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Using Agricultural Residues as a Biomass Briquetting: An Alternative Source of Energy

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Abstract: *Every year millions of tons of agricultural wastes are generated which are either destroyed or burnt inefficiently in loose form causing air pollution. These wastes can be recycled & can provide a renewable source of energy by converting biomass waste into high density - fuel briquettes without addition of any binder. This recycled fuel is beneficial for the environment as it conserves natural resources. For this the biomass briquetting is the main renewable energy resource.*

In this paper the raw material including rice husk, coffee husk, saw dust, ground nutshell and cotton stalks etc. were densified into briquettes at high temperature and pressure using different technologies. We discuss the various advantages, factors that affecting the biomass briquetting and comparison between coal and biomass briquetting. The details of the study were highlighted in this paper.

Keywords- *Biomass, Briquetting, Potential, Process, Technologies*

I. Introduction

Many of the developing countries produce huge quantities of agro residues but they are used inefficiently causing extensive pollution to the environment. The major residues are rice husk, coffee husk, coir pith, jute sticks, bagasse, groundnut shells, mustard stalks and cotton stalks[1,2]. Sawdust, a milling residue is also available in huge quantity. Apart from the problems of transportation, storage, and handling, the direct burning of loose biomass in conventional grates is associated with very low thermal efficiency and widespread air pollution. The conversion efficiencies are as low as 40% with particulate emissions in the flue gases in excess of 3000 mg/ Nm^2. In addition, a large percentage of unburnt carbonaceous ash has to be disposed of. In the case of rice husk, this amounts to more than 40% of the feed burnt. As a typical example, about 800 tonnes of rice husk ash are generated every day in Ludhiana (Punjab) as a result of burning 2000 tonnes of husk. Briquetting of the husk could mitigate these pollution problems while at the same time making use of this important industrial/domestic energy resource. The briquettes can be used for domestic purposes (cooking, heating, barbequing) and industrial purposes (agro-industries, food processing) in both rural and urban areas[3]. Thus Biomass briquetting is the densification of loose biomass material to produce compact solid composites of different sizes with the application of pressure. Briquetting of residues takes place with the application of pressure, heat and binding agent on the loose materials to produce the briquettes [4]. The potential of biomass briquetting in India was estimated at 61,000 MW, while the estimated employment generation by the industry is about 15.52 million and the farmers earn about $ 6 per ton of farm residues. The end use of briquettes is mainly for replacing coal substitution in industrial process heat applications (steam generation, melting metals, space heating, brick kilns, tea curing, etc) and power generation through gasification of biomass briquettes [5]. Being derived from renewable resources, the briquette has superior qualities as well as environmental benefits in comparison with coal, as shown in Table 1.1.

Table 1.1: Comparison Coal and biomass characteristics

Fuel	Density g/cm^3	Calorific value Kcal/Kg	Ash content %
Coal	1.3	3,800-5,300	20-40
Biomass briquettes from :			
Saw dust	1.1	4,600	0.7
Ground nutshell	1.05	4,750	2.0
Rice husk	1.3	3,700	18.0
Sawdust cotton	1.12	4,300	8.0

Source (Farm Waste Utilization – Singh)

II. Advantages of biomass briquetting

Briquettes produced from briquetting of biomass are fairly good substitute for coal, lignite, Firewood and offer numerous advantages

- This is one of the alternative methods to save the consumption and dependency on fuel wood.
- Densities fuels are easy to handle, transport and store.
- They are uniform in size and quality.
- The process helps to solve the residual disposal problem.
- The process assists the reduction of fuel wood and deforestation.
- It provides additional income to farmers and creates jobs.
- Briquettes are cheaper than coal, oil or lignite once used cannot be replaced.
- There is no sulphur in briquettes.
- There is no fly ash when burning briquettes.
- Briquettes have a consistent quality, have high burning efficiency, and are ideally sized for complete combustion.

III. Disadvantages of biomass briquetting

- High investment cost and energy consumption input to the process
- Undesirable combustion characteristics often observed e.g., poor ignitability,smoking, etc.
- Tendency of briquettes to loosen when exposed to water or even high humidity weather

IV. Factors Affecting Densification/ Briquetting

The factors that greatly influence the densification process and determine briquette quality are:

4.1 Temperature and pressure:

- It was found that the compression strength of densified biomass depended on the temperature at which densification was carried out.
- Maximum strength was achieved at a temperature around 220°C.
- It was also found that at a given applied pressure, higher density of the product was obtained at higher temperature.

