TECHNICAL UNIVERSITY OF NORTH

FACULTY OF ENGINEERING IN APPLIED SCIENCE OF ENGINEERING IN MECHATRONICS

WORK DEGREE PRIOR TO OBTAINING THE DIPLOMA OF MECHATRONICS ENGINEER

SUBJECT:

"LINING MACHINE AUTOMATIC OF CAPS PLASTIC OF FORTY MILLIMETERS IN DIAMETER, FOR SERIES PRODUCTION PROCESSES"

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Lining machine automatic of caps plastic of forty millimeters in diameter, for series production processes

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***Overview* - This document presents a system of lining of caps in fast, accurate and safe way according to rules and techniques of industrial production, without the need to do it manually as it comes to do so in small and medium-sized plastic industries.**

The implementation of the lining machine the user to maintain the constant production of caps with liners, the system is mainly based on electro elements visible tires in the industrial market coupled with mechanical elements of manufacturing machines and tools.

I. INTRODUCTION

INDUPLAST S.A. It is an industry, which is engaged in the design and manufacture of plastic lids in various sizes (diameter, height and weight), which depend on requirements and specifications demanded by the customers; this industry is characterized by a broad market for distribution and marketing.

The company is located Cayambe city for some years manufactures and distributes plastic bottles from thirty cubic centimeters up to ten thousand cubic centimeters, to companies such as: Dulacs, San Luis, Ecualac, among others, each of dairy containers with their respective caps.

In addition to the production of caps and plastic containers, it has a process of lining whose function is to guarantee the hermetic of the cover at the time of its use, which has forced to equip its system of lining with automatic equipment of series production.

II. MAKING OF CAPS

In general, a plastic is a flexible, tough, heavy and insulating material of electricity and heat. It is used much in the industry because it is easy to make and shape, is economical, lightweight and supports a wide variety of colors pigments. In addition, can be combined with other materials and thus improve their properties.

The manufacture of plastics and their manufactured involves two basic steps: obtaining the raw materials and molding or deformation of the plastic until its final form. Below is a brief description of the daily routine of the factory to obtain caps lining, see figure 1.

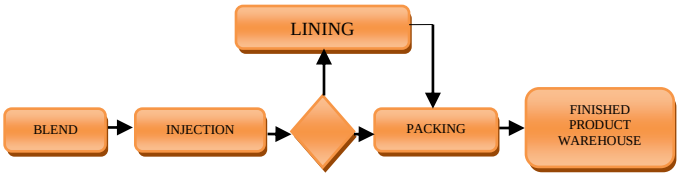


***Figure 1*:** Diagram of the production of caps (Lesther, 2008).

III. LINING CONCEPTS

A. Lining

It is placed on the different models of caps, types of materials such as cardboard, foam, aluminum, induction and EVA so that you have a perfect fit between the lid and the container that contains it. Each system is designed and manufactured, in accordance with the characteristics of tops and at the required speed. The process can be manual, automatic or semi-automatic.

The function of lining machine is automatically place the liner at the top ensuring the tightness of the object at the time of its use, ensuring the quality and safety of products. Companies choose to use caps bearing the material known as "liner", to meet the standards and policies which are governed.

B. Liner

It means liner (lining), material that is placed or attached on the inside of lid (see Figure 2), which complies with the function of giving greater air-tightness, as well as a better seal and greater security to the contents of the package. (Lesther, 2008).

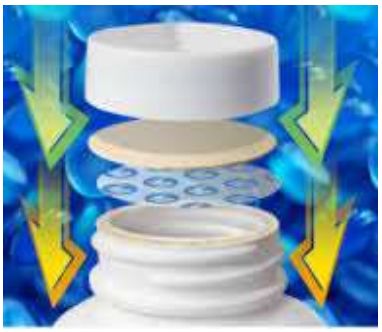


Figure 2: Liner (Facarlyte Cap Liners & Seals, S.A., 2015)

Induplast factory liner is purchased from an outside company, the object is made of expanded polyethylene foam, ideal general purpose coating, to be placed on the lids creates a stable seal which has good chemical resistance against acids, alkalis, solvents, alcohols, oils, cosmetics and household products.

C. Plastic cap

The plastic cap is a moving part that closes or covers the top of a bottle, jar or container in general, which is made with petroleum-based products (thermoplastic), and whose resistance will be depending on the type of raw material used.

It is necessary to indicate that thermoplastics have increasingly more applications in industrial sectors and consumer, which includes the manufacture of plastic caps.

The lining caps in the project shown in Figure 3.

Figure 3: Plastic caps lining

Tops that are shown in Figure 3 have the following characteristics:

- d: 40[mm] Diameter
- h: 17[mm] Height
- e: 1.25[mm] Thickness
- m: 3[g] Mass
- δ: 900[Kg/m^3] density

IV. LINING PROCESS

Commercialized caps are lining, since thus maintaining the quality and safety of the product contained in the package.

The best way to optimize the resources is through the implementation of an automatic system of lining, especially for tops 40[mm] in diameter, since they are the most commercialized within the country with their respective containers, depending on the customer's need.

Table 1 shows the processes that they intervene in the lining caps, these subsystems are essential regardless of the material model.

Table 1: *Inclusion of plastic caps liner subsystems*

SUBSYSTEM	DESCRIPCION
Alimentation	The caps are fed and oriented leaving feeder and rhythmic way to be transported in one or more channels.
Translation	Conveyor takes caps that are ordered from the feeder, which are directed in a controlled manner to the subsystem of the liner are inserted in which.
Position	This subsystem for or stops the movement of caps, fixed so then the liner is placed in an exact position
Insertion	It is the final stage before being stored, which comes to be the central objective of the project, the inclusion of liner in each one of the covers.
Control	This system covers all the automatic control of the pneumatic and electric actuators that are involved in the overall system.

A. Requirement's project

It is assembling a system of automatic lining in a continuous production environment. Factory has high capacity injectors; these produce caps steadily due to the high demand for products, parallel and series blower with the containers needed to compensate for this need.

Elements the lining caps.

The production cycle ends with the implementation of a machine for insertion of liners; the speed of this machine is capable of compensating for the production of the aforementioned teams.

The elements listed below are generalized, they are not are detailed as it performs in the subsequent sections of this document

Pneumatic actuators

The energy of compressed air becomes by means of cylinders in a linear motion back and forth, and by means of pneumatic motors, rotational movement.

Double-acting cylinders (see Figure 4) are those that perform both kick his career forward by compressed air. Its name is because it used the two sides of the piston (air in both houses), by which these components that can work both ways.

Rotary actuators (see Figure 4) are responsible for transforming the pneumatic energy into mechanical energy of rotation, depending on if the mobile turn has a limited or no angle. In the project, implemented Rotary actuator is limited rotation, these are elements that provide movement of rotation but fail to produce a revolution (except any mechanical particular as e.g. pinion - rack).

Figure 4: Actuator gyrator and lineal

Pneumatic elements described above for correct operation is necessary to fit you correctly and accurately to certain accessories such as:

- Straight racors
- Tube polyurethane 6, 8 y 10M
- QST Derivation T
- Rapids racors
- strangulation valve
- Basic valve 2/2 y 5/2
- Other electro-pneumatic elements

Proximity switch
These sensors are the ones to send the input signal to the system of monitoring central is the S7-200 PLC, as the position of the piston in the cylinder, detection of wrong positioning of lids for the insertion of liners, depending on the signal and programming activates the following functions or stop the machine in case of failure.

Inductive sensor proximity
This type of sensors incorporates an electromagnetic coil that is used to detect the presence of a conductive metal object. They ignore non-metallic objects. They are mainly used in the industry, both for positioning applications to detect the presence of metal objects in specific contexts. (Blogspot, 2015).

These devices are responsible for sending the input signal to the system of monitoring central is the S7-200 PLC, as the position of the piston in the cylinder, detection of wrong positioning of caps for the insertion of liners, depending on the signal and programming activates the following functions or stop the machine in case of failure.

