



TECHNICAL UNIVERSITY OF NORTH

FACULTY OF ENGINEERING IN APPLIED SCIENCES

ENGINEERING IN MECHATRONICS

Design and construction of a machine automatic dosing of peat for pylons form pyramidal, trays of 50 x 28, 2cm (10 x 20) in the process of production of seedlings.

TECHNICAL REPORT

AUTHOR:

Gabriela Sofía Estrella Ormaza

DIRECTOR:

Eng. Gabriela Verdezoto

Ibarra - Ecuador

2014

DESIGN AND CONSTRUCTION OF A MACHINE AUTOMATIC DOSING OF PEAT FOR PYLONS FORM PYRAMIDAL, TRAYS OF 50 X 28, 2cm (10 X 20) IN THE PROCESS OF PRODUCTION OF SEEDLINGS.

Gabriela Sofía Estrella Ormaza

OVERVIEW. This project aims to contribute to the development of the production of the country matrix to generate more production of seedlings of vegetables in less time than the manual production through the use of programmable industrial, drivers, among others.

The main objective is implement automatic dosing machine of peat (land) for cells with pyramidal shape, located in trays of 50 x 28.2 cm, in the seedling production process.

The development of this project begins with the mechanical design of the structure and dimensioning of the elements which allow the correct operation of the machine.

To implement an automatic system will reduce the time of dosing of peat in the trays, thus improving the production of seedlings.

1. INTRODUCTION

As technology has evolved, so also the cultivation techniques have improved. Due to climatic changes, farmers have been the need to ensure its production in such a way that these people use already germinated plants acquired in the greenhouses, then transplanting them in its grounds and thus ensure their crops and their crops.

Nowadays people planted lots of seeds in trays to then sell these small plants germinated to greenhouses. They are planting manual, using long in filling land in each of the holes in the trays. For filling of land in each of the trays, workers placed lots of peat on the Pan and then they slide their hands firmly pressing rations of peat against the holes and filling them completely. The large

number of trays that are dose may produce pain in both upper and lower extremities.

In the market there are high cost and large size seeding automatic machines that make that the owners of the greenhouses that are progressing professionally continue the activities of dosage of peat and sowing the seeds manually.

In view of these circumstances in this work is to design and build a low-cost, moderate-sized machine and measure out peat without any intervention of the human effort. It will thus reduce time of dosage and a percentage increase in the production of dosed and sown trays.

2. CONTENT

A. DOSING MACHINE MECHANICAL DESIGN

Design by hoppers: In dispensing it is necessary to use two hoppers because with a single uniform dosing that fill every cell of peat is not obtained.

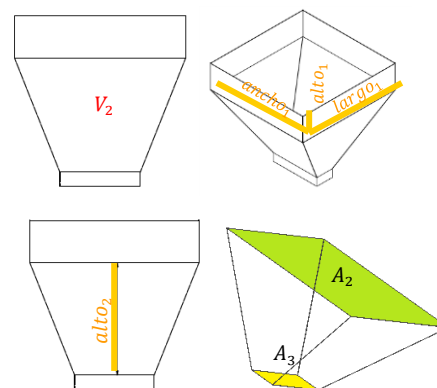


Figure 1. Dimensions of the hopper

$$V_{total} = V_1 + V_2$$

Equation 1. Total volume

Where:

V_{total} : Total volume of hopper [m^3]

V_1 : Volume square section of the hopper [m^3]

V_2 : Volume pyramidal section of the hopper tolva [m^3]

$$V_1 = largo_1 \times ancho_1 \times alto_1$$

Equation 2. Volume of the hopper square section

Where:

$largo_1$: Length of square section [cm]

$ancho_1$: Width of square section [cm]

$alto_1$: Height of the square section [cm]

$$V_1 = 0,054 [m^3]$$

$$V_2 = \frac{alto_2}{3} \times (A_2 + A_3 + \sqrt{A_2 \times A_3})$$

Equation 3. Volume of the pyramid of the hopper section

Where:

$alto_2$: Height of the pyramid section [cm]

A_2 : Area of square section [m^2]

A_3 : Area of the mouth of dosage [m^2]

$$V_2 = 0.065 [m^3]$$

$$V_{total} = 119.194 [L]$$

$$P = \frac{F}{A}$$

Equation 4. Calculation of the maximum internal pressure that support the hoppers

Where:

P : Maximum internal pressure that support the hoppers loaded with peat. [Pa]

F : Force generated by the mob because of gravity. [N]

A : Area occupied by the mob into the hoppers. [m^2]

$$P = 1133.5084 [Pa]$$

Hoppers support structure: For the support of the hoppers, in which peat shall be deposited with a steel structure, will be placed from the bracket of the conveyor belt towards the center of mass of the hoppers.

