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Design of Hand Operated Briquetting Machine

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Abstract: Every year millions of tons of agriculture waste are generated which are either destroyed or burnt inefficiently in loose form causing air pollution. Briquetting technology is one of the renewable sources of energy that was devised to address problems regarding global warming. In India biomass is the most dominant source of energy and is used significantly in the domestic sector notably charcoal and wood fuel. Despite huge amount of agricultural waste generation in the rural areas, the rural folks use charcoal and wood fuel, which leads to deforestation. Therefore to reduce the use of conventional fuels, use of biomass as a fuel can be placed as a substitute. Biomass can be used in the form of briquettes to replace the conventional fuels to some extent. Comparison of different biomass ratio for the briquette production was carried out In initial sample rice straw and cow dung in proportion of produced briquettes, in second sample we take Rice husk, Rice straw and cow dung and in third sample we take saw dust, Rice straw and cow dung in proportionate to produced briquette by using Hand operated Briquetting machine. And compare its finds proximate analysis and ultimate analysis of briquettes.

Index Terms - **Biomass, Briquetting, Potential, Process, Technologies, compacting of Briquetting materials.**

I.INTRODUCTION

The overall pollution in the world is increasing day by day and the major contribution to this pollution is the use of fossil fuels, hence there is huge push to reduce the usage of fossil fuels and to look for the alternative biomass fuel. Developing countries are facing huge problem with waste management and agro residues such as coir pitch, dry leaves, rice husk, coffee husk etc., are contributing majorly to this problem. We usually see these agro residues and saw mill residues are usually burnt on roadside or dump yards, which again results in pollution. There is a need to find a way so that these agro residues and sawmill residues can be converted into fuels. However, these residues are very difficult to transport, handle, store and if these residues are burnt directly it results in very poor thermal efficiency and may create lot of air pollution. These kinds of problems can be avoided by briquetting the waste biomass in to usable energy generating fuel. Hence, if proper efforts are made biomass briquettes will become an alternative for some of the fossil fuels to a greater extent and briquetting of agro residues will help in waste management and reduced air pollution. Biomass briquetting is the densification of loose agro residues; sawmill residues with or without binding agents to produce compact solid composites of different sizes with the application of pressure. The end use of briquettes is mainly for replacing coal in industry for heat applications (steam generation, melting metals, space heating, brick kilns, tea curing, etc) and power generation through gasification of biomass briquettes and for domestic uses. Biomass is an energy organic matter, especially plant matter that can be converted to fuel and is therefore regarded as potential energy sources. There are various types of biomass such as agricultural waste, industrial waste, animal residues, plant residues etc.

Briquetting is a technology for densification of agricultural residues/wastes to increase their bulk density, lower 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 physics mechanical conversion of loose and tiny particle size materials with or without binder in different shapes and sizes. Osarenwinda and Ihenyen (2012) stated that F.P Veshinakov (a Russian inventor) developed a method of producing briquettes from waste wood, charcoal and hard coal. Briquettes have high specific densities ranging from 1100-1200kg/ m^3 and bulk densities of 800kg/ m^3 as compared to lose agricultural residues which have bulk densities that range from 80kg/ m^3 120kg/ m^3 (Srivastra, 2009). This implies that briquetting can reduce the volume of materials by about 10 times.

Historically, biomass briquetting technology has been developed in two distinct directions. Europe and the United States has pursued and perfected the reciprocating ram/piston press while Japan has independently invented and developed the screw press technology. Although both technologies have their merits and demerits, it is universally accepted that the screw pressed briquettes are far superior to the ram pressed solid briquettes in terms of their storability and combustibility. Japanese machines are now being manufactured in Europe under licensing agreement but no information has been reported about the manufacturing of European machines in Japan.

Now a day's briquetting technology plays an important role in the utilization of -agro- wastes for higher calorific value and high-energy utilization. In this study, a briquetting process will aim to investigate production of an alternate eco-friendly fuel. Rajasthan has major contribution towards yellow revolution in the country. Rajasthan is having large production capacity of mustard with large amount of waste after harvesting.