PLC S7-200
It is the main component of the material control, electric, pneumatic and mechanical devices that compose the system, are managed by the logical controller. The PLC has the characteristics shown in table 2.

Table 2: *Features of the PLC S7-200 (SIEMENS, 2008)*

Characteristics	CPU 224
Physique dimensions [mm]	120,5 × 80 × 62
Program memories: with edition runtime without edition runtime	8192 [bytes] 12288 [bytes]
Dates memory	8192 [bytes]
Backup memory	100 [hours]
E/S integrates Digitals Analogical	14 E/10 S
Real time clock	Incorporate
Communications ports	1 RS-485
AC Alimentation	120V
DC Alimentation	24V
Connection	For reel (free power contact)
Programing cable	RS485/RS232 PPI

Vacuum generator
The connection of vacuum pump is performed with a 220 VAC power, controlled by a 110 reel [V] to the contactor with their respective protection. For a constant and high-precision vacuum system is endowed of a pump industries give Shin which is shown in figure 5.

Figure 5: Vacuum pump DS-1S

V. MECHATRONIC SYSTEM DEVELOPMENT

Figure 6 shows the flow diagram of the process of insertion of liners.

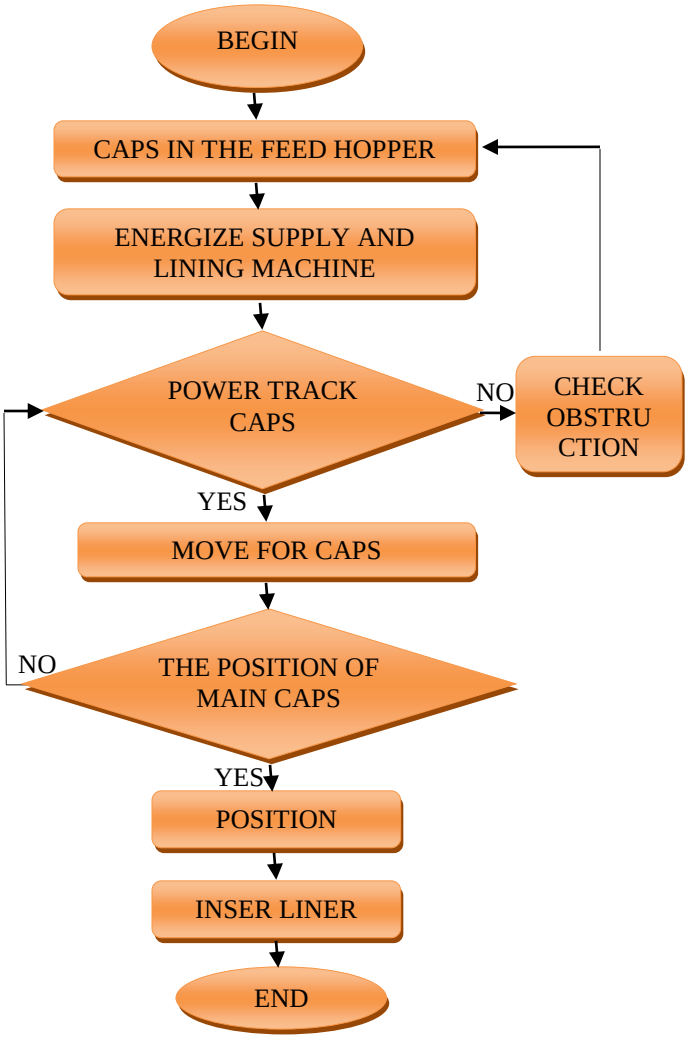


***Figure 6*:** The main system flow diagram

A. Caps feeding

Evaluation criteria for the selection of the feeder caps were obtained by an agreement between the author of this project and the representatives of the company Induplast, which are adjustable speed, easy operation, and maintenance should not be complex with spare parts accessible, with low noise and most importantly the power must be constant. According to the aforementioned specification is selected the centrifugal feeder shown in Figure 7, which also shows the sliding track by which lower caps lining machine.

Figure 7: Centrifuge machine

B. Translation mechanism

The pneumatic elements for the caps translation are selected specifically according to the total distance added by the four caps to be moved. Make up this mechanism two cylinders that are detailed in Figure 8

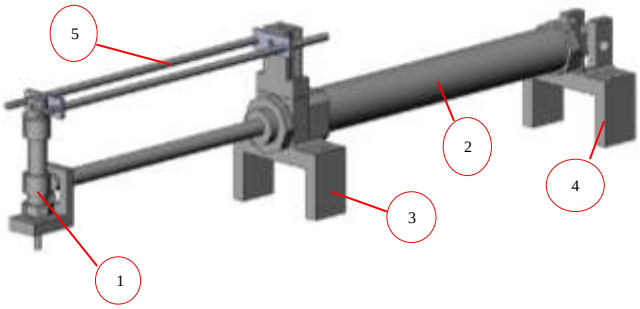


Figure 8: Translation mechanism

Where:

1. Cylinder take caps
2. Translation cylinder
3. Support frontal
4. Support posterior
5. Guides of restraint and balance

Translation subsystem characteristics of cylinders that are shown in tables 3 and 4, these represent the cylinder takes caps and cylinder translation respectively.

Table 3: *Cylinder takes caps characteristics (FESTO, 2004)*

CHARACTERISTICS	VALUE
Run	10[mm]
Piston diameter	10 [mm]
Rod coil	M4
Deadening	Adjustable on both sides (PPV)
Extreme of piston	Exterior coil
Working pressure	1 - 10 [bar]
Way working	Effect double
Fluid	Air dry, lubricated or non-lubricated
Theoretical strength with 6 bar, BACKSPACE	39,6 [N]
Strength with 6 bar, advance theoretical	47,1 [N]

Table 4: *Cylinder translation characteristics (Metal Work, 2014)*

CHARACTERISTICS	VALUE
Run	160[mm]
Piston diameter	24 [mm]
Rod coil	[M8]
Deadening	Adjustable on both sides (PPV)
Extreme of piston	Exterior coil
Working pressure	1 - 10 [bar]
Way working	Effect double
Fluid	Air dry, lubricated or non-lubricated

C. Mechanism of position of tapas

Position of caps subsystem works with two double-acting cylinders with similar characteristics, which are disabled in its initial state (stem retracted), and to the moment of presence of elements to lining in the vertical track cylinder change of state (stem extended).

Figure 9 shows the image of the mechanism which positions and separate caps, prior to insertion of liners for the corresponding mechanism.

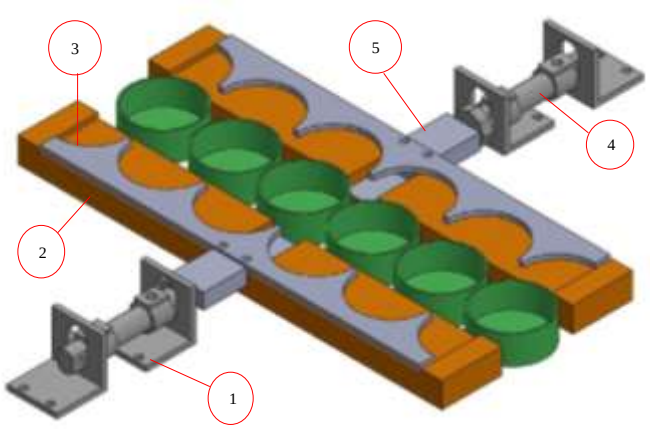


Figure 9: Mechanism caps position

Where:

1. Clamping cylinders
2. Fixed sliding piece
3. Peg clutches of separation and positioning
4. Double-acting cylinder
5. Join cylinder and fixed

The characteristics of the double-acting cylinder implemented in the mechanism of position and separation of lids are shown in table 5.

