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A STUDY OF BIOMASS BRIQUETTE IN BANGLADESH

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ABSTRACT

Biomass Briquette, a dense form of bio-fuel has gained a large popularity in poor developing countries as an alternate cooking fuel. With in a short period it has replaced traditional fuels for its availability and high acceptance in user level. In a country like Bangladesh, where 67% people relay on traditional bio-fuel for energy, briquette has received an immense response. Although large volume of work has been done on developing its production process, little data is available on its physical and fuel properties and reasons behind its high acceptance. The paper consists summery of the findings gained from a research conducted on briquette in Bangladesh, its physical and fuel properties and field survey on local acceptance.

Keywords: Briquette, Physical Properties, Fuel Properties.

1. INTRODUCTION

A briquette (or briquet) is a block of flammable matter used as fuel to start and maintain a fire. Common types of briquettes are charcoal briquettes and biomass briquettes. In Bangladesh biomass briquette has gained a huge popularity and covers a large portion of cooking fuel needs of rural people. Here mainly rice husk is used for producing briquettes by the process of extrusion. Rice being main food of the country, rice husk is easily available at cheap rate for briquette production which contributed significantly towards its rapid popularity.

Biomass plays a vital role in meeting local energy demand. Traditional bio-fuel is hard to collect, transport, use and store. Biomass briquette is an efficient solution to all these problems. Besides that it significantly contributes to economy by generating employment and income. It also contributes to the environment by reducing CO_2 emission and deforestation.

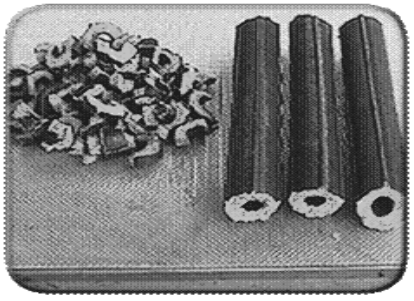

Figure 1: Biomass Briquette

2. BRIQUETTE SYSTEM IN BANGLADESH

Biomass briquette system is not very old to Bangladesh. 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 tackle problems related to disposal of rice husk, which had become a major hurdle for the boatmen and fishermen there. Eventually briquette system spread to neighboring districts and slowly throughout the country. [1]

Briquette system installation in Bangladesh doesn't require any registration and there are no selected numbers of suppliers either. Thus finding an absolute value for production units and production is very difficult. 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 Figure 2. The highest number of machines was found in Sylhet district (248 no. of machine) where the first machine was launched and a significant number of machine was found in Chittagong (103 no. of machine), Khulna (102 no. of machine), and Dinajpur (90 no. of machine) regions. [2]

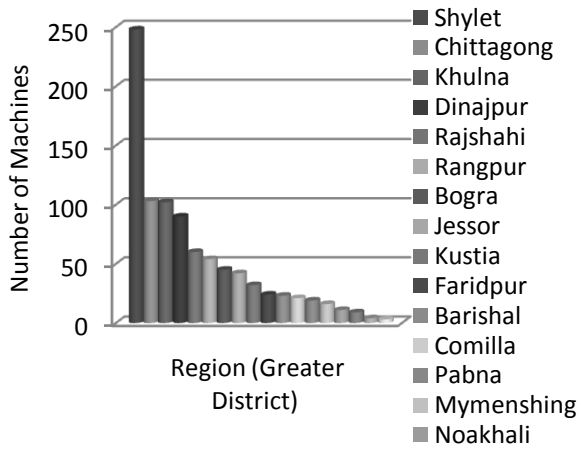

Fig 2. Distribution of rice husk briquette machines by region in Bangladesh

Briquette unit's availability is mostly subjected to raw materials availability. Briquette units are mostly located near rice mills and districts with high availability of rice husk generally have higher number of machines. In year 2004, the number of briquette units was estimated to be more than 1000 [3]. Thus following the growing trend it may be estimated that present number is around 1200.

In Bangladesh about 26% (83.71 PJ) [1 PJ = 10^9 MJ] of total biomass energy comes from rice husk. Production of rice husk energy is steady over decades and day by day it is increasing. In 1991, the production of rice husk energy was 76.35 PJ and it increased to 106.1 PJ in 2004 [1]. According to a report published by APCTT-UNESCAP in 2008, 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%) [4]. Following is a table showing regional briquette production in year 2004-2005. [5]

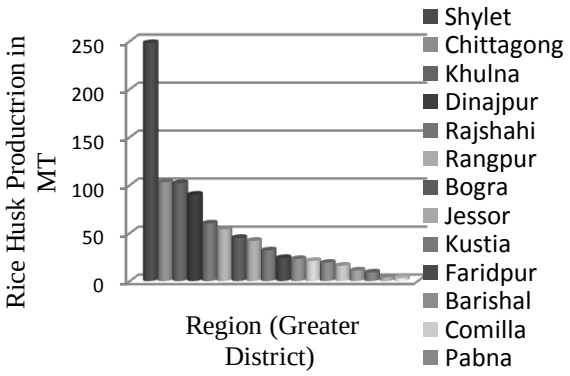

Fig 3. Production of rice husk (in metric tons MT) by region in Bangladesh during the financial Year 2004-2005

3. BASIC CONSTRUCTION

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 [6].