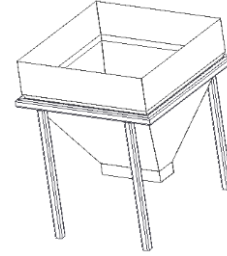


Figure 2. Supporting structure of hoppers

Mechanism of compacted peat: For the compacted peat were built two pieces of aluminum to be light for its activation, is has the same width of the tray of 28.2 [cm] and it has tips for the tacado, which pushed the peat within each cell in the tray.

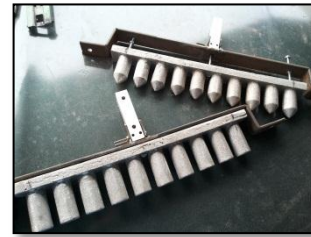


Figure 3. Tacadora peat

B. SELECTION OF CONTROL ELEMENTS

Pneumatic cylinders: Actuators elements used for the activation of the tacadores and for openness in the dosage of the peat of the hoppers on the trays. The moving force is the weight of the item that will mobilize the pneumatic cylinders.

FEATURES	
Pressure [bar]	6
Diameter [mm]	25
Career [mm]	170
Moving force [N]	255
Type of operation	Double effect
Air consumption [L/min]	105

Table 1. Technical characteristics and operation of opening of the hoppers cylinders

Source: (SNS P. , 2008)



Figure 4. Pneumatic cylinder for the opening and closing of the mouth of the hoppers

FEATURES	
Pressure [bar]	6
Diameter [mm]	10
Career [mm]	50
Moving force [N]	5
Type of operation	Double effect
Air consumption [L/min]	9

Table 2. Technical characteristics and operation of the compactors cylinders
Source: (SNS, 2008)

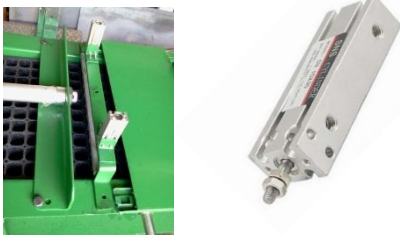


Figure 5. For the compaction peat pneumatic cylinder

Maintenance unit: A maintenance unit was used to prevent water particles from entering pneumatic elements.

FEATURES	
Components	Filter Regulator Lubricator
Pressure range [MPa]	0.05 ~ 0.85
Maximum pressure [MPa]	0.95
Maximum air flow [L/min]	700

Table 3. Technical characteristics and operation of the maintenance unit
Source: (SNS, 2008) (Acosta Jaramillo, 2014)



Figure 6. Maintenance unit

Conveyor belt: The conveyor belt material used for the displacement of the trays is green type ASTER PVC because it is an industrial process that is in contact with Earth and a little moisture.

FEATURES	
Band type	Breda B12 CK
Material	PVC
Color	Green
Special features	Antistatic, resistant to mineral oils and grease and abrasion.
Thickness	2.7 [mm]
Weight	2.95 [kg/m ²]
Dimensions	28 [cm] × 5.4[m]

Table 4. Technical characteristics and operation of the conveyor belt

Source: (Bandas & Bandas, 2013), (Acosta Jaramillo, 2014)



Figure 7. Conveyor belt

Servo motor and driver: Used a servo motor that is easy to control and also has a driver by means of which the number of revolutions can be programmed which must work the engine.

FEATURES	
Engine type	AC Servo motor
Model	SMH80S-0075-30AAK-3LKH
Voltage [V]	220
Power range [W]	750

FEATURES		
Speed range [rpm]		3000
Torque [Nm]	Nominal	2.39
	Maximum	7.17
	Stop	2.63
Current [A]	Nominal	3.9
	Maximum	11.7
	Stop	4.4

Table 5. Technical characteristics and operation of the actuator

Source: (Kinko, 2013), (Acosta Jaramillo, 2014)



Figura 8. Servomotor

FEATURES	
Type of driver	Servo driver
Model	CD 420
Voltage [VAC]	220
Elements of the driver	Power supply for the control of 24 [VDC]
Elements of the driver	7 digital inputs
	Pulse signal input
	2 analog inputs
	4 current outputs 100 [mA]
	Digital outputs of 24 [V]y 100[mA]
	Brake control outputs
	The encoder input/output

Table 6. Technical characteristics and operation of the servo-driver

Source: (Kinko, 2013), (Acosta Jaramillo, 2014)

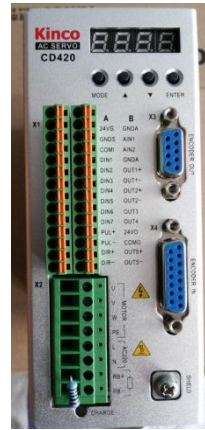


Figure 9. Servo-driver

Sensors: Limit switch sensors were used in the detection of the trays on the conveyor belt for the dosage and the compaction of peat; as well as to detect the level of peat into hoppers used sensors of limit switch lever-type as opposed to the detection of the trays that are of type low roller.