Table 5: *Caps position characteristics (FESTO, 2004)*

CHARACTERISTICS	VALUE
Run	25 [mm]
Piston diameter	10 [mm]
Rod coil	[M4]
Extreme of piston	Exterior coil
Working pressure	1 - 10 [bar]
Way working	Effect double
Fluid	Air dry, lubricated or non-lubricated
Theoretical strength with 6 bar, BACKSPACE	39,6 [N]
Strength with 6 bar, advance theoretical	47,1 [N]

D. Mechanism of inclusion of liners

This mechanism without neglecting the importance of the above comes to be the most significant, because that, at this point, the final work is done or the objective proposed in the project. The function of the mechanism is to take the liners of a certain height and placed at the four caps that were positioned previously, construction and assembly of the mechanism is made according to the dimensions of the liner and caps.

The mechanism of inclusion of liners is shown in the figure 10.

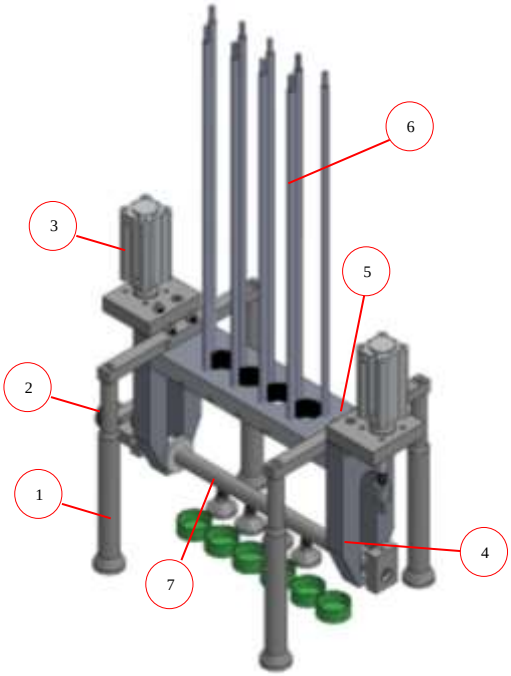


Figure 10: Mechanism of inclusion of liners

Where:

1. The structure stands
2. Gyratory actuator
3. vertical Cylinder
4. Oblong
5. Liner support
6. staking rod of liners
7. Axis of rotation

Axis design

The operation of insertion of liners depends on this element; the sizing is linked directly to the separation of the suction cups and tailored to the support liner, this is essential to initiate the calculation of forces and moments which interfere with the movement of rotation and translation of axis.

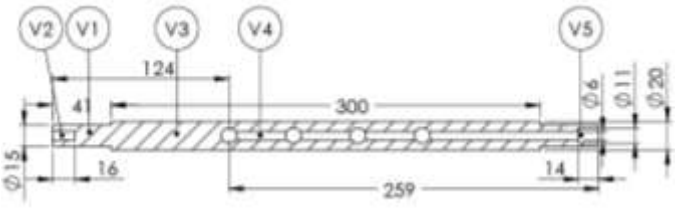


Figure 11: Axis dimensions

The volume of the axis is given by the following formula:

$$V = \frac{\pi \times d^2}{4} \times L$$

Equation 1: Axis volume

Where:

- V: Axis volume $[mm^3]$
- d: Diameter $[mm]$
- L: Axis longitude $[mm]$

Replacing data in Equation 1 is:

$$V_1 = \left(\frac{\pi \times (15)^2}{4} \times 41\right) \times 2$$
$$V_1 = 14490.596[mm^3]$$

$$V_2 = \frac{\pi \times (6)^2}{4} \times 16$$
$$V_2 = 452.389[mm^3]$$

$$V_3 = \frac{\pi \times (20)^2}{4} \times 300$$
$$V_3 = 94247.779[mm^3]$$

$$V_4 = \frac{\pi \times (6)^2}{4} \times (259 - 14)$$
$$V_4 = 6927.211[mm^3]$$

$$V_5 = \frac{\pi \times (11)^2}{4} \times 14$$
$$V_5 = 1330.464[mm^3]$$

The total volume of the axis is defined by:

$$V_{total} = V_1 - V_2 + V_3 - V_4 - V_5$$
$$V_{total} = 14490.596 - 452.389 + 94247.779 - 6927.211 - 1330.464$$

$$V_{total} = 100028.311\ [mm^3]$$
$$V_{total} = 0.0001\ [m^3]$$

As follows is calculated the mass, for which you need the iron of the same transmission density which is$7{,}9\ g/cm^3$.

$$m = Vx\delta$$

Equation 2: Axis mass

Where:

- m: Axis mass $[Kg]$
- V: Axis volume $[m^3]$
- δ: Axis density $[Kg/m^3]$

Transforms the density to the international system of units (SI), which is expressed as follows:

$$\delta = 7.9 \times \frac{1000000}{1000}$$
$$\delta = 7900[Kg/m^3]$$

Then:

$$m = 0.0001 \times 7900$$
$$m = 0.790[Kg]$$

To calculate the total weight of the item analysis refers to equation 3 which expresses the following:

$$W = m \times g$$

Equation 3: A body weight

Where:

- m: Mass [Kg]
- g: Gravitation strength $[9{,}81\ \mathrm{m/s^2}]$

It has replacing:

$$W = 0.790 \times 9.81$$
$$W = 7.752[N]$$

It is to make the diagram of the body to obtain the other necessary variables for the selection of the elements involved. Figure 11 shows the shaft-free body diagram by placing loads and reactions exerted by props, also the distances at which they are located.

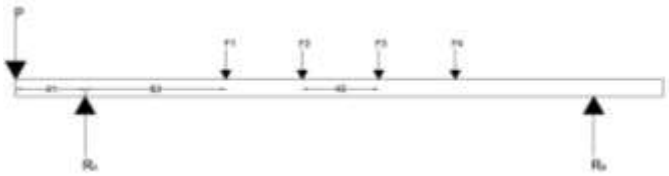


Figure 12: Diagram of forces at the level

Where:

- P: The weight of the Rotary actuator $[N]$
- F1, F2, F3 y F4: Weights of the suction cup holder $[N]$
- Ra y Rb: The reactions $[N]$

The data of the weights of the of the suction cup holder , is obtained by measuring the mass of them, instead on the weight of the swivel actuator estimated data is taken after reviewing the catalog from festo, which yields the following:

- $m = 30[\mathrm{g}]$
- $\mathrm{P} = 0{,}5[\mathrm{Kg}]$

To obtain the weight of each of the suction cup holder refers to equation 3, the same one that expresses the following:

$$P = 0.5 \times 9.81$$
$$P = 4.905[N]$$

Forces or weights of suction cups and holder are defined by:

$$F_1 = 0.03 \times 9.81$$
$$F_1 = 0.294[N]$$

Figure 13 shows the diagram of body free with every one of the charges.

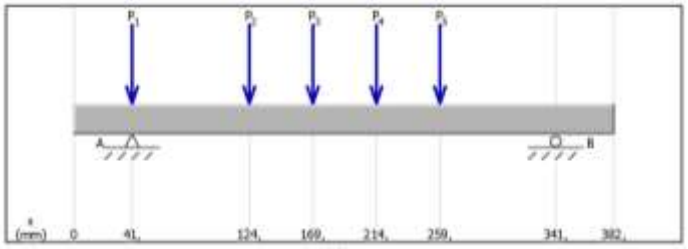


Figure 13: MDSolids-load diagram

Where:

- $\mathrm{P}_1 = 4.905[\mathrm{N}]$
- $\mathrm{P}_2 = 0.294[\mathrm{N}]$
- $\mathrm{P}_3 = 0.294[\mathrm{N}]$
- $\mathrm{P}_4 = 0.294[\mathrm{N}]$
- $\mathrm{P}_5 = 0.294[\mathrm{N}]$

Reactions at point A and B are 5.49[N] and 0.59[N] respectively, the two directed upwards.

