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DESIGN, CONSTRUCTION AND PERFORMANCE EVALUATION OF A COCO PEAT BLOCK MAKING MACHINE

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Abstract

The coco peat block making machine is comprised of a compressing rod assembly, mold box, prime mover, and frame with a pair of wheels enabling easier transportability of the machine. Coco peat of different moisture contents (11-14%; 15-18%; and 19-22%) were compressed at different compressing ratios (4:1; 5:1; and 6:1) using the designed and fabricated machine. The study was conducted to (1) evaluate the blocking capacity; (2) establish the moisture content range and compression ratio of blocking; (3) determine the bulk density of the blocked coco peat; and (4) perform a simple cost analysis of the machine. The results showed that the moisture content range and compression ratio have significant effect on the coco peat block recovery and blocking capacity. The operating parameters in blocking the coco peat were established at a moisture content of 15-18% MC and compression ratio of 4:1 giving a blocking capacity of 68.32 blocks per hour.

Keywords

Coco Peat, Compression Ratio, Moisture Content, Blocking Capacity, Bulk Density

1. Introduction

Coco peat has been studied to be a good growing medium because of its good qualities and uses that it can hold to retain large quantities of water which is a sponge-like characteristic. When it is added to soil, coco peat helps provide air to the soil and gives space for plant roots to develop. It is free of weed seeds and disease, and its natural pH rating ranges from 5.7 to 6.5, enabling it to store and release soil nutrients in almost any soil. Coco peat was developed as an alternative to peat moss in producing cape gooseberry (Diaz, 2010). Tomatoes were also grown on coco peat inside greenhouses with hot and humid conditions (Mawalagedera, 2012). In earthworm toxicity testing, coco peat can also be used as an artificial soil ingredient (Shanmugasundaram, 2014). Moreover, it showed that coco peat has higher seedling emergence of onion (Allium cepa L.) compared to hygromix and compost (Lodama, 2018, and Vivek, 2017). Due to its high availability as an organic component in tropical countries, it is used as a soil media or soil additive.

The lumber from coconut has been widely used in building construction and furniture making (Walukow, 2018). Coconut husk and coconut shell are wastes in copra production. Coconut shell can be processed to treat outside wounds because of its high microbial properties (Kistriyani, 2018). On the other hand, coco peat can be generated from the coconut husk. Producing a coco peat is obtained by soaking the coconut husk and removing the coir fibers. The dusts residue that is called “pith” or peat are washed, compressed and dried; then, these are pressed into briquettes or blocks of coco peat using a blocking machine. Coco peats has now become imported and is sold as compressed products such as briquettes, blocks, bales, discs, pots and grows slabs or grow bags. The bales, blocks and briquettes are either broken down for use in potting mix or are directly retailed for garden use (Dickson and Oslen, 2008). Coco peat has a low bulk density so transporting it from the production area to the consumers will be costly if it is not compressed into blocks.

In India, a machine using a screw jack to compress the coco peat was developed. A chain drive was used to transmit the circular motion from an electric motor to the screw jack. Then, the screw converts that circular motion to linear which compresses the coco peat. They designed and fabricated this machine because they saw the need for small scale machineries in India (Pawar, 2017). Their study focused on testing the machine components rather than the performance of the machine in blocking. They also stated that, at present, piston press and screw extrusion machines

are two methods used in compressing coco peat. Since they used screw extrusion in their machine, the development of a piston press type for small scale production was considered.

This study aims to construct a portable coco peat block making machine that would produce coco peat blocks that are affordable to small-scale farmers. The general objective of the study is to design, construct and evaluate the performance of a coco peat block making machine. Specifically, it aims to (1) establish the moisture content and compression ratio in blocking coco peat, (2) evaluate the performance of the block making machine in terms of blocking capacity, (3) determine the bulk density of the blocked coco peat, and (4) perform a simple cost analysis of the machine.