4.2 Moisture Content:

- Moisture content has an important role to play as it facilitates heat transfer.
- Too high moisture causes steam formation and could result into an explosion.
- Suitable moisture content could be of 8-12%.

4.3 Drying:

- Depends on factors like initial moisture content, particle size, types of densifier, throughout the process.

4.4 Particle Size and Size reduction:

- The finer the particle size, the easier is the compaction process.
- Fine particles give a larger surface area for bonding.
- It should be less that 25% of the densified product.
- Could be done by means of a hammer mill.
- Wood or straw may require chopping before hammer mill.

V. Biomass briquetting process

Briquetting is the process of densification of biomass to produce homogeneous, uniformly sized solid pieces of high bulk density which can be conveniently used as a fuel. The densification of the biomass can be achieved by any one of the following methods: (i) Pyrolysed densification using a binder, (ii) Direct densification of biomass using binders and (iii) Binder-less briquetting [6]. Depending upon the type of biomass, three processes are generally required involving the following steps:

5.1 Sieving - Drying - Preheating - Densification - Cooling – Packing
5.2 Sieving - Crushing - Preheating - Densification - Cooling – Packing
5.3 Drying - Crushing - Preheating - Densification - Cooling – Packing

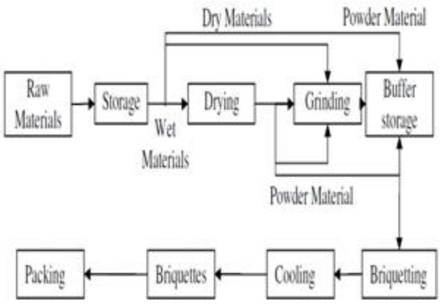

Figure 5.1 Flow diagram of biomass briquette production

When sawdust is used, process A is adopted. Process B is for agro- and mill residues which are normally dry. These materials are coffee husk, rice husk, groundnut shells etc. Process C is for materials like bagasse, coir pith (which needs sieving), mustard and other cereal stalks.

VI. Biomass briquetting technologies

Biomass densification represents a set of technologies for the conversion of biomass residues into a convenient fuel. The technology is also known as briquetting or agglomeration. Depending on the types of equipment used, it could be categorized into five main types:

- Piston press densification
- Screw press densification
- Roll press densification
- Pelletizing
- Low pressure or manual presses

6.1 Piston press densification

There are two types of piston press 1) the die and punch technology; and 2) hydraulic press. In the die and punch technology, which is also known as ram and die technology, biomass is punched into a die by a reciprocating ram with a very high pressure thereby compressing the mass to obtain a compacted product. The standard size of the briquette produced using this machine is 60 mm, diameter. The power required by a machine of capacity 700 kg/hr is 25 kW. The hydraulic press process consists of first compacting the biomass in the vertical direction and then again in the horizontal direction. The standard briquette weight is 5 kg and its dimensions are: 450 mm x 160 mm x 80 mm. The power required is 37 kW for 1800 kg/h of briquetting [7]. This technology can accept raw material with moisture content up to 22%. The process of oil hydraulics allows a speed of 7 cycles/minute (cpm) against 270 cpm for the die and punch process. The slowness of operation helps to reduce the wear rate of the parts. The ram moves approximately 270 times per minute in this process.

6.2 Screw press

The compaction ratio of screw presses ranges from 2.5:1 to 6:1 or even more. In this process, the biomass is extruded continuously by one or more screws through a taper die which is heated externally to reduce the friction [8]. Here also, due to the application of high pressures, the temperature rises fluidizing the lignin present in the biomass which acts as a binder. The outer surface of the briquettes obtained through this process is carbonized and has a hole in the centre which promotes better combustion. Standard size of the briquette is 60 mm diameter.

6.3 Roller Press

In a briquetting roller press, the feedstock falls in between two rollers, rotating in opposite directions and is compacted into pillow-shaped briquettes. Briquetting biomass usually requires a binder. This type of machine is used for briquetting carbonized biomass to produce charcoal briquettes.