FEATURES	
Material	Plastic and metal
Head	<ul style="list-style-type: none"> o Lever with roll o Lever
Contact settings	1 NC + 1 NO
Protection	IP66
Amperage	15 [A]
Voltage	125 – 250 [VAC]

Table 7. Technical characteristics and operation of the limit switch sensors

Source: (Consortio Electrico Industrial S.A.C), (Acosta Jaramillo, 2014)



Figure 10. Micro switch (end of career)

Tongue switches or also called Reed or reed switch switches were used for the detection of the piston of pneumatic cylinders used in the tacadores.

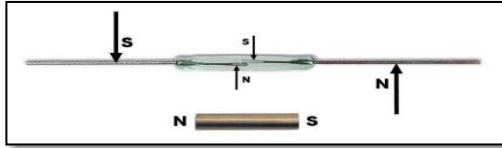


Figure 11. Sensors reed switch

The technical characteristics of the sensors are shown in the following table:

Features	Description
Voltage range	24 [VDC]
Operation time	0.6 [mseg]
Release time	0.1 [mseg]
Useful life	1 a 200 million transactions
Weight	1 [g]

Table 8. Technical characteristics of the magnetic sensors

Source: (Hamlin, 2008)

In magnetic sensors adapted plastic plugs WF2 (2 pin plug) and WM2S (2 pin female connector) to connect the cables of the sensor with the PLC and in this connection and disconnection of sensors make more practical.

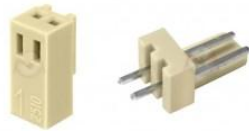


Figure 12. WF2 and WM2S connectors

Actuators: The elements used for the activation of the machine operations are the 5/2 solenoid valves which mobilize the tacadores and caps of the hoppers for the dosage of peat.

FEATURES	
Voltage range	24 [VDC]
Operating pressure	1.5 ~ 8 [bar]
Power	3 [W]
Temperature	35 [°C]
Protection	IP65
Type of valve	5/2
Port size	1/4 "

Table 9. Technical characteristics and operation of the solenoid valves

Source: (SNS, 2008), (Acosta Jaramillo, 2014)



Figure 13. Electrovalve 5/2

Pushbuttons and pilot lights: Two flush type switches were used; a button is for power and the other for the paid machine, button mushroom is to stop the machine in case of emergency.

Pilot lights used are to indicate if the machine is switched on (green) or off (red) and if there is a level of peat bass in some of the hopper, the (yellow) alarm light illuminates.



Figure 14. Placement of the buttons and the pilot light on the control panel lights

C. DESIGN OF CONTROL SYSTEM

The realization of control system used a PLC Logo! OB6, is a programmable controller basic but capable of carrying out industrial activities like the machine of dosing of peat.

FEATURES	
Name of the PLC	LOGO! 12/24RC
Tickets	8 (4 analogue)
Outputs	4 (type relay)
Permissible range	10.8 [V] ... 28.8 [V DC]
"0" logical	Max. 5 [V DC]
"1" logical	Min. 8.5 [V DC]
Intensity of input	0.1 – 1.5 [mA]

Table 10. Technical characteristics and operation of the programmable controller

Source: (Siemens, 2014), (Acosta Jaramillo, 2014)



Figure 15. Selected PLC

Flowchart of the PLC program

The following flowchart shows graphically the development of dispensing of peat:

