

## International Journal of Innovative Research in Science, Engineering and Technology

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# Experimental Study on Improvement of the Properties of Biomass Fuel through Briquetting Technique

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**ABSTRACT:** In this project work, briquettes are made from saw dust, rice husk and straw by using a compound lever press technology without heating device. The briquetting equipment, compound lever press is made of wood, which make it a very easy and cheap way of forming biomass briquettes. The process is economic as there is no need of extra electric energy for pressing. The proximate analysis is carried out to determine moisture content, volatility, ash content and fixed carbon. Calorific values and density of briquettes are also determined. The briquettes produced are dense, easy to store as well as to handle. These briquettes can be used as fuels and can very well substitute coal in commercial applications as fuel.

**KEYWORDS:** Saw-Dust, Briquette, Biomass, Husk

### I. INTRODUCTION

Many of the developing countries produce huge quantities of agro residues but they are used inefficiently causing extensive pollution to the environment. The major residues are rice husk, coffee husk, coir pith, jute sticks, mustard stalks and cotton stalks. Sawdust, a milling residue is also available in huge quantity. Apart from the problems of transportation, storage, and handling, the direct burning of loose biomass in conventional gates is associated with very low thermal efficiency and widespread air pollution. The conversion efficiencies are as low as 40% with particulate emissions in the flue gases in excess of 3000 mg/Nm<sup>3</sup>. In addition, a large percentage of unburned carbonaceous ash has to be disposed of. In the case of rice husk, this amounts to more than 40% of the feed burnt.

Historically, biomass briquetting technology has been developed in two distinct directions. Europe and United States has pursued and perfected the reciprocating ram/piston press while Japan has independently invented and developed the screw press technology.

Worldwide, both technologies are being used for briquetting of sawdust and locally available agro-residues. Although the importance of biomass briquettes as substitute fuel for wood, coal and lignite is well recognized, the numerous failures of briquetting machines in almost all developing countries have inhibited their extensive exploitation.

Briquetting technology is yet to get a strong foothold in many developing countries because of the technical constraints involved and the lack of knowledge to adapt the technology to suit local conditions. Overcoming the many operational problems associated with this technology and ensuring the quality of raw material used are crucial factors in determining its commercial success. In addition to this commercial aspect, the importance of this

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technology lies in conserving wood, a commodity used in developing countries and leading to its widespread destruction of forest.

The recent successes in briquetting technology and the growing number of entrepreneurs in the briquetting sector, are evidence that biomass briquetting will emerge as a promising option for the new entrepreneurs and other users of biomass.

## II. LITERATURE REVIEW

The piston presses which are currently operating in India are also known as ram and die technology. Here the biomass is being punched into a die by a reciprocating ram with a very high pressure thereby compressing the mass to obtain a briquette. The briquette produced is 60 mm in external diameter. The machine has a capacity of 700kg/hr and the power requirement is 25 kW, the ram moves approximately 270 times per minute in this process. In screw press technology, the biomass is extruded continuously by a screw through a taper die which is externally heated to reduce the friction. Another type of briquetting machine is the hydraulic piston press. It is different from the mechanical piston press in the manner that the energy to the piston is transmitted from an electric motor via a high pressure hydraulic oil system. This machine is compact and light. Due to the slower press cylinder compared to that of the mechanical machine, it results in lower outputs. This machine can tolerate higher moisture content than the usually accepted 15% moisture content for mechanical piston press. Pelletizing is closely related to briquetting except that it uses smaller dies so that the smaller products are called pellets. The pelletiser has number of dies arranged as holes bored on a thick steel disc or ring and the material is forced into the dies by means of two or three rollers. The two main types of pellet presses are: flat and ring types.

The main constituents of biomass are the carbohydrates consisting of C, H, O, N elements. Both woody and non-woody biomass has similar composition which can be represented as  $CH_nO_mN_p$ . The biomass is structurally composed of primary cellulose, hemi cellulose, lignin and ash. Cellulose is the main carbohydrate component of plant tissue around 40-50% by weight for the dry wood. Other carbohydrate components such as hemi-cellulose and starch around 20-30% can also be found in most woody biomass materials. The lignin which decomposes at higher temperature as compared to other components is around 20-30% in woody biomass (Ludwig C, 1994).

