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A STUDY OF BIOMASS DENSIFIED FUEL (BRIQUETTE) IN BANGLADESH

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Abstract- *The research and testing of alternative fuel are one of the most focusing points to the scientists and engineers at present. Energy crisis is now a major problem throughout the world. That's why; renewable energy has gained much popularity recently. Biomass briquette is a good example of renewable energy. Briquette is being used for space heating or power generation in developed countries whereas in developing countries like Bangladesh, it is popular as cooking fuel. Although large volume of work has been done throughout the world, little work has been done in Bangladesh except some huge efforts on production side. This paper provides information about briquette in Bangladesh, its production, physical and fuel properties, field survey on local acceptance, challenges and future potential. This will give an idea about the present condition of briquette in Bangladesh at a glance.*

Keywords: Energy crisis, renewable energy, biomass Briquette, production, Physical and fuel Properties.

1. INTRODUCTION

Biomass briquette is the product of biomass densification technology. Briquette is a type of solid fuel in a compacted form. Raw materials are compressed with the application of pressure thus increase the density. That's why; it is known as biomass densified fuel. Biomass briquette is produced from various kinds of raw materials. The most common raw materials are rice husk, saw dust and forest residues. Research is being done on modification of raw materials of briquette.

Biomass briquette is one of the most used renewable energy at present. It is used for different purposes in different regions. Developing countries like Bangladesh mostly use it as a cooking fuel. It is gaining popularity among the people day by day. It is regarded as a better fuel than the other bio-fuels for cooking. Besides significant physical and chemical properties, it has some other important factors which make it better. It is used as a replacement of wood which reduces the rate of deforestation. It reduces the emission of carbon-di-oxide. As various raw materials can be used, so any country can produce this biomass briquette from any convenient material available in their country. Besides that it significantly contributes to economy by generating employment and income. But there are still a lot of limitations in briquette production. These limitations may decrease the efficiency of biomass briquette. That's why, continuous works are being done to identify the problems and solve it. So, this technology is regarded one of the most updated technology in world. Latest technologies are applied to this sector especially in developed countries which is being done in developing countries too. Fig. 1 shows the common physical form of briquette below.

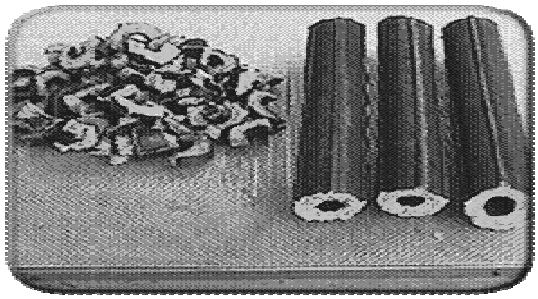

Fig. 1: Biomass Briquette

2. BIOMASS DENSIFICATION TECHNOLOGY

Biomass densification refers to the process whereby biomass in the form of small particles, like straw, sawdust or chips, is concentrated by machines into small pellets or briquettes. Depending on the particular machine used, this process increases the bulk density of the biomass by about 10 to 12 times its original bulk density. The moisture content of the compacted biomass generally should be between 7% and 14%. If higher, the biomass will not compact easily, if

lower it will not bind together as well [1].

History of biomass densification process is very old. People have been using animal dung briquettes for cooking in rural Nepal since time immemorial. These low-pressure traditional briquettes made from a mix of animal dung and biomass (rice straw, jute sticks, etc) were of different shapes, sizes and composition. The first commercial biomass briquetting plant in the country, Nepal Bio-Extruder Industry, was established in 1982 in Thapathali, Kathmandu. An innovative screw extrusion technology for the production of rice husk briquettes was introduced in Nepal in 1986 by a Japanese private company at a demonstration event held in Khumaltar and supported by the Japanese Embassy [2].

Two common types briquette presses employed in developing countries are heated die screw press and piston press. The heated die screw press technology was invented by Japan in mid 1940's, and it has spread now China, Korea, Thailand, Bangladesh etc. the piston press technology is dominant in India, Brazil and Africa, etc. [3].

3. BIOMASS BRIQUETTE SYSTEM IN BANGLADESH

Biomass briquette system has been introduced in Bangladesh a long years before. As heard and found from investigation, briquette system was first introduced in the eastern part of the country, in Sylhet in 1990's. It was first introduced there by a rice mill owner who imported a briquette production unit from Taiwan to reuse the huge amount of agricultural residue, rice husk. Before that, the huge amount of rice husk was thrown into river eventually caused problems for fishermen boatmen [4]. Day by day, it has been spreading within the country.