Table 1: Technical Specifications of the Briquetting Machine

Component	General Specifications
Induction Motor (for Electric system)	20 hp/ 1450 rpm; 380V/ 50Hz
Screw	Total length: 450 mm, Outer diameter: 55 mm, Screw speed: 320 rpm, Material: Mild Steel round rod.
Die	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.
Die heater	Briquette fired metal stove or electric coil
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

4. PHYSICAL 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.

To determine the physical properties of biomass briquette, samples were taken from three different districts of the country to get an overall idea. The districts are namely Sylhet (sample 1), Khulna (sample 2) and Sirajgong (sample 3).

All tests were conducted in Thermodynamics Lab and Structure Lab of MIST.

4.1 General Dimension

General dimension of briquettes vary slightly depending on the size of extrusion barrel and center rod. Generally external diameter varies from 58 - 60 mm; the internal diameter in general is 20 - 22 mm and the average height is 1 meter.

4.2 Density

Table 2: Density of different samples

Sample 1	Sample 2	Sample 3	Average	Rice husk (Raw)	Rice husk (Grinded)
1084.4 Kg/m^3	1109.34 Kg/m^3	1140.14 Kg/m^3	1111.3 Kg/m^3	147.64 Kg/m^3	279.07 Kg/m^3

4.3 Compressive strength

Average compressive strength of the specimens was found to be 10.7 MPa or N/mm^2.

4.4 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.

Table 3: Weight of different samples under water with time

Time (mins)	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

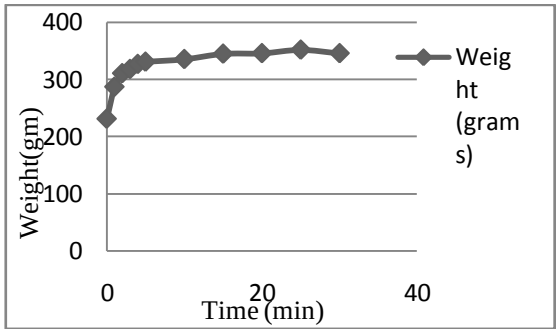

Fig 4. Weight vs. Time curve

After certain interval samples start showing decrease in weight due to loss of mass and after 10 minutes the samples starts losing their compactness and starts breaking apart. Once in water for 20 minutes the briquette gets totally loosened and almost loses its structure. It can still be burnt again after drying as rice husk dust.

4.5 Thermal Properties

For understanding thermal properties of briquette a heated rod was inserted into the bore of briquette and then temperature reading was taken continuously after certain time intervals from the source, temperature at surface of briquette.

Table 4: Data chart for rise in temperature with time.

Time (mins)	Source Temperature (^oC)	Briquette surface temp (^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

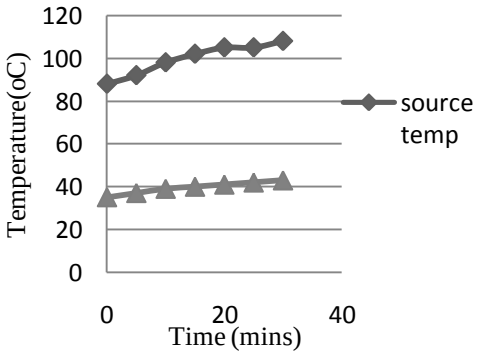

Fig 5. Time vs. Temperature curve

5. FUEL PROPERTIES

Briquette is a moderate quality fuel for cooking and other purpose. It can be ignited easily and burns with a long and steady flame, low smoke and almost no odor. It also has a high burning efficiency.

As before for testing fuel properties two samples were taken from Sylhet (sample 1) and Khulna (sample 2). For comparison rice husk was from Gazipur was also tested.

All tests have been conducted in Fuel Testing Lab of BUET and Thermodynamics Lab of MIST.