The different sources of biomass are rice husk, which is a by-product of rice milling, cotton stalks, and ground-nut shells, residues from tea plantation, bagasse, coffee husk, mustard sticks, sugarcane field trash, coconut residues, saw dust. Residues such as saw dust, rice husk, and coffee husk are in ready to use form. Other residues such as mustard stalk, ground nut shells etc. can be briquetted after grinding. In western part of India primary raw material used are saw dust, ground nut shells and cotton stalks. In northern part saw dust and mustard stalks are the primary material while in the eastern region ground nut shells, saw dust, coffee husk are used.

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## III. EXPERIMENTAL SET UP

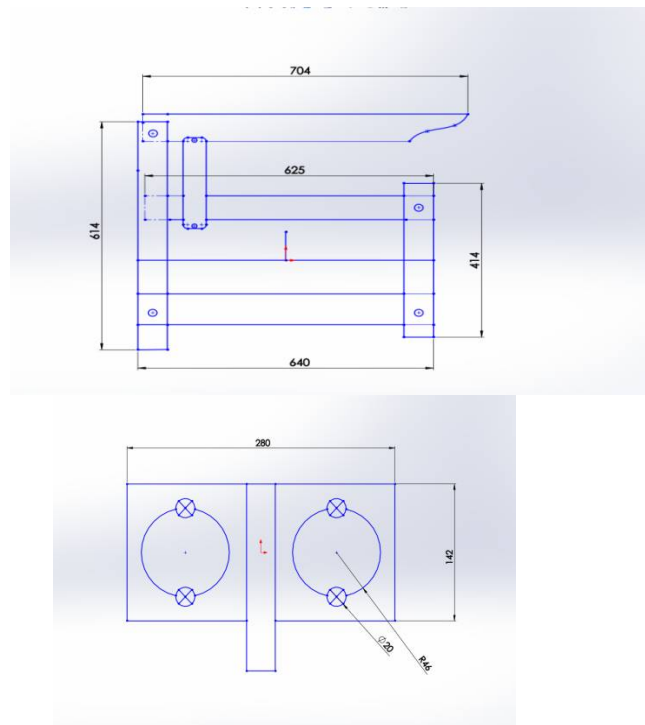


Fig i: CAD of the experimental setup.

For making the preliminary drawing of compound lever press, Solidworks 2015 has been used as shown in figure (i). The different parts are:

- I. Fulcrum
- II. Handle
- III. Connector
- IV. Bar
- V. Lock

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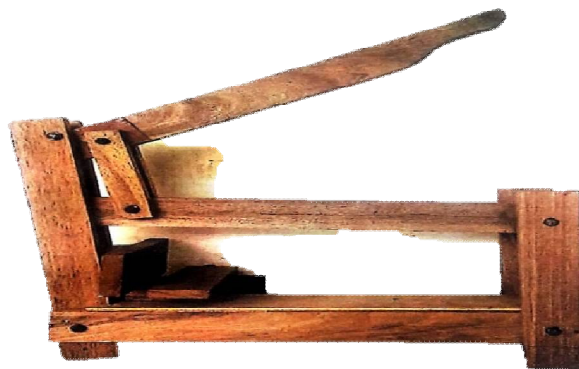


Fig ii: Actual Diagram of Compound Lever Press

The compound lever press technology shown in figure (ii) without heating the biomass is used to produce saw dust, rice husk and straw briquettes. The handle is pressed manually. The agro residues are compressed with the handle pressure with the application of starch as a binder.

During the operation the biomass raw materials mixed with starch are put into the hollow pipes along with a tight fit washer beneath it. The die hole is then blocked by another washer so that the material cannot come out during operation. This assembly is put on the briquetting machine. A dummy pipe is put on washer covering the biomass materials, which carry the pressure from the handle. To produce briquettes, the handle is pressed. As soon as the handle touches the dummy pipe, it slides downwards and it compresses the material inside the pipe. After the required pressure is applied to the biomass, the handle is released. The pipe along with the compressed biomass is put into the small wooden piece with holes and locks. This arrangement is attached to the support of the briquetting machine and then pressed with the handle. Due to the pressure applied the briquettes gently come out from the pipes. The briquettes produced are 2 inch in diameter and 6-7 cm long. The briquettes so produced are enough hard, dry and are not required to be dried under sun or by any other means.

