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Utilization of Animal Power for Low Density Briquettes Production

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ABSTRACT

Draught animals have been the backbone of Indian agriculture through ages for supplying draught power. Animal operated implements available in the country are primarily meant for field operation and haulage. Therefore animals remain idle for a considerable period for which the farmer continues to provide fodder and shelter. It is estimated that the annual use of animals is limited to 300-350 hours only but the potential use of animal in a year is nearly 1800 hours. To achieve this target an appropriate, cost effective and easy to operate biomass briquetting machine operated by animal power rotary mode unit was developed. The machine was tested to produce low density briquettes by different biomass like charcoal, paddy husk, pigeon pea stalk and saw dust. On the basis of proximate analysis charcoal briquette has highest calorific value of 4480 Kcal/kg followed by pigeon pea stalk, saw dust and paddy husk having calorific value of 4200, 3890 and 3200 Kcal/kg respectively. The highest machine efficiency was 88.33 % for charcoal briquette followed by 85.76%, 86.00% and 83.20% for paddy husk, pigeon pea stalk and saw dust briquette respectively.

Keywords: Rotary System, Biomass, Proximate Analysis, Briquettes

Traditional Indian farming was based on the human and animal power and still it has relevance for the mechanization of small farms in the coming years. Marginal and small holding size farmers constitute 85.01% (117 million numbers) of total operational holdings sharing 44.58% (71.15 million hectare) of total operated area (Anonymous, 2014). Even though tractors are replacing draught animals in rural areas, small & marginal farmers (< 2 hectare) continue to depend on human and animal power. The vast difference between the potential and actual utilization of draught animal power needs to be bridged to the greatest extent possible by developing suitable technology for the animals during off-season periods. The availability of electricity in rural areas is intermittent and farmers opt for diesel engine operated machinery for many farm operations. At present the cost of diesel is increasing and farmers need an alternative source to reduce the dependence on fossil fuels.

Therefore, it is necessary to promote the continued use of draught animals in agriculture which is a time tested renewable energy source for sustained agriculture in the face of dwindling reserves of the non renewable sources of energy. There are about 49 million draught animals in the country (Anonymous, 2012). Draught animals are known to be widely used for selected crop production operation during cropping season and left idle for the rest of period. The idle period of draught animal can be very well utilized by other means.

This is possible through employing animal in the rotary mode of power to operate different agro processing machines. One of the potential areas of draught animal power could be application to operate low horse power post harvest machines such as chaff cutter, grain grinder, grain cleaner-cum-grader, water lifting, generation of electricity. Keeping in view the above in this study an attempt has been made for utilization of animal power in Rotary transmission system for low density briquette production using agricultural biomass like charcoal, pigeon pea stalk, saw dust, paddy husk etc. and also to maximize the working hour of draught animal.

MATERIALS AND METHODS

A setup of rotary mode system was installed to operate extruder type screw press briquetting machine using animal power.

Rotary mode system

The animal operated rotary mode system consists of circular track on which the animal moves in a circular path (Fig. 1). The diameter of track may be generally taken 10-12 m. The rotary gear box assembly is installed at the central place of circular track. The gear box assembly involving combination of crown bevel gear and pinion, pairs of helical or spur gear and V-belt and pulleys. Animal power is transferred at right angle through this gear box assembly to operate small capacity machine. The rotary system increases the rpm of the animals from 1.25-2 rpm to about 400-500 rpm at the output shaft. A wooden or steel beam is attached to the vertical shaft of the rotary gear box assembly to hitch the animal. The rotary unit converts the animal power into mechanical power for operating the different agricultural processing machines. To make the complete unit economically viable, one pair of bullocks was used to generate power. For safer design of animal powered rotary unit, the ultimate power developed by a pair of bullocks can be assumed as 0.75 kW for sustained working of 6 hour in a day. This power was used for briquette production.

Fig. 1: Animal driven rotary mode system

Extruder Type Screw Press Briquetting Technology

Low pressure briquetting can be used for materials with a low amount of lignin, such as paper and charcoal dust. In this process, the powdered biomass is mixed into a paste with a binder such as starch, cow dung or clay, and water. A briquetting press is used to push the paste into a mould or through an extruder, or it can simply be shaped by hand. The briquettes thus produced are left to dry, so that the binder sets and holds the biomass powder together. Low pressure briquetting machines are often hand operated, using a lever that drives a piston to compress the paste.

