Study of Combustion Characteristics of Fuel Briquettes

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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. Wet briquetting is a process *of decomposing biomass material up to a desired level under controlled environment in order to pressurize to wet briquettes or fuel briquettes. Upon drying these wet briquettes could be used as solid fuels. This study is aimed at to determine combustion characteristics of briquettes which will facilitate to answer some of the questions regarding the usefulness of fuel in terms of production of harmful gases and fly ashes during combustion which are common indoor air pollutants in many households and effectiveness of the fuel in terms of heat value.*

KEYWORDS: *Biomass, fuel briquettes, calorific value, combustion rate*.

I. INTRODUCTION

With rapid depletion of world petroleum reserves and increased demand of petroleum products, especially of transportation fuels, it has posed a serious problem of energy crisis in India. Rural India is mostly affected by it. Therefore, there is a great demand of cheap and easily available fuel for cooking in rural household sector. In this regard, briquetting could be a viable option. Biomass briquetting is the densification of loose biomass material to produce compact solid composites of different sizes with the application of pressure. Three different types of densification technologies are currently in use. The first, called pyrolizing technology relies on partial pyrolysis of biomass, which is added with binder and then made into briquettes by casting and the first, called pyrolizing technology relies on partial pyrolysis of biomass, which is added with binder and then made into briquettes by casting and pressing. The second technology is direct extrusion type, where the biomass is dried and directly compacted with high heat and pressure. The last type is called wet briquetting in which decomposition is used in order to breakdown the fibers. On pressing and drying, briquettes are ready for direct burning or gasification. These briquettes are also known as fuel briquettes. Fuel briquettes are easy to manufacture at a very cheap cost. This technique has gained popularity in some of the African and Asian countries [1].

II. METHOD AND MATERIAL

India produces large amounts of bio waste material every year. This includes rice straw, wheat straw, coconut shells and fibres, rice husks, stalks of legumes and sawdust. Some of this biomass is just burnt in air; some like rice husk are mostly dumped into huge mountains of waste. Open-field burning has been used traditionally to dispose of crop residues and sanitize agricultural fields against pests and diseases. 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. A dwell time of 40 seconds is observed during briquette formation [5]. Even after pressurization, the briquettes are wet and therefore they need to be dried up to 8% moisture content.

In the second step, we blended wet biomass of rice straw, banana leaves and teak leaves with *Mesua ferrea* L. seed cakes which are a waste material after extraction of vegetable oil for biodiesel production from *Mesua ferrea* L. seeds.Proximate analysis, calorific values combustion rates of briquettes are done to assess effectiveness of briquettes as cooking fuel. For proximate analysis and calorific value determination, ASTM E870 - 82(2013) and ASTM D2015-00 methods are used respectively. But in order to asses burning rate at room condition a simple test as proposed by Joel Chaney [6] is applied. To determine Combustion rate or burning rate which is mass loss per unit time, the briquettes are dried at 105ºC so that it does not affect on combustion or burning. Dried briquette is placed on a steel wire mesh grid resting on three supports allowing free flow of air. Now the whole system is placed on mass balance. Briquette is ignited from top and mass loss data is taken at an interval of 30 seconds.

III. RESULTS AND DISCUSSIONS

3.1 Proximate analysis

Proximate analysis of briquettes samples is done and results are presented in Table 1 and 2. From the analysis, it is found that volatile matter in Nahar added briquettes is more corresponding to non added ones. It is due to oil content of nahar (*Mesua ferrea* L.) seed cake as the seed cake contains 14 % even after oil expulsion.

Table 1: Proximate analysis of rice straw, banana and teak leaves briquettes

Proximate analysis	Rice straw Briquettes (% dry fuel)	Banana leaves briquettes (% dry fuel)	Teak leaves briquettes (% dry fuel)
Fixed carbon	15.59-19.86	12.16-12.63	8.88-9.21
Volatile matter	66.45-68.59	79.2-80.05	77.32-77.88
Ash	12.74-18.68	10.1-13.4	17.27-18.08

Table 2
Proximate analysis of nahar seed cake added briquette samples

Proximate analysis	Rice straw briquettes (% dry fuel)	Banana leaves briquettes (% dry fuel)	Teak leaves briquettes (% dry fuel)
Fixed carbon	7.79-9.88	8.02-10.52	10.49-13.1
Volatile matter	82.32-90.5	83.39-87.625	75.75-86.45
Ash	7.65-9.88	7.51-9.10	8.9-13.55

3.2 Calorific value

Calorific values of rice straw, banana leaves and teak leaves are determined to be 13.57 MJ/kg, 14.98 MJ/kg, and 11.78 MJ/kg respectively. However, when nahar seed cake is added with the biomass materials, calorific values are found to increase in each case. Nahar added rice straw, banana leaves and teak leaves briquettes have calorific values of 19.76 MJ/kg, 19.21 MJ/kg and 19.10 MJ/kg respectively. This is due combine effect of mixing. Calorific value of *Mesua ferrea* L. seed cake is 19.6 MJ/kg. The percentage increase in calorific values in nahar seed cake added rice straw briquette samples are found more than that of the other two nahar seed cake added samples.

