

Design and Fabrication of low cost Briquetting machine and Estimation of Calorific values of Biomass Briquettes.

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ABSTRACT: Fossil fuels are the major source for energy. The excess use of these fuels will lead to serious environmental issues like global warming and air pollution. Since the fossil fuels are getting depleted day by day, it is the high time to convert biomass wastes such as sawdust, coir pitch, coffee husk, rice husk etc., to useful biomass briquettes which will be the substitute for some of the fossil fuels. This paper focuses on the design and fabrication of briquetting machine which is portable and can be done at very low cost. It also focuses on the production of biomass briquettes using raw materials mainly sawdust and dry leaves with binding agents like coffee husk and wheat flour. Also study is carried out to investigate the calorific values of the briquettes using bomb calorimeter. The results indicated that the briquettes made from sawdust, dry leaves and very small amount of wheat flour (binding agent) are compact, dry and have greater calorific value when compared to the briquettes made from sawdust, dry leaves and coffee husk (binding agent) are not strongly bonded and possess slightly lower calorific value.

KEYWORDS: Biomass Briquettes, Calorific value, Sawdust, Coffee husk, Dry leaves.

I. INTRODUCTION

The overall pollution in the world is increasing day by day and the major contribution to this pollution is the use of fossil fuels, hence there is huge push to reduce the usage of fossil fuels and to look for the alternative biomass fuel. Developing countries are facing huge problem with waste management and agro residues such as coir pitch, dry leaves, rice husk, coffee husk etc., are contributing majorly to this problem. We usually see these agro residues and saw mill residues are usually burnt on roadside or dump yards, which again results in pollution. There is a need to find a way so that these agro residues and sawmill residues can be converted into fuels. However, these residues are very difficult to transport, handle, store and if these residues are burnt directly it results in very poor thermal efficiency and may create lot of air pollution. These kinds of problems can be avoided by briquetting the waste biomass into usable energy generating fuel. Hence, if proper efforts are made biomass briquettes will become an alternative for some of the fossil fuels to a greater extent and briquetting of agro residues will help in waste management and reduced air pollution. Biomass briquetting is the densification of loose agro residues, sawmill residues with or without binding agents to produce compact solid composites of different sizes with the application of pressure. The end use of briquettes is mainly for replacing coal in industry for heat applications (steam generation, melting metals, space heating, brick kilns, tea curing, etc) and power generation through gasification of biomass briquettes and for domestic uses.

II. RELATED WORK

Emerhi, E. A.[3] have found that the calorific value of briquettes produced from mixed sawdust of three tropical hardwood species bonded with different binding agents (starch, cow dung and wood ash) are high. Sawdust from each of the species was mixed with the binder in ratio of 70:30 for cow dung and wood ash and 70:15 of starch. The sawdust

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where mixed in a ratio 50:50 for each briquette combination produced. The result shows that, the best briquette was produced when sawdust was mixed with starch.

DahamShyamalee , A.D.U.S. Amarasinghe , N.S. Senanayaka [4] found that the Biomass briquettes are often used as an energy source for cooking purpose and in some industries like bricks and bakery. The briquettes are produced by densification of waste biomass using various processes. In this study manual densification of saw dust was tested with three different binding agents; dry cow dung, wheat flour, and paper pulp. The samples with cow dung as binding agent failed with mould detaching and minimum required binder percentage for other two binders for successful forming were found to be 30%.

Olawale J. Okegbile, Abdulkadir B. Hassan, Abubakar Mohammed*, Barakat J. Irekeola [5] have tested effect of starch and gum arabic as binders in the combustion characteristics of briquette prepared from sawdust of different ratios were investigated. Briquettes of sawdust were produced by mixing with different binders and agglomerate using starch paste and gum arabic. The mixture was compressed at 110kN using manually operated hydraulic briquette machine and sun dried. The calorific value, the volatile matter and flame temperature were determined. Results showed that the briquette formed using starch as a binder performed better in all aspect than the gum arabic.