The biomass briquette production technology has been developed in our country by entrepreneurs without any support from government and donor agencies. The briquetting machines used are of heated-die screw press type similar to Thailand, Malaysia and South Korea. Bangladesh Institute of Technology (BIT), Khulna [Now, Khulna University of Engineering Technology (KUET)] conducted a survey on densification activities in Bangladesh in the year 1999, and reported about 906 number of machine are running throughout the country and all machines are the heated die screw extruder type. The region wise distribution of the biomass densification technology in Bangladesh is shown in Fig. 2. The highest number of machines was found in Sylhet district (248 no. of machine) where the first machine was launched [5]. Briquette unit's availability is mostly subjected to raw materials availability. According to another survey conducted in year 2004, the number of briquette units was found to be more than 1000. Thus following the growing trend it may be estimated that present number is around 1200.

In case of production, different kinds of materials are used as raw materials. The most common raw materials are rice husk, saw dust etc. Like others, some modifications are made in the use of raw materials. For example, the fiber got from sugarcane or coconut is sometimes mixed with raw materials. The most of the production units mentioned the number above, are located at the place where any of the raw materials is available. That's why; no production unit is available in Dhaka. This also reduces the production cost because of low transport cost and comparatively cheaper raw material. Fig. 2 shows the machine distribution throughout the country.

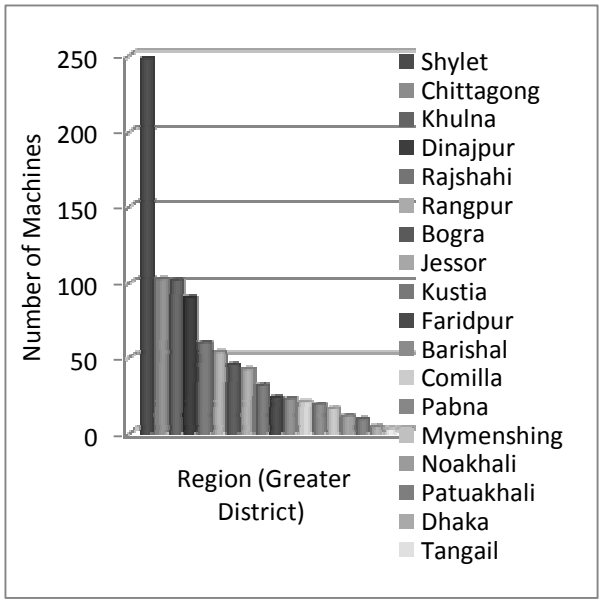

Fig. 2: Distribution of rice husk briquette machines by region in Bangladesh [4]

Among the above raw materials, rice husk is the most used raw material in Bangladesh. Around 26% of biomass energy comes from rice husk [4]. The most of the units use rice husk as their raw material. This is due to the huge production of paddy in our country annually. Bangladesh is one of most rice production countries in Asia. An overview of the contribution of Bangladesh in rice production in the world is given in Fig. 3.

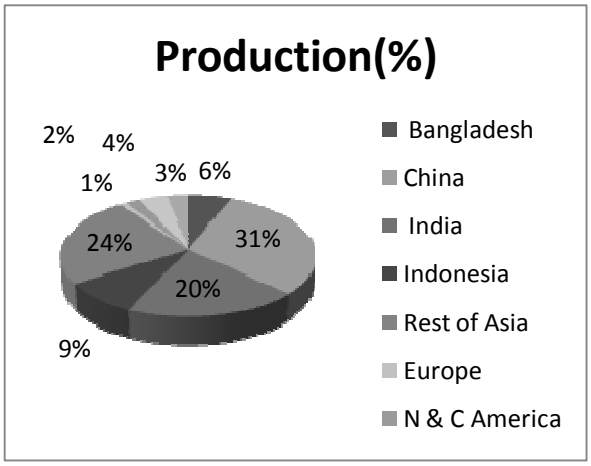

Fig. 3: World rice production in 2004 [4]

According to a report published by APCTT-UNESCAP in 2005, about 40 -45,000,000 metric tons (MT) of Paddy is annually produced in the country. Taking a 20% yield of husk, based on input paddy, this leads to a production of 8 -9,000,000 metric tons of Rice Husk annually. The growth of rice the husk production is calculated 2.57% which is higher than the overall growth of traditional fuel (1.40%). This high production rate of rice husk energy than others inspires the

producers to take it as a raw material for briquette production without any hesitation.

4. BRIQUETTE PRODUCTION SYSTEM

For the production of biomass briquette, a special type of machine is used in which compressive pressure is applied to densify the raw material thus increases bulk density. Normally two types of machines are used worldwide as mentioned before. Heated die screw press machine is used in our country for production. The other type is the piston press machine. In Table 1, some basic differences are given between screw press and piston press machine in production side.