Biomass Briquetting Process

Briquetting is the process of densification of biomass to produce homogeneous, uniform sized solid piece of high bulk density which can be conveniently used as a fuel. It increases strength, density, handling and transport qualities, and the amount of heat emitted per volume of the biomass. The densification of biomass can be achieved by any one of the following method:

- Pyrolysed densification using a binder
- Direct densification of biomass using binder
- Binder less briquetting.

The complete production process of low density briquette is given in Fig. 2.

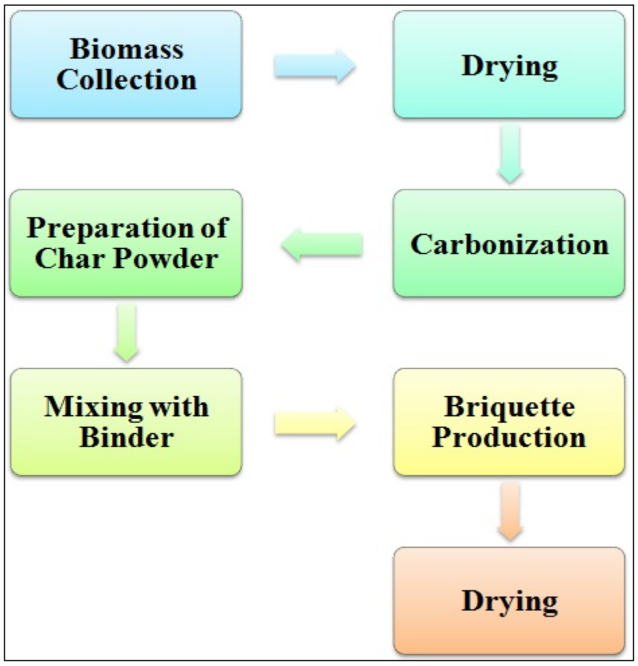


Fig. 2: Production process flow chart for briquette

Collection of Raw Material

The details of raw material used and unit operation performed for preparation of feedstock for briquette production is given in Table 1.

Table 1: Selected raw material for briquetting

Raw Material (Biomass)	Source	Unit Operation Performed
Charcoal	Pyrolysis of wood	Grinding
Paddy husk	Agricultural Field	Sun drying, Chopping & Grinding
Pigeon pea stalk	Agricultural Field	Sun drying, Chopping, Shredding & Grinding
Saw dust	Saw mill	Sieving & Drying

Carbonization and Char Yield

The collected biomass was tightly packed into a cylindrical metal drum (kiln). After loading biomass into kiln a little amount of kerosene was sprayed inside it to ignite the fire. Then the door of the kiln was closed tightly to start the pyrolysis process. In the absence of air, the burning process is slow and fire slowly spreads to the biomass. After 3-4 hours it has converted into char then some water spread over it. After that remove out from the kiln and dried in open sunlight. The carbonization process produces 40-45% char powder from original biomass. The char yield varies from one biomass to another. Carbonized biomass was pulverized in huller mill.

Binder Selection

The binder is a material capable of holding material together by surface attachment. This may be rice powder, boiled rice water, glue, starch, pest etc.

Table 2: Ratio of biomass and cow dung

Particular	Ratio	
	Biomass	Cow dung
Charcoal	50	5
Paddy husk	50	6
Pigeon pea stalk	50	7
Saw dust	50	10

In present experiment cow dung was used as binding material because it was readily available, cheap and burn effectively. The various combinations of binder (cow dung) and selected biomass (viz. Charcoal, Paddy husk, Pigeon pea stalk & Saw dust) is given in Table 2.

Briquetting Machine

For production of briquette in current study a meat mincer machine was modified. It is basically a screw extrusion press machine consists of augur, die, hopper and power transmission system. Pulley and v-belt were used to transmit the power from rotary unit to the machine shaft. The die of machine consist 3 exit tube of dia. 25 mm and length 50 mm. The major components of machine is shown in Fig. 3.

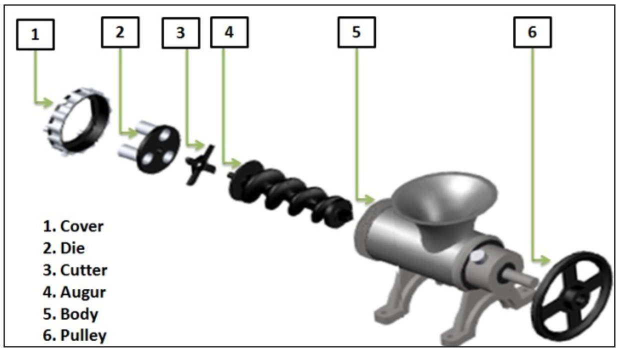


Fig. 3: Components of extruder type screw press briquetting machine

Briquette production

The collected biomass was converted into char and mixed with suitable binder in prescribed ratio. Animal driven rotary mode system was used as a source of power. Rotary mode system developed 1 hp (0.75 kW) from one pair of bullocks. Driving pulley (dia. 60 cm) on main shaft was rotated at 70 rpm and connected to driven pulley (dia. 18 cm) on briquetting machine & rotated at 250 rpm.

