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FABRICATION OF PLANT POT MAKING MACHINE WITH WOOD CHIPS AS RAW MATERIALS

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Abstract: **The purpose of this study is to design and fabricate a plant pot making machine that uses wood chips as raw materials. This study is beneficial to the plant shop owners, community and future researchers. It promotes green earth by using waste wood chips as a medium for the plant pot. The researchers made a prototype that can demonstrate the process of how the plant pot is being produced. The researchers used the fundamental knowledge in machine design to select and evaluate the different materials as well as the force analysis of the whole machine. Hence, this study will be beneficial to the Mechanical Engineering Students of the Lyceum of the Philippines University-Cavite Campus.**

Keywords: **LPU-Cavite, resort Campus, Plant Pot Making Machine.**

I. INTRODUCTION

Wood has been used and adapted by humans since the earliest recognition that they could make use of the materials they found around them. In the Philippines, woods are generally used in making windows, walls, floors, doors, and other durable pieces of furniture. Manufacturing wooden furniture produces waste such as wood chips/shavings and are usually just thrown out. The Philippines being a tropical country, gives home to a lot of plants and flowers like in Silang, Cavite where a lot of flower shops are located. Flower and plant shops use plant pots to display or contain the plant/flower that they are going to sell. There are now a large variety of materials used for making plant pots ranging from plastics to biodegradable materials. With regards to the different cases indicated beforehand, this research is conducted for the development and fabrication of a machine used for making plant pots with wood chips as raw materials. This research will provide another use for wood chips rather than being thrown away and not being used.

II. LITERATURE REVIEW

The limited supply of petrochemicals for conventional plastic containers and the increasing worldwide demand for petroleum will continue to dictate greenhouse and nursery container prices (U.S. Energy Information Administration). Additionally, consumers are becoming increasingly aware of and interested in the green industry’s impact on the environment. Therefore, economic, and social pressure to reduce plastic use and increase sustainable production practices will only increase. The green industry must consider greater reuse and recycling of plastic products as well as containers made of alternative materials. Growers and landscapers must evaluate the compatibility of the entire production system from planting and irrigation, to harvesting, transportation and marketing, as well as, crop species, business location, level of mechanization, and many other factors to successfully integrate a new container type. Identification of container types suited to crop cycles of varying duration (short-term, long-term) is needed. The environmental benefits of using alternative containers must be weighed against potential challenges and associated losses incurred due to the decrease in container integrity over time as well as other increased costs (increased water usage and energy requirements of industrial composting). Alternative containers impregnated with various components such as natural color, slow release fertilizers, fungicides, insecticides, and plant growth regulators that are released during plant growth are gaining entry to the market and could enhance production system efficiency. Members of the green industry, allied industries, and researchers must continue to work together to develop and fine-tune sustainable alternative containers that are compatible with current production practices and are economically feasible.

III. METHODOLOGY

The studies related to this research were used as a guide on how to formulate the operation and function of the equipment being constructed. Experimental method was used in this study and fabrication. The researchers based the construction and design of the prototype to the present process of plant pot making in today's time. Different principles like force analysis, strength of materials, pneumatics, heat treatment, machining and also the anthropometric data for Filipinos are used in the construction of the machine.

Materials and equipment used in fabricating the machine:

- Metal Blanks (Mild Steel)
- Metal Rods/Cylinders (Heat Treated)
- Lathe Machine
- Milling Machine
- Surface Grinder
- Welding Machine (SMAW and TIG)
- Tool Bit
- Drill Bit
- Castle Nut
- Band Heater
- Compressor (2hp)
- Pneumatic Cylinder
- Plastic Tubing
- Pneumatic Fittings