Together these results in the cutting diagram are:

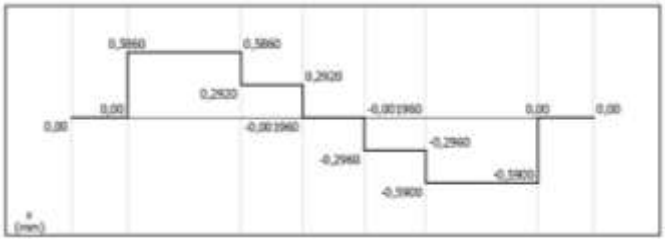


Figure 14: MDSolid-cuts diagrams

The area of each block, the same as this sorted from left to right is obtained through Figure 14.

- $\mathrm{A}_1 = 48{,}64[\mathrm{N.mm}]$
- $\mathrm{A}_2 = 13.14[\mathrm{N.mm}]$
- $\mathrm{A}_3 = -13.32[\mathrm{N.mm}]$
- $\mathrm{A}_4 = -48.38[\mathrm{N.mm}]$

Found areas proceeds to find the moment diagram, which is shown below.

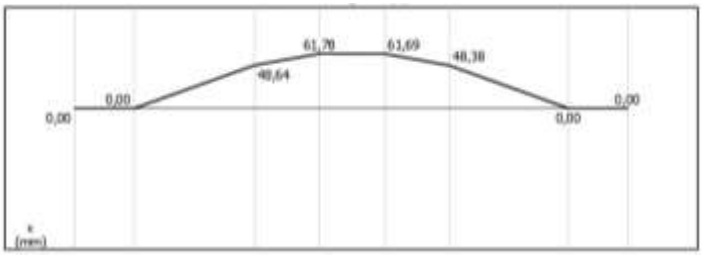


Figure 15: MDSolid-moments diagrams

Figure 15 shows the value of 61.78 [N.mm], the highest in the positive case, but this does not affect anything since always the absolute value is taken.

It seeks the power of the engine which is expressed by equation 4.

$$Pm = \frac{Po}{\eta}$$

Equation 4: Power motor

Where:

- Po: Power transmitter
- η: Efficiency of the motor is considered a conservative efficiency of 90%.

It is estimated the power to transmit, which is expressed by the following equation.

$$P_o = T \times W$$

Equation 5: Power to be transmitted

Where:

- P_o: Power to be transmitted $[hp]$
- T: Top moment $(61.78[N.mm])$
- W: Angular velocity $[rad/seg]$

Prior to the calculation of the power to be transmitted is seeking the angular velocity the same is expressed by the following equation.

$$W = n\frac{2\pi}{60}$$

Equation 6: Angular velocity

Where:

- $n = 133.3[rpm]$ *cycle turn*

Replacing is:

$$W = 133.3 \times \frac{2\pi}{60}$$
$$W = 13.959[rad/seg]$$

Before proceeding to make calculating the power to transmit proceed to transform the units of the international system of units, the same as 0.06178[N.m] is the maximum torque.

This value is calculated the power to transmit.

$$Po = 0.06178 \times 13.959$$
$$Po = 0.862[W]$$

The transform is:

$$Po = 0.001[hp]$$

The calculated data gets the power from the motor.

$$Pm = \frac{0.001}{0.90}$$
$$Pm = 0.001[hp]$$

With the specified data is selected the Rotary drive which has the characteristics listed in table 6.

Table 6: *Characteristics of the Rotary actuator*

CHARACTERISTICS	VALUE
Range of adjustment of the angle of rotation.	0 - 180 [deg]
Turn angle	180 [deg]
Functioning form	Effect double
Working pressure	2 - 8 [bar]
Fluid	Air compressed filter
Torque with 6 bar	2 [N.m]
Pneumatic connection	M5

The vertical cylinders are selected in function of the axis weight with its respective holder suction cups, Rotary actuator and the rotation that provides this along with the other mentioned elements, which comply with the characteristics listed in the table 7.

Table 7: *Characteristics of vertical cylinders*

CHARACTERISTICS	VALUE
Run	125 [mm]
Piston diameter	32 [mm]
Cushioning	Adjustable on both sides
Position detection	with proximity detector
Working pressure	0,6 - 12 [bar]
Way working	Effect double
Fluid	Air dry, lubricated or non-lubricated
Cushioning run	20 [mm]
Theoretical strength with 6 bar, BACKSPACE	415 [N]
Strength with 6 bar, advance theoretical	483 [N]

E. Technical specifications

The total pressure of work is given according to the determinations of functioning of each of the actuators that are involved in the project, which is the same as that shown in the following table.

Table 8: Pressure in work of actuators

ELEMENT	WORK PRESSURE
DSNU-10-10-P-A	1-10[bar]
1130250160CN	1-10[bar]
DSNU-10-25-P-A	1-10[bar]
DNCB-32-125-PPV-A	0.6-12[bar]
DSR-16-180-P	2-8[bar]

According to the specifications displayed in table 8 with greater working range actuators are vertical cylinders (DNCB-

32-125-PPV-A) insertion of liners, whereby for the specification of work pressure takes half plus one of the data provided by this actuator, this latest from different falls of pressure or leaks in the circuit, which is 7 [bars], and minimum is half minus one being 5 [bars]. In practice the pressure which is regulated project is to 90 [PSI] equivalents to 6.2 [bars].

VI. MACHINE EMPLOYMENT

For the construction of the machine were carried out technological operations of machining which are detailed below:

Table 9: Operations *plots*

NÚMERO	OPERACIÓN
1	Layout
2	Material cut
3	Turning / bending
4	Frosted
5	Boring
6	Welding
7	Anchored
8	Painted

The mounting of mechanical and pneumatic elements outlined by the subsystems of the process which are: food, travel, positioning and insertion of liners, for the breakdown of procedures using the symbols shown in table 10.

Table 10: *Flowchart symbols*

ACTIVITY	SYMBOLOGY
Operation: It shows the phases of the process.	○
Inspection: Verification of the quality and/or quantity.	□
Mover or transportation: Equipment, material from one place to another move.	⇨
Provisional deposit or waiting: Delay in the development of the facts indicates.	D
Permanent storage: Indicates deposit a document or information within a file or object in a warehouse.	▽

A. Assembling the worktable

Figure 16 shows the activities carried out in the Assembly of the art board.

