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THEME:

“MODERNIZATION OF A LINEAR WOOD DRILL MACHINE”

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MODERNIZATION OF A LINEAR WOOD DRILL MACHINE

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RESUMEN

The preparation of this work has this purpose of modernization of a linear woodworking drilling machine, which is to streamline processes for vertical positioning of the table, timber holding the table using a pneumatic press, and control of drilling depth using a mechanical stop.

The vertical positioning of the table allows to mobilize the bench in both ascending and descending using manual controls, but the operator activates the movement of the table; the distance is displayed on an electronic device that the operator has his observation.

The timber holding the table is performed by a pneumatic system, the operator activates the pneumatic press with the ON / OFF control of the machine.

The depth of drilling system select the standard depth, in this details the type of furniture and wood type requested, the operator places the light on the perforated bar and fixed it with the pin in the hole indicated.

1. THEORETICAL FOUNDATIONS

The joinery is a specialization of the wood work oriented furniture construction. The term comes from a type of wood, ebony, considered precious since ancient times, from an African tree, hard and heavy, black wood in the center and white in the cortex.

One of the machines most commonly used in the industry of processed wood is horizontal drilling, which has evolved overtime, many artisanal or industrial way, this machine is very useful in the process of building doors, windows and kitchen cabinets.

Linear drilling machine joinery is considered high precision machine building furniture, since its main function is to make the hole in the parts that are subsequently bonded with as lug(short thick piece of wood); therefore erroneously when drilling both raw material and production time is lost.

1.2.DRILLMACHINEJOINERY

Basically the holes can be of two types: hand drill that is portable and desktop drill that easily lose the bit perpendicular to the material to be drilled, which is fixed to a work bench.

1.2.1. HAND DRILL

The hand drill is a tool that is used to drill a variety of materials. The holes are made by a material removal process using tools called bits.

1.2.2. DRILL ON BENCH

The drill bench is an electromechanical machine whose main function is to make holes or cuts with molds in any material, whether metal, wood or plastic.

Figure 1. Linear Drilling machine joinery
Source: Author

1.2.3. DESCRIPTION OF OLD SYSTEM OF DRILLING

This project is oriented to modernize some processes of linear drilling machine joinery, such are the vertical positioning of the table, the timber holding the table by a press and control of drilling depth by a mechanical stop.

1.2.4. VERTICAL POSITION OF THE OLD TABLE

For the vertical positioning of the table, the movement is given by a crank system, which via as haft coupled to a bevel transmits force to move a power screw that moves the table.

Should be noted that the travel distance is 15cm, considering that's six laps crank advances 1cm, applying a minimum force of 1.33[Nm]; machine also not a ruler in what corresponds to the height of the table, so to be measured as required using a tape measure, this process takes the operator about five minutes.

Figure 2. motion transmission 2.Information system for vertical positioning.
Source: Author

1.2.5. OLD SYSTEM DEEP

For drilling depth control a mechanical stop is used, this is done by a rod which is controlled by a "butterfly" (mechanical lock) for this control the operator muster move the rod, measure the distance with a tape measure enter its axis and set with "butterfly" at the required distance for drilling.

The operator pushes the mechanical drive deep until the rod comes into contact with the stop, it should be emphasized that some times this "butterfly" yields, so that the measured distance is no longer correct, so drilling is wrong.

Figure 3.Sistema adjustable stops by "butterfly".
Source: Author

1.2.6. OLD SYSTEM PRESS

In the case of the timber holding the table, this is a purely manual process where the operator uses a crank system.

This crank system consists of three parts, two of them together and regulated by butterflies and for altitude and range, and the last part is at the end which by a worm can provide pressure to secure the tree to the table, should be noted that must exert a force of 500[N] so that the tree does not move from his position and no drilling is done wrong.

Figure 4.Mecanismo for pressing the wood.
Source: Author

2. CALCULATION OF POWER AND CONTROL SYSTEMS

The calculations and the inspection on the three implemented in the linear drilling machine joinery systems and selection of suitable alternatives and resents mathematical foundation.

2.1. VERTICAL POSITION

Modernizing an actuator which replaces the crank, which is located under the bed or table drilling is implemented, it transmits its power to the bezel through a gear system, activated movement by a push button the operator has to view, it is clarified that the operator has the power to choose the speed of ascent or descent of the table, this type using two switches knobs.

Providing the following advantages:

- Optimization of working time.
- Minimize physical wear performed by the operator.
- Protection operator

The actuator is selected by the mathematical foundation that is performed by the transmission ratio, as shown in Figure 5.