I Y Ogwu, ET Tembe, SA Shomkegh [6] have Compared performance in calorific value was determined from the binary and tertiary combination of briquettes produced from biomass materials (sawdust) of *Azelaiafricana*, *Daniella oliveri* and Rice husk at 20% 30%, and 40% starch binder levels. From the proximate analysis of the samples, it was observed that there were significant differences ($p < 0.05$) between the densities, Percentage Ash content, Percentage Volatile matter and Percentage Fixed carbon of the samples. A progressive increase in heating value was observed among briquettes produced as the starch level increased. Briquettes produced at the tertiary combination of *Azelaiafricana* + *Daniella oliveri* + Rice husk biomass recorded the highest heating value of 4827.20kcal/kg at 40% starch level while *Daniella oliveri* + Rice husk briquettes at binary level recorded the least heating value of 4586.72kcal/kg at 20% starch level. Among the various starch levels the tertiary combination had the least Ash content of 4.30% at 40% starch level while *Daniella oliveri* + Rice husk briquettes at 20% starch level had the highest Ash content of 9.29%. It is therefore recommended that 40% starch level be used for briquettes production.

III. METHODOLOGY

The methodology includes designing of briquetting machine, fabrication of briquetting machine, and production of briquettes using sawdust and dry leaves with binding agents such as wheat flour and coffee husk. Further, it includes estimation and comparison of calorific values of briquettes with different compositions.

A: Design of briquetting machine

Initially we decided upon the shape (circular) and size (radius = 70mm) of the briquettes to be produced based on this we started to design a briquetting machine. In order to obtain a briquette of radius 70mm we needed to design a cylinder of the same diameter, where the raw materials are compressed. This cylinder has piston at the bottom (connected to the plunger of jack) and closing plate at the top, both piston and closing plate should withstand the high pressure applied by the jack. In order to make the briquette highly compact we need to apply high pressure, so thickness of the cylinder is made large to withstand this pressure. Here the screw jack is used to apply the pressure and based on the amount of pressure required (usually around 1 ton) the jack of 2 ton capacity is selected. Our aim is to produce 5 briquettes for one completely filled hopper, so hopper is designed by considering the 5 times the volume of cylinder. After designing the hopper and cylinder now its time to consider the size of the raw materials to be compressed. By going through the several journals, we came to know that the raw material of size in between 3 to 5mm can be easily bounded and has a high calorific value. Since it is not possible to obtain the raw material of this size the need for the grinding unit became the major factor. In grinding unit it consists of Blade, Sieve plate and Motor. In order to obtain the raw material of the required size the blade and sieve plate have to be designed. Based on the size of the raw material sieve of 5 mm is selected. To grind the raw material speed at which blade rotates became important factor, so we took the motor of 10,000 RPM. And we designed a blade made of stainless steel, because this

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has high strength. After grinding now time to carry the raw material to the cylinder, to do this the carrying unit have been designed. Here we have used a sliding type carrying unit, which can slide along the guide ways. With the help of sliding unit grinded materials are filled in the cylinder and jack is used to compress it to obtain the briquettes.

B: Fabrication of briquetting machine

Fabrication of the machine is divided into three separate units to make it portable

1. GRINDING UNIT
2. CARRIER UNIT
3. COMPRESSING UNIT

1. GRINDING UNIT: This unit consists of a Hopper, Motor, Grinder Blade, Sieve plate.

The hopper is placed on the hollow circular disc and is supported by two vertical stands, which is placed diametrically opposite to each other. The blade grinder and sieve plate is placed inside the hopper. The motor required to rotate the grinding blades are mounted on the vertical support provided on the hollow disc.

Hopper: This is where the raw materials (sawdust, coffee husk etc) is fed into the machine. It is made of mild steel, and is conical in shape. It is placed on the hollow circular disc, which acts as supporting member and also the hollow space in the disc guides the grinded materials to the box placed under the disc. The size of the hopper is designed such that by one completely filled hopper we are able to produce 5 briquettes, which can increase the production rate.



Fig.1. Hopper

Fig.1. shows hopper where the raw materials are fed. The Larger diameter of hopper is 320mm, smaller diameter is 230 mm, Length of hopper is 350 mm. The material used for hopper is Mild steel.

