Challenges of Wet Briquetting from Locally Available Biomass with Special Reference to Assam

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ABSTRACT:

This study aims at solving energy crisis in rural area via fuel briquettes from locally available biomasses by a well proven technique called wet briquetting. This technique has different operational stages of briquette production. The challenges faced during each operational stage of briquette production are discussed and solutions of the respective problems are tried to be found as well in order to perfect the method. An economic analysis of this method is also done to show profitability margin.

KEYWORDS: *Wet briquetting, biomass, briquetting, economic analysis, durability*

I. INTRODUCTION

With growing development of Indian economy, energy consumption is increasing day by day. Energy consumption in household shares 40% of total energy consumption all over India. Moreover about 30% of total population resides in the villages which consider a good sum of 0.36 billion of total population. In the domestic household sector cooking is the largest end user accounting for almost 90 percent of the total domestic energy use. The rural masses mostly depend on biomass or kerosene for their energy needs. Gradual price hike in crude oil in international market has greatly affected the rural India. In order to cushion fuel price hike, the rural masses are shifting more to biomass. Deforestation for fuel wood has graven the problem of climate change and global warming. The seriousness of the problem can be sensed by seeing depleting forest reserves. This trend needs to be checked from environment point of view. Development of renewable energy sources helps to reduce the degree of dependence on energy imports as well as it can be a tool for curbing carbon emission. So, emphasis is given to the renewable energy program.

The energy requirement in rural household is mainly for cooking and sometimes heating in colder regions. So there is enormous demand for fuel wood. The one option could be the densification or briquetting to counter this problem. It has a great scope in rural India as India produces large amounts of bio waste material every year. This includes rice straw, wheat straw, coconut shells and fibers, rice husks, stalks of legumes and sawdust. Some of this biomass is just burnt in air; some like rice husk are mostly dumped into huge mountains of waste. Open-field burning has been used traditionally to dispose of crop residues and sanitize agricultural fields against pests and diseases. Instead of burning down these wastes or letting to decompose in open air which raises the problem of GHG production, it can be converted to bio fuels to produce power either by direct combustion or transforming these loose biomass to solid fuels [1, 2]. So these processes become automatic candidates for financing under CDM mode [3].

Biomass briquetting is the densification of loose biomass material to produce compact solid composites of different sizes with the application of pressure [4]. Three different types of densification technologies are currently in use. The first, called pyrolizing technology relies on partial pyrolysis of biomass, which is mixed with binder and then made into briquettes by casting and pressing. The second technology is direct extrusion type, where the biomass is dried and directly compacted with high heat and pressure. The last type is called wet briquetting in which decomposition is used in order to breakdown the fibers. On pressing and drying, briquettes are ready for direct burning or gasification. Some of the advantages of briquettes are given below

[1] This is one of the alternative methods to save the consumption and dependency on fuel wood.
[2] Densities fuels are easy to handle, transport and store.
[3] They are uniform in size and quality.
[4] The process helps to solve the residual disposal problem.
[5] The process assists the reduction of fuel wood and deforestation.

[6] Indoor air pollution is minimized.
[7] Briquettes are cheaper than COAL, OIL or LIGNITE
[8] There is no sulfur in briquettes.
[9] There is no fly ash when burning briquettes.
[10] Briquettes have a consistent quality, have high burning efficiency, and are ideally sized for complete combustion.
[11] Combustion is more uniform compared to coal.
[12] Unlike coal, lignite or oil, briquettes are produced from renewable source of energy, biomass.
[13] Loading/unloading and transportation costs are much less and storage requirement is drastically reduced.
[14] Briquettes are clean to handle & can be packed in bags for ease of handling & storage.
[15] Briquettes are usually produced near the consumption centers and supplies do not depend on erratic transport from long distances.
[16] The technology is pollution free and Eco-friendly.
[17] The briquette is easy to ignite.
[18] Continuous burning and long burning duration.