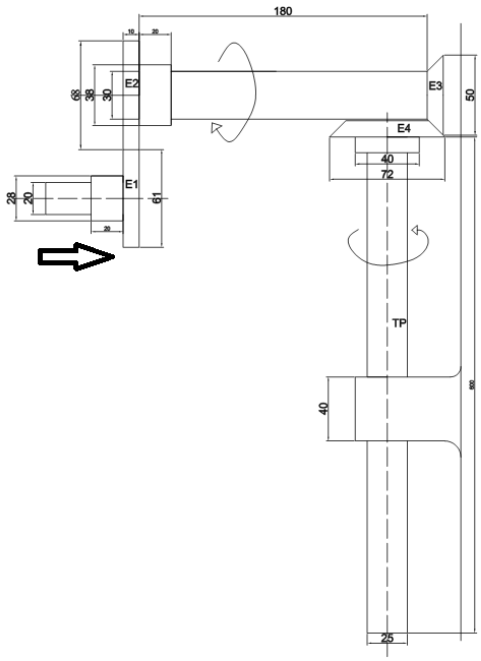


Figure 5. Diagram mechanical elements of the ratio.
Source: Author

The main factor to account for these calculations is the weight of the bed, to meet the same proceeds to separate base which is attached by bolts to the machine, as shown in Figure 6; this is done because the machine is handmade.

Figure 6. Removing bench drilling wood.
Source: Author

Once separated the bed, it is weighed by an electronic scale, which value corresponds to 259,2 [lb], as shown in Figure 7.

Figure 7. Using an electronic scale for the weight of the bed.
Source: Author

To select the engine, it is necessary to calculate the force exerted on the bench power screw:

(W) = 259,2 [lb] -> 117,57 [Kg]

$$F = m \,.\, a$$

$$F = (117{,}57\ [Kg]).(10\ {}^{m}/_{s^2})$$

$$F = 1175{,}7\ [N]$$

where:

F, is the force

m, is the weight of a body

a, is the gravity

After obtaining this value, we proceed to calculate all necessary forces to the vertical positioning operate without problem, where the selection of the servomotor is explained, as well as their characteristics.

2.1.1. CALCULATIONS OF RELATIONSHIP OF TRANSMISSION TO SELECT THE ACTUATOR

2.1.1.1. Par Torsional to raise a load

$$Tu = \frac{F.Dp}{2}\left[\frac{(cos\Phi.tan\lambda+f)}{(cos\Phi-f.tan\lambda)}\right]$$

$$Tu = \frac{(1175{,}7[N])(22{,}1[mm])}{2}\left[\frac{(cos\ 14{,}5°)(tan\ 4{,}2°)+0{,}15}{(cos\ 14{,}5°)-(0{,}15)(tan\ 4{,}2°)}\right]$$

$$Tu = 12991{,}485\ [N.mm]\left[\frac{(0{,}968)(0{,}073)+0{,}15}{(0{,}968)-(0{,}15)(0{,}073)}\right]$$

$$Tu = 12991{,}485\ [N.mm]\left[\frac{0{,}221}{0{,}957}\right]$$

$$Tu = 3001{,}28\ [N.mm] = 3{,}00\ [Nm]$$

Where:

F = 1175,7 [N]

Dp = 22,1 [mm]

Φ = 14,5°

λ = 4,2°

f = 0,15

2.1.1.2. Torque for lowering a load

$$Td = \frac{F.Dp}{2}\left[\frac{(f-cos\Phi.tan\lambda)}{(cos\Phi+f.tan\lambda)}\right]$$

$$Td = \frac{(1175{,}7\ [N])(22{,}1[mm])}{2}\left[\frac{0{,}15-(cos\ 14{,}5°)(tan\ 4{,}2°)}{(cos\ 14{,}5°)+(0{,}15)(tan\ 4{,}2°)}\right]$$

$$Td = 12991{,}485\ [N.mm]\left[\frac{(0{,}15)-(0{,}968)(0{,}073)}{(0{,}968)+(0{,}15)(0{,}073)}\right]$$

$$Td = 12991{,}485\ [N.mm]\left[\frac{0{,}0793}{0{,}978}\right]$$

$$Td = 1053{,}4\ [N.mm] = 1{,}05\ [Nm]$$

For the selection of this servomotor is considered the torque necessary to raise a load and speed needed to move:

Linear Velocity:

Screw= 600mm

Time =20sec

$$V = \frac{600\ [mm]}{44\ seg} = 13{,}5\ {}^{mm}/_{seg}$$

ACME power screw is 1 "in diameter, with five threads per inch, then the loadmoves1/5 inch per revolution, then the speed is:

$$\frac{1}{5}[pulg] = 0{,}2\ [pulg] = 5{,}08\ [mm]$$

$$\boldsymbol{w} = \frac{13{,}5\ [mm]}{1\ [seg]} \cdot \frac{1\ [rev]}{5{,}08\ [mm]} \cdot \frac{60\ [seg]}{1\ min} = 160\ rpm$$

2.1.1.3. Gear transmission ratio between E3 and E4:

$$i = \frac{\omega 3}{\omega 4} = \frac{D4}{D3} = \frac{Z4}{Z3} = \frac{n3}{n4}$$

Angular Velocity:

$$\frac{w3}{w4} = \frac{Z4}{Z3}$$

$$w3 = \frac{Z4*w4}{Z3}$$

$$w3 = \frac{(30)*(160[rpm])}{15}$$

$$w3 = 320\ [rpm]$$

Z3= 15 dientes

w4= 160 [rpm]

Z4 = 30 dientes

w3 = ?