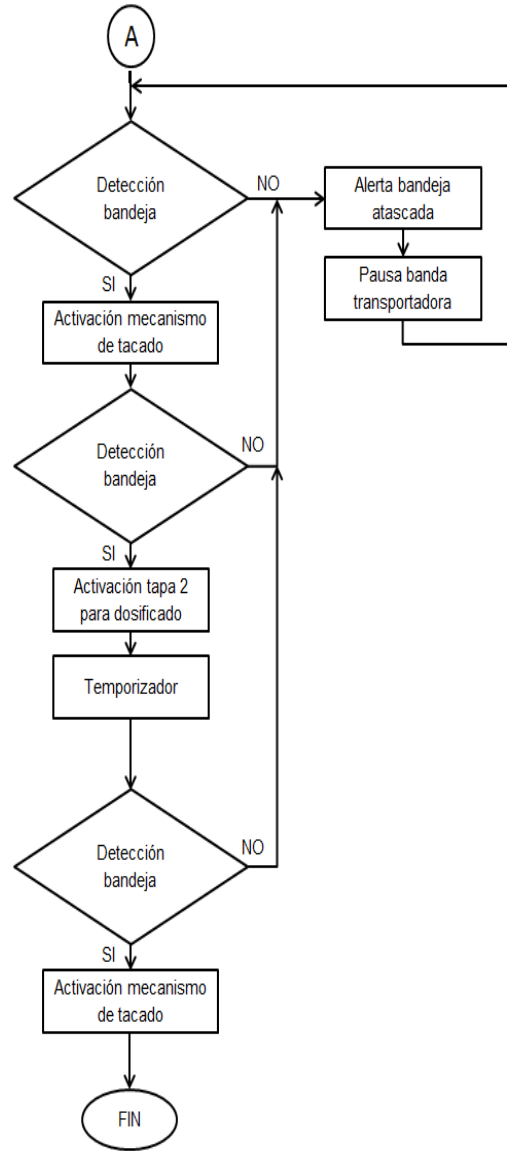
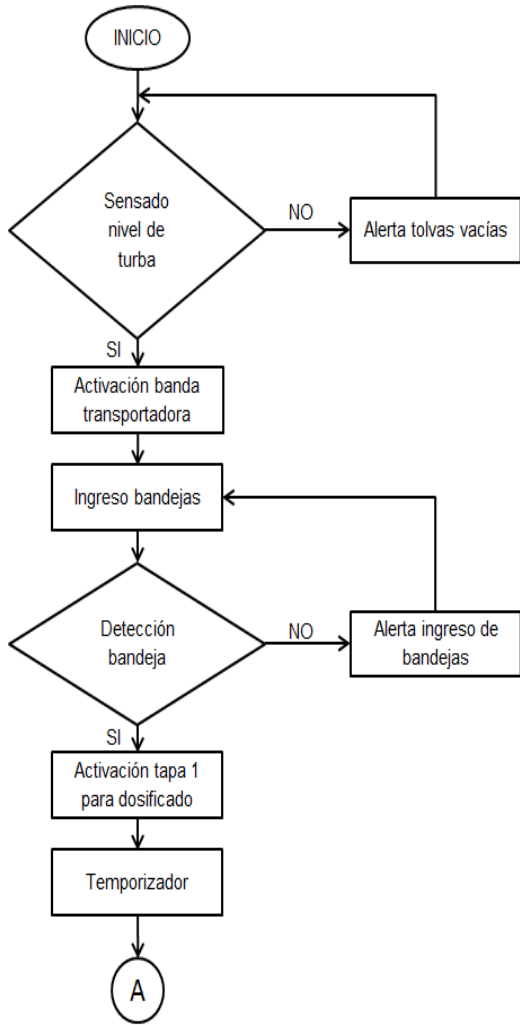


Figure 16. Flowchart of the PLC program

Flowchart of the servo-driver program

The following flowchart details the step-by-step activities of servo driver is scheduled so that engine complies with the specific function within the peat dispensing:

Step by step, these machining operations are represented by graphical symbols used in flow charts:





Symbology	Interpretation	Description of the activity
	Operation	It indicates the phases of the process
	Transport	Indicates the movement of material or element from one place to another
	Inspection	It indicates the inspection of quality or quantity
	End process	Indicates the end of the process

Table 12. Standard the flowchart symbols

Code	Activity
E1	Installation of the conveyor belt structure
E2	Installation of bearings
E3	Installation of conveyor belt rollers
E4	Installation of the conveyor belt
E5	Installation of the brackets of the hoppers
E6	Installation of the brackets of the mechanism of compacted
E7	Installation of the brackets of the pneumatic cylinders
E8	Installation of pneumatic cylinders
E9	Installation of hoppers
E10	Installation of the actuator
E11	Control box installation

Table 13. Activities carried out in the general machine implementation

Code	Activity
1	Selection of the box
2	Placement of rail
3	Placement of protection elements (breaker, fuses, contactor)
4	Placement of the driver of the actuator
5	Placement of terminals
6	Placement of the source of the PLC
7	Placement of the PLC
8	Connection of signal elements
9	Connection push-buttons and emergency stop
10	Connection of sensors
11	Connection of actuators
12	Labeling of cables
13	Energization of the elements

Table 14. Activities in the implementation of the control board

Code	Activity
1	Pneumatic cylinders for dosage of peat placement
2	Placing pneumatic cylinders for compacted peat
3	Placement of fittings
4	Connection of solenoid valves
5	Maintenance unit connection
6	Compressor connection
7	Labeling of cables and hoses