Table 1: Comparison between screw press and piston press machine

Focusing point	Screw press machine	Piston press machine
Moisture content	8-9%	10-15%
Wear of contact parts	High	Low
Maintenance	Low	high
Combustion performance of briquette	Very good	Not so good
Homogeneity	Homogeneous	Non-homogeneous

For the production of briquette in screw type machine, a simple but sensitive procedure is to be followed. Pre-heating biomass before extrusion reduces briquetting energy consumption and also extends the life of the briquetting screw. The biomass pre-heater essentially consists of two concentric pipes. Biomass is forced through the inner pipe under the action of a screw rotated by a variable speed motor. The raw material is pre-heated while being conveyed through the inner pipe. The hot flue gas from the die-heating stove of the briquetting machine enters the pre-heater at one end, passes through the space between the inner and outer pipes, transfers heat to the biomass (rice husk), which is conveyed through the inner pipe, and exits to the atmosphere at the other end. The pre-heater is mounted on a frame, which is 1.2 m long and 42 cm wide. The outer pipe is insulated by a 2.5 cm thick layer of rock-wool to reduce heat losses to the surroundings. The heated raw material from the pre-heater exit is fed directly to the briquetting machine. The speed of the pre-heater screw can be selected based on the required biomass flow rate into the briquetting machine [5]. In Table 2, some technical specifications of the briquette machine are given.

Table 2: Technical Specifications of the Briquetting Machine [4], [5]

Operating parameter	Specifications
Induction Motor (for Electric system)	20 hp/ 1450 rpm; 380V/ 50Hz
Screw	Total length: 450 mm, Outer diameter: 55 mm, Screw speed: 280-450 rpm, Material: Mild Steel round rod, Screw life: 8-12 hours.
Die barrel	Length: 300 mm, External diameter: 97 mm, Internal diameter: 55 mm, Tapered length: 75 mm, No of grooves: 8, Material: Cast iron, Weight: 6 Kg , Barrel life: 20-45 days, Wall thickness: 1-1.3 cm.
Die barrel heating method	Electricity, kerosene, diesel oil.
Power transmission	Pulley & V- belt
Main shaft	Bright steel round rod
Bearings	Type N 6312 & N 6311
Machine bed	Length: 1600 mm, Width: 500 mm, Height: 1165 mm (Excluding motor), Material: Mild steel ‘C’ channel.
Raw material	Rice husk
Electricity consumption	0.13 Kwh/ Kg
Production rate	80 Kg/h
Briquette diameter	5.5-7.5 cm
Die barrel surface temperature	400-500^{0}c

4. PROPERTIES

Briquette is a long cylindrical shaft with an inner bore for high burning efficiency. It is hard and brittle and has a black coating on outer side caused by heating during extrusion.

Normally two types of properties are determined to evaluate the efficiency of a biomass briquette. The properties

tested of a briquette are given in the following Fig. 4:

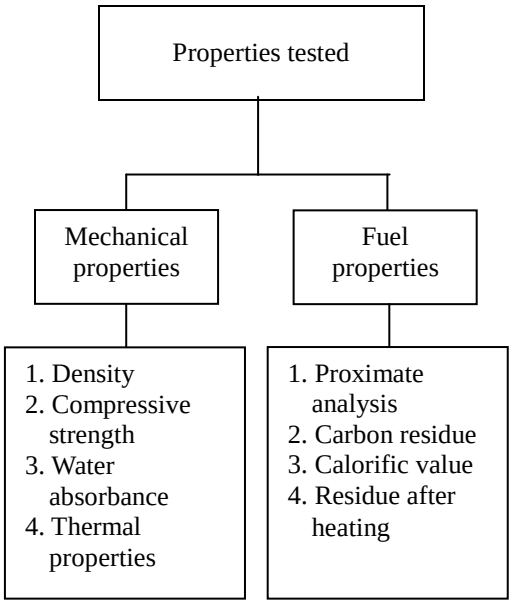

Fig. 4: Mechanical and fuel properties

4.1 Mechanical Properties

To determine the mechanical properties mentioned in Fig. 4 , the following samples (Table 3) were taken:

Table 3: Sample distribution

Sample no.	District
1.	Sylhet
2.	Khulna
3.	Sirajgong

Generally the external diameters of the above sample vary from 58-60 mm and the internal diameters are 20-22 mm. The height is normally 1m.

4.1.1 Density

The following table (Table 4) provides a feature of the increase of bulk density by using densification technology.