Par torsional:

$$T3 \cdot \omega 3 = T4 \cdot \omega 4$$

$$T3 = \frac{T4*w4}{w3}$$

$$T3 = \frac{(3{,}00[Nm])*(160[rpm])}{320[rpm]}$$

$$T3 = 1{,}5\ [Nm]$$

T4= 3,00 [Nm]

w3= 320 [rpm]

w4= 160 [rpm]

T3= ?

2.1.1.4. Gear transmission ratio between E1 and E2:

$$i = \frac{\omega 1}{\omega 2} = \frac{D2}{D1} = \frac{Z2}{Z1} = \frac{n1}{n2}$$

Angular Velocity:

$\frac{w1}{w2} = \frac{Z2}{Z1}$	Z1= 32 dientes
$w1 = \frac{Z2*w2}{Z1}$	w2= 320 [rpm]
$w1 = \frac{(36)*(320[rpm])}{32}$	Z2 = 36 dientes
$\boldsymbol{w1 = 360\ [rpm]}$	w1 = ?

Par torsional:

$T1 \cdot \omega 1 = T2 \cdot \omega 2$	T2= 1,5 [Nm]
$T1 = \frac{T2*w2}{w1}$	w1= 360 [rpm]
$T1 = \frac{(1{,}5[Nm])*(320[rpm])}{360[rpm]}$	w2= 320 [rpm]
$\boldsymbol{T1 = 1{,}33\ [Nm]}$	T1= ?

As shown T1 shows the minimum torque that must have the servomotor, and w1 shows the minimum angular velocity of the fundamental data for selecting the servomotor.

Table 1allows to compare the data needed to work the system of vertical positioning data of the selected servomotor, fulfilling the device as required.

Table 1. Comparative table of data needed and selected servomotor

	Par torsional [Nm]	**Angular velocity [rpm]**
Necesary	1,33	360
Selection	2,39	3000

Source:author

2.1.2. MOTION DISPLAY SYSTEM

The display of the distance which runs the work table of the machine is thanks to the data (pulses per revolution) that acquires the portX3, which is the output of theen coder whose pulses(A and B) are admitted to a pulse counter, which displays the distance traveled by said table, vital in the operator's work.

Internal Encoder Servo Driver:

Encoders are electromechanical transducers converting the rotation axis in output pulses that can be counted to measure the shaft speed or shaft angle, which provides information about the position and speed of the motor shaft.

The encoder resolution determines the positioning accuracy of the motor. For example, the resolution of the servomotor used for the vertical positioning is 2500 pulses/revolution, in a rotation of motor shaft (360) can be divided into 2500 parts.

Obtaining an optimal resolution of 0,144° angle of rotation of the shaft servomotor for each pulse.

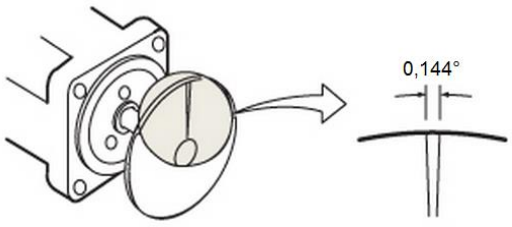


Figure 8. Resolución del encoder.
Source:(Servo Motor Glossary Terms, sf)

2.1.2.1. Pulse Count

The Servo contains an incremental encoder whose pulses are not linearized, noise displayed on the oscilloscope signal exceeds these for that reason decided convenient to use a pulse counter, the selected deviceisFH8-6CRNB-F of Counter/ Length/ Batch meter myPin brand, the decision for their great advantage over any other pulse counter bends, as this has the power to convert the pulses admitted to an adjustable distance scale, allowing visualize the movement of the actuator, and so that the location of the bench.

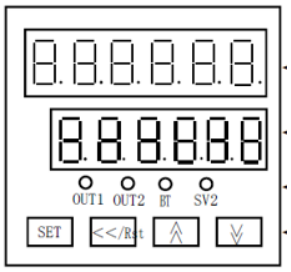


Figure 9. Panel de control y visualización del contador de pulsos, Mypin FH Series

Source:(MYPIN ELECTRICAL CO., LTD, sf)

2.2. PRESSING SYSTEM

The pneumatic system basically has the primary function press the tree to the table of the bench, for operator safety.

2.2.1. GRAFCET CHART

The following diagram describes the operation and the actions that the pneumatic system will perform.

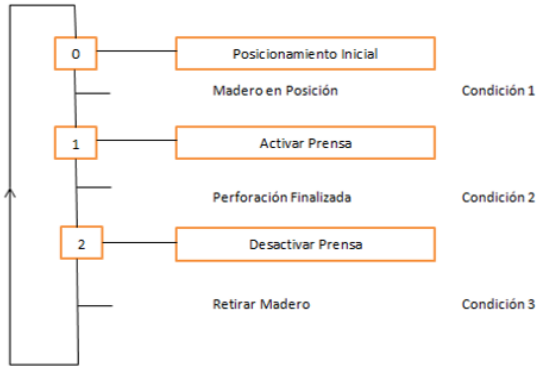


Figure 10. Diagrama Grafcet
Source: Author

2.2.2. PHASE-TIME CHART

This diagram displays the distance traveled versus time:

Table 2. Diagrama fase-tiempo

Elemento	Función	Posición	Tiempo
A	Alimentación Extracción	+ 0 -	1 Prensa On ⇨(A+) Prensa Off ⇨ (A-)

Source: Author

2.2.3. PATTERN TIRE

Figure 11 shows the pneumatics choose implemented for the pressing operation, with the respective feed elements, maintenance, and labor control.