Table 15. Activities carried out in implementation of the pneumatic system

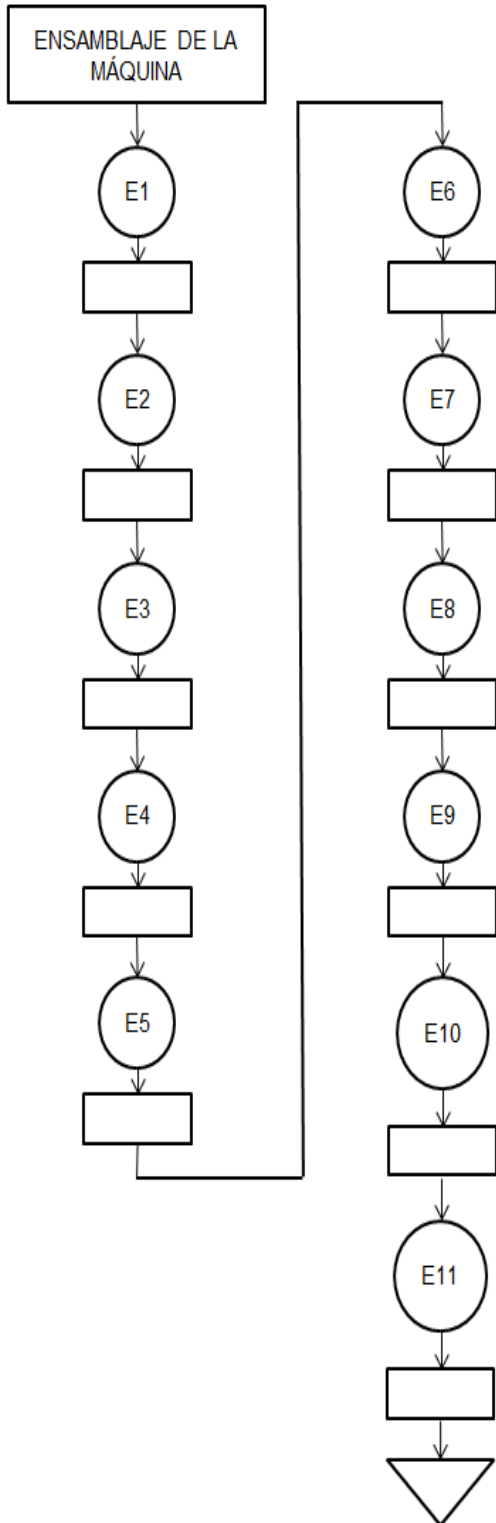


Figure 18. Flowchart of activities carried out in the general machine implementation

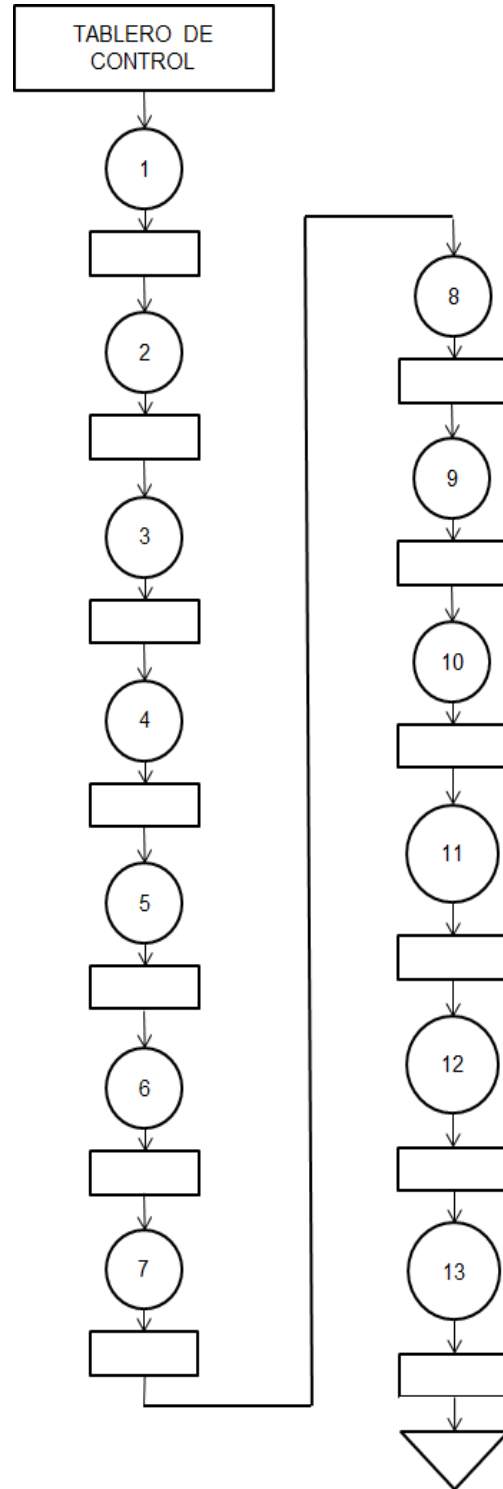


Figure 19. Flowchart of activities undertaken in the implementation of the control board

