of time using the units per hour or minute.

4.7.3. Performance:

We will measure the ratio between the quantity of cans produced and the theoretical maximum quantity that will be produced under ideal conditions. A high yield will indicate an efficient use of the machine and resources.

4.7.4. Power consumption:

Measuring the energy consumption of the can crusher can be useful to evaluate energy efficiency and make improvements in case of high consumption levels.

Chapter 5: Investment and operating costs

Proof of payment

Racor 6mm 3/8 = c/u S/ 12.00 se compro 2 unid.

NEUMATICA INDUSTRIAL NELY E.I.R.L

RUC: 20602200681
AV.ARGENTINA N°523 INT F-1 LIMA-LIMA-LIMA
CEL: 994010827 EMAIL: nelysar20@hotmail.com

FECHA:	20/04/2023
RUC:	
NOMBRE:	LEONARDO
REFERENCIA:	

BOLETA	4236

ITEM	CANT.	DESCRIPCION	MARCA	P/U	PT
1	1	PISTON NEUMATICO 80X125		S/300.00	S/300.00
2					
3					
				TOTAL:	S/300.00

DATOS ADICIONALES	
PAGO:	CONTADO
ENTREGA:	INMEDIATA
IGV (18%):	SI INCLUYE

0

NRO CUENTA .
BCP(SOLES) : 191-2438696-0-91

NELY E. SARMIENTO CCOSCCO
GERENTE GENERAL

Repuestos Industriales DENNIS E.I.R.L.

REPUESTOS INDUSTRIALES DENNIS E.I.R.L.

Av. Argentina 523 tienda C6 C.C. "ACOPROM" Cercado de Lima-Lima
NEUMÁTICOS, HIDRÁULICOS Y ELECTRICOS
Vendedor: Renee
991803080
dennis.rfdc@gmail.com

PRESUPUESTO
EST098

FECHA
27-05-2023

TOTAL
PEN S/.6.60

TO

Señores: UNIVERSIDAD RICARDO PALMA

ARTÍCULO	TARIFA	CANT.	TOTAL
Manguera neumática de 6mm. AST	S/.2.20	3	S/.6.60
x	S/.0.00	1	S/.0.00

TOTAL PARCIAL	S/.6.60
IMPONIBLE	S/.5.59
IGV (18%)	inc S/.1.01
TOTAL	PEN S/.6.60

INTRODUCCIÓN DE PAGO
Transferencia Bancaria
BCP cuenta corriente
Soles: 191-2593747-0-62
CCI: 00219100259374706250

Repuestos Industriales DENNIS E.I.R.L.

REPUESTOS INDUSTRIALES DENNIS E.I.R.L.

Av. Argentina 523 tienda C6 C.C. "ACOPROM" Cercado de Lima-Lima
NEUMÁTICOS, HIDRÁULICOS Y ELECTRICOS
Vendedor: Renee
991803080
dennis.rfdc@gmail.com

PRESUPUESTO
EST093

FECHA
25-05-2023

TOTAL
PEN S/.82.30

TO

Señores:

ARTÍCULO	TARIFA	CANT.	TOTAL
Conector neumático recto 1/4x8mm. AST	S/.2.60	3	S/.7.80
Electroválvula 5/2 de 1/4 de 24vdc AST	S/.60.00	1	S/.60.00
Manguera neumático de 8mm. AST	S/.2.50	3	S/.7.50
Silenciador de 1/8 bronce	S/.3.50	2	S/.7.00

TOTAL PARCIAL	S/.82.30
IMPONIBLE	S/.69.75
IGV (18%)	inc S/.12.55
TOTAL	PEN S/.82.30

INTRODUCCIÓN DE PAGO
Transferencia Bancaria
BCP cuenta corriente
Soles: 191-2593747-0-62
CCI: 00219100259374706250

