PRODUCTION BRIQUETTE FROM RICE HUSK AND RICE STRAW

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Abstract: Present work is an attempt to production of biomass briquettes using rice husk and rice straw as raw material. The energy consumption and economic viability of biomass briquettes production were analysed in detail. The maximum proportion of rice husk instead of rice straw enhances the quality of briquette. The caloric value of briquette obtained in the range of 15077-13923 kJ/kg. The economic viability of the briquette production is sensitive to briquette market price, discount rate and capital cost.

Keywords: Rice Husk, Rice Straw, Briquette, Calorific Value

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INTRODUCTION

In the most of cases AWs are openly burn that not only create air pollution but also avoid extra benefits of former. For example the waste generated from the rice such rice husk can be used for the production low grade paper. Nowadays AWs are used to produce several products including biofuel, mushroom, khad, tempeh, briquette etc. However the selection of AW to produce any useful product depends on composition and internal properties of AW. For example, the fermented grapes are mostly used for the production ethanol. Because fermented grapes contains upto 15% ethanol that used for the manufacturing of several chemicals as well good blending material for the gasoline. As Chhattisgarh is large producer of rice hence the rice waste can be used as basic raw material for briquette production. In addition, a brief description of utilization AWs are given below.

POSSIBLE AW WITH THEIR CHARACTERISTICS

The selection of raw material for briquette formation is a major concern. In general, the good quality of AW has no storage problem as well as easy in drying. In Indian scenario number of AW such as residue of rice and coffee, wastage of groundnut, coffee husk and coir are used in practice.

Number of factors should be considered, before the use of different AW as raw material for briquetting (Huang et al, 2023). The availability of AW is major concern for briquette production, although it must be showed the following characteristics:

Minimum presence of moisture: The feedstock should be content very low moisture in the percentage range of 10-15 percent. In the presence of high percentage of moisture in AW creates problems in grinding consequently additional energy is needed for drying.

Ash content and composition: For the briquette production AW should be low ash content however rice husk has high ash (20%) content. But the presence of alkaline minerals, especially potash enhances its briquetting potential. These compositions have nature to promotes to devolatilise in period of burning and condense on tubes hence it is well applicable for super heaters. One of major advantage of these content has lower the sintering temperature of as that promotes deposition of ash on the boiler's exposed surfaces.

The presence of large ash content in AW offers slagging behaviour that in influence the quality of briquette. Generally, slagging behaviour of briquette depends on the ash percentage of raw material. In other words, larger amount of the ash content enhances the slagging behaviour. However lower ash content also shows slagging behaviour of the briquette. However, the presence of ash is not only generating slagging problem but also operating temperature, the mineral constituent of ash and their percentage combined determine the slagging behaviour. In the favourable condition the degree of slagging will be automatically enhances. Some specific minerals such as SiO_2 Na_2O and K_2O creates major problem.

Flow behavior of raw material: If the raw material has granular and uniform then it could be flow easily in bunkers and storage silos. Some remarkable AW are described below.

Rice husk:

Rice husk contains about 10% moisture and ash, although it well acceptable for briquette formation due the good flowability and minimum alkaline minerals causes it offers a high ash sintering temperature. In fact, it makes an excellent fuel although its calorific value is less than wood and other agro-residues.

OTHER AW

Shell of groundnut: It is a good briquette material due to the less ash (1.5-4%) and presence of moisture lower than 10%.

Cotton sticks: It contains great amount of alkaline minerals, also required more precautions for the use. In addition, it can be storage after the chops and then stored in dry form. During the storage it has tendency to degrade.

Bagasse: It have high moisture content of 50% after milling, hence drying of bagasse makes it energy intensive. While bagasse pitch (Pith is fibrous material that separated from the bagasse) have low ash content as compared to bagasse along with good heating value around 4400 kcal/kg.

Coffee husk: very effective material for manufacturing of briquette due to the and low ash as well as moisture (10 %) moisture content. As Karnataka and Kerala are major coffee producer hence its husk is available there.

Mustard stalks: This is good quality of raw material for production of briquette. A part from this other material such as corn stover (stalks, leaves, husks, and cobs), wheat straw, oat straw, barley straw, sorghum stubble, in hilly areas, tea wastes, and coir pith are also potential AW for briquetting.