A. Project Construction Procedures

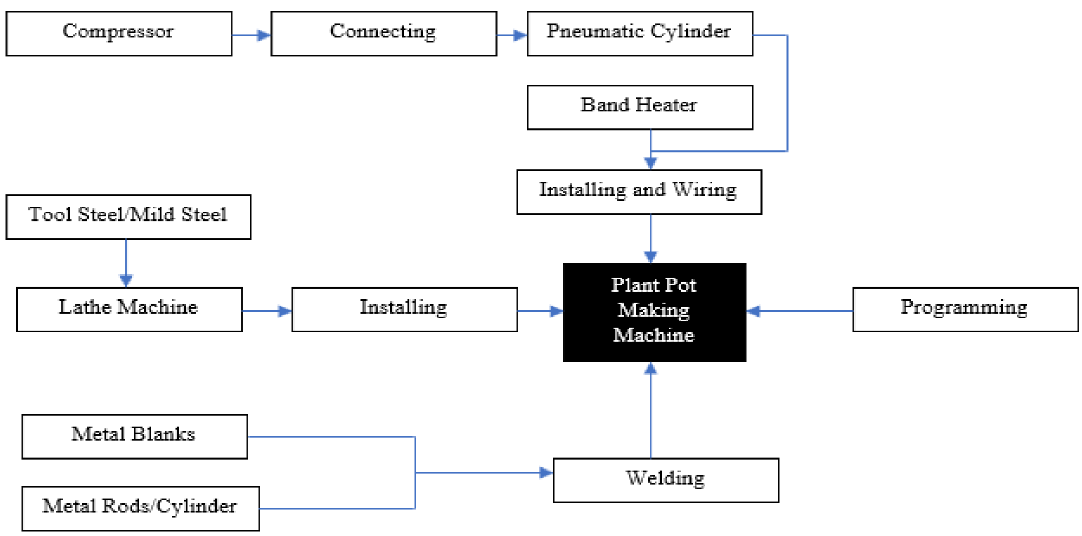


Figure 1: Project Construction Flowchart

B. System Model, Parts and Description

1. Pneumatic Cylinder - The pneumatic cylinder drives the tool up and down via air pressure.

2. Up Switch - A button, when pressed, the pneumatic cylinder will retract the tool upward.

3. Down Switch - A button, when pressed, the pneumatic cylinder will exert pressure to drive the tool downward.

4. Tool and Die - Tool and die are precision tools or metal forms that are used to cut, shape, and form metal and other materials. The output product is based on the shape and dimension of the tool.

5. Upper Frame - It supports and holds pneumatic cylinder, circular disc, tool and die, band heater, and the power switch.

6. Band Heater - It is a device used to heat any interior or exterior cylindrical surface it is attached to. In the machine, it is used to heat up the die.

7. Process Button - These two buttons when pressed, will start to rotate the circular disc which holds the die clockwise.

8. Circular Disc - It holds the die and is driven by a motor to rotate.

9. Control Panel - It is the device that controls the speed, and temperature. It also displays the current speed of the motor and the temperature of the band heater.

10. Stepper Motor - This motor is used to rotate the circular metallic disc plate where the two dies are attached for automation.

