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Analysis of Physical Properties of Biomass Briquettes Prepared by Wet Briquetting Method

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Abstract:- Biomass material such as rice straw, banana leaves and teak leaves (*Tectona grandis)* are densified by means of wet briquetting process at lower pressures of 200-1000 kPa using a piston press. Shear strength, durability, impact resistance and calorific values are determined. Optimum densities for each type of briquette for good quality and their corresponding die pressures were determined. Shear strength and durability increases with the applied die pressure while impact resistance is not influenced by increasing die pressure.

Keywords:- Biomass, Briquettes, wet briquettes, Shear strength, Impact resistance, calorific value

I. INTRODUCTION

Rural India houses 0.36 billion of total population and cooking consumes 90% of domestic energy consumption. In rural India, 76% of households are not getting the access to modern fuel system like LPG. As a result, this section of population are facing fuel crisis. Excessive pressure on our forest resources due to increasing dependency is also another concern. The rural fuel crisis is associated with poverty and illiteracy and rural women are mostly affected by it [1]. An affordable and sustainable technique for conversion of loose biomass into solid and usable fuel for rural people is the need. There are, however, abundant loose biomass resources (in the form of agro residue, tree leaves) available in rural areas. Most of these are still unutilized. One of the ways is to use this biomass as fuel would be densification by wet briquetting method. The objective of this work is to determine the optimum density and corresponding pressure required to produce best quality briquettes by this method.

II. METHODOLOGY

Based on wide availability in country side and composition such as lesser amount of lignin and ash content compared to other available biomass, rice straw, banana leaves and teak leaves are selected for wet briquetting [2]. The first step of wet briquetting process is decomposition of biomass material up to a desired level in order to pressurize to wet briquettes at a lower pressure [3, 4]. The biomass materials are chopped in sizes about 10 mm. The chopped biomass materials are soaked in water and kept in open at an ambient temperature. At regular interval of days, hand test such as shake test is performed to check the desired level of decomposition in biomass materials. The good briquette material does not fall apart when held over the upper 1/2 portion and shaken vertically a few times in the hand test [3]. Decomposition loosens fibers of biomass materials. Time requirements for desired level of decomposition vary with biomass types. Rice straw and teak leaves take 19 days while banana leaves take 28 days to reach the desired status. The wet biomass which reaches optimum level of decomposition are pressurized by manually operated piston press of internal diameter 45 mm at varying pressure level ranging from 200 kPa to 1000 kPa. Pressure is varied by changing dead weight on the piston press during briquette manufacturing. A dwell time of 40 seconds is observed during briquette formation [5]. Even after pressurization, the briquettes are wet and these need proper drying for two weeks in sun.

The initial and the relaxed density of the briquettes were determined using the die dimension and ASAE standard method of determining densities. Durability, impact resistance and shear strengths of briquettes are determined according to their respective ASTM and ASAE standards. These parameters indicate quality of briquettes.

III. RESULTS AND DISCUSSION

A. Effect of die pressure on density of briquettes

After briquette is removed from die, it starts to relax or try to recover its former length. It continues until it becomes stable. Generally, wet briquettes take 1 to 2 weeks to become stable.

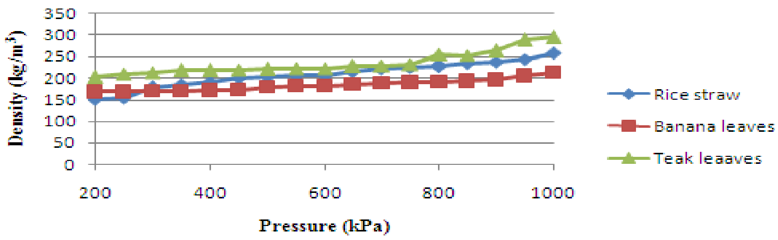

Fig.1: Relation between relaxed density and die pressure for different briquettes

Relaxed length of briquettes is measured after 2 weeks of proper sun drying and then stable or relaxed densities are calculated. Figure 1 shows the relaxed density of briquettes of various biomass materials with increasing pressure up to 1000 kPa or 1 MPa. Teak leaves briquettes have highest density followed by rice straw and banana leaves briquettes.