Volume calculation for hopper:

$$\text{Volume of cylinder} = \pi \times r \times r \times h$$

$$\text{Volume of cylinder} = 3.14 \times 35 \times 35 \times 200 = 0.769 \times 10^6 \text{ mm}^3$$

When the raw material is grinded by blade in the hopper, the volume of raw material added to hopper will be reduced to approximately 1/3rd of its initial volume after grinding, so to get the volume raw material required need multiply volume of cylinder by 3.

And since we are aiming to produce 5 briquettes for one completely filled hopper then again multiply volume by 5.

$$\begin{aligned} \text{so we get, Required Volume} &= 769300 \times 3 \times 5 \\ &= 11.539 \times 10^6 \text{ mm}^3 \end{aligned}$$

$$\begin{aligned} \text{Actual Volume of hopper} &= 1/3 \times \pi (r_1 \times r_1 + r_1 \times r_2 + r_2 \times r_2) \times h \\ &= 1/3 \times 3.14 \times (135^2 + 135 \times 160 + 160^2) \times 180 \\ &= 12.326 \times 10^6 \text{ mm}^3 \end{aligned}$$

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Fig.2. Motor with legs

Fig.2. shows motor, here we have used an AC motor of 750Watts, 230 Volts and 18000 RPM (with no load). And we have used a regulator to control the speed of the blade which is connected to the motor, as required on the amount of raw material to be grinded inside the hopper. The motor is placed on the circular disc with the legs as shown. Motor specification: Ac motor 750 Watts, 230 Volts and 18000rpm, weighs 1.8Kg.



Fig.2. Grinding blade

Fig.3. shows blade, this acts as a grinding member, and is made up of stainless steel. Based on the power input from regulator the blade rotates at certain RPM and grinds the raw materials, which then passes through the sieve plate. The dimensions of blade: Width = 15mm and length = 250mm. Material: Stainless steel.

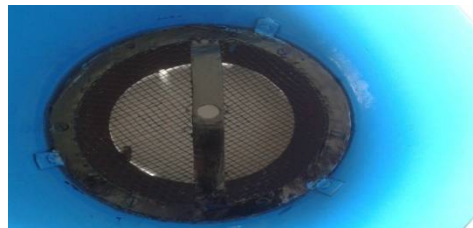


Fig.4. Sieve plate

Fig.4. shows sieve plate through which the grinded raw material passes and collected in the sliding member. The size of sieve 5mm. This dimension is taken by referring journals, which says that the grain size between 3mm to 5mm is best suited for good compactness. Here the sieve plate made by cutting the sieve in circular shape and placed in between the two thin hollow disc with nut and bolt arrangement.



Fig.5. Guide ways

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Fig.6. Sliding member

2. CARRIER UNIT: This unit consists of guide ways and sliding member. Fig.5. shows guide way, which is used to guide the sliding member through it, so that the sliding member shown in Fig.6. can move easily in the specified path to carry the grinded raw materials from the hopper to the cylinder (compressing unit). The guide way is attached to the thick hollow disc to which the legs are attached to that act as a support. Sliding member is rectangular box, it is used to carry the raw material from hopper to the cylinder.

3. COMPRESSING UNIT: It consists of a Telescopic jack, cylinder and a piston. The jack drives the piston inside the cylinder, here we are using a jack which upon rotation move the piston in and out of the cylinder. The piston and cylinder are machined to the close dimensional tolerance so that the piston moves easily inside the cylinder. The grinded raw materials are put in to the cylinder, these materials inside the cylinder are compressed into briquettes upon the application of force by the jack. Thus formed briquettes are taken out by pulling the plate at the top of the cylinder.



Fig.7. Telescopic jack

Fig.7. shows telescopic jack having 2-ton capacity and the plunger can extrude to maximum of 250mm height. This jack is used to compress the grinded particles in to briquettes.



Fig.8. Cylinder

Fig.8. shows the cylinder. The Outer diameter of cylinder is 90 mm, inner diameter is 70mm, length of cylinder is 200 mm. Material of cylinder is Mild Steel with coating.

