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Research Paper :

Physical and thermal properties of briquettes by piston press and screw press

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ABSTRACT

The present study was undertaken to the test the briquettes. For this study availability of the biomass in Akola area and select the best suitable biomass for briquette making was studied for groundnut residue, sawdust, soybean residue, sole and mass mixing ratio, respectively. Briquettes made from screw press and piston press were tested for their physical and thermal properties in laboratory. The best suitable material for briquette making with the wood chips and wood species. In case of piston press, groundnut residue (19180.2 kJ/kg), sawdust (18204 kJ/kg), groundnut with sawdust (19569.55 kJ/kg) and ground nut residue with soybean residue (18694.67 kJ/kg) gave better CV or similar to the wood chips (20030.01 kJ/kg) and wood species (babool) (20038.38 kJ/kg). Groundnut residue briquette and groundnut with sawdust briquette gave higher density in piston press of nearly 0.53 to 0.663 g/cm^3. In screw press, density of sole and combination briquette gave 0.392 to 0.433 g/cm^3. The result found that groundnut with soybean residue, groundnut residue and groundnut with sawdust has been most suited for briquetting.

Key words : Briquettes, Piston press, Screw press, Physical and thermal properties of briquettes

As the world population increases (along with an increase in consumption and standard of living), so does the demand for chemicals and energy. Energy is considered as the basis for the progress and prosperity of nation and societies. It is also the cornerstone of economic and social development. Biomass has been one of the main energy sources for the mankind ever since the dawn of civilization, although its importance dwindled after the expansion in use of oil and coal in the late 19th century. Biomass is also capable of providing firm energy. Estimates have indicated that 15-50 per cent of the worlds primary energy used could come from biomass by the year 2050. Biomass is of great importance with respect to energy for developing countries, 15 per cent of the world energy consumption and 43 per cent of energy consumption in developing countries are supplied from biomass.

In the very near future charcoal is expected to be big replaced by natural gas in most of the big cities but in most rural areas and small towns the situation of dependence on forests and farm waste may remain unchanged for more few years. In order to combat the negative handling aspects of bulk biomass, densification is often required. If such crop residues are converted in to briquettes they can provide huge and reliable source of feedstock for thermo chemical conversion (Anonymous, 2002). Thomas *et al.* (1998) concluded that more research efforts should be directed towards the effects of individual constituents and their respective properties the effects of raw material constituents both their level and physical chemical properties, may provide more information on briquetting characteristics and briquette quality than the ingredient inclusion level.

METHODOLOGY

The experimental methodology included study of physical and thermal properties of briquettes. Finally select the best suitable material for high density briquettes.

The following are the important properties to be considered for the selection of material for biofuel.

- High calorific value
- Fast growth and high biomass fuel.
- Should not have major alternative use.
- Should have low nutritive value.
- High biomass / ash ratio

Material including groundnut husk, sawdust and soybean straw were collected from University experimental plots, in Akola and their physical and chemical properties were determined. All samples were then ground in hammer mill and sieved to less than 100 microns. The physical and chemical properties of groundnut husk, sawdust, soybean residue were determined in laboratory using standard test procedure. Physical properties of material included determination of moisture content and bulk density, using oven drying method, overall length and diameter of briquette, as per the ASTM standard no. E871. Moisture content of material was measured by oven drying method. The

material was placed in hot air oven at 105 ±110 ^{0}C for 1 hour. Loss in weight was measured as moisture content (on percentage basis). Shatter and tumbling resistance are resistance to water penetration and equilibrium moisture content. Chemical analysis of material was carried out in radiant laboratory at Nagpur. Chemical analysis to determine carbon, hydrogen, sulphur and nitrogen content was conducted by organic elemental analysis (OEA) using combustion apparatus, kjeldahl's flask. The important thermal properties of briquette included their calorific value, volatile matter and ash content, fixed carbon. All these physical and thermal properties were studied for briquettes prepared by piston press and screw press.