The calorific value of biomass is high and finally used as fuel for cooking at domestic level or it is burnt on farm as it causes spoilage and disposal problem all over the year. The use of mustard stalk waste for production of briquette improves the net calorific value per unit volume and also helps to reduce deforestation by providing a substitute for fuel wood as well as conventional fuel. The technology of briquetting is defined as the densification process for improving the biomass fuel characteristics.

It is proposed to develop an efficient briquetting machine capable to produce briquettes of biomass that can be used as eco-friendly fuel for cooking in chulha as well as for gasification to produce electricity. It has also potential to sale directly in market for use in boilers. It is worth mentioning that briquetting technology in India has not yet reached at maturity stage and there is considerable scope for design improvements, leading to increased reliability and reduced energy consumption for the briquetting of agricultural residues.

Also, the direct burning of loose agro waste residues like rice husk, palm kernel shells, groundnut shells in conventional manner is associated with very low thermal efficiency, loss of fuel and widespread air pollution. When compressed into briquettes, these problems are mitigated, transportation and storage cost are reduced and energy production by improving their net calorific value per unit is enhanced (Grover et al, 1996). This work is focussed on the preliminary production of briquettes from biomass and cow dung.

For rural communities the most suitable briquetting methods are those which are based on available waste and building materials. The manufacturing should be done in locally made hand operated presses and the briquettes held together mainly by a binder.

1. Briquette making saves trees and prevents problems like soil erosion and desertification by providing an alternative to burning wood for heating and cooking.
2. Briquetting agricultural waste like hulls, husk, corn stocks, grass, leaves and other for a valuable resource.
3. Briquetting engenders many micro enterprise opportunities making the presses from locally available materials, supplying materials, supplying materials and making the briquettes, selling and delivering the briquettes.

The availability of briquette as an alternative fuel to replace firewood can also improve the living conditions of the rural women and children spend most of their time collecting firewood instead of engaging in other income generating activities or attending school.

II.MATERIAL AND METHODS

This chapter deals with the assumption and methodology adopted for briquetting of biomass. The experiment was carried out at Department of Farm Machinery and Power Engineering. The plan of research work had been briefed here. The methodology followed during the course of this research work was discussed in brief under this chapter. The following methodology was adopted.

2.1 Experimental Site

An experimental set up of pellet briquetting system installed by the Renewable Engineering and Technology, Department of Farm Machinery and Power Engineering.

2.2 Climatic condition

Jalgaon has got pretty diverse climate. It is exceptionally hot and dry during summer with temperature reaching as 45 degrees Celsius.

Jalgaon receives about 700 mm rainfall during monsoons, which is followed by pleasant temperature in winter.

2.3 About the Briquetting Machine

It is designed to produce briquettes of 79 mm diameter and 32mm thickness and 25mm diameter passing through the central axis of the briquette length. The goal in this design is to design an efficient briquetting machine capable of compacting biomass by applying pressure. The machine will be manually operated. The design will be transportable, storable.

Table 2.1: Specification of Briquetting Machine

PART	PCS	DESCRIPTION
A	1	Vertical Support Height-1090mm, Width-100mm, Diameter-5mm
B	1	Top Spacer Lenth-200mm, Width-100X 50mm
C	1	Pusher Lever Lenth-1080mm, Diameter-30mm
D	1	Base plate Lenth-200mm, Width-175mm
E	1	Mold box, Lenth-200mm, Diameter-110mm, holes on 3mm centre
G	1	Mold box Cover, Lenth-450mm, Height-150mm
H	1	Piston, Lenth-310mm, Diameter-105mm, hole 32 mm Deep.
I	1	Center pipe Height-700mm, Diameter-30mm.