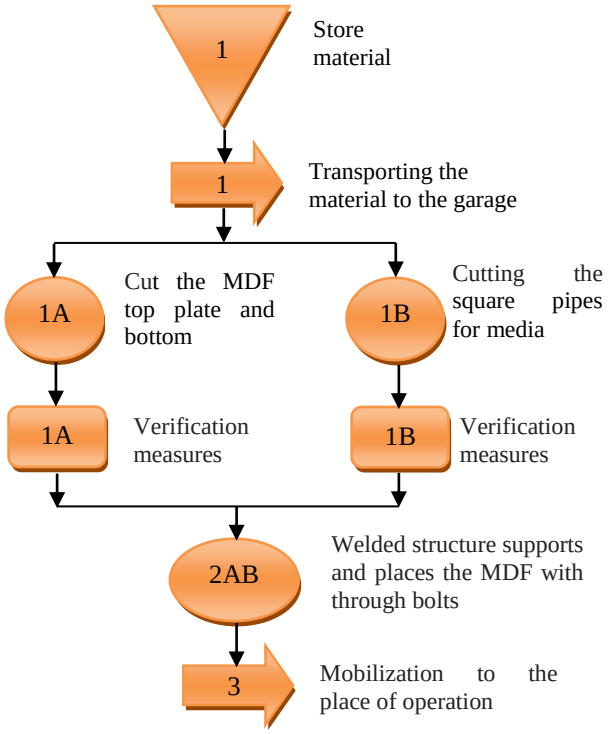


Figure 16: Flowchart assembly workbench

B. Mounting of the power subsystem

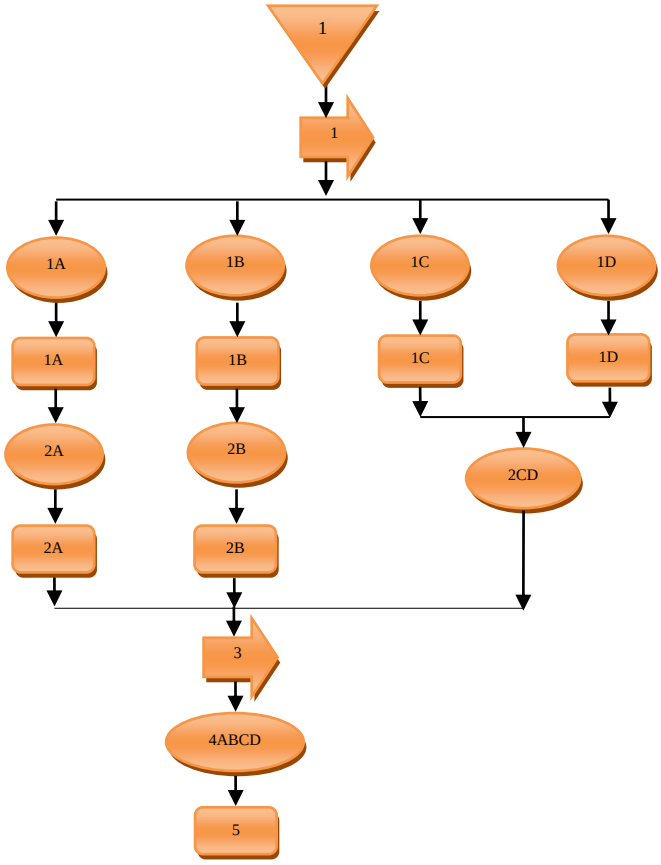
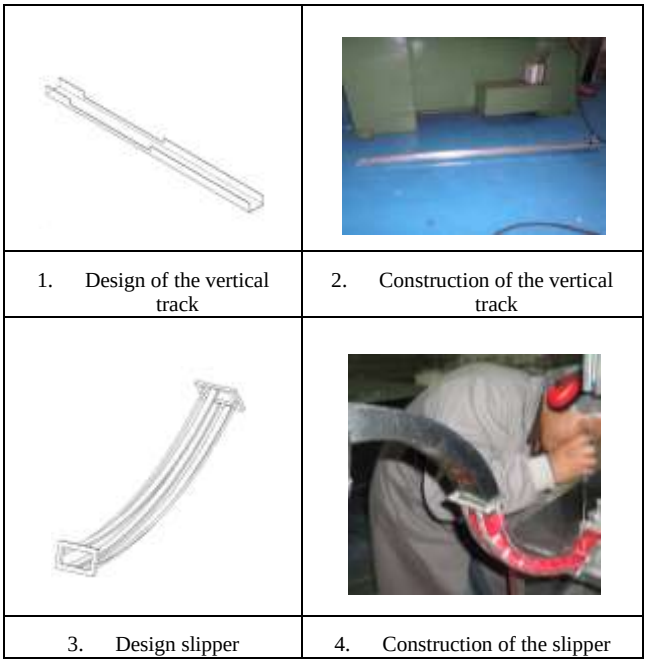


Figure 17: Flowchart of the feed mechanism Assembly

Table 11: *Description of figure 17*

Symbol	Identification	Description
▽	1	Store material
⇨	1	Transport of material to the mechanical workshop
○	1A	Cut the plate in stainless steel for the vertical track 1 and 2
○	1B	Cut the mica plate to lock the output caps
○	1C	Cut the rod of $1/8''$ to the slider
○	1D	Cut the bar $12 \times 4[mm]$ and turning frames input and output tops slider
□	1A, 1B, 1C y 1D	Verification measures
○	2A	Fold and cut the cavity of the vertical track 1 for position mechanism.
○	2B	Strawberry perform in the oblong and screw evictions
○	2CD	Welding rod and bar with frames input and output
□	2A y 2B	Verification measures
⇨	3	To the place of operation mobilization
○	4ABC	Screw the mica on the vertical track 2 and attach the slider out of the feed hopper
□	5	Verification of position of mechanisms.



1. Design of the vertical track
2. Construction of the vertical track
3. Design slipper
4. Construction of the slipper

Figure 18: Construction of the power subsystem

C. Assembling of the subsystem of translation

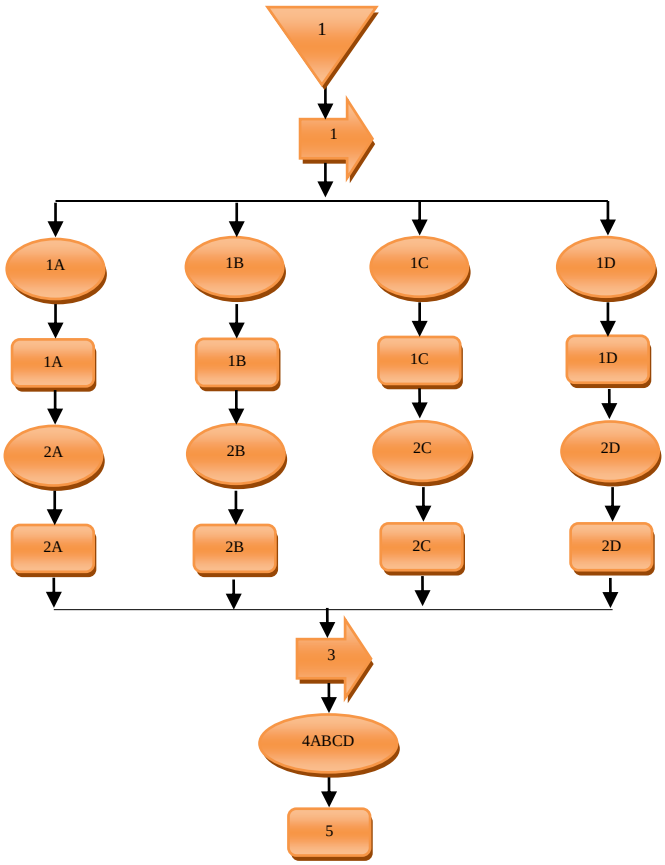
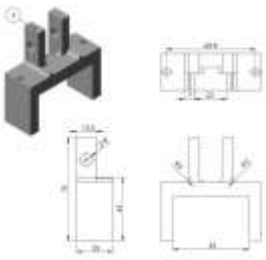


Figure 19: Flowchart undercarriage assembly

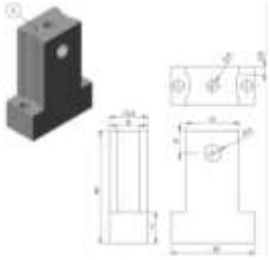
Table 12: *Description of the figure 19*

Symb.	Ident.	Description
▽	1	Store material
⇨	1	Transport of material to the workshop
○	1A	Cutting and milling the aluminum plate for the front and rear support.
○	1B	Cutting and milling the iron aluminum L-shaped for the coupling of cylinder
○	1C	Cutting and milling support and guides aluminum deck.
○	1D	Cut the M8 rod to set the axis of the cylinder of translation
□	1A, 1B, 1C y 1D	Verification measures
○	2A	Sanding and respective interns to support with screw M4
○	2B	Sand the piece
○	2C	Sanding and M4 screw holes for the bracket on the plate
○	2D	Thread one end in M4.
□	2A, 2B ,2C y 2D	Verification measures
⇨	3	To the place of operation mobilization
○	4ABCD	Screw the mainstays on the work table and assemble the guides and support with the rod
□	5	Position verification mechanisms.



1. Design of main brackets

2. Construction of the main stands



3. Stand design guide

4. Construction of the support guide

Figure 20: Construction of the mechanism of translation

D. Mounting position mechanism

Figure 21: Covers positioning subsystem

The flowchart of the Assembly of the mechanism's position is shown below (see Figure 22) and in the same way its design and construction (see Figure 23).