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

5.1 Proximate Analysis

Table 5: Data chart for Proximate Analysis

Content	Sample 1 (Sylhet)	Sample 2 (Khulna)	Average value
Moisture %	6.8	7.83	7
	6.9		
	5.81		
	7.6		
Ash & Volatile Material %	68.15	73.83	72
	71.76		
	73.10		
	69.8		
Fixed Carbon %	25.05	18.34	21
	21.34		
	21.01		
	23.15		

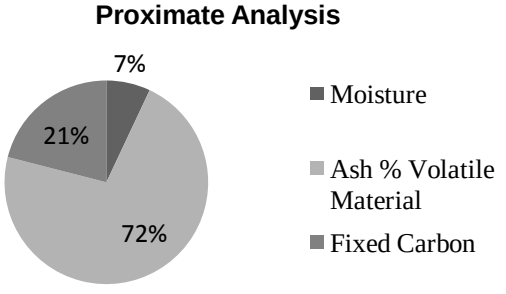

Fig 6. Briquette constituent by percentage (average value)

5.2 Carbon Residue

Table 6: Data chart for Carbon Residue

Sample 1 (Sylhet)	42.39 %	44.04 %
Sample 2 (Khulna)	41.42 %	
Average value	42.6 %	
Rice husk (Gazipur)	40 %	

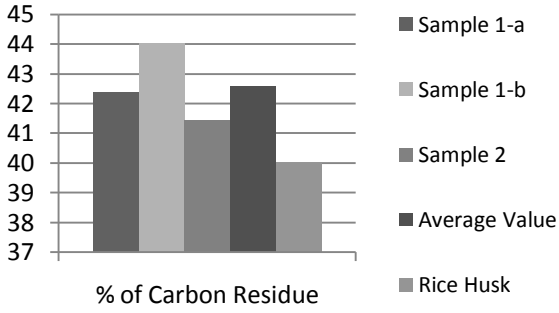

Fig 7. Percentage of Carbon Residue

5.3 Calorific value or heating value

Table 7: Data chart for Calorific Value

Sample 1 (Sylhet)	4300 cal/gm or 18 KJ/gm
Sample 2 (Khulna)	4580 cal/gm or 19.17 KJ/gm
Average value	4250 – 4600 cal/gm
Rice husk (Gazipur)	4270 cal/gm or 17.87 KJ/gm

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

5.4 Residue after direct heating

Table 8: Data chart for unburned carbon

Sample 1 (Sylhet)	Unburned portion %	22.73	23.5
Sample 2 (Khulna)	Unburned portion %	18.90	18.25
Average value	Unburned portion %	20.85	

6. SURVEY REPORT

The survey was conducted in four different locations of the country namely Kawran bazaar, Shavar, Joypurhat and Bagerhat. Several users of biomass fuel were interviewed in the selected locations and their opinions have been listed understanding the reasons behind the rapid development of biomass briquette and its possible further development.

Survey in Kawran Bazaar revealed that in city briquette consumption is significantly low due to high availability of alternative high quality fuel like gas. Those who don't have access to gas looks for alternate like kerosene stove, fuel wood or briquette. The only wholesaler of the bazaar revealed that only hand full of people buy briquette for large scale cooking. His average monthly sell of briquette is around 20 to 25 mons (1 mon = 40 Kg) which is significantly low comparing to fuel wood sell which is about 30 mons. As he is the only vendor of Briquette in Kawron bazaar, it gives a fair idea that Briquette demand with in the city is very low comparing to fuel wood which is sold in many other shops in great mounds.

An interview with the owner and cook of a small make shift hotel in the Kawran bazaar, revealed their

experience with briquette. They have been using Briquette for about 2 years now. Previously they used kerosene stove, but it required frequent repair, which was both hazardous and costly. So they switched to Briquette. They claimed that considering current market price, costing remains almost same for Briquette and Kerosene. Briquette on the other hand doesn't require any maintenance, lights up easily and heats up things quickly. They were satisfied using it.

Another interview with a tea seller and retailer of briquette at Polli Biduut Bazaar, Nobinogor, Shavar; revealed his more than 7 years' experience with briquette. He buys briquette at 280-285 Tk per mon and sells at 8 Tk per Kg. Previously he used to use Kerosene stove but it was expensive. He required about 3 liters of kerosene which required about 150 Tk, whereas he requires only 5-6 kg of briquette which costs about 50 Tk. Briquette produces a very fine and long lasting flame as per his claim. It also shows no deviation in properties if stored for long time. But it is critical to water and once it is wet it deforms and becomes useless. It is also hard to light up in the morning.

In Railroad, sadar upozila, Bagerhat a commercial user of Briquette was interviewed. He uses both briquette and kerosene for fuel. Unavailability of briquette switches him to kerosene. His experience with briquette is 10 years. He buys them at 300Tk per mon from Khulna. His prefers briquette for its low cost and consumes about 30 to 40 kg a week. He complains about the unavailability and storage problem during rains. He also mentioned problems about lighting it in damp condition.