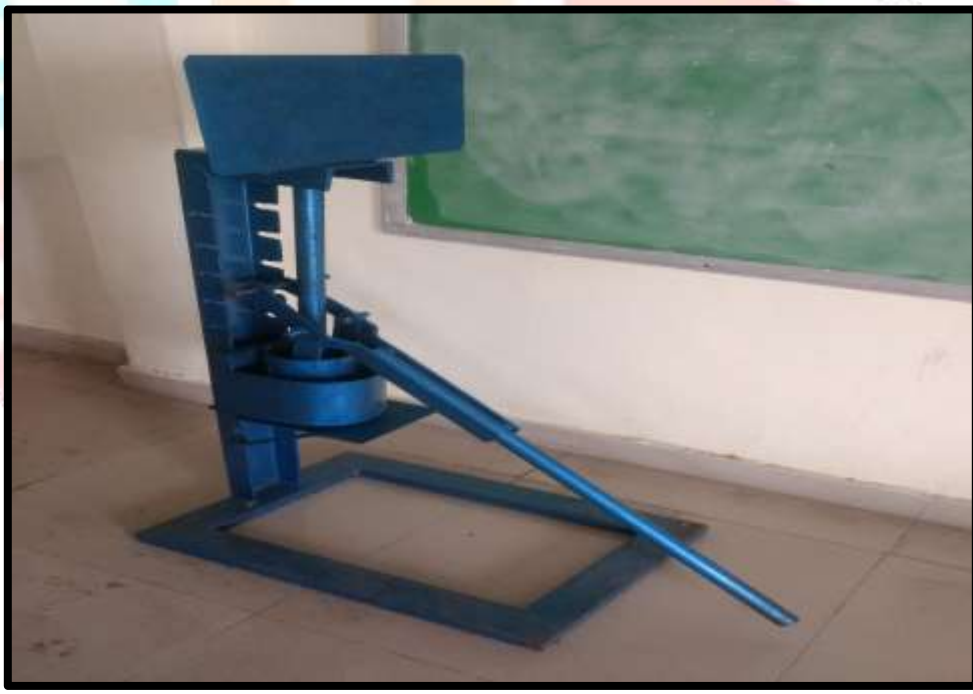

Fig: 2.1 Hand operated piston press briquetting machine.

Briquetting process:

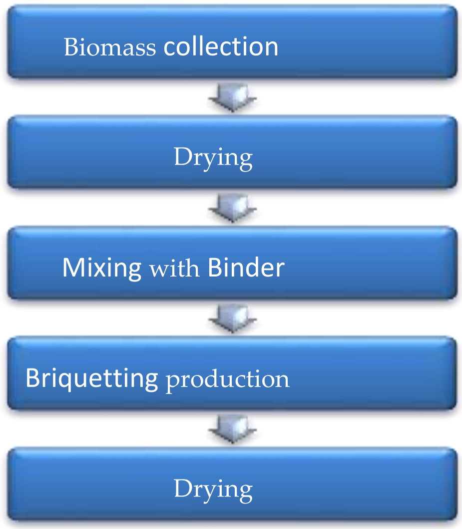

Fig 2.2 Flow chart for briquette process

2.4 Raw material used:

Rice Straw on a one of the abundant lignocelluloses crop residue in the world and in India. It is a major field residue, this is energy input, given the high fuel price and the great demand for reducing green house gas emissions as well as air pollution rice straw is rarely use as source of renewable energy.

Fig .2.3 Rice Straw

- **Rice Husk:**

Rice husk is the hard and protective shell covering over the rice kernel.
For every tones of polished rice, 280 – 300 kg of rice husk is produced .It has medium calorific value and high ash content. Silica crested tubular structural composition of husk prevents uniform and complete burning of these material in high percentage of residual carbon in the ash obtained in common furnace like the step grate furnace. It is highly abrasive.

Fig 2.4 Rice husk

•Saw Dust:

Saw Dust is the composed of fine particle of wood. This material is producing from cutting wood with a saw, hence its name. The particle size ranges from 0.3 – 0.6 mm. The calorific value of saw dust as a raw material is about 3600 kcal / kg.

Fig 2.5 Saw Dust

2.5 Binder materials

•Cow dung:

Cow dung is itself a good fuel when dried in the sun . It can be used as a bind material along with the raw materials. It is a sticky in nature and is recommended to used as binder in proportions ranging from 50 – 85 % with the raw material. The calorific value of fuel can be increased by using the cow dung as its calorific value I also higher

Fig 3.6 Cow Dung

2.6. Mixing with binder

The binding material is used for strengthening the briquettes. The rice straw is mixed with binder. Cow dung was used as binding material, the various combination of measure constituents were tried in order to get briquettes of the desired quality. The different combination **B1** rice straw and cow dung as (10:40), **B2** rice husk, rice straw and cow dung (10:05:40) and B3 saw dust, rice straw and cow dung as (20:05:40) by weight was used for briquette production .The measure quality of water was adds in mixture using thumb rule for that the material should get bind by hand pressing after addition of water.