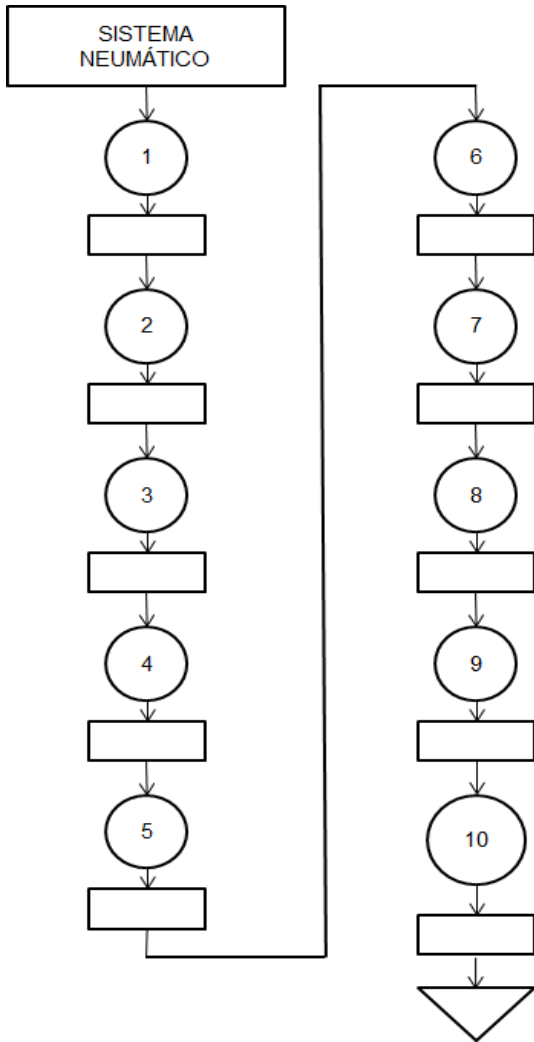


Figure 20. Flowchart of activities undertaken in the implementation of the pneumatic system.

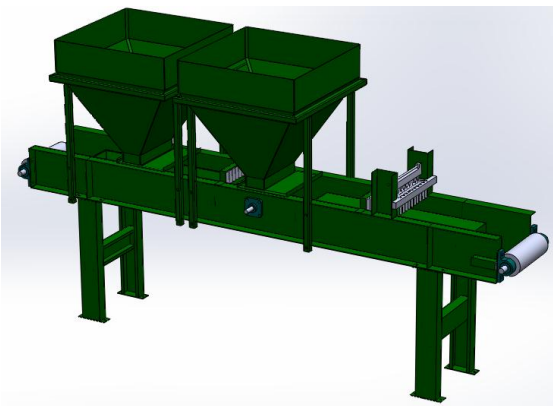


Figure 21. Mechanical the machine scheme

Connection diagram

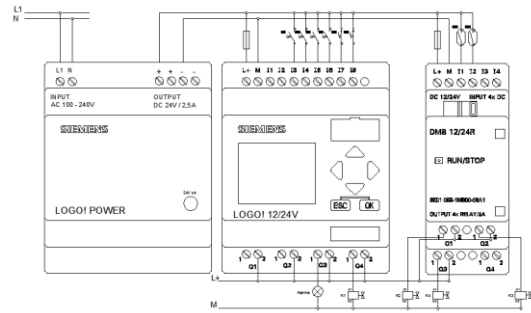


Figure 22. Connections of the machine scheme

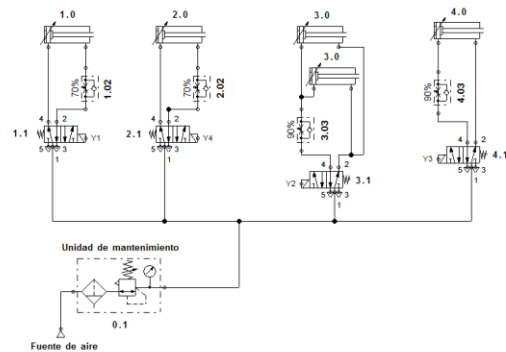


Figure 23. The pneumatic machine wiring diagram

3. TESTS AND RESULTS

The machine design is optimal because it not only resists the pressures of possible loads that will be presented during the operation of the machine, but it is built to avoid as much as possible, failure of resistance or support of each one of the mechanical elements.

As well as in the analysis of the hoppers, hoppers support structure, opening of hoppers covers are oversized to prevent any possible future failure.

$$P = \frac{F}{A}$$

Equation 5. Calculation of the maximum internal pressure that support the hoppers

Where:

P : Maximum internal pressure that support the hoppers loaded with peat. [Pa]

F : Force generated by the mob because of gravity. [N]

A : Area occupied by the mob into the hoppers. [m^2]

The internal pressure calculated for the hoppers is:

$$P = 1133.5084 [Pa]$$

And according to the yield strength minimum of material, which are built the hoppers which is 250 [MPa], then you can determine that the hoppers if they withstand the pressure generated by peat inside of them.

Analysis of opening of the hoppers tops:

SOLIDWORKS can be determined with the aid of the software effort of Von Mises, which indicates the minimum and maximum opening of hoppers caps value.

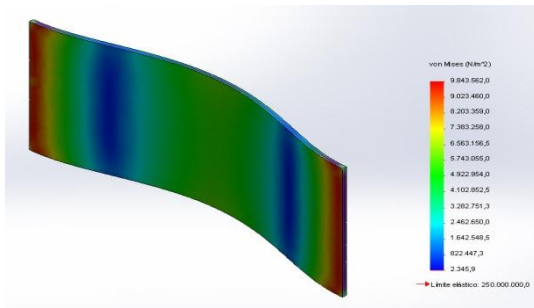


Figure 24. Effort of Von Mises of the dosing Cap

The following table shows the values of effort that shall be the closing of the mouth of the hopper-open lid.