Table 4: Density of different samples

Sample 1 (Kg/ m^3)	Sample 2 (Kg/m^3)	Sample 3 (Kg/m^3)	Average (Kg/m^3)	Rice husk (Raw) (Kg/m^3)	Rice husk (Grinded) (Kg/ m^3)
1084 .4	1109.34	1140.1 4	1111. 3	147.6 4	279.0 7

4.1.2 Compressive Strength

Average compressive strength of the samples was found to be 10.7 MPa or N/mm^2. A briquette with higher compressive strength is safer for storage and transportation.

4.1.3 Water Absorbance

For water absorbance test, the samples were submerged under water at room temperature for certain duration of time and weight of the samples was taken at certain time intervals. This property would enable us the storage method of briquette. Table 5 and Fig. 5 are given below according to test result.

Table 5: Weight of different samples under water with time

Time (min)	Sample 1 (Weight in grams)	Sample 2 (Weight in grams)	Sample 3 (Weight in grams)
00.00	216.94	136.8	231.3
01.00	239.70	151.70	287.2
02.00	250.55	170.69	310.85
03.00	255.30	182.75	318.17
04.00	264.11	192.2	327
05.00	269.1	200.18	330.96
10.00	277.36	206.5	335.6
15.00	288.86	211	345
20.00	292.12	204	345.95
25.00	294.00	209	352
30.00	298.77	212.9	345.89

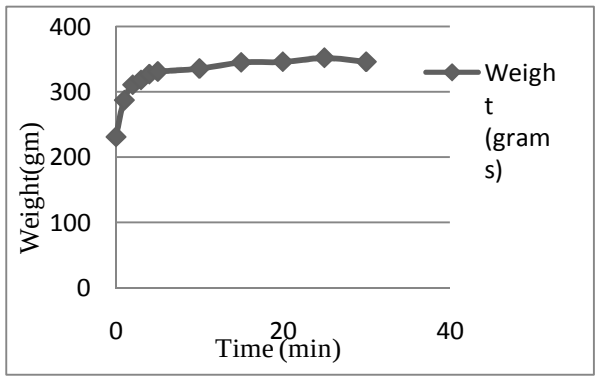

Fig. 5: Weight vs. time curve

After certain interval samples start showing decrease in weight due to loss of mass and after 10 minutes the samples starts loosing their compactness and starts breaking apart.

Once in water for 20 minutes the briquette gets totally loosened and almost looses its structure.

4.1.4 Thermal Properties

To determine the thermal conduction properties of a biomass briquette, it was heated by a heater by inserting a heated rod into the bore of briquette and then temperature reading was taken continuously after certain time intervals from the source and outer surface of briquette by using thermocouples. Table 6 is given below to have a look of the thermal conduction through briquette. Then Fig. 6 is provided to show the temperature increasing with time.

Table 6: Data chart for rise in temperature with time.

Time (min)	Source temperature (^oC)	Briquette surface temperature (^oC)
0.00	88	35
5.00	92	37
10.00	98	39
15.00	102	40
20.00	105	41
25.00	105	42
30.00	108	43

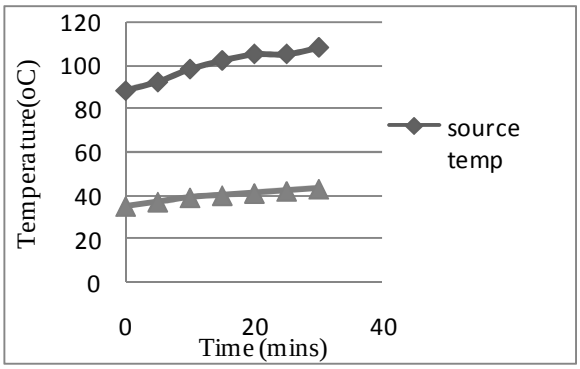

Fig. 6: Time vs. temperature curve

4.2 Fuel Properties

The fuel properties mentioned in Fig. 4 were tested to determine the efficiency of biomass briquette as fuel and compare it with the other traditional fuel. For these testing, sample 1 and sample 2 were taken. Rice husk from Gazipur was also taken as sample for some tests.

All experiments were done in atmospheric pressure and room temperature and humidity. The sample grade size was 60 (250 microns).

4.2.1 Proximate Analysis

Proximate analysis was performed to determine the composition of the biomass briquette. The ash component determines the ignition efficiency of the briquette. The ash content reduces the combustion efficiency. The sample of 60 grades was heated 107^0C, 750^0C and 950^0C accordingly to determine the moisture, ash, volatile and fixed carbon contents. Table 7 provides information of laboratory test findings.

