

**DESIGN AND FABRICATION OF A BRIQUETTE MAKING MACHINE.**

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**ABSTRACT**

The mechanical compaction process for increasing the density of bulky material is referred to as briquetting. Briquetting of agricultural waste represents one of the possible solutions to the local energy shortages in many developing countries. It constitutes a positive solution to the problem of increasing rates of desertification in many areas worldwide. This study puts forward a machine of simple design which could be manufactured locally in any part of the country and has high productivity. The study presents a detailed design of the briquette making machine. The prototype was made and tested in Niger state in Nigeria. The low-pressure briquette making machine is powered by a hydraulic jack which is easy to operate and thus can be operated by a large range of people. It is a batch operational process which extrudes 16 briquettes per batch. Each batch which comprises of loading the cylinder, closing the machine lid and pumping the jack hydraulic jack took between 3 to 6 minutes depending on the operator. Bath saw dust and rice hull were used to test the developed machine and it was observed that the saw dust had a higher compression ratio than the rice hull of 3:1. Both briquette fuels produced were found to dry in relatively short time due to their size.

**INTRODUCTION**

Agricultural waste is not usually attractive as a household fuel source because of their low energy intensity and associated bulkiness. Briquetting or biomass densification represents a set of technologies for the conversion of biomass into fuel (Adegoke, 2002). It has the objective of concentrating the light energy of agricultural and environmental waste such as wood residues, rice husk, biogases, sawdust, paper, and other materials of both high and low calorific values, into high density particles of varied forms and sizes known as “briquette”. The briquetting process increases the net calorific value per unit volume, ease of transportation and storage, disposal of residue is facilitated and the fuel produced is uniform in size and quality. This process eases handling of biomass and reduces the costs of transportation and also addresses storage problems. There might be a need to eliminate the biomass constituents that are not combustible such as water, when aiming to improve the briquette property.

Machines for biomass densification can be grouped into three main groups based on their pressure (Elmagzoup, 1986; Abasaed, 1988; Eriksson, *et al.*, 1990; Ehab El Saeidy, 2004; Abakr *et al.*, 2006). The first type is the high-pressure machines where the pressure reaches values more than 100 MPa. This type is suitable for the residues of good lignin content. At this high pressure the temperature rises to about 200-250°C, which is sufficient to fuse the lignin content of the residue, which acts as a binder and so, no need of any additional binding material. The second is the medium pressure machines, with a pressure ranges between 5 MPa to 100 MPa, which results in lower heat generation. This type of machines requires in most of the cases the use of an additional heat source to melt the internal lignin content of the feedstock thereby eliminating the need for additional binder. The third type is the low-pressure machines that work at pressure less than 5 MPa and room temperature. This third type of machines requires the addition of binding materials and is considered to be the most suitable type for the carbonized materials, due to the lack of the lignin material due to the carbonization process. The production of these machines is between 25-1800 kg/h, depending on the press canal diameter, the kind of materials pressed, and their properties. The objective of this work was to design a briquette making machine, fabricate the designed briquette making machine and test the machine. Therefore, this project work covers the design, fabrication and performance evaluation of briquette making machine.

**MATERIALS AND METHOD**

The briquette making machine consisted three components, pressure chamber, frame, and a pressure device. These are a hydraulic bottle jack, steel frame, piston, compression cylinder, steel plate of various sizes.

**Conceptual Design And Calculation**

The conceptual diagram of the machine is shown in Fig 1 with the under listed design specifications used. The capacity of the machine was put at 240 briquettes per hour.

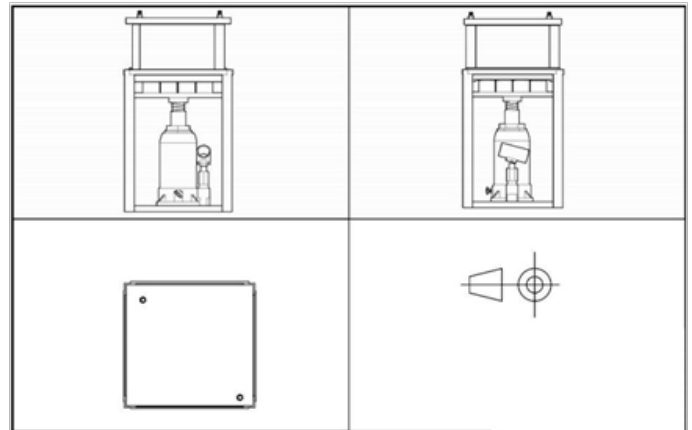


Fig 1. The Conceptual Diagram of the Machine

**DESIGN SPECIFICATIONS**

- Hydraulic jack capacity for this project is 5 tonnes
- Maximum cylinder diameter = 35mm
- Length of cylinder = 120mm
- Number of cylinder 16
- The dimension of the pressure plate is 150mm×150mm
- The dimension of the base plate is 220mm×210mm
- The length of the piston is 120mm
- The piston is fixed at both ends.

**DESIGN CALCULATION**

Table 1 shows the summary of design calculations for parameters used in the development.

Table 1. Summary of design calculations.

S/N		Equation	Result
1	Compaction Pressure	$P = \frac{F}{A}$	2.18N/mm <sup>2</sup>
2	Thickness of Cylinder Wall	$t = \frac{Pd}{2\sigma_c}$	0.763mm
3	Maximum Shear Stress in The Cylinder	$\tau_{max} = Pd/8t$	9.54 N/mm <sup>2</sup>
4	Cylinder Volume	$V = \frac{\pi}{4} d^2 l$	1.1545×10 <sup>-4</sup> m <sup>3</sup>
5	Mean Breaking Stress of the Piston Rod	$P = \frac{\sigma_c A}{1 + a(\frac{l}{k})^2}$	42707.85N
6	Thickness of the Bottom Plate	$t = \sqrt[3]{\frac{KFb^2}{E\delta^2}}$	51.7mm
7	Size of Welded Joints	$s = \frac{F}{2 \times 0.7071l\sigma}$	24.8mm

(Khurmi *et al.*, 2006 and Khurmi *et al.*, 2005)

## Fabrication

The design diagram of the machine is presented in Fig 2 with dimensions of the various parts as obtained from calculations using standard engineering procedures.

