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Development of Animal Power Briquetting Machine to Produce Low Density Briquettes

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Abstract - **In this study, an appropriate, cost effective and easy to operated biomass briquetting machine was developed through animal power rotary mode unit. The machine was tested to produce low density briquettes by different biomass like charcoal, paddy husk, pigeon pea and saw dust. The physical properties and proximate analysis was carried out for produced briquettes. The maximum compressed density 1.82gm/cm^3 obtained in charcoal briquettes and Maximum shattering resistance 90.14% was determine in charcoal briquettes. The maximum moisture content 63.11% was found in pigeon pea briquettes and minimum 47.23% in charcoal briquettes. Paddy husks briquette and pigeon pea briquettes were found maximum and minimum ash content 10.6% and 3.40% respectively. The optimum volatile matter was found in pigeon pea briquettes 21.3% and minimum 17.74%for paddy husk. The charcoal briquettes contained maximum fixed carbon percentage 29.85% and minimum 7.85% in saw dust. The higher calorific value was obtained for charcoal briquette as 4500 Kcal/kg which emits the higher energy as compare to other biomass and the minimum value was found for paddy husk as 3250 Kcal/kg.**

Key words: Briquette, Biomass, Rotary Unit,

INTRODUCTION

India has a large population of draught animals and bullocks are main draft animal in the country followed by he-buffaloes. Bullock is one of the cheapest sources of draught power for all kinds of agricultural operations in village areas of Chhattisgarh .Use of draught animals as source of energy is very dominant and will continue to be so for many more years (Srivastava, 2000). There are about 56 million draught animals in the country. These animals, cultivate about 60 to 65% (Ghosal ***et al***) of total cultivated area (approximate 85–93 million ha). The animals give stability to agriculture by subsidizing the income of the farmers. 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 (Srivastava, 2000). One of the potential areas of draught animal power could be application to operate low horse power post harvest machines such machines are chaff cutter, grain grinder, grain cleaner-cum-grader, water lifting, generation of electricity. This study attempt to operate a biomass briquetting machine through power developed from rotary unit to produce low density briquettes.

Recent estimates state that the total agro-residue availability in India is more than 500 million metric tons per annum. Around 20-25 % of it is used to produce energy (Murali *et al*, 2015). Fossil based technology is the primary source in India that meets the energy requirement in small as well as large industrial applications. Still 2.5 billion people around the world do not have access to modern fuels. Briquetting is a technology for densification of agricultural residues/wastes to increase their bulk density, reduce their moisture contents and make briquettes of uniform sizes and shapes for easy handling, transport and storage. Briquettes can be defined as a product formed from physic-mechanical conversion of loose and tiny particle size materials with or without binder in different shapes and sizes (Obi, 2013). Commercialization of briquetting technology is essential to know whether the technology is economically viable or not. Keeping in view the above in this study an attempt has been made for utilization of agricultural biomass to prepare briquettes from pigeon pea, charcoal, saw dust and paddy husk biomass as well as maximizes the utilization of animal energy through rotary mode system.

MATERIALS AND METHODS

An existing setup of rotary mode system installed by the AICRP on Utilization of Animal Energy in department of Farm Machinery and Power Engineering was used in this experiment at Swami Vivekanand College of Agricultural Engineering and Technology, Faculty of Agricultural Engineering IGKV Raipur.

Rotary mode system: The rotary unit, in fact is basically a power transmission system which convert 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. This power was used for briquette production.

BRIQUETTES

Briquette is a compressed block of coal dust or other combustible biomass material such as charcoal, sawdust, wood chips, peat, or paper used for fuel and kindling to start a fire. The term comes from the French language and is related to brick.

BRIQUETTING TECHNOLOGY

Briquetting is the process of converting low bulk density biomass into high density and energy concentrated fuel briquettes. Briquetting increases strength, density, handling and transport qualities, and the amount of heat emitted per volume of the biomass.

In present study the meat mincer machine was found suitable for briquette production by screw press with some modification in its die. It is basically a screw extrusion press machine; this machine consists of screw, 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 number of small holes of dia. 5 mm, which was not suitable for making briquette. So a new die having 3 exit tube of dia. 25 mm and length 50 mm was fabricated for the same machine as shown fig.1.