3.3 Combustion rate

Fig.1 shows the variation of combustion rates of briquettes over applied die pressures of briquette production. With increase in applied die pressure, briquettes become more compact and hence combustion rate is reduced. It may be due to increase in density, voids which contain trapped air decrease. It is observed that nahar added teak leaves have the highest combustion rate.

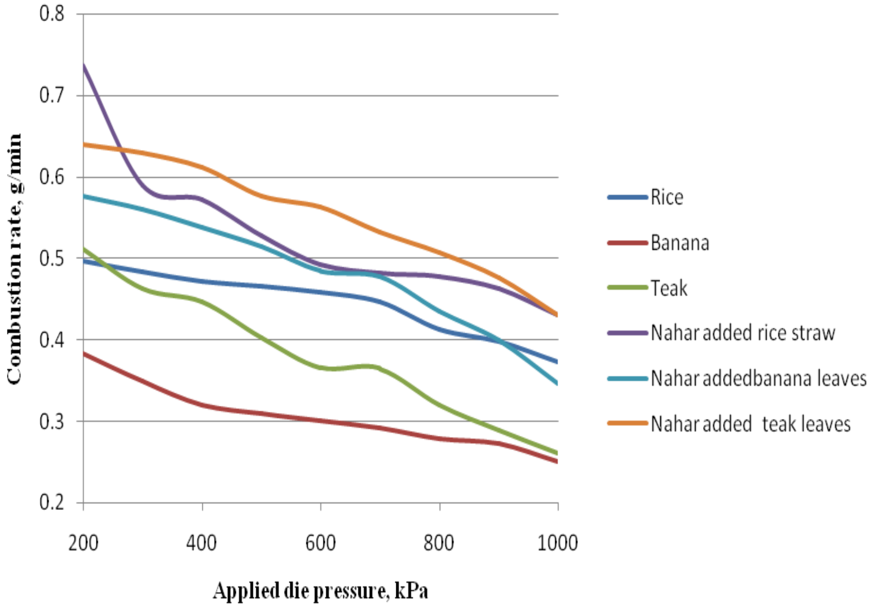

Fig.1 Variation combustion rate of briquettes over applied die pressure

IV. CONCLUSION

With the help of this study we aim to standardize the practice of briquette making for the commercial purpose from the combustion characteristics point of view. In the present study, the burning rates of briquettes in room condition are assessed to arrive at an conclusion increasing applied die pressure negatively effect combustion characteristic like burning rate as density of briquettes increases which in turn reduces porosity of the briquettes . It is also noticed that combustion characteristics are improved on blending of nahar seed cakes with the existing biomasses. It has raised calorific value and burning rate of briquettes. Nahar added rice straw shows the highest combustion rate of 0.43 g/min. Apart from that proximate analysis and calorific value tests will so help us to give answer to some of the questions regarding the fuel such as whether it produces too much harmful fly ash and unwanted gases which are general indoor air pollutants many households and effectiveness of the fuel in terms of heat value. A fuel without heat value would be useless as a lot of fuel will be needed during use for its lower heat value.

REFERENCES

[1] Saikia M. and Baruah D.C. Analysis of Physical Properties of Biomass Briquettes Prepared by wet briquetting method, IJERD, vol 6, issue 5, pg 12-14.

[2] Johnson Sarah, Brar D.S. and Buresh R.J. . Faster anaerobic decomposition of a brittle straw rice mutant: Implications for residue management, Soil Biology & Biochemistry, vol 38, pg 1880–1892(2006).

[3] Liang C and McClendon R. W. The influence of temperature and moisture contents regimes on the aerobic microbial activity of a bio solids composting blend, Bio resource Technology, vol 86, pg 131–137 (2003).

[4] Stanley R. Fuel Briquette making. Legacy Foundation (2003).

[5] Chin O.C., Siddiqui K.M. Characteristics of some biomass briquettes prepared under modest die pressures. Biomass and Bioenergy 2000; 18: 223-228.

[6] Chaney J. O., Clifford M. J., Wilson R. An experimental study of the combustion characteristics of low-density biomass briquettes. Biomass magazine 2010, Vol 1.