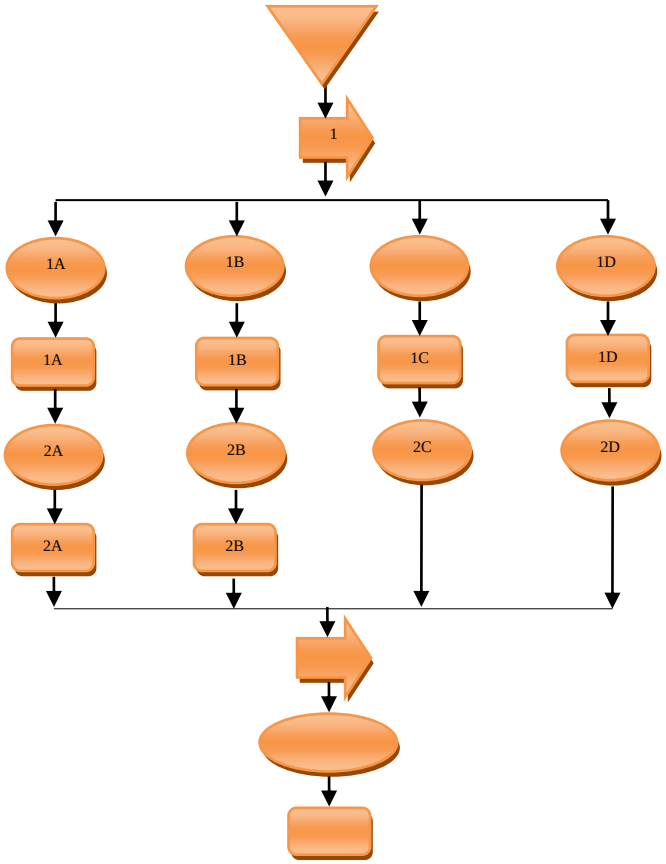
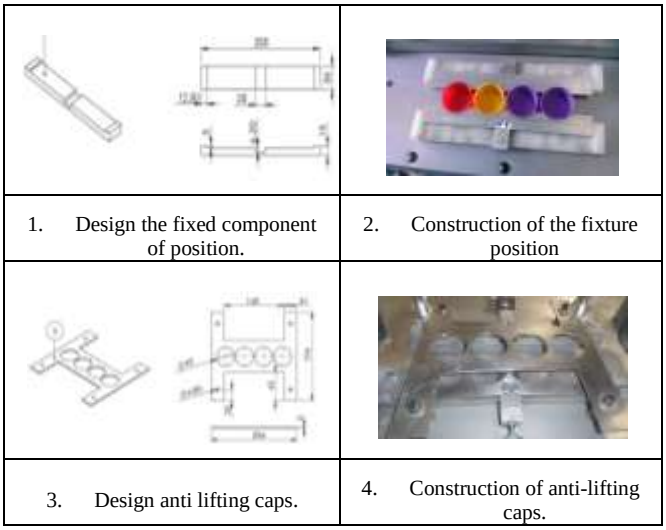


Figure 22: Flowchart of the travel unit Assembly

Table 13: *Description of figure 22*

Symb.	Ident.	Description
▽	1	Store material
⇨	1	Transport of material to the workshop
○	1A	Cutting and milling duralon for the fixed element plate.
○	1B	Cutting and milling stainless steel plate to stop the lifting of caps and the claw position
○	1C	Cutting and milling aluminum plate for the coupling with the cylinders.
○	1D	Cutting and milling the brackets of the piece that stops the lifting of caps.
□	1A, 1B, 1C y 1D	Verification measures
○	2A	Sanding and the respective through holes for bracket with the screw M4.
○	2B	Sanding part and interns of M4 in claw and M10 in the part of the uprising
○	2C y 2D	Sand the piece
□	2A y 2B	Verification measures
⇨	3	To the place of operation mobilization
○	4ABCD	Screw the fixture on the desk, put the coupling and locate the piece stops lifting caps on their respective supports.
□	5	Position verification mechanisms.



1. Design the fixed component of position.
2. Construction of the fixture position
3. Design anti lifting caps.
4. Construction of anti-lifting caps.

Figure 23: Construction of the trolley

E. Fitting the insertion of liners

This subsystem in comparison to the previous ones has more elements of analysis, which has been divided him into two which are the support structure and the rotating mechanism.

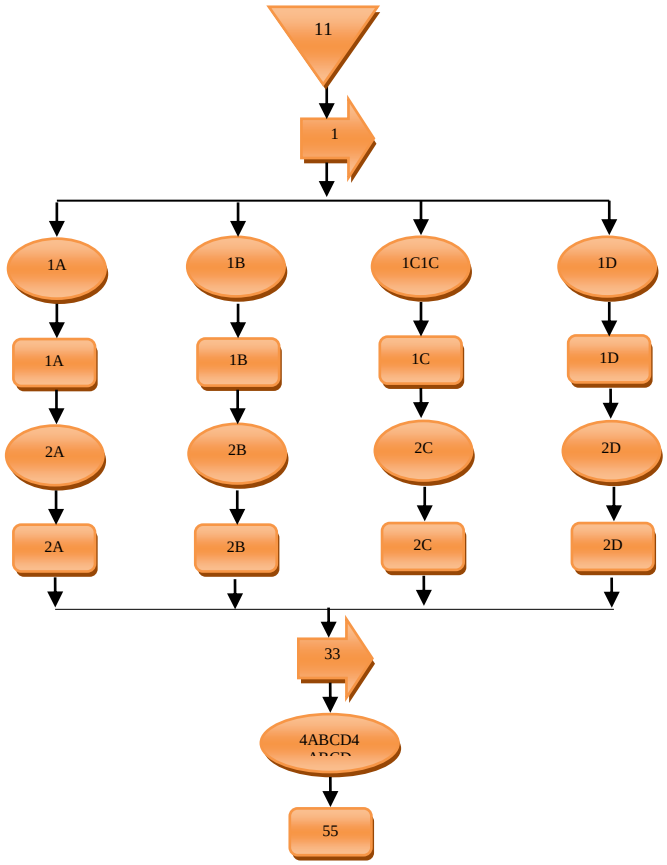
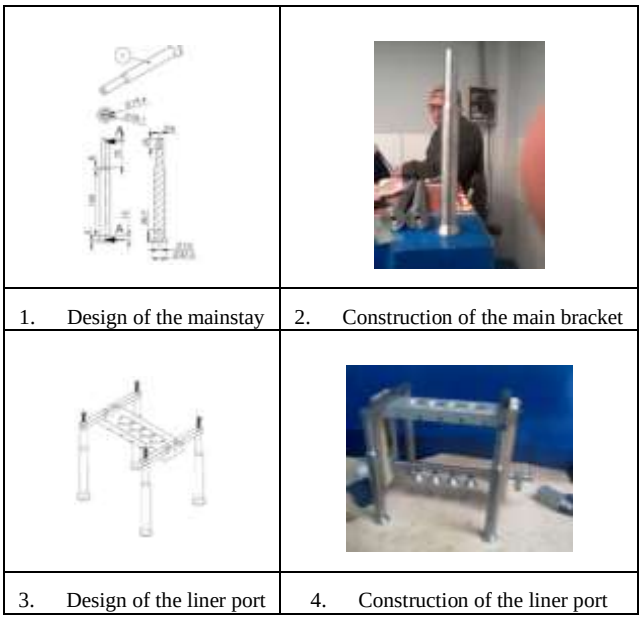


Figure 24: Flowchart of the structure of insertion of liners

Table 14: *Description of figure 24*

Symbol	Identification	Description
▽	1	Store material
⇨	1	Transport of material to the workshop
○	1A	Cutting and milling pin main support and the slash.
○	1B	Cutting and milling plate holder aluminum liner
○	1C	Cutting and milling the aluminum sheet to support the vertical cylinders.
○	1D	Cut the stainless steel M10 rods to stack liners.
□	1A, 1B, 1C y 1D	Verification measures
○	2A	Perform clamping interns in the diagonal bar and upper and lower bracket hole
○	2B	Make trainees of restraint and accommodation for type Allen M2 with head screws.
○	2C	Make trainees of fastening according to the measurements of the cylinder.
○	2D	Perform with tap thread M8 and the other side coupling for the M8 wrench.
□	2A, 2B ,2C y 2D	Verification measures
⇨	3	To the place of operation mobilization
○	4ABCD	Place the main support in the work table with M8 bolts type Allen and about this item attach liner port and the main cylinder brackets.
□	5	Position verification mechanisms.