B. Effect of die pressure on shear strength

To measure shear strength, shearing test set up has been fabricated. The instrument consists of three wooden plates. The middle plate with a central cylindrical hole of 4.5 mm diameter and 30 mm thickness slides over the bottom plate. In the top plate, a cylindrical hole of same diameter as that of moving plate with 20 mm thickness is being provided in such a way that it coincides with the one that is provided in the movable plate when this plate is fully inserted between top and non moving bottom plate. The movable plate is connected to dead weights. Shear strength per unit $m^2 = \frac{2W}{\pi D^2}$ W= weight causing shear, D= diameter of briquette

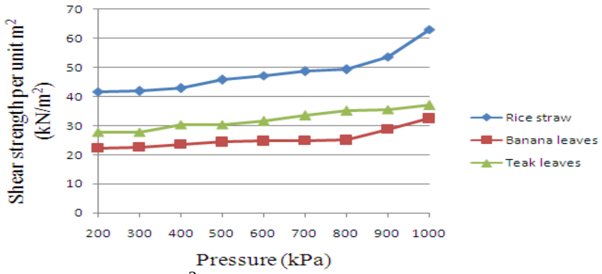

Fig.2: Variation of shear strength per unit m^2 of rice, banana leaves and teak leaves briquettes with increasing pressure

The shear strength per unit m^2 of briquettes increases with increase in die pressure. Figure 2 shows shear strength per m^2 results for various biomasses with increasing pressure. Rice straw has the highest shear strength per unit m^2 followed by banana leaves and teak leaves briquettes. This means rice straw briquettes are less likely to crumble upon transportation and storage.

C. Effect of die pressure on durability

Durability of briquettes gives the mechanical handling of the solid fuel [6]. This is measured by standard procedure ASAE S269.4. To measure durability, 100 g of sample is taken and sample is tumbled at 50 rpm for 10 minutes in a dust tight enclosure of size 300mm×300mm. Metal cloth of aperture size 4mm is used to retain crumbled briquettes after tumbling.

Briquette durability index in % is given by = $\frac{\text{Briquette remaining}}{\text{Original weight}}$

Figure 3 shows clearly variation of durability of briquettes with increase in pressure. Durability above 90 is considered to be good for transportation and handling purposes. Therefore, briquettes produced pressure above 600 kPa for rice straw, 500 kPa for banana leaves and 700 kPa for teak leaves have above 90 durability indexes.

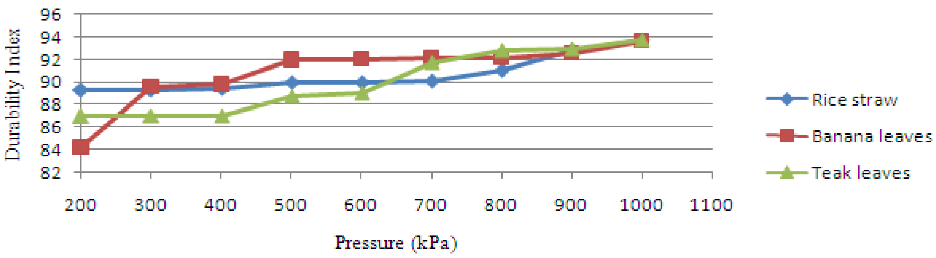

Fig.3: Variation of durability index with increasing pressure for rice straw, banana and teak leaf briquettes

D. Impact resistance of briquettes

This test simulates the forces encountered during emptying of densified products from trucks onto ground, or from chutes into bins. Drop tests or impact tests can be used to determine the safe height of briquette production during mass production [7]. ASTM D440-86 method is used to determine impact resistance index. In the drop test, briquettes are dropped twice from a height 1.83 m onto a concrete floor. An impact resistance index (IRI) is calculated. Highest IRI is 200.

$$IRI = \frac{100 \times N}{n}$$

Where N= Number of drops,

n= Total number of pieces

Impact resistance is found to be constant for all types of briquettes at all pressure. Impact resistance index 200 is found for all.

E. Calorific values of briquettes

Calorific value of the briquettes is measured in auto bomb calorimeter.
The calorific values of briquettes are showed in table 1.

Table I: Calorific values of briquettes of various biomass material

	Rice straw briquette	Banana leaves briquette	Teak leaves briquette
Calorific value (MJ/kg)	13.57	14.98	11.78

Calorific values obtained from briquettes are lower than that of their respective biomasses calorific value. This may be due to decomposition undergone by the biomass material as required by wet briquetting method.

IV. CONCLUSIONS

From the experimental results, we can say that increasing die pressure and keeping dwell time at optimum value of 40 seconds [5], the quality of briquette has increased.

Shear strength and durability increase with applied die pressure while impact resistance is constant for briquettes of all types at all applied die pressure. Die pressure above 600 kPa for rice straw, 500kPa for banana leaves and 700 kPa for teak leaves yields durable briquettes. Therefore corresponding densities of rice straw, banana leaves and teak leaves briquettes are 207.48 kg/m^3, 179.69 kg/m^3 and 227.53 kg/m^3 respectively

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