11. Lower Frame - It holds and supports every part of the machine.

12. Air Compressor - Supplies air pressure to the pneumatic cylinder via tubes.

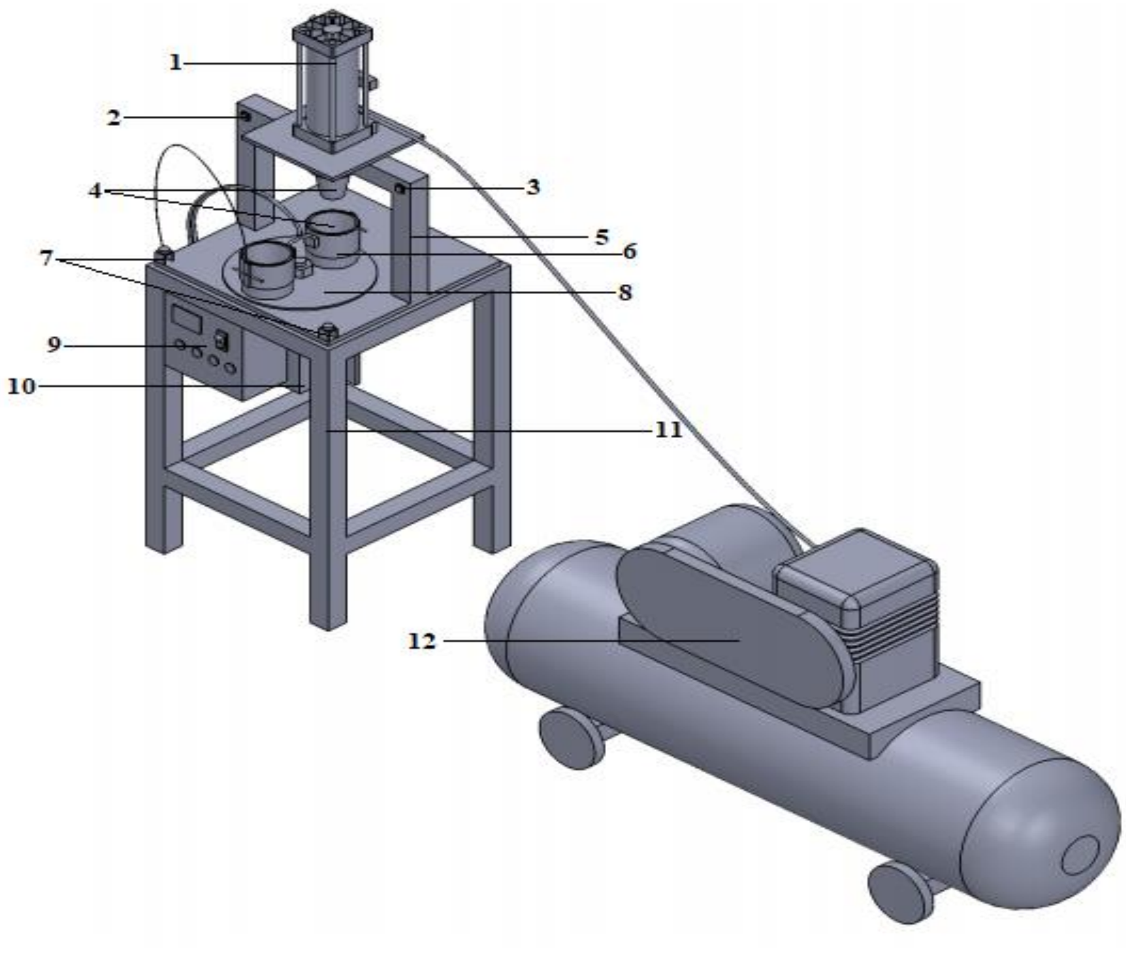


Figure 2: Isometric View of the Plant Pot Making Machine with Air Compressor

IV. ANALYSIS AND PRESENTATION OF DATA

A. Machine Evaluation

TABLE I: THIS TABLE PRESENTS THE RESULTS OF THE SURVEY FOR MACHINE EVALUATION WHICH WAS ANSWERED BY TEN PROFESSIONALS.

CHARACTERISTIC	4	3	2	1
FUNCTIONABILITY				
1. The mechanism operates according to the researcher's intended function.	5	5		
2. The machine is able to exert compressive force.	3	7		
3. The controls give the user the ability to change the inputs for the speed of the motor and temperature of the band heater.	2	6	2	
RELIABILITY				
1. The machine can perform its tasks repeatedly.	4	6		
2. The machine performs properly while it is being used.	2	5	3	
USABILITY / USER-FRIENDLINESS				
1. The overall controls of the machine are easy to understand.	4	4	2	
2. The machine's function is easy to perform.	3	6	1	
3. The controls are labeled properly to determine each of their functions.	7	3		
EFFECTIVENESS				
1. The system responds immediately to control inputs.	6	4		
2. The machine does not slowdown in performing tasks.	1	3	6	
3. The band heater's temperature output is identical to the input.	3	6	1	
4. The machine is able to output the pot as the exact shape between the tool and die.		6	4	
MAINTAINABILITY				
1. It is easy to find the cause of the failure when it occurs.	6	4		
2. The system of the machine is easy to modify.	4	6		
3. Changes are easy to test and check if properly functioning.		10		
4. It is safe to change the machine's settings to suit needs.	2	8		

TABLE II: % FUNCTIONALITY, RELIABLITY, EFFECTIVENESS AND MAINTAINABILITY

FUNCTIONALITY	**Mean**
1. The mechanism operates according to the researcher's intended function.	3.5
2. The machine is able to exert compressive force.	3.3
3. The controls give the user the ability to change the inputs for the speed of the motor and temperature of the band heater.	3
Total Mean	3.27
Legend Interpretation: Strongly Agree: 3.25 – 4.00 Agree: 2.50 – 3.24 Disagree: 1.75 – 2.49 Strongly Disagree: 1.00 – 1.74 % Functionality = (Total Mean / 4) * 100 = (3.27/4) *100 % Functionality = 81.75	
RELIABILITY	**Mean**
1. The machine can perform its tasks repeatedly.	3.4
2. The machine performs properly while it is being used.	2.9
Total Mean	3.15
% Reliability = (Total Mean / 4) * 100 = (3.15/4) *100 % Reliability = 78.75	

USABILITY / USER-FRIENDLINESS	Mean
1. The overall controls of the machine are easy to understand.	3.2
2. The machine's function is easy to perform.	3.2
3. The controls are labeled properly to determine each of their functions.	3.7
Total Mean	3.367
% Usability = (Total Mean / 4) * 100 = (3.367/4) * 100 % Usability = 84.175	
EFFECTIVENESS	**Mean**
1. The system responds immediately to control inputs.	3.6
2. The machine does not slowdown in performing tasks.	2.5
3. The band heater's temperature output is identical to the input.	3.2
4. The machine is able to output the pot as the exact shape between the tool and die.	3.1
Total Mean	3.1
% Effectiveness = (Total Mean / 4) * 100 = (3.1/4) * 100 % Effectiveness = 77.5	
MAINTAINABILITY	**Mean**
1. It is easy to find the cause of the failure when it occurs.	3.6
2. The system of the machine is easy to modify.	3.4
3. Changes are easy to test and check if properly functioning.	3.0
4. It is safe to change the machine's settings to suit needs.	3.2
Total Mean	3.3
% Maintainability = (Total Mean / 4) * 100 = (3.3/4) *100 % Maintainability = 82.5	