Briquette densification parameters

Briquettes are manufactured by several materials including AW and various forms of biomass feedstock hence operating parameter plays very important role for the production of briquette because different raw material have different characteristics. The most considered operating parameters during the production of briquette are pressure of machine, temperature of the system, size and shape of the die holding or retention time while raw material parameters include moisture level, type, composition, size and shape (Huang et al, 2023).

Temperature: During the production of briquette, the temperature of the system should be very high because it reduces the tendency of the briquette material to expand. In addition, it improves the durability and bulk density of briquette along with better bonding of briquette components. Also, the density of material increased. Most of researcher used temperature at the range of 200°C in a briquetting machine and found compressive strengths as compared to briquette produced at at room temperature Chou et al. (2009).

Pressure: Pressure is one of the surrogate parameter during the production of briquette. When the pressure of briquette machine is high materials are easily compressed. In other words, high pressure promotes plastic and elastic deformations and filling of voids consequently production of higher density briquettes occurs. The use of high pressure in briquetting improves the particles at the contact point, further improving briquette density. The value of pressure used in briquetting depends on the raw material. For example, Li and Liu (2000) applied pressure variations of 0.24 to 5 MPa to produce briquette using sawdust as raw material. Yaman et al. (2000), work in the pressure range of 150 to 250 MPa for production of briquette from olive residues and waste of paper mill. Demirbas (1999) used AW for briquette production and examined at pressures range of 300 to 800 MPa and found a sharp increase in briquette density, from 0.18 to 0.325 g/ml.

Holding or retention time (RT): RT plays an important role for the manufacturing of good quality of briquette that commonly defined as the time expended by the briquettes in a pressurized condition inside the die. It can alters the quality of briquette in term of densification and compactness. To produce good quality of briquette, the value of applied pressure and holding time should be balanced. Because expansion rate of briquette achieved high when once the die pressure is released. However, briquette expansion gets decreases with respect to time until the briquette not reaches at constant volume. Hence with same applied pressure for small duration, briquettes quality kept best that commonly known as RT. Li and Liu (2000) reported that at the low pressure die operation retention time is much higher as compared to high die pressure operation. They observed that expansion rate is lower with higher RT.

Moisture: Moisture content in feed stock is also a significant parameter that impacting the quality of briquettes. When the feedstock has contained the high value of moisture content then the obtained briquette suffers poor compactness and stability. A part from this, poor presence of moisture requires higher energy input to compress the feedstock. Hence, to produce good quality of briquette the moisture content should be adequate. Most of the researcher suggested that the moisture content of feed stock should be limited in the range of 10 to 15 (Yaman et al. 2000; Demirbas, 1999; Li and Liu, 2000).

Particle size: The irregular and large size of particle can highly degrade the stability of briquette. Hence it is suggested that the size of the particle should be small and uniform as possible. However, the residue of hard shell can be breaks into small particles with irregular shape. Further it can be applied with non-fibrous biomass to enhance the bonding as well as agglomeration characteristics. Faborade et al. (1987) used both unchopped and chopped straw to produce briquette and found that the binding was poor in the case of unchopped straw as compared to chopped straw.

Briquetting rate (BR): The BR can be defined as the mass of briquettes produced per unit time. The unit of briquette rate is given by kg/h. The briquette rate depends on several factor including category and operating principle briquetting machine, amount of moisture present in the raw material, Nature and particle size of the feedstock. For example, to achieve the briquette rate in the range of 200-2500 kg/h, the mechanical piston press briquetting device is used in practice. The rate of increases as the particle size is reduced in the case of screw extruder briquetting machine. For the long BR, the hydraulic press briquetting machine is used because the coarse feedstocks adhere easily during ramming (Tumuluru et al. 2011). In the case of roller press device, the BR depends on the diameters of the rollers, the distance between them and the roller force. A higher roller force with an optimum roller gap increases the briquetting rate (Yehia, 2007).