6.4 Pelletizing

Pelletizing is closely related to briquetting except that it uses smaller dies (approximately 30 mm) so that the smaller products are called pellets. The pelletizer has a number of dies arranged as holes bored on a thick steel disk or ring and the material is forced into the dies by means of two or three rollers. The two main types of pellet presses are: flat/disk and ring types. Other types of pelletizing machines include the Punch press and the Cog-Wheel pelletizer. Pelletizers produce cylindrical briquettes between 5mm and 30mm in diameter and of variable length. They have good mechanical strength and combustion characteristics. Pellets are suitable as a fuel for industrial applications where automatic feeding is required. Typically pelletizers can produce up to

1000 kg of pellets per hour but initially require high capital investment and have high energy input requirements.

6.5 Manual Presses and Low pressure Briquetting

There are different types of manual presses used for briquetting biomass feed stocks. They are specifically designed for the purpose or adapted from existing implements used for other purposes. Manual clay brick making presses are a good example. They are used both for raw biomass feedstock or charcoal. The main advantages of low-pressure briquetting are low capital costs, low operating costs and low levels of skill required to operate the technology. Low-pressure techniques are particularly suitable for briquetting green plant waste such as coir or bagasse (sugar-cane residue). The wet material is shaped under low pressure in simple block presses or extrusion presses. The resulting briquette has a higher density than the original material but still requires drying before it can be used. The dried briquette has little mechanical strength and crumbles easily.. The use of a binder is imperative.

VII. Economic analysis of biomass briquetting

About 70 biomass briquetting machines were installed in India by 1995. By 2007 the number of briquetting plants increased to 250. As the technology is locally mastered and economically viable, the number is increasing annually. Two biomass briquetting technologies dominate the Indian market: the ram and die machine and the screw machine. These two machines use different processes to densify sawdust and agricultural waste, and the end products also have different densities and shapes. The two types of machines are locally manufactured. A third kind of press, the hydraulic press has not been used in India and is considered unsuitable for Indian raw materials. The most common raw materials for heated-die screw-press briquetting machines are saw dust and rice husk.

In this paper economic analysis of biomass briquetting is studied. The table 7.1 presents the values of different heads for economic analysis of biomass briquetting factory in India. Table 7.2 presents the economic analysis in India.

Table 7.1 Values of different heads for economic analysis of biomass briquetting factory in India

No.	Head (unit)	Value (Rs.)
1	Initial cost of machine	12,000,000
2	Life (yr)	10
3	Annual use time (hr)	960
4	Interest on cost (%)	15
5	Depreciation (%)	10
6	Junk value (%)	10
7	Annual repair	5% of the initial cost of machine
8	Labour required	4
9	Labour rate (Rs./hr)	15
10	Av. machine capacity (t/hr)	1
11	Fuel consumption (kwh)	9
12	Fuel cost (Rs/kwh)	4.68 (commercial charges)
13	Oil and lubricant charges	20% of fuel cost
14	Working capital	12,000,000

Table 7.2 Economic analysis for biomass briquetting factory

Item	Value (Rs.)
Fixed costs	429,000
Variable costs	1,298,035.2
Total cost /yr	1,727,035.2
Revenue :	
1-Returns from 960 tons of briquettes at Rs. 3.0 per kg	
2- net returns(assuming 5% losses during storage)	2,880,000
3-Total revenue per yr	2,736,000
4- Total cost incurred per year	1,727,035.2
5- Net profit per year (3-4)	1,008,657.2
6- Total initial cost	1,825,000
7- Payback period	6 months

VIII. Conclusion

It is concluded that two biomass briquetting technologies dominate the Indian market: the ram and die machine and the screw machine. These two machines use different processes to densify sawdust and agricultural waste, and the end products also have different densities and shape. The hydraulic press has not been used in India and is considered unsuitable for Indian raw materials. The most common raw materials for heated-die screw-press briquetting machines are saw dust and rice husk. The economic analysis of biomass briquetting in India is shown in table 7.2. We conclude that apart from the transportation, storage and handling problems biomass briquetting have several advantages over coal, oil etc. so we have to use it for our domestic purposes like heating and cooking. Thus biomass briquetting an alternative source of energy.

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