#### IV. EXPERIMENTAL RESULTS AND DISCUSSIONS

##### FOR SAW DUST BRIQUETTE

###### 1. To find the calorific value of saw dust briquette using Bomb Calorimeter:

Bomb calorimeter is used to find the calorific value of the biomass briquette. First of all, the weight of the crucible is taken and introduced into it, the sufficient quantity of the sample to cause a temperature rise of 2°C-3°C. The weight of the sample is taken carefully.

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A piece of firing wire is connected across the terminals of the bomb in such a way that it touches the sample taken in the crucible.

1ml of distilled water is put into the bomb. The bomb and the charge are assembled with oxygen to a pressure of 30atm without displacing the original air. Now the water is out into the calorimeter vessel to cover the flat upper surface of the bomb cap.

The calorimeter vessel is transfer to water jacket and any leakage of gas escaped from the bomb is checked. Now, the stirrer and the circulator arrangement are assembled so that it can be continuous operation throughout the determination. After the interval of 10 minutes, the temperature are recorded continue the reading for several times so that the constant value of temperature is reached. It is the initial temperature.

After getting the initial temperature, battery circuit is closed momentarily to fire the charge and continue the observations of the temperature at an interval still to come the constant temperature. It is the final temperature. Hence the calorific values of biomass samples using oxygen bomb calorimeter are determined and are listed in the following table I:-

Sl. No.	Name of Samples	Binder to Biomass ratio	Calorific Value (Cal/gm)
1	Saw Dust	1:3	4450.525
2	Saw Dust	1:4	4317.445
3	Saw Dust	1:5	4270.714
4	Rice Husk	1:3	3874.284
5	Rice Husk	1:4	3728.022
6	Rice Husk	1:5	3692.637
7	Straw	1:3	3972.835
8	Straw	1:4	3817.688
9	Straw	1:5	3771.455

Table I: Calorific values of biomass briquettes.

Table I shows the samples used and binder to biomass ratio and calorific value. Calorific value is highest for sawdust with binder to biomass ratio of 1:3 and is the least for rice husk with binder to mass ratio of 1:5.

### 2. Proximate Analysis of saw dust briquettes

#### i. To find the moisture content of the briquette

Moisture is calculated at 100°C. At 100°C all the moisture present in the saw dust briquette is removed. Here 1-2 gm of sample is put into the crucible and the crucible is placed inside the furnace where the entry of air is excluded and the briquette is heated up to 100°C.

#### Calculations

Weight of crucible + Sample= 38.563 gm

Weight of crucible= 37.411 gm

Weight of sample= 1.152 gm

After heating the sample at 100°C, we get

Weight of Sample= 1.031 gm

Loss of weight= 0.121 gm

Moisture Content=  $0.121 \times 100 / 1.152 = 10.52\%$

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### ii. To find the volatility content of the briquette:

To find the volatile material present in the sample, 1-2 gm of sample is taken in a crucible and is placed in the furnace and is heated to 600°C so that the volatile material present in the sample is removed.

#### Calculations

Weight of crucible+ Sample= 38.563 gm  
Weight of crucible = 37.563 gm  
Weight of sample after removing moisture content= 1.013gm

After heating the sample at 600°C, we get  
Weight of sample= 0.155gm  
Loss of weight= 0.876 gm  
Volatility Content=  $0.876 \times 100 / 1.031 = 84.96\%$

### iii. To find the ash content of the briquette:

To determine the percentage of ash present in a given sample, 1-2 gm of sample is burned in a crucible inside the furnace at a temperature nearly 950°C. At this temperature complete combustion of the sample will occur and ash will remain in the crucible.