EXPERIMENTAL METHOD

Raw material: Rice husk and rice straw

Description of the briquette machine: In the present study screw press type briquetting machine (locally made) is used in practice and presented in figure 1. It can be seen from figure 1 that a screw press type briquetting machine is consist with heated die. In addition. driving motor, screw, die, hopper, and power transmission system are other important part of briquetting machine. For the transmission system both pulley and belt were used. Both were played very important role to transmit power from motor to the screw. For the proper run of machine three phase 30 kW motor was used. For conveys the feedstock to screw in gravity a storage hopper was placed with machine. Further, material was pushed forward and it encounters a rotating, tapered screw feed mechanism. In this condition via due to the application of high pressures, the temperature rises fluidizing the lignin present in the biomass which acts as a binder. As the material was pushed, it got compressed and bonded material come out of die in the form of briquette. A flow chart of briquette production is presented in figure 2.

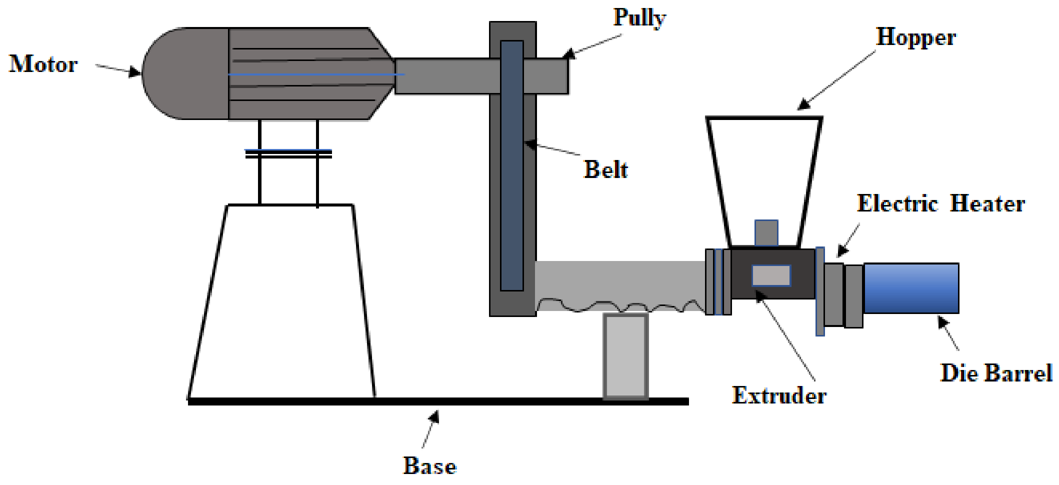

Figure 1. Schematic view of screw press extruder type briquetting machine

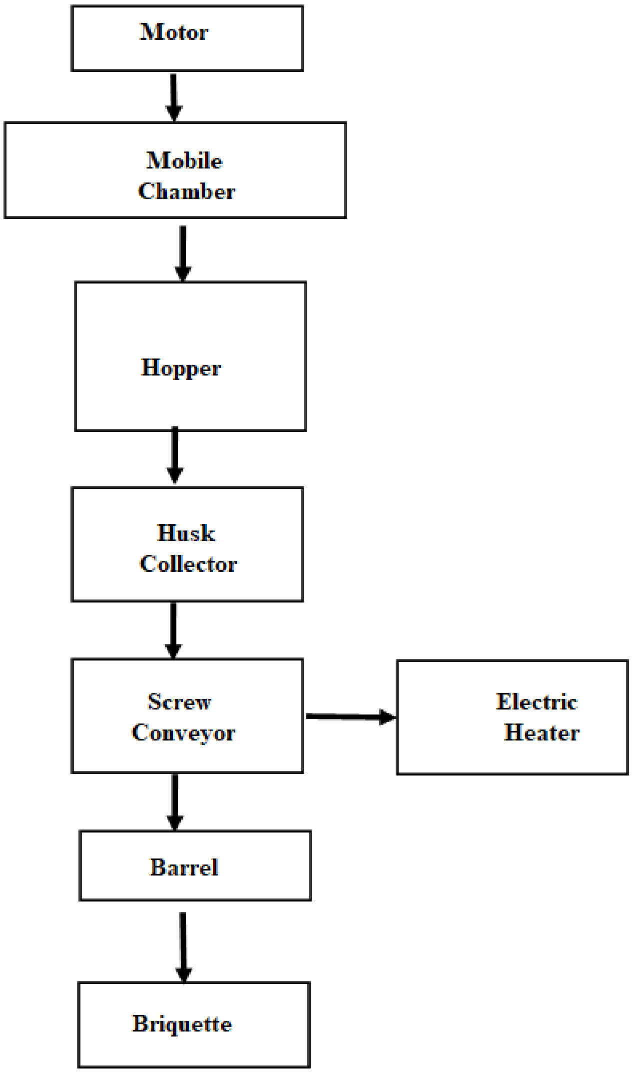

Figure 2. Flow diagram of briquette production

Chopper machine: To chopping the straw a chopper machine was purchased from local market. For run the machine, the single phase 2.2 kW induction motor was used. The machine is capable to chop straw into 1.50 – 8.0 cm length and capacity of this machine is 240 kg/h. schematic view of power chopper machine is shown in figure 3.