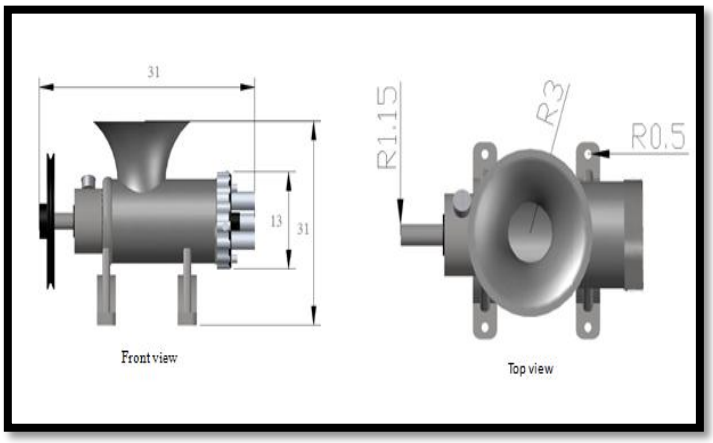

Fig.1: Screw press extruder type briquetting machine

Table 1: Specification of modified briquetting machine

S.No.	Particular	Specification
1.	Screw dimensions :	
	No. of turns	4
	Screw pitch, cm	6
	Maximum diameter of screw, cm	9
	Minimum diameter of screw, cm	6
2.	Die dimensions :	
	No. of exit tubes	3
	Diameter of exit tube, cm	2.5
	Length of exit tube, cm	5
3.	Pulley and belt:	
	Diameter of driving pulley, cm	18
	Belt type	V – belt
4.	Overall dimensions:	
	Overall length of machine, cm	31
	Overall width of machine, cm	31
	Overall height of machine, cm	62

Experimental Details:

Biomass collection

A wide choice of biomass collection was presented there to produce briquettes. The raw materials such as saw dust, charcoal, paddy husk, and pigeon pea stalk were used in the present study. Biomass paddy husk and pigeon pea stakes was collected from the field of IGKV Raipur and dried open in sunlight at required moisture content for carbonization.

Carbonization

Carbonization of biomass was carried out in charring kiln which designed at Central Institute of Agricultural Engineering, Bhopal (2009) and it is fabricated in the workshop of FAE, IGKV, Raipur.

For carbonization, charring kiln was filled with biomass and little amount of fuel was used to ignite the fire in kiln and door of the kiln 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.

Char yield: 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 holler mill.

Mixing of binder: Cow dung was used as a binding material, the various combinations combination (biomass char: cow dung) as 50:10, 50:7, 50:6 and 50:5 (Shugumuran, 2009) by weight (kg) for saw dust, paddy husk, pigeon pea and charcoal respectively used for briquette production.

Briquette production

For the production of briquettes; animal driven rotary mode system was used as a source of power. Rotary mode system developed 1Hp (0.75KW) from one pair of bullocks. Driven pulley (dia.60cm) attached on shaft which rotated at 70 rpm, it connected to the driving pulley (dia. 18 cm) of briquetting machine which was rotated at 250 rpm as shown in fig.2.

Fig.2: briquette production through rotary unit

Observation Recorded:

- Machine Performance
- Physical Properties of Produced Briquettes such as Density, Moisture Content, Shattering Resistance etc.
- Combustion Characteristics
- Proximate Analysis

RESULT AND DISCUSSION

Machine Performance

In general performance of machine was found economical for briquette production using rotary mode, it varied with 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 putted in table 2.

Table 2: Machine performance

S.No.	Briquettes	Feeding rate (kg/h)	Machine output (dry wt. kg/h)	Machine efficiency (%)
1.	Charcoal	30	26	86.67
2.	Paddy husk	30	25	83.33
3.	Pigeon pea	24	20	83.33
4.	Saw dust	24	20	83.33

It was observed from the table 2 that the feeding rate of charcoal and paddy husk was higher as compare to pigeon pea and saw dust. Similarly machine output was recorded maximum 26kg/h in charcoal followed by paddy husk 26kg/h. Minimum machine output 20kg/h was recorded in pigeon pea and saw dust.

From the table it is clear that the machine efficiency was better for the charcoal briquette 86.76 % production as compare to other biomass as 83.33%.

Density of briquettes

Density of briquettes was determined for relative compactness, easy to transportation and improves the burning quality of briquettes and also used for increase the combustion properties. Density of different briquettes was determined and presented in table 3.