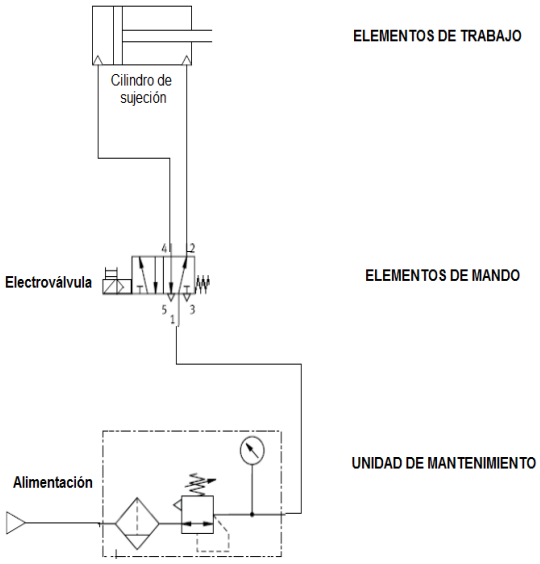


Figure 11. Esquema neumático
Source: Author

2.2.4. TIRE SELECTION OF DEVICES

The various devices that make up the pneumatic system are selected using the following parameters

Selecting the pneumatic cylinder:

Load factor depending on the required application:

Table 3

Funcionamiento requerido		Factor de carga η
Funcionamiento estático (amarre, engarce de tornillo a baja velocidad, etc.)		0.7 o menos (70% o menos)
Funcionamiento dinámico	Movimiento horizontal de la carga en la guía	1 o menos (100% o menos)
	Movimiento vertical y horizontal de la carga	0.5 o menos (50% o menos)(1)

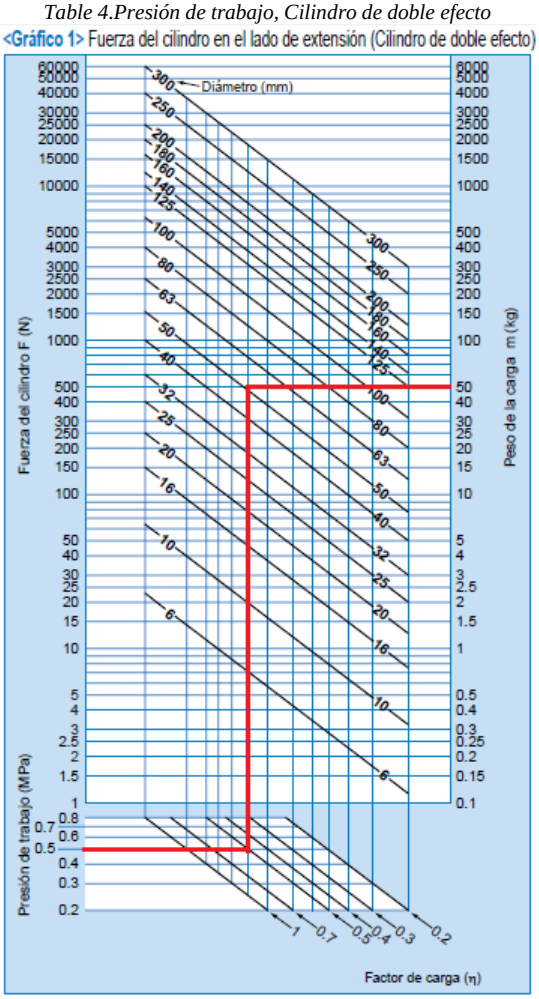
Source: (FESTO, 2013)

The air press performs a vertical movement, thus the corresponding load factor is 0,5.

Significantly for the force with which the tree to the table is pressed, is obtained by applying weight on the tree, until it is completely immobile for further drilling, this value corresponds to50[kg] or 500[N]if one takes into account the gravity of10 [m/s ^ 2].

Table 4 provides information on the respective working pressure of 0,5[MPa] (5bar), this pressure indicates the margin between minimum and maximum permissible pressure required for correct operation of the pneumatic system.

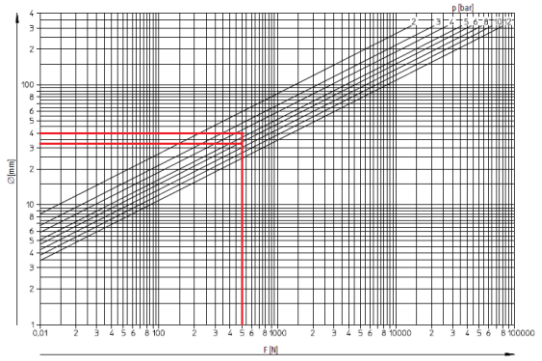
Table 4.Presión de trabajo, Cilindro de doble efecto



Source:(FESTO, 2013)

Table 5 allows to know the diameter of the piston necessary operating pressure and, using the known values of force (F =500[N]), and available on the network pressure (6 bar) which is above operating pressure.