Several persons in Joupurhat were interviewed, both residential and commercial. Briquette is relatively new to Joypurhat and available from 2.5 years. Briquette comes from nearby district of Naogoan and is sold at 240-250 Tk by 7-8 dealers in in local bazaar. So it is easily available throughout the year. Most preferred by commercial users due to low cost, easy storage and hassle free use. Although some complains have been received by residential users like- large space requirement for storage, criticality in initial burning, requirement of special stove, need of cutting it into pieces before use and high water absorption quality. Still briquette is highly preferred to avoid the smell created by kerosene. It also proves to be a little expensive than fire wood, still it gained high popularity in the region. Thus user satisfaction lays both in commercial and residential level.

Table 9: Briquette availability in regions concerned

Region	Kawran Bazaar, Dhaka	Nobinogor, Shavar	Sadar upozila, Bagerhut	Sadar Upozila, Joupurhut
Availability	Low	High	Low	High

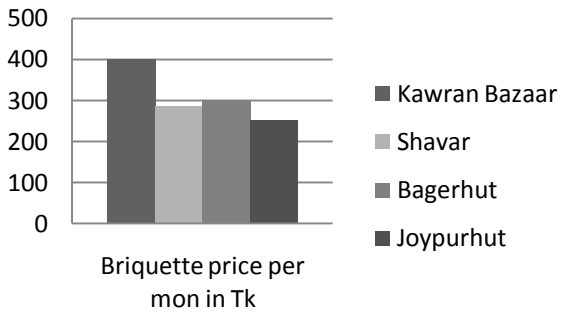

Fig 8. Briquette price at different regions

6.1 List of Limitations

User level survey provided us with a number of limitations in the system. They have been listed below.
- It is critical to water and loses its compactness once wet and becomes unusable.
- Storage requires large space and must be kept in dry condition.
- Initial burning is critical and is very hard to burn in damp condition like in winter morning.
- Ash disposal is also a hurdle.
- Requires to be pieced before use, which is a tough task as briquette is quite hard.
- Special stove is required.
- Can prove expensive depending on volume of use.

6.2 Reasons Behind High Acceptance

Briquette gained high popularity in Bangladesh with in a very short period. Study suggests the common reasons behind its high popularity are-
- Easy and high availability.
- Economical to use.
- Good fuel properties.
- Low moisture content and high burning efficiency.
- Easy storage.
- High compactness and easy to transport.
- High availability of rice husk and good profit in briquette business.
- Burns with a steady flame for a long period.
- Produces almost no smoke and odor.
- High user friendliness and less hazardous.
- Good physical properties.
- Environmental friendliness.

7. CONCLUSION

Experiments and observations show that rice husk biomass briquette is a very effective biofuel that has appreciable physical and fuel qualities and burns with good efficiency. Its cheap rate, high availability and admirable fuel characteristics gained it high acceptance in a short time. Another reason for its quick expansion is the profit gain from its production thus more and more people are attracted to the business and raises its availability. It reduces emission and also reduces deforestation by serving as an alternative cooking fuel in rural areas. Still there is scope for development in this sector by researching for more effective ways to use biofuel and make it more environment and user friendly.

8. REFERENCE

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9. NOMENCLATURE

Serial No	Property	Unit
1	Energy	1 PJ = 10^9 MJ
2	Mass	1 Metric Ton = 1000 Kg
3	Pressure	1 Mega Pascale = 10^6 Pascles
4	Length	1 micron = 10^{-6} meter
5	Calorific value	1 cal/gm = 1 Kcal/Kg = 0.0041858 KJ/gm
6	Mass	1 mon = 40 Kg
7	Currency	1 USD = 76 Taka (BDT or Tk)

10. APPENDIX

Content	Sample 1 (Sylhet)	Sample 2 (Khulna)	Average value
Ash %	64.2	73.83	69
	65.08		
	72.77		
	69.8		
Volatile Material %	-	.03	3
	6.68		
	0.37		
	-		

User no & Location	User type	Period of use (years)	List of Advantages				
			Easy to use	Easy storage	Low cost	No smoke & odor	Good fuel properties
User 1, Kawran Bazaar	Commercial	2	Y				Y
User 2, Shavar	Commercial	7	Y	Y	Y		Y
User 3, Bagerhut	Commercial	10	Y	Y	Y		
User 4, Joypurhut	Commercial	2.5	Y		Y		
User 5, Joypurhut	Residential	2.5	Y			Y	Y
User 6, Joypurhut	Residential	2	Y			Y	Y

*****Here y represents yes.

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