Table 3: Density of briquettes

Biomass	Weight of briquette, (gm)	Volume of briquette, (cm^3)	Density of briquette, gm/cm^3
Charcoal	14.2	7.670	1.82
Paddy husk	12.08	13.69	0.88
Pigeon pea	12.98	14.02	0.93
Saw dust	13.98	14.09	0.99

Hence the density of charcoal briquette was found maximum 1.82gm per cm^3; it means it is more durable and higher strength for transportation as well as higher burning time as compare to other biomass briquettes.

Moisture Content

Moisture content test was determined for drying of briquettes and used in the loss of chemically bound structural water. It is shown in table 4.

It was observed from the table that charcoal briquettes contained low moisture content 47.25% which is better for combustion and safer for storage & transportation as compare to other biomass briquettes. While pigeon pea briquettes was contained highest moisture percent 63.11%.

Table 4: Moisture content

Biomass	Initial wt. before drying, (gm)	Final wt. after drying, (gm)	Percentage moisture content (%)
	A	B	C = (A-B)/A *100
Charcoal	26.91	14.2	47.25
Paddy husk	26.05	12.08	53.64
Pigeon pea	35.18	12.98	63.11
Sawdust	37.49	13.98	62.65

Shattering Resistances

This test was determined for durability of briquettes and also for checking breakability during transportation.

Table 4: Shattering resistances

Biomass	Initial wt. before shatter (gm)	Final wt. after shatter (gm)	Percentage wt. Loss (%)	Shatter resistance
	A	B	C = (A-B)/A *100	100-C
Charcoal	14.2	12.8	7.14	90.14
Paddy husk	12.08	10.3	14.73	85.26
Pigeon pea	12.98	11.2	13.71	86.28
Saw dust	13.98	12.1	13.44	86.55

Charcoal briquettes was found minimum weight loss 7.14% during the shattering test of the produced briquettes, therefore it consist maximum shattering resistance as 90.14; it was found more durable and safer for handling and transportation of briquettes. Paddy husk briquettes was found minimum shattering resistance as 85.26 and maximum percentage weight loss 14.73.

WATER BOILING TEST

Briquettes produced from saw dust, paddy husk, charcoal dust, pigeon pea and cow dung mixture were selected for water boiling test for checking their suitability in domestic use as fuel. The result from obtained the experiment is presented in the table 5.

From the results, it was observed that the briquettes were burnt completely in locally available cook stove and gave uniform flame. Charcoal briquette was found better burning rate and water evaporated to fuel used ratio. Charcoal briquette was observed minimum time 15.32 minute taken to evaporate the maximum amount of water 152ml as compare to other briquettes.

Table 5: Water Boiling Test

S. No.	Parameter	Briquettes			
		charcoal	Paddy husk	Pigeon pea	Saw dust
1.	Fuel taken, gm	250	250	250	250
2.	Time taken to burn briquette, min	5.30	6.4	5.55	5.40
3.	Water boiling time, min	15.32	18.45	17.2	15.55
4.	Water evaporated, ml	152	143	138	145
5.	Ratio of water evaporated to fuel used ml/gm	0.61	0.57	0.55	0.58

Proximate Analysis

The value of proximate analysis of fuels is important because they give an approximate idea about the energy values and extend of pollutants emission during combustion. The percentage proximate values of the different contents shown in table 6 and fig.3 shows the comparison among the different contents.

From the figure it is observed that the maximum moisture content as 63.11% was found in pigeon pea briquettes and minimum as 47.23% in charcoal briquettes compare to other biomass. While paddy husks briquettes was found maximum ash content as 10.6% and minimum as 3.40% for pigeon pea briquettes.

Table: proximate analysis of briquettes

S.No.	Briquettes	MC (%)	Ash (%)	VM (%)	FC (%)	Calorific Value (Kcal/Kg)
1.	Charcoal	47.23	4.5	18.4	29.85	4500
2.	Paddy husk	53.64	10.6	17.74	18.02	3250
3.	Pigeon pea	63.11	3.40	20.32	13.17	4150
4.	Saw dust	62.65	8.2	21.3	7.85	3898