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IV. WORKING OF BRIQUETTING MACHINE



Fig.9. Briquetting Machine

Fig.9. shows the Briquetting machine which can be easily disassembled and hence it is portable. A rigid frame provided for jack supports the whole unit.

Here we are using Sawdust, Coffee husk, Dry leaves and Rice husk etc as raw materials. These raw materials are gathered and are added to the hopper in required ratio to get the compact briquette. After filling the raw materials the top portion of hopper is closed this is because due to high speed of the blade the raw material may move out. These raw materials are grinded by the blades, which is driven by the motor. Here the regulator is used to regulate the speed of the blade so that the grinding operation can be controlled. That is by using high speed rotation the raw materials are finely grinded and so on for the medium speed. These grinded raw materials are allowed to pass through the sieve plate, which is placed in between the blade and motor (size of sieve 5 mm).

After complete grinding of the raw materials in the hopper the motor is switched off. These grinded raw materials are stored at the bottom of hopper and sliding member. Sliding member is a rectangular box with top portion open and having small hole at the bottom. This sliding member is dragged along the guide ways to fill the grinded raw material in the sliding member to the cylinder through the small hole at its bottom. While filling the cylinder with grinded raw materials the bottom portion of the hopper is closed by the stopper. And also the bottom portion of cylinder is closed by the piston.

After complete filling of the cylinder with raw materials, the sliding member is moved back to its initial position. Now the top portion of the cylinder is closed by the locking mechanism. Then the lever of hydraulic jack is rotated in clock wise direction to move the piston upwards and to compress the raw materials into briquette. Now the locking cap at the top of the cylinder is opened and the lever of jack is further rotated to move the briquette out of the cylinder. Then the lever is rotated in anticlockwise direction to move the piston to its initial position for preparing another briquette and this process further repeated to manufacture a briquette in continuous manner.

V. CALORIFIC VALUE COMPARISONS

By taking the briquette manufactured by the industry on a commercial machine using raw materials such as sawdust, coir pitch, coffee husk and the briquettes manufactured by our machine the calorific value have been calculated and are compared as follows.

Formulae for water equivalent of calorimeter: $W = \frac{H \times M}{T} \times (C_T + C_F)$

Formulae for Calorific value of fuel sample: $C_V = T \times W - (C_T + C_F)$

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Specification:

- T - Final temperature rise of water in degree Celsius.
- M - Mass of the sample in grams.
- H - Known calorific value of benzoic acid in Cal /gm=6464Cal/gm.
- L_F - Length of the Fuse wire = 10 cm.
- W - Water equivalent of the Calorimeter in Cal /deg = 6699.97Cal/deg.
- C_{V_s} - Calorific value of Fuel Sample.
- C_{V_F} - Calorific value of Fuse wire = 2.33 Cal /cm.
- C_{V_T} - Calorific value of the Thread wire = 2.1 Cal / cm.

Calculation:

- Initial temperature = 28.1 °C.
- Rise in temperature = 28.80 °C.
- Difference in in temperature = 0.7 °C.
- L_T - Length of the Thread = 10 cm.
- C_F - Heat liberated by the Fuse wire in Cal = $2.33 \times L_T = 2.33 \times 6 = 13.98$ Cal.
- C_T - Heat liberated by Thread in Cal = $2.1 \times L_T = 2.1 \times 10 = 21$ Cal.



Fig.10. Briquette with coffee husk

Fig.10. shows the briquette, which is made using sawdust, dry leaves and coffee husk. Here we have not used any binder the coffee husk itself acts as a binder under pressure. The rise in temperature recorded in bomb calorimeter is 0.72 °C and hence we got the calorific value, $C_v = 4789.17$ Kcal / kg.



Fig.11. Briquette with starch

Fig.11. shows the briquette, which is made using sawdust, dry leaves and starch as binder. Here we have used wheat flour (starch) as binder. The rise in temperature recorded in bomb calorimeter is 0.73 °C and hence we got the calorific value, $C_v = 4856.17$ Kcal / kg.

The industrial sample when tested in a same bomb calorimeter gave a calorific value of 4655.179 Kcal / kg. The results show that the briquettes produced by our briquetting machine have little higher calorific value when compared to the industrial sample. And results revealed that the briquettes produced using starch as binder has slightly higher calorific value.