1. Design of the mainstay
2. Construction of the main bracket
3. Design of the liner port
4. Construction of the liner port

Figure 25: Construction of insertion of liners

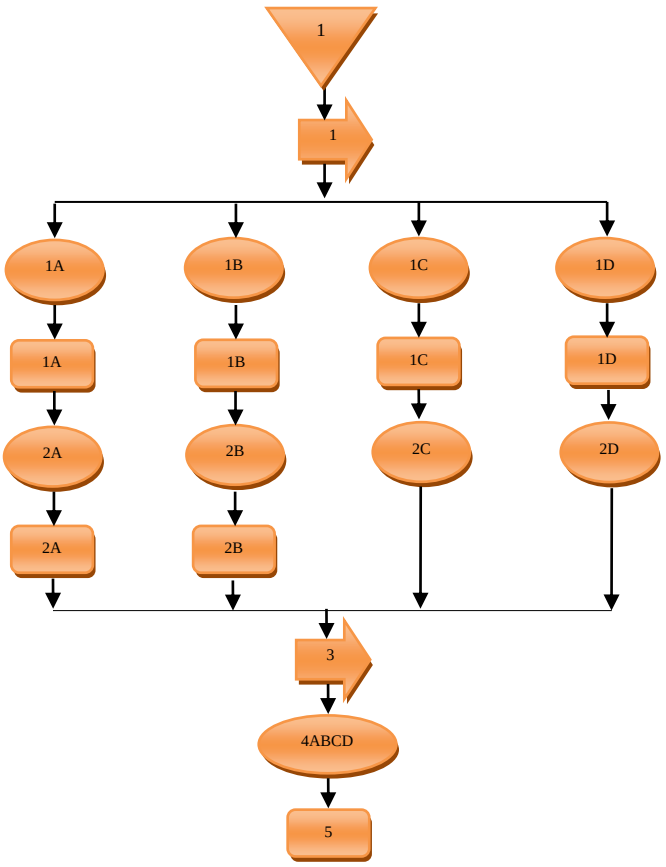


Figure 26: Flowchart of the Assembly of the swivel mechanism

Table 15: *Description of the figure 23*

Symbol	Identification	Description
▽	1	Store material
⇨	1	Transport of material to the workshop
○	1A	Cutting, milling and turning the solid stainless steel main shaft.
○	1B	Cutting and milling of aluminum for the oblong iron and cylinder with rotary actuator and shaft fittings
○	1C	Cutting and milling for the bocin duralon
○	1D	Cutting and turning the suction holder copper rod
□	1A, 1B, 1C y 1D	Verification measures
○	2A	Sanding and accommodations for the windy port and the keyway to attach actuator.
○	2B	Sanding, and interns in the attach Rotary drive shaft and the oblong
○	2C	Sand the piece
○	2D	Sanding and filing with the round file
□	2A y 2B	Verification measures
⇨	3	To the place of operation mobilization
○	4ABCD	Screw the fixed element on the art board, position the coupling and locate work piece stops lifting of lids on their respective stands.
□	5	Position verification mechanisms.

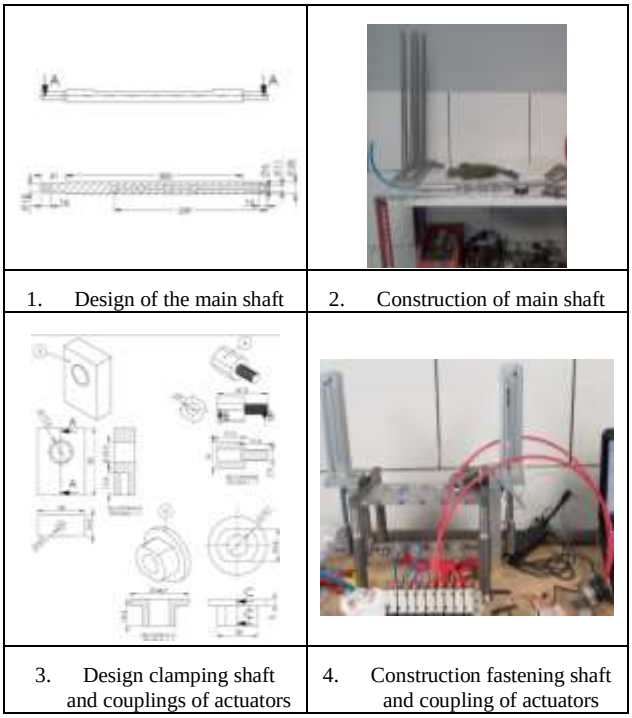


Figure 27: *Construction of the swivel mechanism*

F. General tire system

Analysis of pneumatic elements Assembly is done in general of the whole system of insertion of liners

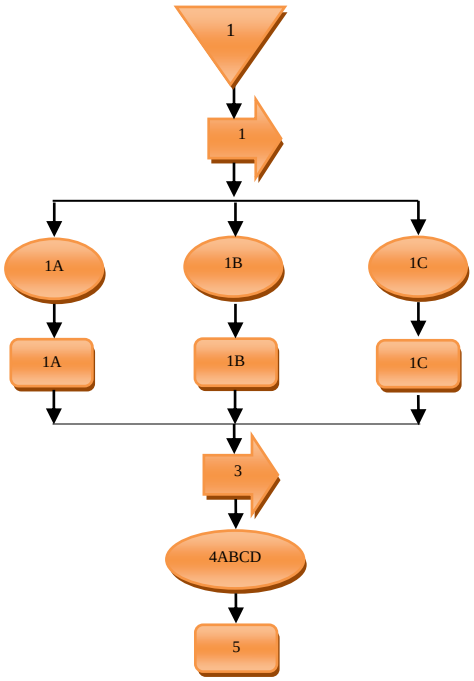
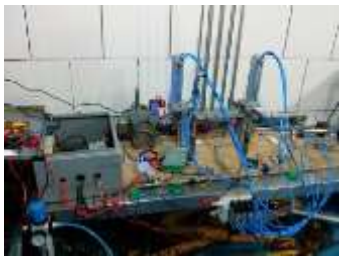


Figure 28: General pneumatic system flow diagram

Table 16: *Description of the figure 28*

Symbol	Identification	Description
▽	1	Store material
⇨	1	Move to the place of operation
○	1A	Place the vertical cylinders in each of the brackets but with allen head type
○	1B	Install the swivel actuator with the respective connections into the main shaft.
○	1C	Cut flexible tubing according to the measures of the output of basic valve to its respective connector.
□	1A	Check the position and are fixed.
□	1B	Check balance and that the shaft is completely vertical
□	1C	Verification measures
○	2ABC	Place choke in the inlet valves and the departure of vertical cylinders, and the respective connection.
□	5	Verify the installation and all connections



1. Pneumatic connection of vertical cylinders in initial state

2. Pneumatic connection of vertical cylinders in the final state

Figure 29: *Assembly of pneumatic system*

VII. COST-BENEFIT ANALYSIS

The analysis cost-benefit is no more than the process of placing figures in dollars in the various costs and benefits of an activity or change within a company. The study on the insertion of liners is carried out manually and automatic.

A. Analysis with the inclusion of manually liner

The production of 5000 caps (objective) uses raw material specified below in table 17.