Effort	Minimum	Maximum
Von Mises	2345.93 [N/m^2]	984356×10^6 [N/m^2]

Table 16. Values of the effort of Von Mises

Due to the force applied to the top is a displacement, this is a very important factor because if the displacement varies markedly take corrective action piece.

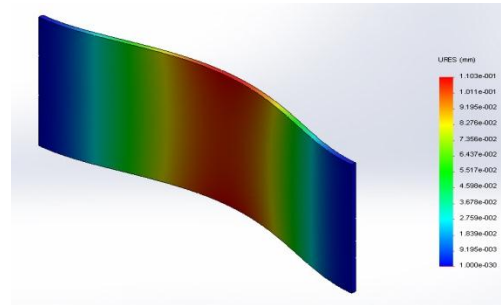


Figure 25. Displacement by the force exerted on the lid

The displacement values obtained are as follows:

Displacement	Minimum	Maximum
	0 [mm]	0.110341 [mm]

Table 17. The carried out offset values

Analysis of the structure of support of hoppers:

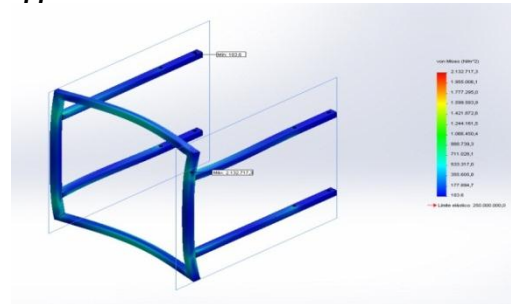


Figure 26. Effort of Von Mises

With the help of computer-aided design software, Solidworks, the effort exerted on the structure and the same way resistance or change it to any overload can be determined.

The following table shows the values of the minimum and maximum effort that can be exercised on the supporting structures:

Effort	Minimum	Maximum
Von Mises	183.554 [N/m^2]	2.13272×10^6 [N/m^2]

Table 18. Values resulting from the analysis of the supporting structures

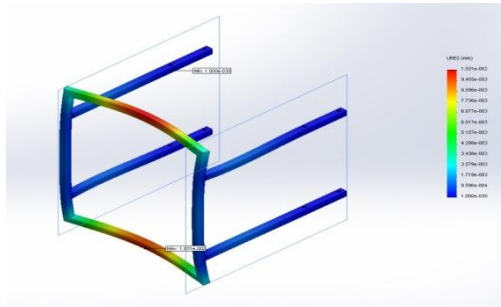


Figure 27. Resulting displacement

Figure 24 shows the maximum and minimum displacement resulting from the effort of tension that the structures of the peat-filled hoppers are subject graphically.

Resulting displacement	Minimum	Maximum
	0 [mm]	0.010315 [mm]

Table 19. Resulting displacement

Dosing of peat in the trays:

Dosing of peat in the trays was presented a problem in sensing the presence of the trays because the limit switch sensors were very attached to the trays and that not allowed to change state (activated/deactivated), so it was required to take these sensors approximately 3 [mm] backwards so that the detection of the trays is appropriate.



Figure 28. Failure of dosed peat trays on.

Dispense time of peat in the second hopper should be less than the first hopper otherwise peat builds up out of the tray.



Figure 29. Accumulation of peat on the conveyor belt

Movement of the conveyor belt:

It was used for the transmission of the movement from the engine onto the conveyor belt drive drum a type coupling marriage or also known as type spider which has two round sections of steel with three teeth that fit between both sections, in the Middle has a coupling elastic star shaped to avoid damage of the coupling.



Figure 30. Attach transmission of movement of the conveyor belt motor

4. CONCLUSIONS

- Was dosed peat in trays in less time, approximately 3 [min] which represents 30% of the time that remained delayed from manually testing each tray, which was 10 [min], for this reason gets that dosing machine reduces to less than half trays dispense time.
- Defined the parameters involved in the process of production of seedlings primarily in the dosage of peat, these parameters are the

speed of opening and closing the cover of the mouth of the hoppers that are controlled by PLC, the determination of the speed of opening and closing the covers of the hoppers is given by 0.8 seconds timers time that cannot be more than the one assigned in the PLC because the exceed that time peat falls without control and generates an excess of peat on the band and more weight for the actuator.