Table 7: Data chart of Proximate Analysis

Component	Sample 1 (%)	Sample 2 (%)	Average value (%)
Moisture	6.8	7.83	7
	6.9		
	5.81		
	7.6		
Others (ash + volatile)	64.2	73.83	72
	71.76		
	73.14		
	69.8		
Fixed Carbon	78.6	18.3	21
	21.34		
	21.01		
	23.15		

The composition of biomass briquette is given in following figure (Fig. 7),

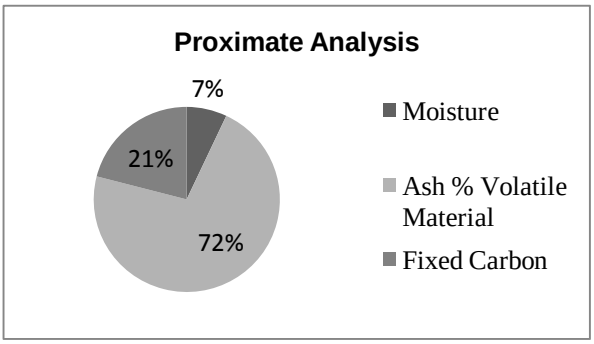

Fig. 7: Average composition in %

4.2.2 Carbon Residue

Carbon residue test was performed to determine the burning efficiency of briquette. The percentage of residue found in test for two sample and grinded rice husk is given in the following table (Table 8). The higher residue percentage reduces the burning efficiency.

Table 8: Data chart for Carbon Residue

Sample 1 (%)	42.39
Sample 2 (%)	41.42
Average value (%)	42.6
Rice husk (%) (Gazipur)	40

4.2.3 Calorific Value or Heating Value

Calorific value determines the heat energy produced during combustion. The calorific value of briquette was tested in a bomb calorimeter. The calorific value found during testing is given in following Table 9.

Table 9: Data chart for Calorific Value

Sample 1	4300 cal/gm
Sample 2	4580 cal/gm
Average value	4250 – 4600 cal/gm
Rice husk (Gazipur)	4270 cal/gm

Heating value or calorific value per unit volume found in test is $4.61 \times 10^6 - 5.08 \times 10^6$ Kcal/m^3.

5. PROSPECT OF BREQUETEE IN BANGLADESH

Biomass briquette has been being used in Bangladesh since many years. This technology has been being promoted by individual efforts. Research or improvement has been done a little by our government or donors. That's why; the production process is still marked as semi-matured system by specialists. But, some significant researches has made on production system by specialists. A thesis conducted by Dr. Ahiduzzaman has indicated some problems in production such as short life of heater and screw, die barrel, health hazard and quality of rice husk [4]. Some researches have also made to improve the above life. These all the researches should be done in a united form by government to increase its feasibility.

A survey was also performed by us on some areas to determine various factors. In Dhaka, only one briquette selling shop and briquette using shop was found in kawronbazar. The cost of briquette found is given in following table (Table 10).

Table 10: cost analysis

Area	Informer	Cost (Tk per 40 kg)
Kawronbazar	Briquette seller	600
Railroad, Bagerhat	Tea seller	300
Sadar, Joypurhat	Tea seller	240-250
Nabinagar,Savar	Tea seller	250

From the above table, it is seen that, the cost per 40 kg is almost same except in Dhaka. This may be due to the cost required for transportation. That's why; a little briquette selling or using shop is situated here.

Now form the survey, the following advantages of briquette found, are given as follows:

1. Less smoke than wood.
2. The smoke is non-toxic, no smell and thus cook feels comfortable.
3. It requires 1-2 kg less than wood per day.
4. It continuously produces good amount of heat with less human effort.
5. Environment friendly.

And the disadvantages found from the survey are given below:

1. Difficult to catch fire. Sometimes kerosene is to be mixed.
2. Not available everywhere and every season, thus cost sometimes is high.
3. Sensitive to water. It becomes damage due to water.

The above survey indicates that, biomass briquette can be regarded as an efficient fuel. Again under the guidance and with the assistance of government, more effort is needed in production system to identify the problems and solve them. Then our production system will become standard.

6. CONCLUSION

Considering the properties of briquette tested and the survey performed, it can be decided that it can be a popular alternative fuel in Bangladesh. For this, the assistance of the government is must. It can be replaced the other traditional fuels.

7. ACKNOWLEDGEMENT

For this study on briquette, we are grateful to the Head of Me department of BUET and MIST to permit us to use the labs such as fuel testing lab, solid mechanics lab. We are also grateful to those lab technicians helped us in testing

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