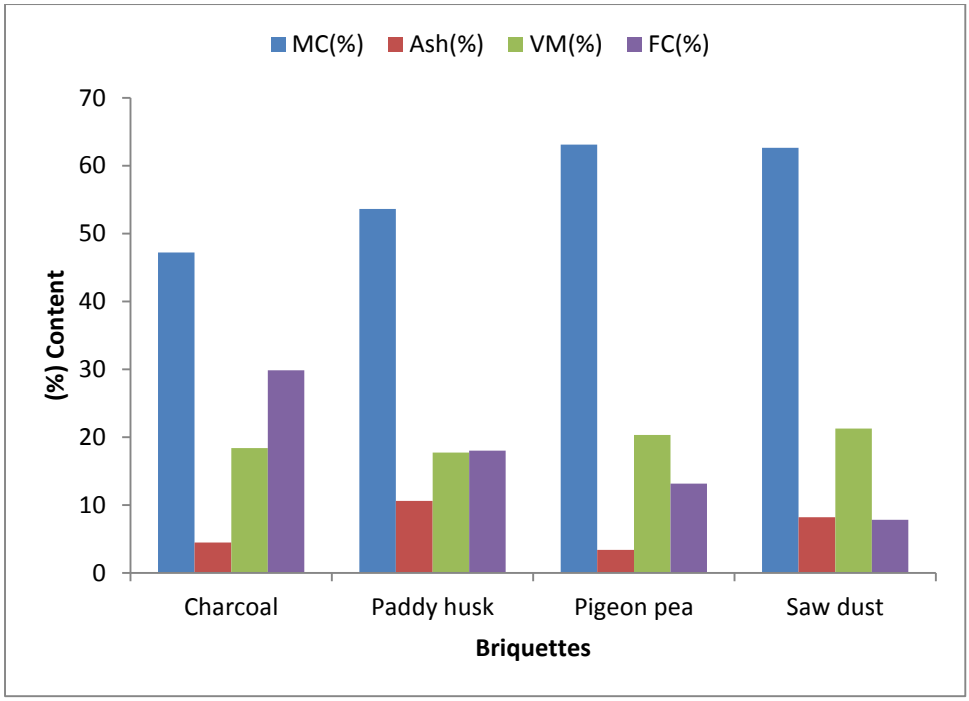

Fig. 3 Percentage contents of briquettes

The optimum volatile matter was found in pigeon pea briquettes as 21.3% and minimum as 17.74 for paddy husk. The charcoal briquettes contained maximum fixed carbon percentage as 29.85% and saw dust was found minimum as 7.85%.

CALORIFIC VALUE OF BRIQUETTES

The higher calorific value was obtained maximum for charcoal briquette as 4500 Kcal/kg which emits the higher energy as compare to other biomass and the minimum value was found for paddy husk as 3250 Kcal/kg. It is shown fig.4.

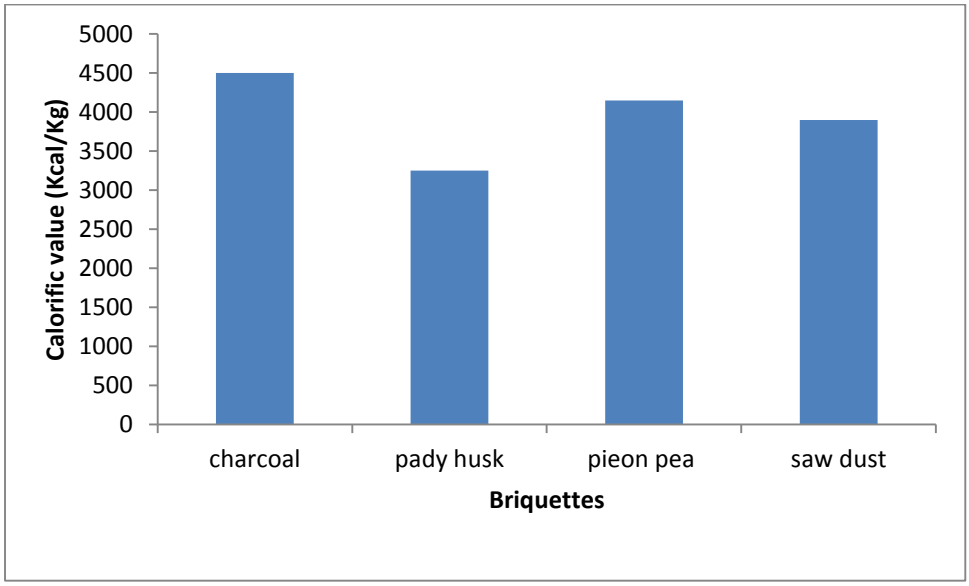

Fig.4 Calorific value of briquettes

CONCLUSION

It was concluded from the study that developed briquetting machine to produce low density briquettes was worked satisfactorily in animal powered rotary mode system to produce briquettes or pellets from agricultural biomass. Among agricultural biomass briquettes, higher calorific value of the produced briquettes was obtained in pigeon pea stalk.

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