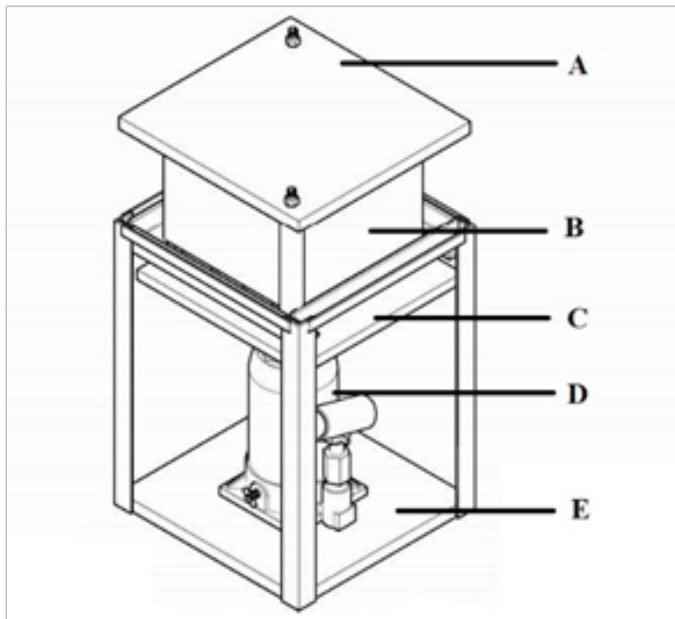


Fig 2. Showing an Isometric View with labels.

A, C and E are 12mm thick steel plates, B is the cylinder housing, made up of mild steel 150×120mm with thickness of 5mm housing 16 compaction cylinders each having a diameter of 33mm and length 120mm and, D is the 5-tonne hydraulic jack.

The various components of the machine were assembled together using fabrication tools in the workshop including welding and drilling processes. Mild steel was used in making the plates of the machine. Plate 1 depicts the various stages of fabrication of the machine while plate 2 shows the developed machine.



Plate 1. Fabrication process of the briquette making machine



Plate 2. The developed machine.

## No Load testing of Machine components

The cover of the compaction has the same specifications as that of the base plate, the cover is fitted in place with the aid of a bolt and nut which is connected at opposite angle sides by a column. The machine was tested to make sure the parts are properly aligned then it was welded together to give a more permanent fill. Sixteen cylinders 35mm in diameter and 1mm thick was arranged in block and due to the thin nature of the cylinder they could not be welded or tacked as this may damage the cylinder wall and thus cause hindrance to the movement of the piston. Therefore, they were glued with epoxy resin, and due to the compacted sitting arrangement, it was firm. The pistons were dropped inside the cylinder to fall on the pressure plate and were not weld either for ease of flow in case of any movement of the pressure plate.

The entire machine was tested as whole to make sure it functioned properly, then the welded joints were grinded and the entire machine was sand papered and then painted.

## Machine Testing Procedure

Saw dust and rice hull were used as test materials for the machine. Cassava starch was mixed with the samples to act as a binder before putting into the developed machine. The hydraulic jack was lowered by removing the handle and valve slowly released in the counter-clockwise direction to allow the jack to be at its lowest point. The percentage of binder was 10% to 25% of the total weight of test samples (rice hull and saw dust). The amount of water needed to gelatinize the starch ranged from 66% to 100% of the weight of the raw materials.

The test sample mixed with a binder was fed into the cylinders and covered in place with the screw on the plate cover then compressed by the base plate by activating the hydraulic jack which moves up thereby creating the pressure needed to compress the material in the chamber. After enough pressure is introduced, this is indicated by the resistance of the jack handle. The system is left for about 3 to 5 minutes for water to drain and so the briquette will be fully compacted, the top cover was opened and the jack is further pump up to push the briquettes up for discharge. The wet briquettes are gently removed and place on a tray to be dried under the sun. The whole process was repeated severally to obtain quantifiable number of briquettes. 16 number of briquettes were produced in each batch operation Each batch operation was completed between 3 to 6 minutes.

### Drying

The briquettes were placed in trays under the sun for one to two days so it can dry properly, the testing was conducted during the dry season.

### Compaction ratio

The ratio of compression of the material made into briquettes was based from the depth of cylinder to

the height of briquettes that was compressed. Table 2 shows the compaction ratios of the briquettes incorporated in the machine. The compaction ratio for rice hull and saw dust was 2:1 and 3:1 respectively.

Table 2. Compaction ratio for the two test samples used in the developed machine

Raw Materials (mm)	Depth of cylinder (mm)	Depth of compressed briquette (mm)	Compression ratio of briquette
Sawdust	80	27	3:1
Rice hull	80	40	2:1

### CONCLUSION

The developed machine was found to achieve its set objective by the production of compressed byproducts in form of briquettes from agricultural byproduct of rice husk and saw dust mixed with binder fed into it. The design showed that with the right amount of binder, the 5-tonne hydraulic jack, which is a low source of pressure, was able to produce briquettes from two agricultural byproducts mixed with binder. Other materials and binder ratios was not factored in this design. The design has been carried out with due considerations of the major factors as applied to the operational characteristics and cost effectiveness.

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