Proximate Analysis

Ash Content: It is the mass of incombustible material remain after burning a given briquette sample as a percentage of the original mass of the briquette. The percentage ash content was determined by heating 2g of the briquette sample in the furnace at a temperature of 550 ºC for 4 hours duration and weighed after cooling. The percentage ash content is determined as:

$$\text{Percentage ash content} = \frac{C}{A} \times 100 \quad (1)$$

Where; C is the weight of ash and A is the weight of oven dried sample.

- **Volatile Matter Content:** For determining the percentage volatile matter; 2g of briquette was placed in the furnace at a temperature of 550 ºC for 10 minutes and weighed. After cooling the percentage volatile matter was determined with the following equation:

$$\text{Percentage volatile matter} = \frac{(A-B)}{A} \times 100 \quad (2)$$

- Where; A is the weight of oven dried sample and B is the weight of sample after 10 minutes in the furnace at 550 ºC.
- **Fixed Carbon:** Fixed carbon is the solid combustible residue that remains after heating the biomass and expelling the volatile matter. The Percentage fixed carbon was calculated by subtracting the sum of percentage volatile matter and percentage ash content from 100.
- **Calorific Value:** The gross or high heating value is the amount of heat produced by the complete combustion of a unit quantity of fuel. This was calculated using the formula:

$$\text{Calorific value} = 2.32(147.6D + 144V) \quad (3)$$

Where; D is the percentage fixed carbon and V is the percentage volatile matter (Bailey *et al.,* 1982).

RESULTS AND DISCUSSION

Physical Properties of Briquettes

Physical properties of different briquettes such as density, shrinkage percentage, moisture content and shattering resistance were determined for relative compactness, shrinkage percentage in diameter, ease of transportation and increase combustion properties and presented in Table 3.

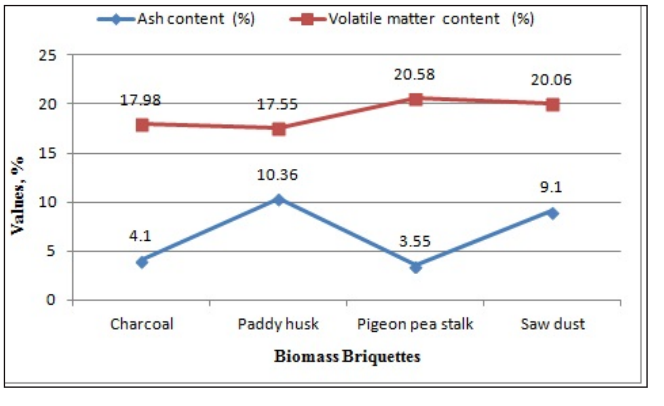
Table 3: Physical properties of produced briquettes

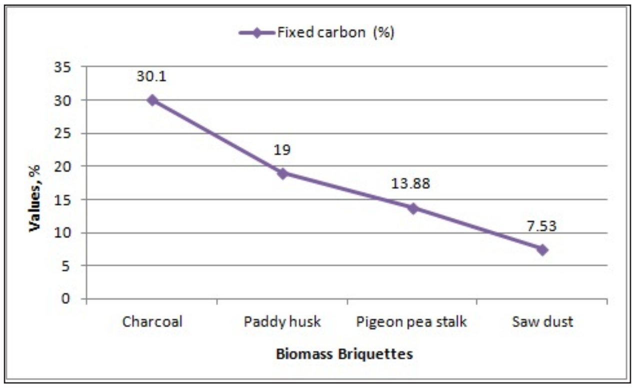
Biomass	Charcoal	Paddy husk	Pigeon pea stalk	Saw dust
Shrinkage, %	14.13	17.90	18.11	17.20
Moisture content, %	08.15	11.23	12.25	11.55
Shattering Resistance, %	91.12	86.20	86.13	86.36
Density of briquette, gm/cm^3	1.80	0.89	0.94	0.98

The result shows that the physical property of briquette made of paddy husk, pigeon pea stalk and saw dust is approximately same. But in case of charcoal briquette the shrinkage percentage & moisture content is low and shattering resistant & density is higher. Hence the charcoal briquette has good burning quality, more durable and higher strength for transportation compared to other biomass briquette.