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been summarized under following heads:

Physical and thermal properties of briquette (Piston press result):

Moisture content:

Moisture content (W.B.) in sawdust briquette was lowest (3 per cent) and combination of sawdust and soybean residue briquettes, it was maximum (6.6 per cent). It was due to initial moisture content of biomass residue. It is observed that the moisture content in biomass should be low for efficient briquetting.

Bulk density:

The bulk density of briquette by piston press technology ranged from 0.52 to 0.89 g/cm^3. Density of material was affected by the moisture content and the particle size of the material. Fig.1 indicates that the bulk density of combination of groundnut husk and sawdust was highest (0.89 g/cm^3) than other residue.

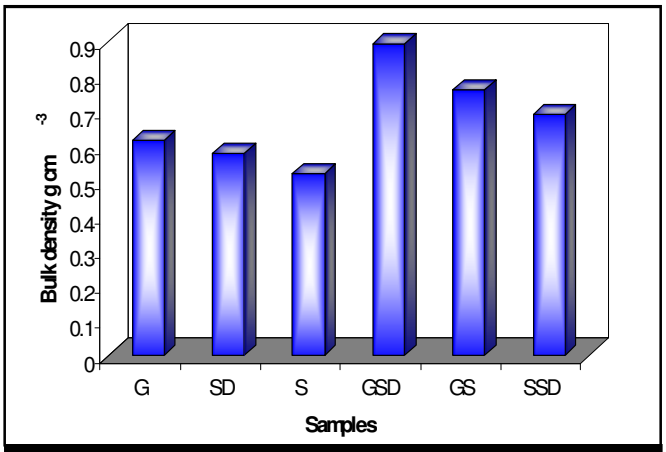

Fig. 1 : Bulk density of briquettes by piston press

Length and diameter of briquettes :

The length of briquettes varies from 11 cm to 15.5 cm where as diameter of briquette was uniform *i.e.* 9.0 cm. The diameter of all briquettes was same as they were produced through same die.

Tumbler and shatter resistance :

The average material loss was observed to be less than 4 per cent in both tumbling and shatter test for sole and combination of biomass briquettes. The tumbler resistance ranged between 83.85 to 97.95 per cent. The tumbler resistance of briquette was maximum in sawdust (97.95 per cent).The shatter resistance of briquettes ranged between 94.78 to 99.41 per cent. In case of soybean residue briquettes gave minimum shatter resistance. In groundnut residue with sawdust briquettes gave maximum shatter resistance (99.41 per cent) it is depicted in Fig.2. This much shattering and tumbling loss for soybean residue briquettes indicated that less is the moisture content at the time of briquette more will be the shattering loss.

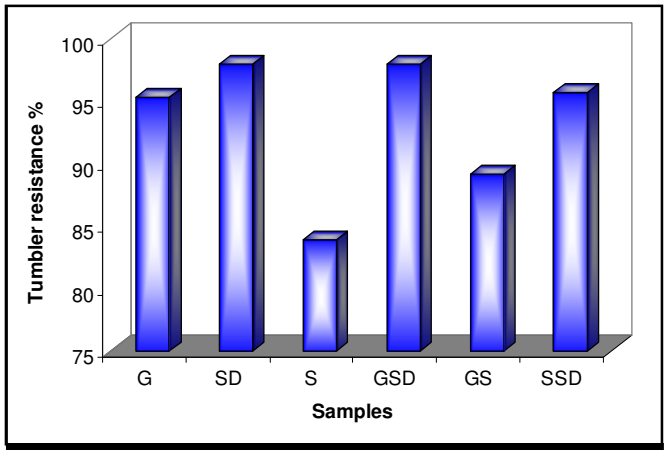

Fig. 2 Tumbler resistance of briquettes in piston press

Resistance to water penetration :

Resistance to water penetration of groundnut residue, sawdust, and soybean residue briquettes was 66.15 per cent, 71.11 per cent, 55.93 per cent, respectively. From their bulk density, it was observed that less the density less is the resistance to water penetration. Resistance to water penetration was very low in soybean residue briquette and also depicted in Fig.3 In soybean residue with sawdust gave lower resistance to water penetration of nearly 63.05 per cent

Equilibrium moisture content:

Result of equilibrium moisture content showed the value from 5.3 per cent to 6.6 per cent. Result indicated

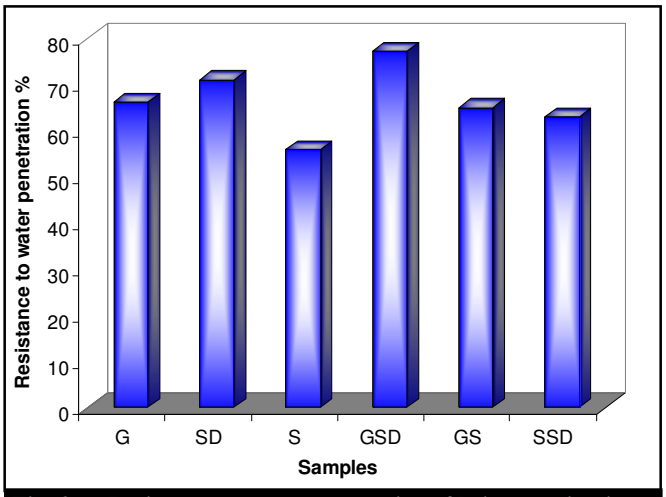

Fig. 3 : Resistance to water penetration of briquettes in piston press

that the lower the initial moisture content of residue, lower the equilibrium moisture content.

Calorific value:

It was observed that calorific value of groundnut residue and combination of groundnut residue and sawdust was 19180.2 kJ/kg, 19569.55 kJ/kg, respectively. Sole briquettes had higher calorific value of nearly 4582 kcal/kg (19180.2 kJ/kg). A combination of briquettes only gave calorific value of 19569.55 Kcal/kg. Sawdust briquettes have given higher calorific value than soybean residue briquette of nearly 14713.79 kJ/kg. Graphical presentation is shown in Fig. 4.

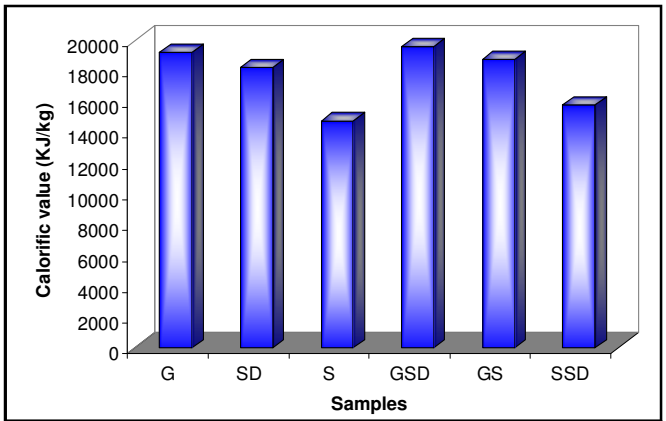

Fig. 4 : Calorific value of sole and combination of briquettes in piston press technology

Ash content:

The ash content of briquettes ranged from 6.9 per cent to 8.6 per cent, which has been found within the limit. Ash content in ground nut residue with soybean residue briquettes was very low (7.0 per cent) as compared to the other. An ash percentage was highest in groundnut residue with sawdust briquettes. Ash content of briquettes should be low, which indicated their suitability in gasification and this will not be detrimental in further combustion process.

Volatile matter and fixed carbon:

The volatile matter content ranged from 72.80 per cent to 82.70 per cent. Volatile matter of groundnut residue with sawdust briquettes gave (82.70 per cent) maximum. Volatile matter of groundnut residue with soybean residue briquettes gave 81.80 per cent. As the volatile matter content was more then 70.00 per cent hence, it was suitable for gasifier. Fixed carbon content ranged from 2.30 to 16.0 per cent. Fixed carbon percentages of groundnut residue with sawdust briquettes was 2.30 per cent. Fixed carbon content was found to be maximum in sawdust briquettes.

Physical and thermal properties of briquettes (screw press):

Moisture content:

The moisture content of briquettes varied from 31.30 to 42.28 per cent. The moisture content of soybean residue with sawdust gave lower value as compared to other. The groundnut residue with soybean residue briquettes gave highest moisture content of nearly 42.28 per cent.