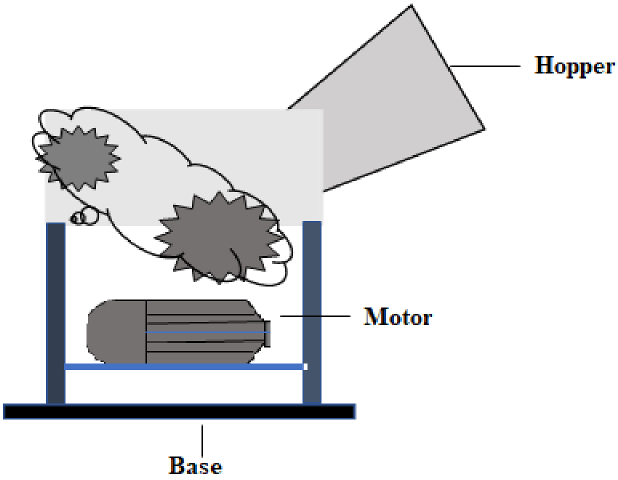

Figure 3. Chopper machine

RESULTS AND DISCUSSIONS

Density: It is well known fact that the briquette density is depends on original density of biomass (Demirbas and sahin 1998). The average density of rice husk is 135 kg/m^3 while the average density rice straw is 91 kg/m^3. The density detail with respect to different feedstock ratio is presented in figure 4. It was observed that the briquette density lies in the range of 765 kg/m^3 – 875 kg/m^3. Hence it can be say that the briquette density increases with increase in rice husk proportion in feedstock because the density of rice husk is greater than rice straw.

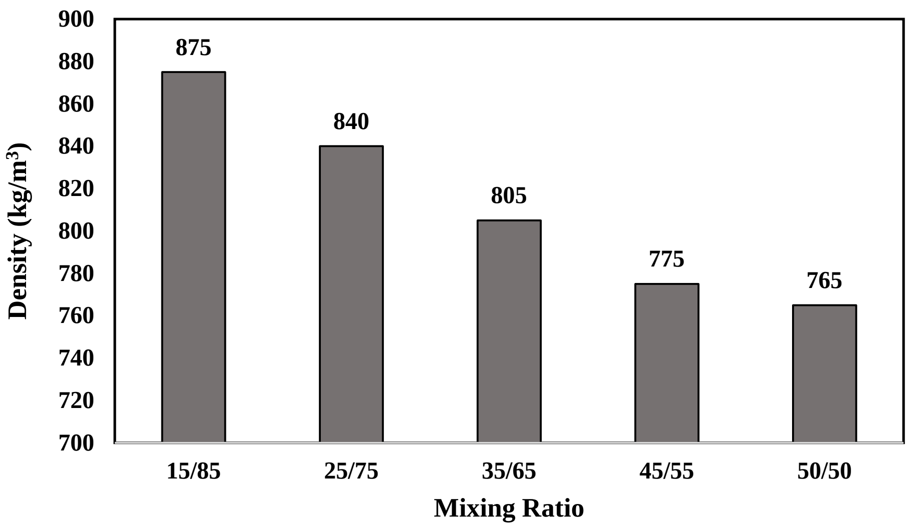

Figure 4. Density of briquette with respect to different feedstock ratio.

Proximate Analysis: To produce good quality of briquette, the properties of feedstock should be well known especially proximate analysis is required. This analysis given the information about the percentage of volatile mater, fixed carbon, moisture content and ash content of briquette. The detail proximate analysis of briquette has been presented in Figure 5. The volatile mater is compound of biomass which is given off in gas of vapor form when subjected to standard temperature (up to 400^0C to 500^0C). During the temperature is applied the feedstock is decompose decomposes into volatile gases and solid char. The volatile matter present in Rice straw-husk based briquette of 60.25 to 63.74% depending on the deferent mixing ratio, which is similar to shakya and shakya (2002) findings for rice straw 63.06% of Dolakha variety and 53.03% of Khumaltar variety and rice husk 63.06% (AIT) and 57.83% for Khumaltar.