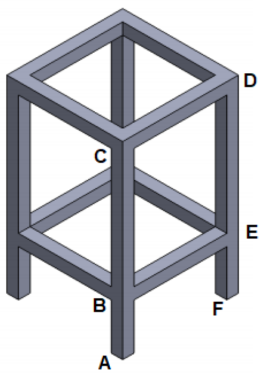
B. Computation of Forces

Reference: Virgil Moring Faires (Design of Machine Elements)

Frame

$\rho_{material} = 0.284\ lb/in^3$

Total Mass of the Machine = 150kg or 330lbs



Frame is symmetrical

$\therefore AC = DF = 165lbs$

Table AT 8 (Design of Machine Elements by Virgil Moring Faires)

Material C1045 Hot Rolled

$Su = 87\ ksi \quad Sy = 54\ ksi$

Maximum Force that can be Exerted to the Frame

$A = (2 \times 2)in^2 - (15/8 \times 15/8)in^2$

$A = 31/64 \text{ or } 0.4844\ in^2$

Max Actual Stress, Sa

$Sa = F/A$

$$Sa = \frac{330\ lbs}{0.4844\ in^2}$$

Sa = 681.2552 lb/in²

Design Strength, Sd

Sd = N x Sa

$$N = \frac{54000\frac{lb}{in^2}}{(681.2552\frac{lb}{in^2})} \qquad N = 79.2655 \rightarrow \text{Factor of Safety}$$

Faires, p.211 – Columns, Central Loads

$I = 0.3034in^4 \quad A = 0.4844in^2$

$$k = \sqrt{\frac{I}{A}} = \sqrt{\frac{0.3034in^4}{0.4844in^2}} = 0.7914in$$

$$Fc = \frac{\pi^2 EA}{\left(\frac{Le}{k}\right)^2} = \frac{\pi^2 (30x10^6 psi)(0.4844in^4)}{\left(\frac{36in}{0.7914}\right)^2} = 17328.15139lbs \text{ or } 17 \text{ kips}$$

Fc = N x F

17328.1514 = N(330lbs)

N = 53 → Factor of Safety

V. CONCLUSION

In this study, the focus is to design, and develop a machine that is capable of using compressive force for making plant pots that use wood chips as raw materials. The developed plant pot making machine uses a tool and die to mold the plant pot through the application of compressive force and heat. The compressive force comes from the pneumatic cylinder where in it uses air pressure to drive down the tool onto the die. Another objective in this study is the alternative use for the wood chips. The unused wood chips from woodworks are used as the main material for the plant pot along with several types of binders, like the pioneer wood glue, epoxy resin, candle wax and water. Epoxy resin is a slightly toxic chemical however, after the curing of the epoxy resin, it loses its toxicity which can be used as a material for the plant pot. Candle wax-wood chips plant pots are also a viable container for the plants however they can only be placed indoors seeing that they may melt if left outside exposed to the heat of the sun. The wood glue is a non-toxic binding agent; however, it has a very long set time and adheres itself to the tool and die after curing. The main plant pot mixture that is used was the candle wax-wood chip because, it was able to pass the three tests which are the ability to form a plant pot, rigidity, and water resistance. These products are constructed from woodchips and binding agents. These containers are semi porous and promote water and air exchange between the rooting substrate and surroundings. The containers may be biodegradable or compostable. The product includes a natural or synthetic binding material such as resins, glue, and wax. The process provides stability and extended life span for long term use. Pressed containers tend to have varying degrees of rigidity, material strength, and decay resistance. Unlike plastic, which provides relatively consistent performance in a mechanized production system, the resiliency of pressed these containers may depend on the container material, material moisture content, binder, irrigation practices, plant rooting pattern, and time in production. Also, some of these containers weigh significantly more than a thin walled plastic container especially when saturated. The containers absorb water into the wall resulting in softening of the container wall and causes reduction in strength. These plantable containers would biodegrade in a few months depending on the environmental conditions. According to related studies, it can extend the lifespan of biocontainer using various natural or synthetic adhesives, resins, waxes and binding agents which later determine the rate of biodegradability or compostability of the containers. In general, these containers last from one to three years and usually are not quickly biodegradable but may be compostable. In terms of automation, the semi-automation of the prototype makes it viable for production of plant pots, with a slight assistance for the operator in placing the mixture. The height design of the prototype, which is acquired through the anthropometric data, is also comfortable for the operator in sitting and standing position while operating the machine. The main plant pot mixture used was the candle wax-wood chip, because it was able to pass the three tests which are the ability to form a plant pot, rigidity, and water resistance.

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