Table 5. Diagrama presión-fuerza



Source::(FESTO, 2013)

Procedure:

Since F =500[N] draw a vertical line to line 6bar; larger diameter piston immediately available is 40mm, and is located between the lines 4 and 5bar, in the working pressure is adjusted approximately to 4,5bar.

Festo says that in this diagram has been considered about 10% of frictional losses.

Air consumption of the air cylinder and the air volume required

Air consumption is consumed air volume in the cylinder key to select the data compressor; the required air volume is the volume of air required to operate a load at a given speed.

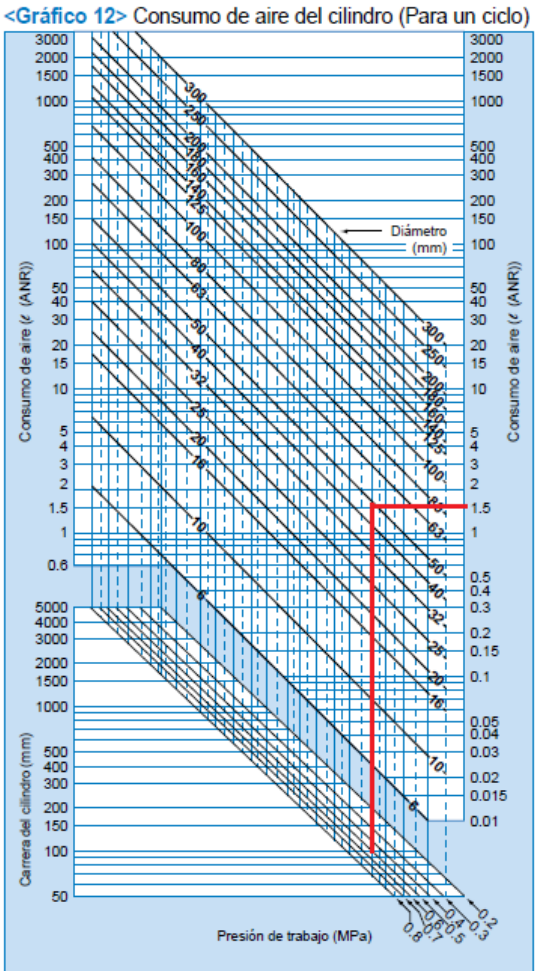
For which it you must follow these steps:

1)Find the point of intersection between the working pressure (diagonal line) and the cylinder stroke from that point draw a vertical line up.

2)From the point of intersection with the diameter(diagonal line) of the cylinder used in one side shows the power consumption required cycle air cylinder.

Table6 shows the selection described:

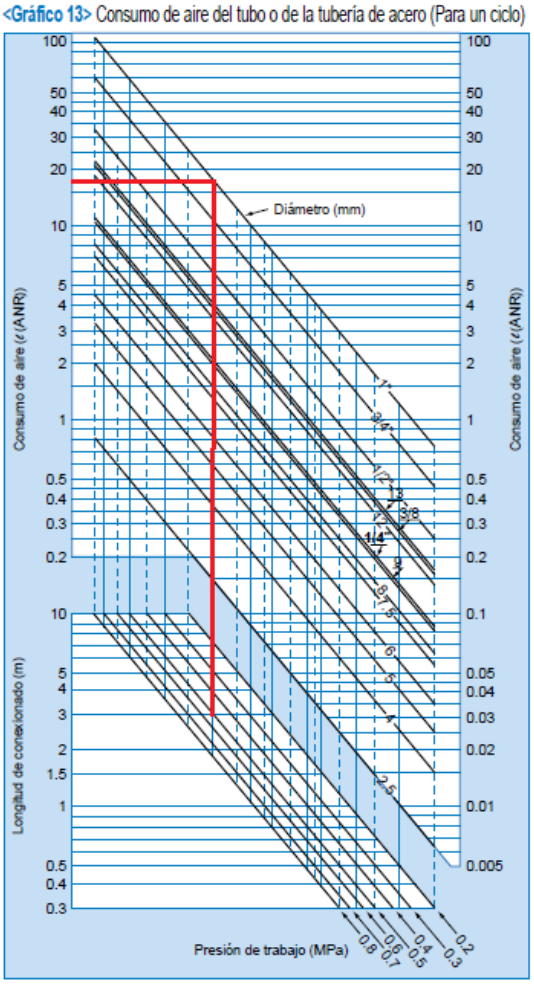
Table 6. Consumo de aire del cilindro para un ciclo



Source:(FESTO, 2013)

3) Calculate the air intake tube as in the previous steps, length of wiring that connects the cylinder with the valve.

Table 7. Consumo de aire del tubo para un ciclo



Sourcee:(FESTO, 2013)

4) Calculate the total air consumption per minute as follows:

Total air consumption = (air consumption of the pneumatic cylinder + air consumption of the tube) * number of cycles per minute * number of cylinders used
Total air consumption = (1,5+20) * 6 * 1 = 129 l/min (ANR)

2.2.5. SELECTION OF COMPRESSOR

The selection of the compressor is essential to the operation of the pneumatic system as it provides the air compressed with which they work, to select a compressor must take into account the drop in temperature, leakage and consumption of intermediate equipment, and therefore you must select a sufficient capacity with a discharge that exceeds the total air consumption.