Bulk density:

Bulk density of briquette ranged from 0.388 g/cm^3 to 0.433 g/cm$^{3.}$ Bulk density of groundnut residue with sawdust briquettes was highest value of nearly 0.433 g/cm^3. Increased moisture content resulted in higher density of briquette. Fig. 5 shows that the density of combination of briquette gave higher bulk density. Bulk density is a

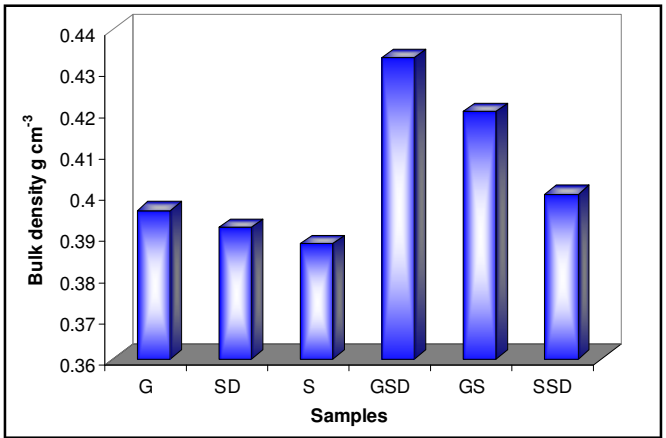

Fig. 5: Bulk density of sole and combination of briquettes in screw press

function of both the density of individual briquette and its geometry

Length and diameter of briquettes :

The length and diameter varied from 3.0 to 8.2 cm whereas diameter of briquette was uniform *i.e.* 2.87 cm. The diameter of all briquette was same.

Shatter and Tumbler resistance:

Tumbler resistance of briquettes ranged from 67.41 to 77.85 per cent. Tumbler resistance of soybean residue briquettes was very low (67.41 per cent). Shattering resistance of sole briquette ranged from 72.80 per cent to 95.23 per cent and combination of briquettes ranged from 77.27 to 96.256 per cent. Shattering resistance of groundnut residue with sawdust was 96.26 per cent. Groundnut with sawdust gave higher shattering resistance and tumbler resistance which were also highest in groundnut residue and sawdust briquette.

Resistance to water penetration :

The sole and combination of biomass briquettes have average gain water ranging from 39.74 per cent to 73.41 per cent from their bulk densities. Soybean briquettes and soybean brick sawdust gave lower resistance to water penetration, the graphical presentation is depicted in Fig 6. It is observed that less the density, less is the resistance to water penetration

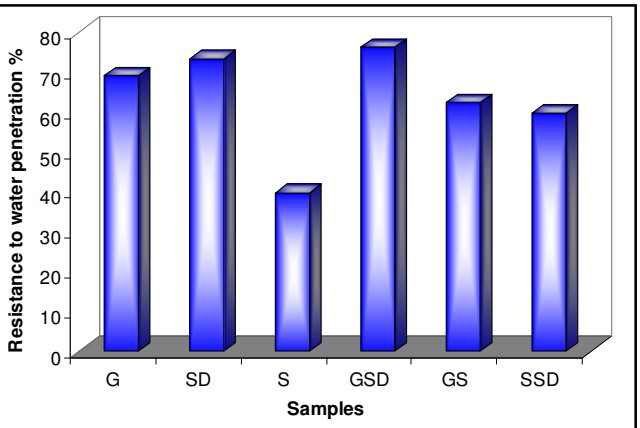

Fig. 6 : Resistance to water penetration of briquette by screw press

Equilibrium moisture content :

Equilibrium moisture content of sawdust briquettes was lowest at nearly 5.6 per cent. Equilibrium moisture content of groundnut residues with sawdust briquettes was higher at nearly 7.53 per cent. Lower equilibrium moisture content of sawdust briquettes indicated that they were most porous.

