Design and Development of a Briquetting Machine for Bagasse and Coconut Coir along with Testing of its Calorific Value

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Abstract— Every year large quantities of agricultural wastes are generated which are either destroyed by natural processes such as decaying or burnt inefficiently in loose form causing extensive pollution in the environment. These wastes can be recycled by converting this biomass waste into high-density fuel briquettes using corn starch as a binder. In this work, the mixtures of bagasse and coconut coir were prepared as briquettes. The briquettes were prepared from bagasse and coconut coir with varying composition of corn starch. The results indicate that the briquettes with 50:50 of composition with 8% of binder gave the highest calorific value. The calorific values of the various compositions are ranked as follows: 50:50>60:40>70:30.

Keywords: Carbonaceous, Briquetting, Densification, Compaction Ratio, Homogeneity

I. INTRODUCTION

Many of the developing countries produce huge quantities of agro residues but they are used inefficiently causing extensive pollution in the environment. The major residues are rice husk, coffee husk, coconut coir, jute sticks, bagasse, groundnut shells, mustard stalks, bagasse 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 grates is associated with very low thermal efficiency and widespread air pollution. In addition, a large percentage of un-burnt carbonaceous ash has to be disposed of you to compress wastes like sawdust, chips, sugarcane bagasse and other agro-wastes into briquettes that are environmental friendly and have high calorific value. Burning briquettes as a fuel completes a natural cycle; on combustion they only release as much carbon dioxide back in the atmosphere as was originally absorbed by the growing tree during photosynthesis. Biomass briquettes can be used for power generation or for thermal application but mostly they are used for thermal application in industries replacing conventional fuel.

At present two main high pressure technologies: ram or piston press and screw extrusion machines, are used for briquetting. While the briquettes produced by a piston press are completely solid, screw press briquettes on the other hand have a concentric hole which gives better combustion characteristics due to a larger specific area. The screw press briquettes are also homogeneous and do not disintegrate easily. Having a high combustion rate, these can substitute for coal in most applications and in boilers. Maharashtra is the only state where the briquetting sector is growing gradually in spite of several problems. As a result of a few successes and Governments promotional efforts, a number of entrepreneurs are confidently investing in biomass briquetting in the state of Maharashtra. These entrepreneurs are also making strenuous efforts to improve both the production process and the technology.

II. BRIQUETTING TECHNIQUES

Biomass densification represents a set of technologies for the conversion of biomass residues into a convenient fuel. The technology is also known as briquetting or agglomeration. Depending on the types of equipment used, it could be categorized into following types:

- Piston press densification
- Screw press densification

A. Piston Press Densification

There are two types of piston press 1) the die and punch technology; and 2) hydraulic press. In the die and punch technology, which is also known as ram and die technology, biomass is punched into a die by a reciprocating ram with a very high pressure thereby compressing the mass to obtain a compacted product. The standard size of the briquette produced using this machine is 60 mm, diameter. The power required by a machine of capacity 700 kg/hr is 25 kW. The hydraulic press process consists of first compacting the biomass in the vertical direction and then again in the horizontal direction. The standard briquette weight is 5 kg and its dimensions are: 450 mm x 160 mm x 80 mm. The power required is 37 kW for 1800 kg/h of briquetting. This technology can accept raw material with moisture content up to 22%. The process of oil hydraulics allows a speed of 7 cycles/minute (cpm) against 270 cpm for the die and punch process. The slowness of operation helps to reduce the wear rate of the parts. The ram moves approximately 270 times per minute in this process.

Fig. 1: Briquetting Machine

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B. Screw Press

The compaction ratio of screw presses ranges from 2.5:1 to 6:1 or even more. In this process, the biomass is extruded continuously by one or more screws through a taper die which is heated externally to reduce the friction. Here also, due to the application of high pressures, the temperature rises fluidizing the lignin present in the biomass which acts as a binder. The outer surface of the briquettes obtained through this process is carbonized and has a hole in the centre which promotes better combustion. Standard size of the briquette is 60 mm diameter.

Optimum moisture content of raw material	Piston press	Screw press
Wear of contact parts	10-15%	8-9%
Output from the machine	Low in case of ram and die	High in case of screw
Power consumption	In strokes	Continuous
Density of briquette	50kWh/ton	60kWh/ton
Maintenance	High	Low
Combustion performance of briquettes	Not so good	Very good
Homogeneity of briquettes	Not homogenous	homogenous

Table 1: Comparison between Piston Press and Screw Press

III. Briquettes Fabrication

Firstly, the bagasse and coconut coir were dried for 10-15 hours. The next process was down-sizing, the bagasse and coconut coir were smoothed by using a blender. Briquettes have been made from mixtures of bagasse and coconut coir with three different compositions. For each composition, three adhesive content variations (mass % of corn starch): 6% and 8% were used. The mixture of each briquette was prepared from 100 g of the any composition and 60 ml of water and adhesive materials according to the its percentage level. The adhesive material was prepared in advance by mixing the corn starch with water in a pan. The starch is then poured into the mixture and stirred until blended. The mixture was then set up into the briquetting machine and compressed with the help of hydraulic compression tool. The last step was drying process to reduce the moisture content of the briquette so that make it easy to light when burned. All briquettes that have been made were sun dried for about a day.