Festo recommended to select a compressor with 1.4 times the total air consumption, and one with a greater volume if required.

That is why making total consumption of the pneumatic system of 129 l / min (ANR), decides to select a compressor with 2.0 times the total air consumption, ie twice (258 l / min (ANR)).

It should be noted that classical furniture factory Chandi "FAMUCLACH", has a compressor 300 l / min (ANR), 600 [kPa] (6 bar), which meets the desired parameters.

Figure 12. Esquema neumático
Source: Author

2.2.6. DESCRIPTION OF OPERATION AIR

The compressor serves to feed the system with compressed air, which enters the filter maintenance to remove unwanted particles, entering clean compressed air to the solenoid valve, the control element.

Compressed air enters the solenoid on channel 1, leaving it in its natural state for channel 2 to the pneumatic cylinder, which in this connection remain inside the stem.

When activating the solenoid coil air expelled into the air cylinder changes state, exiting channel 4, causing the stem to be pressed out of wood, for consistent air was inside the cylinder channel 3 is discharged .

This process is controlled by a relay 110V AC, which is activated by the ON-OFF contact that is in the control panel.

2.3. SYSTEM OF DEPTH

The system depth stops in the modernization of the machine straight punch cabinetry has an important role to optimize the raw material, used in the construction of each piece.

The cap system is vital in the process of drilling wood, because through this process can have different depths of holes in the wood, the operation of this process is already mentioned in the article, the old system was selecting the depth by a sure pressure (butterfly), but this system was not as efficient due to the failure of insurance.

For this reason, the new system implements a rod with holes, along with insurance, metal pin, wherein each hole and brings the right distance for drilling wood accurately.

2.3.1. STANDARD TYPE OF FURNITURE

The furniture is commonly built in the factory FAMUCLACH are three doors which are comfortable and fitted so that drilling of parts for processing has been prioritized, the factory has set different standards for their respective perforation.

In Table 8 can identify the different standards (distances) to drill to various parts to assemble furniture :

Table 8. Profundidad estándar a perforar.

Mueble \ Madera	Suave[cm]	Dura[cm]	MDF[cm]
Puerta	2,5	3,5	X
Cómoda	2,0	2,0	1,5
Clóset	1,5	1,5	3,0

Source: Author

2.3.2. DRILL ROD

For drilling rod has been taken into account the distances to be drilled, as shown in Table 9:

Table 9*.Cantidad de orificios correspondientes a las distancias a perforar en la varilla*

Quantity	Depth [cm]
1	3,5
2	3,0
3	2,5
4	2,0
5	1,5

Source: Author

2.3.3. DISPLAYING THE CHOSEN STANDARDS

The visualization of the chosen standards is through a LCD screen, which is set by the microcontroller PIC 16F876A, whose digital inputs and outputs are managed through the selection of standards that the operator needs to configuring this control device takes into account the number of pins that will be used, as well as its architecture and robustness to work.

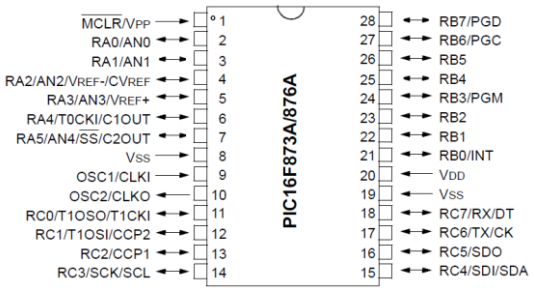


Figura 13. Pines de conexión del microcontrolador PIC16F876A
Source: Author

The family PIC16F87X devices support a wide range of supply voltages ranging from 2.0 V to 5.5 V. The voltage which is feed determine the maximum frequency.

The maximum power dissipation is 1W is calculated by the following formula:

$$P_{disipada} = V_{DD}(I_{DD} - \Sigma I_{OH}) + \Sigma[(V_{DD} - V_{OH})I_{OH}] + \Sigma(V_{OL}I_{OL})$$

Where:

- V_{DD} is the voltage supplied by the power supply.
- I_{OH} is the current supplied by the outputs of the PIC in the high state.
- I_{OL} is the current drawn by the outputs of the PIC in low state.
- V_{OH} is the voltage delivered by the terminals in the high state.
- V_{OL} is the voltage at the terminals on low.

$$V_{DD} = 5V$$
$$I_{DD} = 250mA$$
$$I_{OH} = 20mA \rightarrow 1\ led\ encendido$$
$$V_{OH} = 4{,}30\ V \rightarrow Resistencia\ de\ 220\ \Omega$$
$$I_{OL} = 1{,}3mA$$
$$V_{OL} = 0{,}3V$$

$$P_{disipada} = 5[V].(250[mA] - (11).(20[mA])) + \Sigma[(5V - 4{,}30[V])20[mA]] + (13).[(0{,}3[V]).(1{,}3[mA])]$$
$$P_{disipada} = 5[V].(250[mA] - (220[mA])) + (11).[14[mW]] + (13).[(0{,}4[mW]]$$
$$P_{disipada} = 150[mW] + 154[mW] + 5{,}2[mW]$$
$$P_{disipada} = 309{,}2[mW] = 0{,}3[W]$$

The PIC16F876A is chosen due to their specific characteristics, which are central to this work, offering their 28-pin performance, processing speed, safety and efficiency to display the depth system is implemented.