3.4.5 Briquetting production

The rice straw, rice husk ad saw dusts were used as major constitutes for briquetting with cow dung as a biding material. For the production of briquettes; hand operated machine was use source of power. The material was push forward due to geometry of piston.

2.6 Cost Analysis

The cost analysis was carried for complete briquetting production from rice straw, rice husk, and cow dung by piston press technology. In order to compare the cost of production of different briquettes, the cost of operation of power operated system was also consider for economic analysis. The detailed cost of economic of briquette production is given in Appendix A (C). Following economic indicators were used for cost analysis of briquettes prepared under this study.

Table 2.2- Cost of Fabrication of Hand Operated Briquetting Machine

Sr. No.	Material Specification	Quantity	Rat e	Cost
1	**Steel metal** 1.Vertical Support	1	1000	1000
	2.Base stand	1	1500	1500
	3.Base Plate	1	300	300
	4.Piston	1	200	200
	5.Pressure lever	1	700	700
	6.Top Spacer	1	900	900
				4600
2	**Material**			
	1.Mold	1	1100	1100
				1100
3	**Other Material** 1.Brush	1	100	100
	2.Colour	2	350	700
	3.Polish Paper	4	15	60
				860
	Total Cost			**Rs. 6560**

III.RESULT AND DISCUSSION

The chapter deals with the results and discussion regarding physical, combustion properties and proximate analysis, ultimate analysis of the produced biomass briquettes. Cost analysis and machine performance.

3.1 Comparison of different ratio of biomass

It is obvious that, there different ratio of raw material **B1-** rice straw and cow dung (10:40), **B2 –** rice husk, rice straw, cow dung (10:05:40) and **B3-** saw dust, rice straw, cow dung (20:05:40) was used to produce briquettes have little different in dimension of briquettes. The **B3-** saw dust, rice straw, cow dung in proportion of (10:05:40) produced heavier briquettes as compare to the other two ratio. Diameter is briquettes in each case same. But little different in length was observed. Longest briquettes (6.19) are produced with the **B3-** saw dust, rice straw, and cow dung (20:05:40) followed by the first and second ratio of materials.

3.2 Physical Properties of Produced Briquettes

3.2.1 Density of briquettes

Density of briquettes was determine for relative compactness, easy to transportation and improves the burning quality of briquettes and also used for increase It is clear that rice straw briquette has more density as compare to other biomass. Average weight of briquettes was found different with the different biomass used .it was found maximum for B3 and minimum for the briquette .Average volume of the briquette was also found different for the each type of briquette because of shrinkage of briquette in diameter , it depend on the moisture content of the biomass . Hence the density of B3, briquettes was found maximum 0.91g/cm^3 , this show that means it is more durable and has higher strength for transportation as well as higher burning time as compare to other biomass briquettes.

Table 3.1: Density of briquettes

Briquettes	Average Weight of briquette, (gm)	Average Volume of briquettes, (cm^3)	Average Density of briquette, (kg/m^3)
B1	500	28.09	1.7
B2	450	22.77	1.9
B3	400	28.09	1.4

3.3 Combustion Characteristics:

3.3.1 Proximate Analysis:

The value of proximate analysis of fuels is important because they give an approximate idea about the energy values and extends of pollutant emission during combustion. The percentage is proximate value of the different contents. Data recorded that the maximum moisture content 7.64% was found in B1 briquette and minimum 6.18% in B3 briquette as comparison to other biomass. B1 briquette left maximum ash content (16.23%) as residue while minimum (9.56%) ash content was observed in B3 briquette after combustion. The optimum volatile matter was found in B1 briquette (66.09%) and minimum (63.29%) for B3. The B3 briquette content maximum (18.97%) fixed carbon percentage and minimum (10.01%) was observed on briquettes. The higher calorific value was obtained maximum for B3 as 4086 kcal/kg which emits the high energy as compare to other briquettes and the maximum value was found for B1 as 3356 kcal/kg.