2. Methodology

2.1 Design

The coco peat block making machine is comprised of a frame, rod and piston assembly, mold box, and prime mover. The frame is made of 6mm MS plate and 1.5-inch diameter pipe welded together. Extended length of frame is bent on the other side to serve as handle in transporting the machine. At the bottom end, a pair of 7-inch diameter rubber wheels is installed which enables the transportability of the machine. The compressing rod assembly, connected to a four-ton capacity hydraulic jack, does the compressing of the coco peat. Welded above the hydraulic jack is the mold box (6mm MS Plate). The mold box is rectangular prism that has a door (6mm MS Plate) on top connected using a pair of ½-inch diameter cylinder hinge. Lastly, a 2 hp motor was used to power the compressing rod assembly.

2.2 Design Consideration

The design of the coco peat block making machine considered the following factors:

- The machine must be made out of locally available materials;
- Portable and easy to operate;
- Batch fed;
- Produce 10 cm x 10 cm x 5 cm blocks that expands 5-8 times to fill the medium size, plastic flower and garden pots.

2.3 Construction

The entire construction utilized locally available materials. The machine's mold box is made up of a 6 mm MS Plate welded together. The door on the top is made up of a 6 mm MS Plate, and has a handle made of 2.5 cm diameter galvanized pipe. The door is connected to the mold box

using a pair of 1.25 cm diameter cylinder hinge. The stopper, made of a 12 mm MS Plate, is used to stop the coco peat in the mold box while it is being blocked, and then released it after the blocking.

Next constructed was the compressing rod assembly of the machine. It was made of 6 mm MS Plate and two 8 mm diameter rod welded together.

Then, a 4-ton capacity electric hydraulic jack was installed on the frame made up of 6mm MS plate and 1.5-inch diameter pipe welded together. A pair 7-inch diameter wheel is attached to the frame using twisted pins. Finally, a 2 hp motor was used as a prime mover.

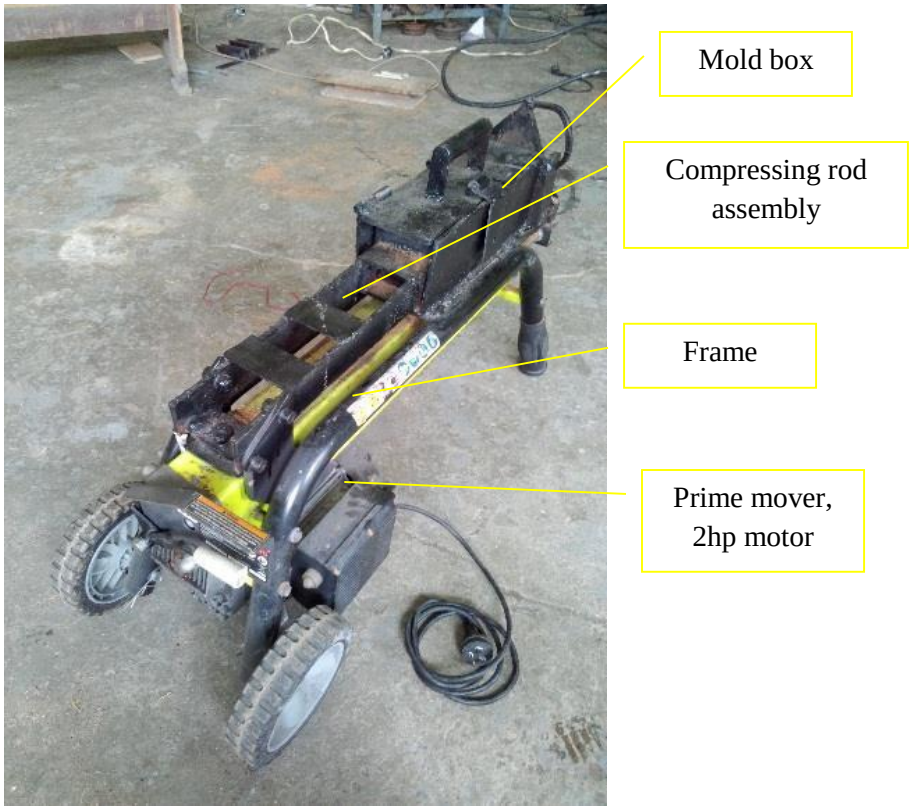

Figure 1: *The Coco Peat Block Making Machine*

2.3 Test Procedures

The blocking machine was tested by the following procedures:

- 3 sacks of coco peat were bought from Longlong, La Trinidad, Benguet. Each sack weighs 9.6 kg.
- The coco peat was screened to remove the coco fiber and other impurities.
- After screening, the bulk density and moisture content of the coco peat was determined using the oven-dry method.