Programming the microcontroller:

The first tests were performed using the simulation program "ISIS Professional" or also known as "Proteus" which after setting the pins of the LCD on the programming platform "MikroC PRO for PIC" display standards shown after selecting the type of furniture and wood type.

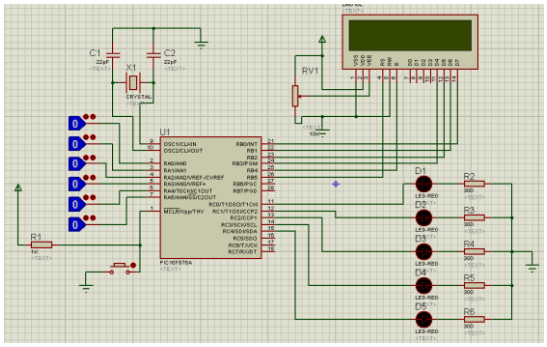


Figure 14. Simulación del circuito de selección de estándares para el sistema de profundidad
Source: Author

Once the simulation successfully circuit, it is necessary to test the armed circuit breadboard, for which the compiler "PICkit2" from Microchip, which performs an interface between the recorder PICs and computer, transferring the program is used carried out in MikroC 16F876A PIC microcontroller.

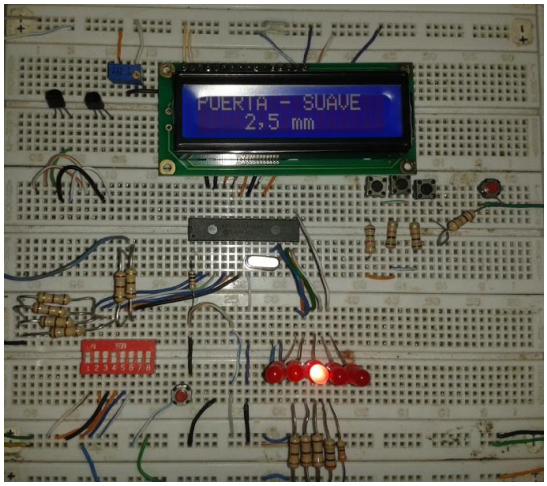


Figure 15. Implementación del circuito en protoboard.
Source: Author

With the proper operation of the circuit on the breadboard, we proceed to design the circuit board that carries the operating system that gives depth using the "PCB Wizard" software.

The plate design can be seen in Figure 16:

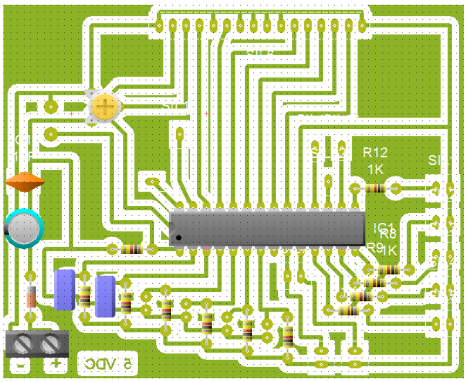


Figure 16. Implementación del circuito en protoboard.
Source: Author

Combinations of type and type of wood furniture which are chosen can be seen in Table 20.

Table 10.*Combinaciones respectivas para salida de estándares de profundidad*

Significado de siglas:

A=Puerta, B=Cómoda, C=Clóset, X=Suave, Y=Dura, Z=MDF.

Salida	Distancia	Combinación	Visualización
1	3,5	A_Y	Puerta – Dura
2	3,0	C_Z	Clóset – MDF
3	2,5	A_X	Puerta – Suave
4	2,0	B_X , B_Y	Cómoda – Suave, Cómoda- Dura
5	1,5	C_X, C_Y, B_Z	Clóset - Suave, Clóset - Dura, Cómoda - MDF

Source: Author

3. SYSTEMS MODERNIZED

Once selected and modernized systems that make up the linear boring machine joinery, proceed to link them to each other, for optimal work.

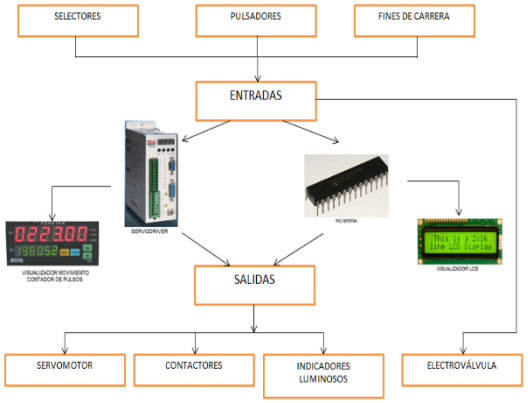


Figure 17. Diagrama de bloques de los sistemas implementados para modernizar la máquina.
Source: Author

3.1. CONTROL PANEL

The control panel allows the operator to control all deployed systems and instantly view vital information that allows the status of systems, such as the movement of the servomotor and system deep.