Table 3.2 Proximate Analysis of Produce briquettes

Sr. No	Briquette	Parameters				
		MC (%)	Ash (%)	VM (%)	FC (%)	CV (kcal/kg)
1.	B1	9.77	24.44	64.44	1.35	2389.86
2.	B2	12.00	20.00	63.00	5.00	3188.1
3.	B3	6.66	15.00	62.22	16.12	3227.52

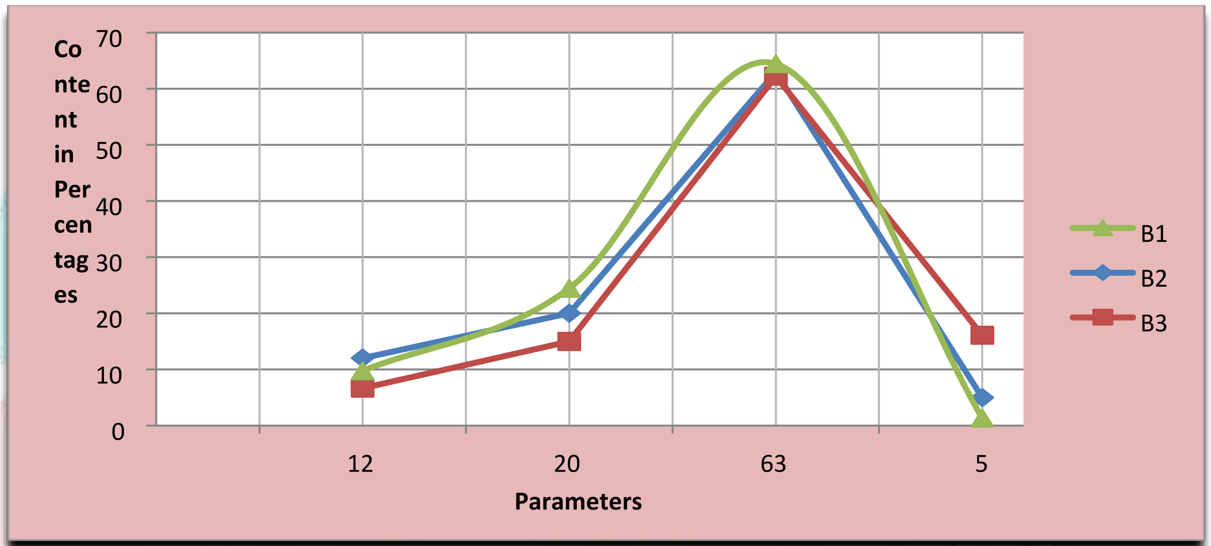

Fig 3.1 Proximate analysis of Briquette

3.4 Ultimate analysis

The ultimate analysis indicates the various elemental chemical constituent such as carbon, hydrogen, oxygen, sulphur. It is useful in determining the quantity of air required for combustion rate and the volume and combustion gases. The composition of the briquette analysis on an as – received basis showed B1 briquette 43.26% carbon, 5.2% hydrogen, 32.72% oxygen, 2.16% nitrogen, and 0.43% sulphur, and B2 briquette 46.46% carbon, 5.6% hydrogen, 30.3% oxygen, 2.27% nitrogen, and 0.56% sulphur.

Table 3.3 Ultimate analysis of briquettes

Sr. No	Content	Briquettes		
		B1	B2	B3
1	C	43.26	46.42	49.86
2	H	5.2	5.6	5.72
3	O	32.72	30.3	33.16
4	N	2.16	2.27	1.31
5	S	0.43	0.56	0.39

And B3 briquette 49.86% carbon, 5.72% hydrogen, 33.16% oxygen, 1.31% nitrogen and 0.39% sulphur. The results agree with the observation made by Chaney (2010) who reported that analysis of biomass using the gas analysis procedure reveled the principle constituents as carbon, which comprises between 30% to 60% of the dry matter and typically 30% to 40% oxygen. Hydrogen, being the third main constituent, makes up between about 5% and 6% and nitrogen and sulphur normally makes up less than 1% of dry biomass.