DESCRIPCION	CANTIDAD	PRECIO UNIT	PRECIO TOTAL
Cilindro Neumatico 80x125	1	S/ 300.0	S/ 300.0
Electrovalvula de 5/2 -1/4 6mm 24V	1	S/ 60.0	S/ 60.0
Electrovalvula de 5/2 -1/4 6mm 24V 2da	2	S/ 50.0	S/ 100.0
Racor Regulador 6mm 3/8	2	S/ 22.0	S/ 44.0
Triplay	1	S/ 10.0	S/ 10.0
Conectores 1/4 6mm 2da	10	S/ 3.0	S/ 30.0
Conectores 1/4 6mm	3	S/ 2.6	S/ 7.8
Manguera 8mm 3m	1	S/ 7.5	S/ 7.5
Cilindro Neumatico	2	S/ 65.0	S/ 130.0
Silenciador de 1/8 bronce	2	S/ 3.5	S/ 7.0
Manguera 6mm 3m	1	S/ 6.6	S/ 6.6
Melamine	1	S/ 10.0	S/ 10.0
Perno	6	S/ 1.0	S/ 6.0
Arendales precion	8	S/ 0.5	S/ 4.0
Arendales de fijacion	12	S/ 0.5	S/ 6.0
Arendales gruesas	4	S/ 1.0	S/ 4.0
Tornillo	8	S/ 0.4	S/ 3.2
Transporte	1	S/ 84.0	S/ 84.0
TOTAL			S/ 820.1

5.1. Cash flow

The total cost for the factory of a can crushing machine was s/.820.10, we take this cost as a reference and we will obtain income for the machine's operating time, counting the time of use and the depreciation that it may generate.

We will earn our profits from the time of use of our can crushers and will be charged by the hour.

PRECIO POR HORA DE USO	5	Soles
TIEMPO DE USO	5	Horas
Año	100	Dias
Ingresos anuales	2500	Soles

Our can crusher will have a useful life of 5 years working 100 days per year and a residual value of 15% of the initial price.

Valor de venta	1500	Soles		
Vida Util	5	años	Depreciacion	
Valor residual	15%		VL-R=	119.02
Total de inversion	820.1	Soles	#AÑOS	
VR=	225			

	0	1	2	3	4	5
MAQUINA	820.1	701.08	582.06	463.04	344.02	225
DEPRECIACION		119.02	119.02	119.02	119.02	119.02

Valor de mercado de 5°Año	1500
Tasa impositiva	20%

RAF (5°AÑO)	1245

FLUJO DE CAJA DE UN APLASTALATAS

DESCRIPCION	0	1	2	3	4	5
INGRESOS		2,500	2,500	2,500	2,500	2,500
Costos		900	900	900	900	900
Depreciación		119	119	119	119	119
GANANCIA ANTES IMP.		**1,481**	**1,481**	**1,481**	**1,481**	**1,481**
IMPUESTOS (30%)		444	444	444	444	444
Depreciación		119	119	119	119	119
FCO		**1,156**	**1,156**	**1,156**	**1,156**	**1,156**
RAF						1,245
FI	**-820**	**0**	**0**	**0**	**0**	**1,245**
FCE	**-820**	**1,156**	**1,156**	**1,156**	**1,156**	**2,401**
TIR	142%					
COK	10%					
VAN	4,333.98					

5.2. Economic viability (NPV, IRR).

Our economic viability was found in relation to a can crusher having an opportunity cost of capital of 10%, completing our cash flow with 5 years of projection shows us an IRR and our NPV positive so it is concluded that our investment will produce profits.

Conclusions

- This project fulfills the main objective, which is to design, create and build an aluminum can compactor machine thanks to the application and practice of the industrial automation course.

- The machine is able to reduce the initial volume of the can, so that it can be stored in a smaller space.

- The final product will be used for recycling, benefiting the environmental impact.

- The automated machine reduces operator fatigue and ensures the possibility of reducing the risks and dangers that the operator was exposed to at the beginning when using a manual machine.

- The automated system frees operators from having to perform routine functions, allowing them to carry out more value-added tasks.

- This design allows to automate the process, allowing a continuous production at a rate of approximately 4 cans per minute. Improving productivity and reducing times.

Recommendations

- Perform preventive maintenance to the machine if necessary, so that it does not cut the flow of work due to any failure.
- Train the personnel that will use the machine for a correct performance of their functions.
- Verify that the cans to be compacted do not contain liquids or are not wet. If so, discard the liquid beforehand.

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