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VI. CONCLUSION AND FUTURE SCOPE

The main objective of this work is to fabricate a low cost portable machine, which can be used in rural areas to produce briquettes with waste materials and use these briquettes in their daily domestic works like cooking and also can be used as a fuel for boilers. So this work helps in waste management and also provides a way to reduce the use of fossil fuels in turn reduces pollution. A valiant effort can be made in future to increase the productivity by increasing the number of cylinders. Here we concentrated only on some waste like coffee husk, sawdust and dry leaves so further work needs to be carried out so that the different wastes can be converted into briquettes, so this machine can be used in different regions. And there is a need to find a way to replace motor which requires electricity for grinding purpose in this work so that this can be used in remote places.

REFERENCES

- [1] Stout, B.A. and Best, G., "Effective Energy Use and Climate Change: Needs of Rural Areas in developing countries", *Agricultural Engineering International: The CIGR E-Journal*. Vol.III, Pp19-20, 2001.
- [2] S. H. Sengar , A. G. Mohod , Y. P. Khandetod , S. S.Patil , A. D. Chendake , "Performance of Briquetting Machine for Briquette Fuel", *International Journal of Energy Engineering*, Vol.2 No.1, pp. 28-34, 2012.
- [3] Emerhi, E. A., "Physical and combustion properties of briquettes produced from sawdust of three hardwood species and different organic binders", *Advances in Applied Science Research*, Vol.2, pp. 236-246, 2011.
- [4] DahamShyamalee , A.D.U.S. Amarasinghe , N.S. Senanayaka., "Evaluation of different binding materials in forming biomass briquettes with sawdust", *International Journal of Scientific and Research Publications*, Volume 5, Issue 3, March 2015.
- [5] Olawale J. Okegbile, Abdulkadir B. Hassan, Abubakar Mohammed*, Barakat J. Irekeola, "Effect of Starch and Gum Arabic Binders in the Combustion Characteristics of Briquette Prepared from Sawdust", *International Journal of Scientific & Engineering Research*, Volume 5, Issue 3, March-2014.
- [6] I Y Ogwu, ET Tembe, SA Shomkegh., "Comparative Analysis of Calorific Value of Briquettes Produced From Sawdust Particles of Daniella oliveriandAfzeliaafricana Combination at Binary and Tertiary Levels with Rice Husk", Vol.6, Issue 2, 2014.
- [7] Risser PG, *Agricultural and Forestry residues*.In: Soffer SS, Zaborsky OR, editors. *Biomass conversion process for energy and fuels*. New York: Plenum press, 1981. pp. 25-26, 2003.
- [8] Olawole, A., Aina, K.S. and Egbewole , Z.T., "Potential use of wood residues for briquette production; an alternative to energy generation", *Production Agriculture and Technology Journal* Vol.5 (1), ISSN 0794-5213 Pp18-22, 2008.
- [9] Kuti, O.A. and Adegoke, C.O., "Comparative Performance of Composite Sawdust Briquette with Kerosene Fuel under Domestic Cooking Conditions", *AU J.T.* 12: Pp57-61, 2008.
- [10] Himraj D ., "Fuel Substitution in Sub Sahara Africa", *Journal on Environmental Management*, Vol. 17, pp. 283-288, 2003
- [11] Demirbas A and SahinA., "Evaluation of Biomass Residue; Briquetting Waste Papers and Wheat Straw Mixtures", *Journal on Fuel Processing Technology*, Vol. 55, pp. 175-183, 2003.
- [12] Martin J and Mae R and Manaay A., "Design and Development of Charcoal Briquettes Machines", *Journal on Mechanical Engineering*, Vol. 16, pp. 85-90, 2008.
- [13] Ndiema C, Manga P and Ruttoh R., "Densification and Characteristics of Rice Straw Briquettes", *Journal of the Institute of Energy*, Vol. 75, pp. 11-13, 2002.
- [14] Wilainpon P., "The Effect of Moderate Die Pressure on Maize Cob Briquettes", *Journal on Energy Conversion and Management*, Vol. 43, pp. 167-174, 2007.