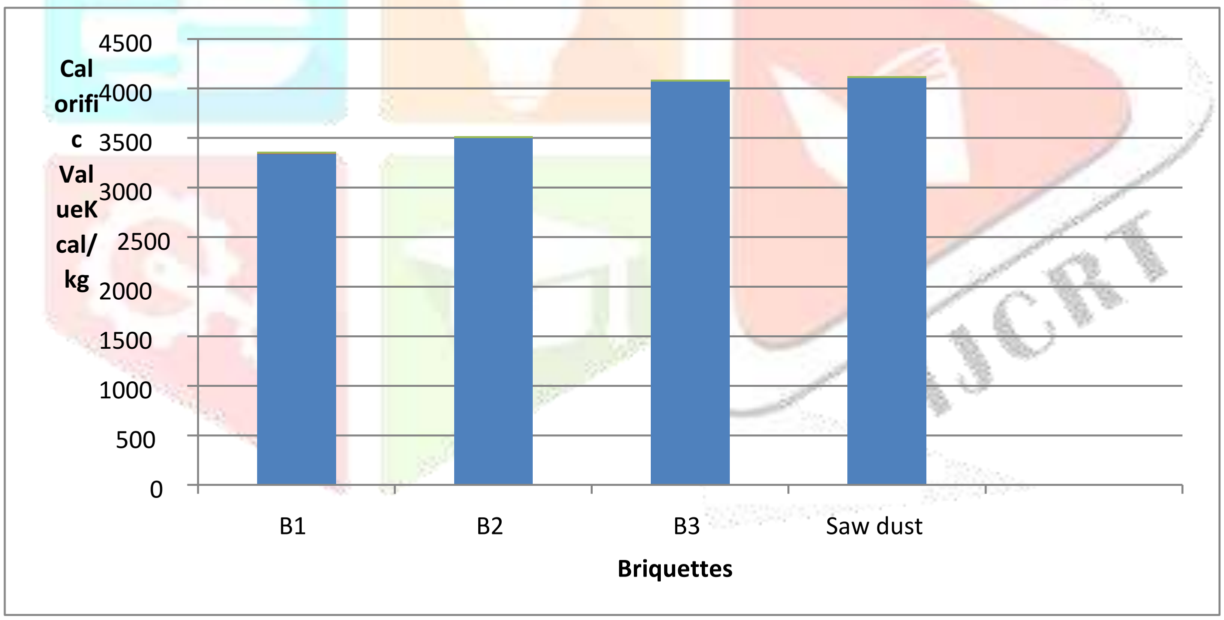

Fig 3.2: Calorific Value of briquette

3.5 Cost Analysis

Data on cost of production of briquettes with different biomass is presented. It is clear that cost of production varies with the different type of biomass used for briquette production.

Table 3.4 Cost analysis of briquette production.

Sr. No	Briquette	Cost of production. Rs. (Machine unit+ briquetting)	Gross income (Rs/h)	Net income (Rs/h)	Cost of production (Rs/kg)
1	B1	123.63	164	40.37	0.98
2	B2	128.63	184	55.37	1.2
3	B3	138.63	188	49.37	1.05

The cost of operated machine was remaining constant Rs. 23.63 per hour for all types of biomass briquette production, while cost of production of briquettes was determined different for each biomass due to its purchasing rate. Cost of production by power operated machine was found maximum for the production of B3 briquettes as Rs. 138.63 per hour and minimum for the B1 briquette as Rs. 123.63 per hour. The gross income (Rs/h) from the selling of briquettes @ 4 Rs/kg was found maximum for the B3 briquettes as Rs.188 per hour and minimum for the B1 and briquettes as Rs. 164.00. The net income generated was found maximum for the B2 briquettes as Rs. 55.37 per hour and minimum for the B3 Rs. 49.37 per hour. Hence, the briquette production from the B2 using power operated machine was found more profitable compared to other biomass briquettes.

•**Cost of operation of Production:**

The cost of operation of briquetting production by power operated machine was calculated by piston press machine.

Rice Straw= Rs 1 /kg

Rice Husk= Rs 1 /kg

Cow Dung = Rs 1 /kg

Saw Dust= Rs 2 /kg

1)**B1 (Rice straw + Cow dung): (10:40)**

Material cost = 10×1+40×1
= 10+40
= 50
Cost of production = labor cost + material cost
= 50+ 50
= 100 /hr.
Income from briquette sold @4 Rs/kg
Production = 41 kg/hr.
Gross income = 41×4
= Rs 164 /hr
Net income = Gross income – Cost of production
= 164-100
= Rs 64 /kg.
Cost of production of 1 kg briquette = 64/41
= 1.56 Rs/kg.