Table 17: *Cost of production for 500 caps*

Raw material	Cant.	unity	Price unit $	Total $
Polyethylene (PE)	17,5	[Kg]	1,93	33,775
Liner	5000	[unity]	0,0042	21
Red coloring	0,21	[Kg]	0,2796	0,05872
			TOTAL	**54,84**

Performing an analysis of the unit production cost as specified in table 17, the product with their respective liner has a cost of $0,011 approximately.

In table 18 is the breakdown of the monthly of the operators responsible for the production of caps in general, should be noted that for this analysis is does not take into account the additional hours (extra), but if the night hours since they do rotating shifts, this applies since the production is constant.

Table 18: *Labor in the production of caps without the material*

Work area	N° of employees	Monthly payment	Total month
Blower	1	480	480
Mill and packaging	2	420	840
I cap lining	3	380	1140
		TOTAL	**2460**

For the analysis, it is necessary to know the amount of caps lining through manual labor, which can be seen in the area of production obtaining the data shown in table 19. It should be noted that the amounts shown is an average

Table 19: *Lining caps in 8h*

Workface	Cases of 500/hour	Hour	Total
1	3	8	12000
2	4	8	16000
3	3,5	8	14000
		TOTAL	**42000**

After analyzing the production of caps, it is to revise earnings acquired product, for it is necessary to make a relationship between the cost of the raw material and the price which sold lining caps, at this point the factory works with two types of clients preferential and generals, the first are fixed with brands and others are those who tend to purchase from time to time.

Table 20: *The price of caps*

Customer type	Unit value	Total $
General	0,0265	132,5
Preferential	0,019	95

After reviewing the tables 19 and 20, it is known that the margin of profit on the sale of every lining cap is 0.8% (data from the factory). then for a total sale of the product (ideally) to insert the liner by hand is the fact that shows the table 21.

Table 21: *Utility sales without the lining cap*

Utility	Total whole (month)	Utility month
0,008	560000	4480

If these utilities are canceled salary operators and workers of caps lining production line should be the following:

$$Uf = Us - St$$

Equation 7: Final utility

Where:

- Uf: Final utility
- Us: Month utility
- St: Wages of workers in the area

Replacing the data in table 19 (salary of the workers of the insertion of liners) and 21 in the equation 7 are:

$$Uf_1 = \$4480 - \$1140$$
$$Uf_1 = \$3340$$

Equation 8: Monthly utility without the lining machine

B. Analysis of the inclusion of automatic liners

Table 22: *Labor in the production of caps with the lining machine*

Work area	N° of employees	Monthly payment	Total month
Blower	1	480	480
Mill and packaging	2	420	840
I cap lining	1	380	380
		TOTAL	**1700**

For the calculation of the monthly utility takes into account the production of the lining machine which is 5000 tapas every hour, it should be noted that the value is constant in each time compared to the previous method (traditional way).

By performing the same analysis of the above method is a monthly production of caps of 800000 and utility is shown in table 23.

Table 23: *Utility by sales with the lining machine*

Utility	Total whole (month)	Utility month
0,008	800000	6400

For the final utility replaced data from table 19 and 23 in the equation 7 which is shown below:

$$Uf_2 = \$6400 - \$380$$
$$Uf_2 = \$6020$$

Equation 9: Monthly utility with the lining machine

It should be noted that final utility shown in equation 23 other expenses such as maintenance and energy consumption is subtracted, but these earlier does not represent a considerable amount by which is not mentioned in the analysis

C. The investment recovery period

We determine with the recovery period, the time that it takes the company to recover the investment in machinery, to which analyzes the equations 8 and 9 which is shown in table 24.

Table 24: *Analysis of earnings*

Operation	Others payments	Utility	Pure utility
Without machine	100	3340	3240
With machine	200	6020	5820

Other costs shown in table 24 are energy and transport costs, added $ 200 more to the lining with the deployed machine since the process uses compressed air and electricity.

The additional utility is applied according to the equation 10 is shown below:

$$Ua = Um - Usm$$

Equation 10: Additional utility

Where:

- Ua: Additional utility
- Um: Utility with the machine
- Usm: Utility without the machine

Applying the equation 10 and replacing the values in the table 24 should be the following:

$$Ua = 5820 - 3240$$
$$Ua = \$2580$$

Now just to see the recovery period is the rule three simple, the same as that shown in table 25.

Table 25**:** *Payback period*

2580	1	Month
4915,40	?	
	1,9	Time

According to table 25 machine recovery time is two months you, knowing that the factory makes and sells caps of different sizes and there is not always a production estimated per month, then the maximum time of recovery according to the experience is five months.

D. Analysis

They are set to cost, the value of the machinery and benefit the income provided by the implementation of the project, these data are presented by way of estimated values. Table 26 shows the analysis of the cost-benefit of the project.

Table 26: *Cost-Benefit*

Cost	Value	Benefice	Value
Investment in the project	4915,40	Increase in the utility	5820
Maintenance	50	Decrease in labor	760
		Increased demand	1500
TOTAL COSTS	**4965,40**	TOTAL BENEFICE	**8080**

E. Calculation of the cost-benefit

To obtain the cost-benefit ratio, agreement numbers should be placed as shown in equation 11:

$$Cost - benefit\ ratio = \frac{T_{in-ac}}{T_{c-ac} + inversion}$$

Equation 11: Cost-benefit ratio

Where:

- T_{in-ac}: Total updated income
- T_{c-ac}: Total costs to date

Then replacing the data in table 26 in equation 11 should be the following:

$$Relación\ beneficio - costo = \frac{8080}{4965{,}40}$$
$$Relación\ beneficio - costo = 1{,}627$$

In conclusion the above output shows that implementation of the machine is cost-effective due to 1,627 > 1.

This value is considered a positive return on investment, this way it has been shown that if a plastic industry, performs the investment in an automatic machine of inclusion of liner in the plastic caps of 40 [mm] diameter would provide greater production, meet the existing demand, an increase in their utility, as well as changing their production processes through the use of technology.

VIII. CONCLUSIONS

1. Caps lining system is operating in the **INDUPLAST S.A** Company of the city of Cayambe, fulfilling the expectations of the company sponsoring the project.

2. Through the implementation of the automatic lining is optimized the process of inclusion of liner in 40×17[mm] plastic caps screw, reducing time and increased production of 3000 [caps/hour] to 5000 [caps/hour], fulfilling the objectives in the design of this system.

3. Insertion of the liner through the implementation of four suction cups on the lining, helps to reduce the working time considerably, taking into account that two workers inserted from 3000 to 3500 maximum in one hour, and machine with a single operator and at the same time reach lining 5000 caps, increasing production by 40%, with this leaving obsolete the traditional way.

4. The costs generated in automating the process of lining are high, but through an analysis cost-benefit is demonstrated that it is recoverable in a period of five you months, in the worst case if demand decreases time is increased to eight you months, specified investment is medium-term by increase of manufactured tops in less time and with a single operator.

IX. RECOMMENDATIONS

1. The implemented design is performed with industrial elements of the place, in the same way the mechanical assembly with easy access and manufacture parts, reason for which there is a possibility of a series production.

2. For a correct starter and team work, it is necessary to read and study the operation manual and maintenance attached in the annexes of the project, this guarantees correct handling, service life and optimal functioning of the system

3. Perform a safety induction and training the staff involved in the system, in order to assure the good performance of the machine.

4. Verify the correct state of the variables involved in the system as 110[V], power supplies 220 [V] and compressed air to 85-90 [PSI] pressure gauge

5. For the simulation of inputs and outputs in line with the PC program must be identical to the PLC, also check that

the transfer cable RS485/RS232 PPI of is connected correctly

6. The operator or technician who manipulates the machine must use at all times adequate personal protective equipment according to the standards of safety and quality required by the company.

7. For those wishing to continue this project is recommended a general autonomous system which carry covers outgoing of the injection to the cutter and east to the material, so that the process of production of caps is unified..

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