In Figure 18 the distribution of both control devices, and display devices is observed:

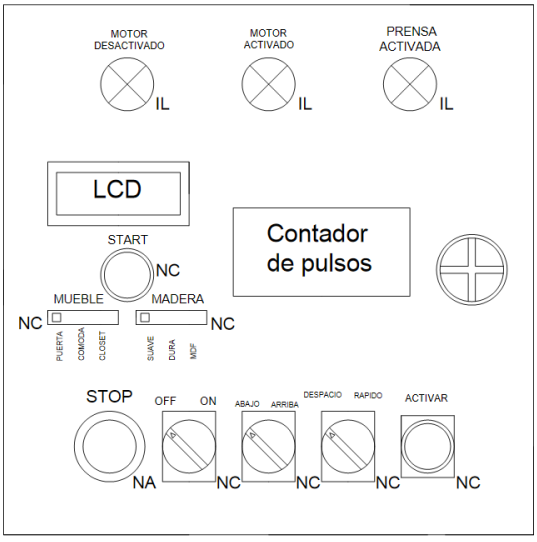


Figure 18. Panel de control con nomenclatura de estado normal.
Source: Author

Where:

NA -> Normally open

NC -> Normally Closed

IL -> Light indicator

3.2. ASSEMBLY AND INSTALLATION

The main cabinet is what allows feed all systems also leads all guards, and contains one of the most fundamental parts of control, as is the Servo Driver, for which it has taken the manufacturer's recommendations for their respective installation.

Figure 19. Conexiones del gabinete del gabinete principal.
Source: Author

Implemented all components of the modernization of the linear boring machine joinery, proceed to check all connections to the meter, being successful verification, energizes the main cabinet, the machine is turned on with the switch (ON) panel control and different test runs performed, Figure 20muestra straight punch machine modernized joinery.

Figure 20.Máquina perforadora lineal de ebanistería modernizada.
Source: Author

4. RESULTS

The results obtained in carrying out this modernization, were clearly positive for expedite the production process, both at optimizing working time machine, operator safety and optimum utilization of raw material.

That is why the data acquired in tests of modernization are compared with data obtained before performing this work:

Table 11.*Optimización del tiempo de trabajo al realizar la perforaciones requeridas para construir cada mueble*

		ANTES	AHORA	OPTIMIZA	OPTIMIZA
Estándar	N° perforacio_ nes	Tiempo [mm:ss]	Tiempo [mm:ss]	Tiempo [mm:ss]	Porcentaje
Puerta-Suave	12	72:00	48:00	24:00	33%
Puerta-Dura	12	84:00	60:00	24:00	28%
Cómoda-Suave	26	138:20	86:20	52:00	37%
Cómoda-Dura	26	138:20	86:20	52:00	37%
Cómoda-MDF	26	130:00	78:00	52:00	40%
Clóset-Suave	50	250:00	150:00	100:00	40%
Clóset-Dura	50	250:00	150:00	100:00	40%
Clóset-MDF	50	315:00	215:00	100:00	31%

Source: Author

Table 11 shows that the modernization of the linear woodworking drilling machine optimizes on average 30% of the time spent in the construction of each piece.

Table 12.*Optimización de materia prima requerida para construir cada mueble en veinte días laborables*

			ANTES	AHORA	OPTIMIZA	OPTIMIZA
Proceso	Materia prima	Cantidad muebles	Cantidad materia prima	Cantidad materia prima	Cantidad materia prima	Porcentaje
Puerta	Madero	12	84	72	12	14%
Cómoda	Madero	4	44	40	4	9%
Clóset	Plancha	4	16	12	4	25%

Source: Author

Table 12 shows that the modernization of the linear woodworking drilling machine optimizes on average 16% of the raw material used to work twenty (20) working days.

Implementation shows pneumatic system favorable in performance operator safety, this is because neither of the other two systems are powered by electricity, if the timber is not pressed.
Therefore the operator must necessarily turn the tire to perforate the timber and in turn safeguard the physical integrity system.

5. CONCLUSIONS

- The modernization of linear drilling machine joinery expedite the furniture production process, reducing time in the drilling process raw materials by 30%.

- Depth system optimizes the use of the raw material required to manufacture each piece, reducing consumption by 16%, considering twenty weekdays.

- Through the force transmission ratio and speed of the vertical positioning is optimized.

- The pneumatic system implemented in linear woodworking drilling machine operator protection rises by 12%.

- Through testing it was possible to correct mistakes and shortcomings in the field of precision, speed, pneumatic clamping and depth, presented in linear drilling machine, reaching a 1% failure.

6. RECOMENDACIONES

- Comply fully with the maintenance of the machine straight punch joinery at the indicated time to avoid major setbacks in the long term.

- We recommend reading this manual before starting to work for properly operating.

- In case of any damage to the machine straight punch joinery are advised to seek qualified technical assistance or contact the authors of modernization.

- It is important to check the tire pressure entering the system from the compressor, which must not exceed 100 psi, the disregard this warning may cause damage to equipment and operator.

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