- Then, the coco peat was sun dried at different duration to produce 11-14% MC, 15-18% MC, and 19-22% MC. Every 30 minutes, 3 samples are collected and weighed to check the moisture content. This was done until all the moisture content ranges were completed. Sun drying is the commonly used drying method for coco peat. According to Pawar (2017) drying by means of sunlight will prevent wasting electricity. In this case, an exact value to represent the entire volume of dried coco peat is difficult. That is why a moisture content range was used instead of an exact value.

Figure 3: *Sun Drying of Coco Peat*

- The coco peat of different moisture contents were place in plastic bags properly sealed. Then, three containers of 2000cm^3, 2500cm^3, and 3000cm^3 were prepared. These were used to have different loading volumes to produce compression ratios of 4:1, 5:1, and 6:1.

Figure 4: *Three different loading volume used: 2000cm^3, 2500cm^3, and 3000cm^3*

- When the machine was ready, the coco peat was blocked. The weight of the coco peat was determined before and after blocking.
- The time of blocking the given sample was recorded.

2.4 Data Gathered

The data gathered during the final testing were:

- Initial weight (g) –weight of the coco peat before drying
- Final weight (g) –weight of the coco peat after drying
- Electrical energy consumption (kW-hr) –electrical energy used by the machine during operation
- Time of operation (hr) –time used during the operation of the machine

2.5 Formulas Used

The following formulas were gathered from Philippine Agricultural Engineering Standards (PAES) 210:2000 and 251:2011.

- Moisture Content

$$MCwb = \frac{Wi\text{-}Wf}{Wi\text{-}Wf} \text{ x100 \%} \quad (1)$$

Where:

MCwb = moisture content, %
Wi = initial mass of the sample, %
Wf = final mass of the sample, %

- Volume

$$Volume = l \text{ x } w \text{ x } h \quad (2)$$

Where:

V = Volume, cm^3
l = Length, cm
w = Width, cm
h = Height, cm

- Bulk Density

$$D_B = W/V \quad (3)$$

Where:

D_B = Bulk density, g/cm^3
W = Weight, g
V = Volume, cm^3

- Electric Energy Consumption

$$E_c = P \text{ x } t \quad (4)$$

Where:

E_c = Electric energy consumption, kW-hr
P = Power consumed, kW
t = Time of operation, hr

- Blocking Capacity

$$BC = N_b / t \quad (5)$$

Where:

BC = Blocking capacity, blocks/hr
N_b = Number of blocks, blocks
t = Time of operation, hr

2.6 Statistical Analysis

Two-way factorial analysis in Completely Randomized Design (CRD) experiment was used in the study. The two factors were moisture content and compression ratio with three levels. The three levels were 11-14%, 15-18%, 19-22% for moisture content and 4:1, 5:1, 6:1 for compression ratio. This study used five replications for each treatment combination. Sources of variation were presented on ANOVA table. Comparison among means was tested using Duncan's Multiple Range Test.

3. Results and Discussion

3.1 Machine Description

The coco peat block making machine is comprised of a frame, rod and piston assembly, mold box, and prime mover. At the bottom end of the frame, a pair of wheels is installed which enables the transportability of the machine. Extended length of frame is bent on the other side to serve as handle in transporting the machine, at the same time, acting as stand during operation. The rod and piston assembly is a four-ton capacity hydraulic jack. It is connected to the compressing rod assembly that compresses the coco peat in the mold box. The mold box is rectangular prism that has a door on top that facilitates the input of coco peat to be blocked. Lastly, a 2 hp motor was used to power the hydraulic jack connected to the compressing rod assembly.

3.2 Influence of Moisture Content and Compression Ratio

3.2.1 Blocking Capacity

Table 1 shows the effect of moisture content and compression ratio on the blocking capacity.