Mixtures of bagasse and coconut coir were prepared with the composition-I (50%:50%), composition-2 (60%:40%) and composition-3 (70%:30%). To each composition, adhesive of corn starch was added in varying levels (% mass) which were: A=6% and B=8%.

Fig. 2: Raw Materials

Fig. 3: Bagasse – Coconut coir Briquettes

Sr.No.	Sample No.	Composition (%)		Adhesive Content (%)
		Bagasse	Coconut Coir	
1	1A	50	50	6
2	1B	50	50	8
3	2A	60	40	6
4	2B	60	40	8
5	3A	70	30	6
6	3B	70	30	8

Table 2: Bagasse: Coconut Coir Briquettes Sample Identification

IV. Results and Discussion

The result table includes calorific value, ash content and moisture content:

Sample	Calorific value (kcal/kg)	Ash content (%)	Moisture content (%)
1A	3811	2.67	9.56
1B	3788	2.32	9.07
2A	3746	1.95	8.32
2B	3712	1.87	8.14
3A	3695	1.63	8.19
3B	3671	1.41	8.07

Table 3: Analysis of Properties of Bagasse: Coconut Coir Briquettes

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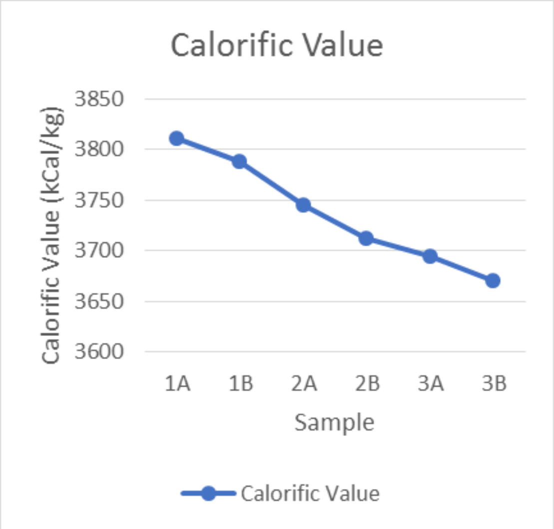

Fig. 4: Calorific Values of Briquettes

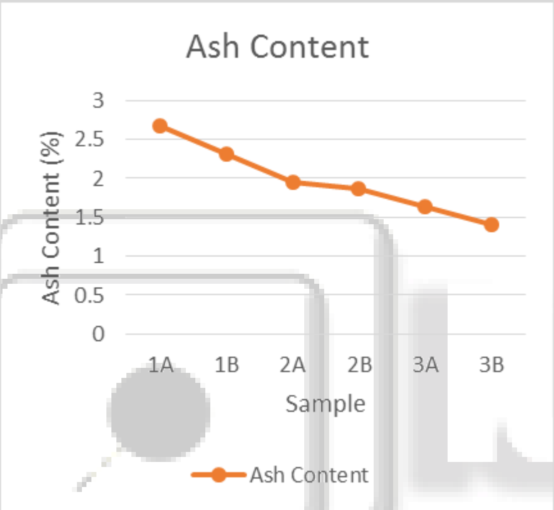

Fig. 5: Ash Content of Briquettes

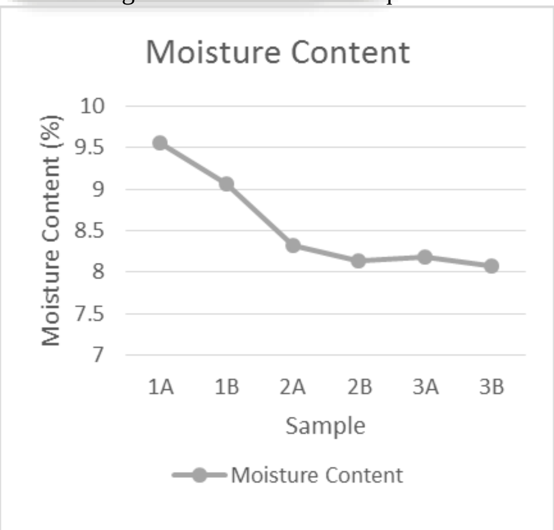

Fig. 6: Moisture Content of Briquettes

V. Conclusion

Briquette models made from the mixtures of bagasse and coconut coir have been created successfully in this research. The results show that the sample 1A shows highest calorific value of 3811kcal/kg whereas the sample 3B has lowest calorific value of 3671kcal/kg.

Factors affecting the calorific value are moisture content, ash content and volatile matter content.

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