Calorific value:

Calorific value of sole briquettes ranged from 13035.20 to 17522.59 kJ/kg, while calorific value of combination of briquettes ranged from 12352.88 to 18204.91 kJ/kg. Calorific value of groundnut residue with sawdust briquettes was maximum 18204.91 kJ/kg. It is observed that calorific value of soybean residue briquettes was lower in other sole type of briquettes. Calorific value of groundnut residue with soybean residue briquettes and soybean residue with sawdust briquettes gave nearly same value. Calorific value of raw material decides the calorific value of briquettes when binder per cent was kept same. Graphical presentation is shown in Fig.7.

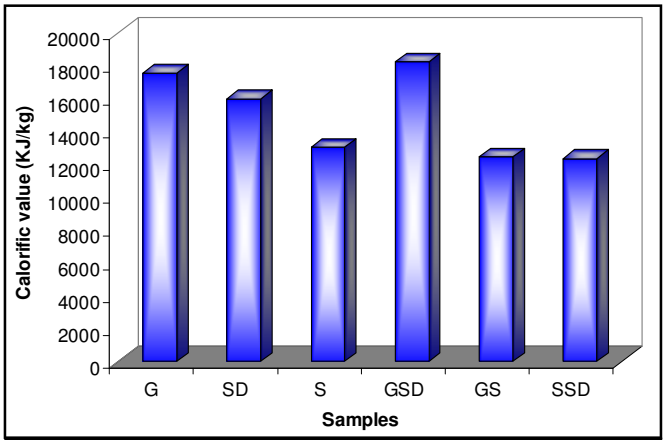

Fig. 7 : Calorific value of briquette by screw press

Ash content:

The ash content of briquettes ranged from 11.99 to 19.46 per cent. Ash percentage of ground nut residue briquettes was highest. Ash percentages must be low due to slagging. It has been found within the limit which indicated their low suitability for gasifier.

Volatile matter and fixed carbon :

The volatile content ranged from 70.00 to 76.00 per cent. Groundnut residue briquettes and sawdust gave higher volatile content of nearly 75.08 and 76.04 per cent, respectively. A fixed carbon percentage of briquettes ranged from 7.64 to 17.90 per cent. Fixed carbon content in groundnut with sawdust briquettes gave maximum (17.90 per cent).

Comparative result of biomass:

From Table 1 it is observed that wood species like anjan and bihada had nearly same calorific value. The calorific value of soybean residue briquette was minimum

Table 1 : Calorific value of wood chips and materials

Sr. No.	Sample	Calorific value kJ/kg
1.	Wood chips	20030.01
2.	Wood Species (babul)	20038.38
3.	Wood Species (piwerwel)	16720
4.	Wood species (Anjan)	17800
5.	Wood species (Bihada)	17000
6.	Groundnut + sawdust husk	19569.55
7.	Groundnut + soybean husk straw	18694.67
8.	Soybean + sawdust husk	14713.79

(14713.79 kJ/kg). The calorific value of wood chips was found 20030.01 (kJ/kg). Calorific value of wood species like anjan, bihada, piwerwel had lower than groundnut + sawdust husk and groundnut + soybean husk straw material. The groundnut residue had been nearly same value of wood chips and other wood species. Groundnut residue with sawdust and sawdust briquettes gave maximum calorific value.

Conclusion:

– Moisture content of ground residue, sawdust, soybean residue was 9.0, 7.0, and 7.7 per cent, respectively. Moisture content of ground residue was highest but less then 12 per cent. Suitability of briquetting, moisture content should be less then 12 per cent. Average bulk density of biomass material ranged from 0.281 to0.315 g per cc.

– Carbon percentage was higher in groundnut residue, which leads to higher calorific value. Nitrogen percentage was lower in soybean residue, which helps to protect the metal from corrosion or atmospheric pollution.

– Groundnuts with sawdust combination gave higher calorific value 19569.55 kJ/kg than other residue. It was considered the best biomass for briquette making as this would also facilitate land clearing.

– Groundnut residues have nearly same calorific value as compared to that of wood chips and wood species. Wood species (anjan) gave lower calorific value than Groundnut + soybean husk straw.

The space requirements for storage of briquettes fuel are much less as compared to various aggravate.

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