Table 1: *Blocking Capacity as Influenced by Moisture Content and Compression Ratio*

MC	4:1 CR	5:1 CR	6:1 CR	Total	Mean
11-14%	59	57	50.5	166.5	55.5c
15-18%	68.32	59.34	64.34	192	64a
19-22%	63	63.33	63	189.33	63.11b
Mean	63.44a	59.89b	58.33c		

Means with same letters are not significantly different at 5% by DMRT

As observed during the evaluation, the coco peat with 15-18% moisture content obtained the highest blocking capacity of 68.32 blocks per hour at 4:1 compression ratio. It was observed that although the four-ton capacity hydraulic jack can block the coco peat until 6:1 compression ratio, the machine experienced no difficulty at 4:1 compression ratio. The compressing rod assembly was moving nicely inside the mold box without cracking sounds.

With regards to moisture content, the blocks formed at19-22% MC has the tendency to expand few millimeters after compression because of its high moisture content. At 11-14%MC, it was too dry that some coco peat particles came out of the mold box during compression.

3.3 Physical Characteristics of Coco Peat Blocks

The physical characteristics of the coco peat blocks were determined in order to describe the convenience of using the blocks. The bulk density, water retention and volume expansion were gathered.

3.3.1 Bulk Density

Table 2 shows the bulk density of coco peat in loose form and the bulk density of blocked coco peat at 15-18% moisture content and 4:1 compression ratio.

Table 2: *Difference in bulk density of coco peat block and coco peat in loose form*

Coco Peat Forms	Bulk Density (kg/m)
Block	354
Loose form	20

The bulk density of coco peat increases when it was blocked. The bulk density of the blocked coco peat is almost 18 times greater than the coco peat sold in sacks. Higher bulk density is an advantage in transportation because more products can be delivered by a smaller carrying area; in short, the space is maximized.

Water retention is one of the most important quality parameters for compressed coco peat products (Fernando, 2017). As observed during the evaluation, the coco peat block with 15-18% MC and 4:1 compression ratio can retain 2 liters of water, and expands 8 times its original volume.

3.4 Cost Analysis of the Use of the Machine

The cost of fabricating the machine is PhP 32,730. Some basic assumptions were considered to perform the simple financial analysis of the machine. The depreciation was determined using the straight line method with such other assumptions as: the machine has a life span of 10 years; interest on investment of 10%; tax and insurance of 3%; and repair and maintenance of 10%.

One and a half sacks of coco peat can be blocked in one hour. A sack cost PhP 150 per sack. The operation will be 8 hours per day so 12 sacks will be blocked in a day. Thus, with 20 working days in a month and 12 months in a year, a total of PhP 432, 000 would be used for buying coco peat. Two sacks of coco peat can be screened in 15 minutes. The annual cost of screening is P 267,456. The machine can block 64 blocks in an hour. The 2 laborers were assumed to have a labor of P275/day each. The annual cost of operating the machine is PhP 1,086,000.18.

The annual use was assumed to be 1920 hours in a year. With the assumptions in computing the annual operating cost and income, the annual net profit was PhP 547,343.82 when a block is sold at P15/piece. Thus, PhP 115,343.82 will be the annual machine's income after removing the PhP 432, 000 used for buying the coco peat. The calculated payback period is 0.284 years (3.5 months) and a return on investment of 75.03%.

4. Conclusion

- The operating parameters for coco peat blocking was established at a moisture content of 15-18% and compression ratio of 4:1 giving a blocking capacity of 68.32 blocks per hour.
- The bulk density of the blocked coco peat is almost 18 times greater than the coco peat in loose form.
- The coco peat block with 15-18% moisture content at 4:1 compression ratio can retain 2 liters of water. It expands to 8 times its original volume when soaked in water for 3-5 minutes.
- After a simple cost analysis of the machine, the computed initial cost is Php 32,730.00. Assumed that the machine's life span is 10 years, the computed payback period, return on investment and annual net income are 3.5 months, 75.03% and Php115, 343.82 respectively.
- This study is only limited to studying the effects of moisture content and compression ratio in blocking coco peat.

- In the future, the establishment of the pressure as part of the operating parameters in coco peat blocking can be studied.

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