The ash of the feedstock is stands as the non- combustible residue after combustion of the biomass. Most of biomass have poor ash content while the rice husk and rice straw contain ash percentage with 13-16% and 15-17% respectively. However, their ashes have higher percentage of alkaline minerals. If biomass contains high percentage of ash, machinery parts wear out consequently inefficient briquetting. The ash content should in the range of approximately 5-10%. The presence of high ash content offers the higher the residue left which create a serios problem. It can be seen from the figure 6.4 that ash in biomass is lies in the range of 12.7-16.2% this is the percentage of impurity that will not burn during and after combustion. Dasgupta et al, (2003) reported that higher ash percentage usually leads to lower calorific value while the low ash content offers a good thermal utilization of product.

The moisture content of agricultural waste should be lies in the range of 10-15%. Additionally. high moisture content creates problems in grinding and excessive energy is required for drying (shakya and shakya, 2002). Similar type of work done by Wilaipon, (2008) and reported that moisture should be within the limits of 15% for briquetting of agro-residues. It can be seen from the figure 6.4 that the produced briquettes have been contains moisture range of of 6.5-7.99% therefor, this result was much lower within the limits of 15% recommended by Wilaipon, (2008) and shakya and shakya, (2002) for briquetting of agro residues.

The fixed carbon of the briquette is very important property that shows the portion of burns in solid state in the fuel bed. It can be seen from figure 6.4 that the fixed carbon is found in the range of 14.2-20.8% which is the percentage of carbon (solid fuel) available for char combustion after volatile matter is distilled off. Fixed carbon gives a rough estimate of the heating value of the fuel and acts as the main heat generator during burning.

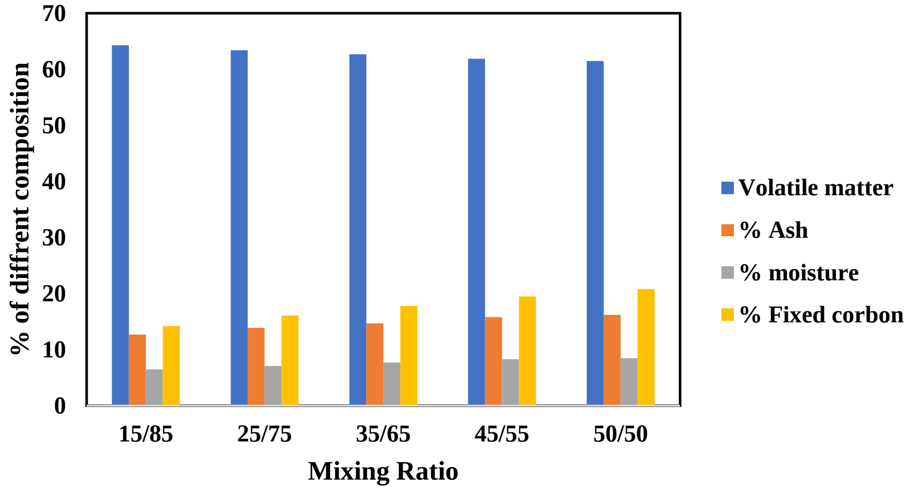

Figure 5. Composition of different matter includicing volatile, ash. Moisture and fixed carbon with respect to different feedstock ratio.

Calorific/ heating value: The calorific value of different briquette with respect to their feed stock proportion is presented in figure 6. It is reflected in figure 6.5 that the feedstock proportion of rice straw: rice husk (15:85) provided highest caloric value of 15077 kJ/kg. Apart from this, the feedstock proportion of rice straw: husk (50:50) is offered low calorific value of 13923 kJ/kg. This energy value is well acceptable for domestic purpose as well as for small-scale industrial applications. Hence it is suggested for the good quality of briquette the amount of rice husk proportion in feedstock should be sufficient.