#### Calculations

Weight of crucible+ Sample= 38.563 gm  
Weight of crucible= 37.566 gm  
Weight of sample after removing moisture content= 1.013 gm

After heating the sample at 950°C, we get  
Weight of sample= 0.010 gm  
Ash Content=  $0.010 \times 100 / 1.031 = 0.965\%$

### iv. To determine the fixed carbon content of the briquette:

Fixed carbon is not a constituent of biomass. It represents the volatile and volatile decomposition of briquettes under specified condition. It is non-volatile residues of organic mass. It is calculated using the formula:

% of fixed carbon=  $100 - (\% \text{ moisture} + \% \text{ ash} + \% \text{ volatile material})$   
Moisture Content of the briquette= 10.50%  
Volatility Content of the briquette= 84.96%  
Ash Content of the briquette= 0.96%  
% of fixed carbon=  $100 - (10.50 + 84.96 + 0.96)$   
= 3.58%

### 3. Calculation of density of saw dust briquette

Radius of briquette= 1.27 cm  
Length of briquette= 10 cm  
Weight of briquette= 59 gm  
Volume of briquette=  $\pi r^2 h = 50.68 \text{ cc}$

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Density of the briquette=Weight/Volume  
=59/50.68= 1.164gm/cc

Sl. No.	Name of the sample	Binder to biomass ratio	Moisture (%)	Volatile Matter (%)	Ash (%)	Fixed Carbon (%)
1	Saw Dust	1:3	13.06	83.59	0.93	2.42
2	Saw Dust	1:4	10.50	84.96	0.96	3.58
3	Saw Dust	1:5	9.25	81.48	0.98	8.29
4	Rice Husk	1:3	11.24	83.44	4.35	0.97
5	Rice Husk	1:4	10.73	82.52	5.51	1.24
6	Rice Husk	1:5	9.50	80.60	6.84	3.06
7	Straw	1:3	9.52	77.86	11.12	1.50
8	Straw	1:4	8.41	73.68	11.36	6.55
9	Straw	1:5	7.78	68.05	11.79	12.38

Table II: Proximate analysis of biomass briquettes.

Table II shows the sample used and relevant results associated with it, as such binder to biomass ratio, moisture content, ash, and percentage of fixed carbon available. From table II, we can find that moisture content is highest for Sawdust and volatility of matter. For straw, percentage of ash content and fixed carbon is highest.

## V.OBSERVATIONS

From the experimental results, the following observations have been made:

- The calorific value of the briquettes decreases as the binder to biomass ratio decreases.
- The volatility decreases as the binder to biomass ratio decreases.
- The moisture content decreases as the binder to biomass ratio decreases.
- The ash content increases as the binder to biomass ratio decreases. Saw dust has the minimum ash content.
- The fixed carbon increases as the binder to biomass ratio decreases.

## VI. ECONOMIC ANALYSIS

Number of hours per day: 16  
Capacity of the machine: 80 kg/day  
Equipment cost: ₹2000  
Fixed labour cost: ₹50/day  
Total fixed cost (first month): ₹3500

### Raw material cost includes:-

Transportation cost: ₹90/day  
Direct labour cost: ₹100/day  
Power cost: ₹13/day  
Repair and maintenance cost: ₹5/day  
Others: ₹10/day  
Total variable cost: ₹218/day  
Total cost (first month): ₹10040

Cost of Briquettes: ₹4.5/kg  
Total sales price: ₹360/day

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Total profit: ₹92/day  
Profit in first month: ₹760  
Profit in second month: ₹2760

After 22 days the fixed cost (cost of machine) will be recorded i.e. the payback period is 22 days

Capacity of the machine: 2400kg/month  
Fixed cost: ₹3500  
Variable cost: ₹6540/month  
Total cost: ₹10040/month  
Sales cost: ₹10080/month

The break-down point is = 1957kg  
= ₹1957×4.5  
= ₹8806.5

The unit should produce and sell more than 1957 kg of briquettes to seek profit.

### VII. CONCLUSION

In this project work, briquetting is used as a tool for efficiently using biomass as a renewable source of energy. A simple technology is used and briquetted biomass gives desirable properties like moisture, volatility, ash content, fixed carbon, calorific value and density, which shows that a briquetted biomass can be a suitable substitution for coal and other conventional sources of energy.

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