2)B2 (rice husk + rice straw + cow dung): (20:5:40)

Material cost = 10×1+ 5×1+ 40×1
= 10+5+40
= 55

Cost of production = labor cost + material cost
= 50+ 55
= 105 /hr.
Income from briquette sold @ 4 Rs/kg
Production = 46 kg/hr.
Gross income = 46×4
= Rs 184 /hr
Net income = Gross income – Cost of production
= 184-105
= Rs 79 /kg.
Cost of production of 1 kg briquette = 79/41
= 1.92 Rs/kg.

3)B3 (Saw dust + rice straw + cow dung): (10:5:40)

Material cost = 10×2 + 5×1+ 40×1
= 20+5+40
= 65
Cost of production = labor cost + material cost
= 50+ 65
= 115 /hr.
Income from briquette sold @ 4 Rs/kg
Production = 47kg/hr.
Gross income = 47×4
= Rs 188 /hr
Net income = Gross income – Cost of production
= 188-115
= Rs 73 /kg.
Cost of production of 1 kg briquette = 73/47
= 1.55 Rs/kg.

IV.SUMMARY AND CONCLUSIONS

Recent estimate 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. Briquetting is a technology for densification of agricultural residues or wastes to increase their bulk density reduce their moisture 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.

In this study, an appropriate, cost effective an low density briquette produce by different biomass like rice straw, and saw dust on the basis of varies studies conducted in the present research work following result are obtained.

1. Comparison of different biomass ratio of the briquette production was carried out. The B3 – saw dust, rice straw, and cow dung in proportion of (20:05:40) produced heavier briquette as compared to the other two ratio. Diameter of briquette in the each case are same. But little in length observed. Longest briquette (6.19cm) is produced with the B3 briquette followed by the first and second ratio of material.

2. The physical properties and proximate analysis was carried out for produced briquette. Maximum compressed density 0.91 g/cm^{3}wasobtained in B3 briquette. Maximum moisture content (63.11%) was found in B2 – rice husk, rice straw, cow dung (10:05:40), briquette and minimum moisture content (53.64%) B3 briquette.

3. Maximum (16.23%) and minimum (9.56%) ash content was obtained in B1 rice straw and cow dung (10:40), briquette and B3 briquette respectively. Optimum volatile material was found in B1 briquette as 66.09% and minimum 63.2% for

B3 briquette, maximum fixed carbon percentage (18.97%) and minimum (10.03%)was determined in B3 and B1 briquette respectively. The higher calorific value was obtained for B3 briquette as 4086 kcal/kg which emits the higher energy as compared to other biomass.

4. Ultimate analysis indicate the various elemental chemical constituent such as carbon, hydrogen, oxygen, sulphur, in B1 briquette 43.26% carbon, 5.2% hydrogen, 32.72% oxygen, 2.16% nitrogen, 0.43% sulphur, and B2 briquette 46.46% carbon, 5.6% hydrogen, 30.3% oxygen, 2.27% nitrogen, and 0.56% sulphur, and B3 briquette 49.86% carbon, 5.72% hydrogen, 33.16% oxygen, 1.31% nitrogen, and 0.39% sulphur.
5. Comparison of combustion behavior of produced or commercial briquette that the for B3 briquette have highest highest calorific value among B1 and B2 that is 4086 kcal/kg, but it is less as compared to coal (4726 kcal/kg), and it is also show that the ratio of water evaporated to fuel used coal contains the higher value that is 0.61 ml/g that the rest three.
6. The cost of briquette production per hour was maximum Rs 135.63 for B, Rs 123.63 and Rs. 128.63 for B1 and B2 briquettes respectively.

4.1 Conclusion

1. Rice straw produced in large quantity as a byproduct of crop production can be converted into high quantity and durable soil fuel briquette that will be suitable for both domestic and industrial energy production.
2. The power operated machine can be used to produce low density briquette which can use as domestic fuel in local stove and for industrial purpose.
3. The heating value calculated at the optimum biomass binder ratio were sufficient to produce heat required for household cooking in rural communities and small scale industrial application like furnace and boiler.

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