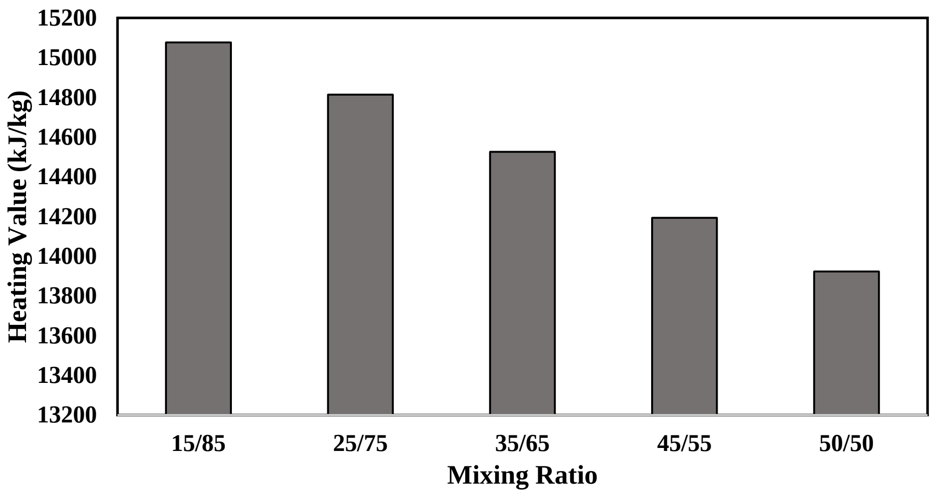

Figure 6. Heating values of briquette with respect to different feedstock ratio.

Number of AW used for briquette production. These briquettes offer good calorific value. However, the production of briquette mainly depends on the availability of raw material. The typical comparison of different agro waste with present study in term of calorif value is given below.

Table 1. Calorific value of briquettes made from different raw materials.

Raw Materials	**Caloric value (kJ/kg)**
Present Study (Rice straw, husk:15:85)	15077
Arhar stalk	16736
Babool stalk	19694
Bagasse	17991
Coconut waste	21757
Cow dung	13556
Groundnut Shells	19502
Jute waste	18527
Mustard shell	17991
Soyabean husk	17447
Tea Waste	17728
Tobacco waste	12175
Whet husk	17154

Cost analysis: The cost of briquette production mainly depends on the avaibility of raw materials and site specific and depends on the number of machines deployed in the plant. Following are the feasibility report prepared briquetting unit installation.

Capacity

Basis: Two machines each 500 kg/hr

Production capacity = 1T/hr (20 hrs/day operation)

Operating days per year	300
Operating hours per year	6000
Capacity utilization	85%
Raw material	5280 TPY
Moisture losses	231 TPY
Briquettes produced	5050 TPY
Briquettes consumed (Dryer)	396 TPY

Saleable	4653 TPY

Infrastructural facilities

Power consumption	100 KW
Land area required	2100 m^2
Operational shed area required	200 m^2
Briquetting storage area required	200 m^2

Investments

	Rs. (lac)
Installed cost of plant & machinery (based on 9 lac for each machine)	35
Land	1.9
Building	2.8
Total investment	39.7
Working capita	5

Cost of production

	Cost (Rs./tonne)
Power	91
Manpower	45
Water	5.3
Maintenance (Including consumables)	50.6
Administrative overheads	28.4
Depreciation (plant 10% Building 5%)	50
Subtotal	270
Financial cost	60.4
Cost of production	330.4 = Rs 331/tone
Overall cost of production per year	25.3

Profitability

Basis:

Cost of raw material	Rs = 500/ - per tonne
Net sale price of briquettes	Rs. 1400/- per tonne
	Rs (lac)
Total sales (1450 x 4653)	67.45

Production cost (500 x 5050)	25.24
Raw material (500 x 5280)	26.4
Gross profit before taxes	15.51
Pay-back period	1.7 years

The analysis is oriented on the screw press costing of Rs.6.0 lat. Plants with less than two machines are not recommended. Hence it can be say that from above analysis the production of briquette from rice waste is very economic and smart choice to increase the additional income of formers.

CONCLUSION

1. The feedstock ratio of rice straw and husk with 15: 85 provided best quality of briquette in term of density, binding, and caloric value.
2. The caloric value of briquette obtained in the range of 15077-13923 kJ/kg.
3. Produced briquette can be used for both domestic and industrial purpose.
4. The production of briquette using rice husk and straw were economic feasibility.

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