- As initial idea for the dosage of the peat was thought placing vibrators to hoppers that peat not be compact and lower onto the trays, but since for the opening and closing of the hoppers caps were placed pneumatic cylinders which, at the time, close the fall of peat, generate a little blow to the hopper allow the peat that is compacted to lower automatically towards the mouth; This alternative allowed to rule out the use of vibrators, causing a reduction in the costs of the implementation of the project.
- In the testing of dosed peat was presented the drawback that conveyor belt is sliding to the right side of the rollers which generated an overload on the actuator because it generates friction against metal structure, was necessary to verify if the drums were well focused and at the same level from each other, so that registered a rise of approximately 1.5 [mm] thick one of the rollers, with this procedure it was found that at several speeds the band not slipping.
- By the presence of peat at the ends of the steel structure near the section of dosed settled coatings of rubber side of each rail, this way reduces the binding at the time of dispensing the mob.
- During the operation of the conveyor belt is presented unexpected movement, since the union of the ends of the conveyor belt across made it and as such section is thicker than the rest of the band at the time of the union through the rollers, the band gives a sudden movement and accelerates its speed for a moment therefore in dispensing the band will stopping per-row when compact peat so the

sudden movement that is generated does not affect the tacadores and get caught; but a ratchet which ensures that the engine is not returned by the inertia of the band and can thus compact peat trays per-row was used to be able to stop the actuator whenever it moves a row.

- For placement of the valves unions is needed to enlarge the thread with a tap type NPN fittings fit properly and do not generate loss of air or damage on the thread of the elements.
- Tray should move per-row compact peat to make holes to deposit the seeds, so it was necessary to position limit switches at a distance of approximately so that each one of the cells stop the sensor and to give a signal of presence of the tray.
- The amount of peat that stored the hoppers of the machine allows the dosage of about 10 shelves, is worth mentioning that the level of peat for the dosage of these trays is designated as maximum filling level of 100 hoppers [L].
- Dosing machine is part of a process of production of seedlings of tomato and pepper; the production process is composed of the dosing and also a seeder, both machines are placed on the same metal structure and share the use of the conveyor belt as well as programmable controller.

5. RECOMMENDATIONS

- ✓ Before operating any machine, it is necessary to realize to check that the mechanical components are correctly adjusted and leveled otherwise will be presented further problems of noise or movement thereof.
- ✓ To easily determine which meet each of the elements of a machine control function it is essential to identify symbols that allow to publicize its location within the control panel as well as in the rest of the machine.

- ✓ Elements of a machine with a certain degree of security should be built or an extra value to the dimensions calculated so that they do not occur fail by bad sizing or friction of the elements at the time of fully assembled machine.
- ✓ Cleaning the machine must be daily with the help of hose maintenance after each use to prevent waste from peat is compacted and generate which in dosage sleepers there is no appropriate displacement of tapas as well as peat waste moving conveyor belt on either side, and this does not focus properly.
- ✓ Check bearings drums or rollers of the conveyor belt that are operating properly and very good tight to each of the roller shafts.
- ✓ Follow step by step the machine maintenance manual to avoid damage of the same and correct any possible problem arising during operation of the machine.

BIBLIOGRAPHY

Acosta Jaramillo, C. A. (December 2014). *Diseño y construcción de una máquina automática sembradora de semillas de tomate y pimiento en bandejas de 50x28.2 cm en el proceso de producción de plántulas. (Thesis Mechatronics Engineering)*. Ibarra, Imbabura, Ecuador.

Bandas & Bandas. (24 de Mayo de 2013). *Bandas & Bandas*. Recovered 2014, <http://bandasybandastransportadoras.blogspot.com/2013/05/bandas-industriales-bandas.html>

Consortio Electrico Industrial S.A.C. (s.f.). *Empresa comercializadora de productos de ingeniería*. Recovered 2014, http://www.consortio-electrico.com/pag_camsco/indice_z-15.html

Hamlin. (2008). Retrieved from <http://www.hamlin.com/specSheets/AN104.pdf>

Kinko. (2013). *Kinko*. Recovered 2014, <http://www.kinco.cn/html/en/products/Servo&Stepper/Servosystem/Servomotor/201104/28874.html>

Kinko. (2013). *Kinko*. Recovered 2014, <http://www.kinco.cn/html/en/products/Servo&Stepper/Servosystem/Servodriver/CDseries/201104/28872.html>

Siemens. (September 10, 2014). *Automation24*. Recovered 2014, <http://media.automation24.com/datasheet/es/100916.pdf>

SNS. (2008). *SNS Pneumatic*. Recovered 2014, http://www.sns.com/eng/products_read.asp?id=104&sid=29&bid=3

SNS. (2008). *SNS Pneumatic*. Recovered 2014, http://www.sns.com/eng/products_read.asp?id=15&sid=2&bid=1

SNS. (2008). *SNS Pneumatic*. Recovered 2014, http://www.sns.com/eng/products_read.asp?id=41&sid=11&bid=2

SNS, P. (2008). *SNS Pneumatic*. Recovered Julio 2014, http://www.sns.com/eng/products_read.asp?id=99&sid=27&bid=3

REFERENCES AUTHOR



Gabriela Sofia Estrella Ormaza

Born March 14, 1992 in the city of Ibarra, Bachelor of Computer Science of the Colegio Nacional de Señoritas "Ibarra", now called Unidad Educativa Ibarra.

University studies were conducted at the Technical University North in Engineering in Mechatronics.

The areas of interest are: electricity, mechanics, electronics, industrial automation, robotics and control.

(gabystatr@hotmail.es)