Proximate Analysis

The proximate analysis of fuels gives an approximate idea about the energy values and extends of pollutants emission during combustion. The percentage proximate values (ash content, volatile matter and fixed carbon) of the different biomass briquette along with their calorific value are shown in Fig. 4.





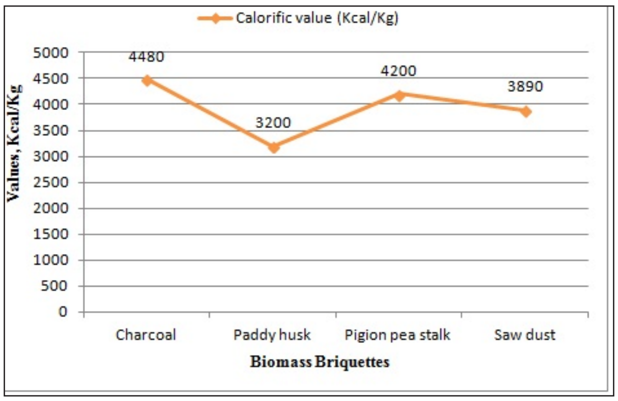


Fig. 4: Result obtained from proximate analysis of briquettes

From the above graphs it is reveled that the pigeon pea stalk briquette has minimum ash content and maximum volatile matter and i.e. 3.55 & 20.58 % respectively compared to other briquettes. Also the fixed carbon percentage and calorific value is moderate. So the pigeon pea stalk briquette has better fuel quality among other biomass briquette. The calorific value was obtained maximum for charcoal briquette as 4480 Kcal/kg; which indicates that the charcoal briquette emits higher energy as compare to other biomass briquette.

Machine Performance

The performance of machine was found economical for briquette production using rotary mode. It varied with type of raw material used for briquetting. The feeding rate of raw material was varies with the type of biomass. Rate of feeding biomass and machine output was measured and value is given in Table 4.

Table 4: Machine performance

Briquettes	Charcoal	Paddy husk	Pigeon pea stalk	Saw dust
Feeding rate (kg/day)	180	177	150	150
Machine output (dry wt. kg/day)	159	151.80	129	124.80
Machine efficiency (%)	88.33	85.76	86.00	83.20

The result indicates that the machine output is fully depending on feeding rate. Feeding rate of charcoal is higher compared to other biomass because it flows very easily through augur as it has very fine particle. The machine output was recorded maximum 159 kg/day in charcoal followed by paddy husk 151.80 kg/day and pigeon pea stalk 129 kg/day. Minimum machine output of 124.80 kg/day was recorded for saw dust briquette. It is also clear that the machine efficiency was better for the charcoal briquette 88.33 % production as compare to other biomass as 85.76, 86.00 & 83.20% for paddy husk, pigeon pea stalk and saw dust respectively.

Cost Analysis

Data on cost of production of briquettes with different biomass is presented in Table 5.

Table 5: Cost analysis of briquettes production

Briquettes	Charcoal	Paddy husk	Pigeon pea stalk	Saw dust
Cost of production (₹/day) (Rotary unit + briquetting	630	528	456	540
Gross income (₹/day)	795	759	645	624
Net income (₹/day)	165	231	189	84

The cost of production of briquette is fully depend on the cost of raw material because the cost of rotary power unit was constant as ₹ 162 per day for all type of biomass briquette production. Cost of production of briquette by rotary unit was found maximum for the production of charcoal briquettes as ₹ 630 per day and minimum for the pigeon pea stalk briquette as ₹ 456 per day.

The gross income (₹/day) from the selling of briquettes @ 6 ₹/kg was found maximum for the charcoal briquettes as ₹ 795 per day and minimum for the saw dust briquettes as ₹ 624 per day. The net income generated was found maximum for the paddy husk briquettes as ₹ 231 per day and minimum for the saw dust briquette as ₹ 84 per day. Hence, the briquette production from the paddy husk using rotary mode was found more profitable compared to other biomass briquettes.

CONCLUSION

It is concluded that the developed briquetting machine to produce low density briquettes was performed satisfactorily using animal powered rotary mode system to produce briquettes or pellets from agricultural biomass. It definitely maximizes the utilization hour of animal during the idle period. This experiment enhances the utilization of animal power as well as creates an opportunity of employment in rural areas with the use of local agricultural waste.

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