II. CHALLENGES IN WET BRIQUETTING TECHNOLOGY

The conventional briquetting technologies are capital intensive and unfriendly for smaller scale production. There is a technique called wet briquetting which involves less capital and very low technical machinery which can suit the rural environment for production of briquettes. It is possible to form briquettes from waste crop residues, using a wet process with a hand operated press [5, 6]. First of all suitable biomass is selected. The biomass is decomposed under control environment which is later on pressurized to briquettes. The steps are given below
1) Selection of suitable biomass
2) Decompose biomass
3) Pressurization to form wet briquettes
4) Sun dry wet briquettes

A. Parameters of Selection of biomass

While selecting biomass for wet briquetting, emphasis is given on the local availability of certain type of biomass with lower lignin and ash content. Rice straw, wheat stalks, maize stalks, cotton stalks and barley stalks are some locally available loose biomass or agro residue in rural India. But, the entire available agro residue is not suitable for wet briquetting. For wet briquetting, biomass material is needed to be decomposed before compaction to briquettes. The decomposition period of lignocellulosic biomass depends largely on their lignin content. High lignin containing biomass takes longer time for decomposition. Similarly, biomass having higher ash content is not acceptable for conversion to solid fuel as ash forms clinkers and chances of buildup on the burn pot surfaces, restricting air flow and influencing the removal of ash from the . High ash content also means more frequent dumping of the ash pan. Table 1 shows lignin and ash contents of some locally available agro residues.

Table 1

Lignin and ash contents of some locally available biomasses [7, 8, 9]

Fiber source	Rice straw	Banana fronds	Wheat straw	Barley straw	Maize stalks	Cotton stalks
Lignin (wt %)	9.9	8.0	8.9	13.8	41.0	21.5
Ash (wt %)	17.5	4.7	5.5	10.3	10.2	3.7

B. Parameters governing decomposition of biomass:

Though for other purposes, information on decomposition of lignocellulosic biomass like rice straw is available. Studies on decomposition of brittle rice straw having lower cellulose content revealed that rice straw decomposes fast by anaerobic mechanism when it is incorporated to soil under continuously flooded condition [10]. It is found that at 25ºC under non-flooded conditions, the equivalent of 55% of the rice straw added was mineralized compared to 27% at 58ºC, after 160 days of incubation in soil. Under flooded conditions, the equivalent of 47% of the straw C added was mineralized at 25ºC compared to 19% at 58ºC [11]. The temperature range for optimal decomposition of organic matter is between 52ºC and 60ºCfor aerobic condition [12, 13]. On other hand Acharya et. al., 1935 [14] found that aerobic decomposition of rice straw at about 30ºC is more than that of anaerobic decomposition. He conducted tests in aerobic, anaerobic and water logged condition on rice straw at 30ºC.

Among all condition, decomposition was highest in aerobic condition within a period of 6 months. But lignin decomposition was found in higher amount in water logged condition in which biomass specimen was kept one inch below water level. The tests show same trend on use of ammonia. Decomposition of biomass feedstock can also be enhanced by application of some fungi or bacteria. Hesham et al. 2006 [15] performed tests on rice straw with actinomycetes and observed a weight loss of 61% within a period of 2months. The high carbon content, high solid content and the low nitrogen content of rice straw require the use of other sources of nitrogen and water to get the proper substrate for the anaerobic digestion process. Nitrogen can be added in inorganic form (ammonia) or in organic form (urea, animal manure or food wastes). Addition of chopped rice straw to dairy manure enhanced the anaerobic digestion process and increased the methane production rate (Hills & Roberts 1981) i.e. more methane means higher carbon mineralization. Somayaji & Khanna et al., 1994 [16] confirmed that addition of chopped rice straw to cattle dung enhanced the organic matter degradation to a high extent (35–51%).

Apart from other biomass, lignocellulosic biomass like rice straw needs some pre-treatment to enhance its degradation. Zhang& Zhang et al., 2006 [17] showed that without thermal pre-treatment, grinding resulted in a significant improvement in terms of solid reduction. Jagdish et al. [18] in his study on wheat straw found that straw size should not increase 1cm. Lower size residue becomes more accessible for the initial microbial attack and led to an enhanced stabilization of microbial biomass. The impact of temperature is immense and it is widely accepted environmental variable. Finstein and Morris, 1975; Finstein et al., 1986 [19] found that minimum temperature level is necessary for high rates of decomposition. MacGregor et al. (1981) [12] found that optimum composting temperatures, based on maximizing decomposition, were in the range of 52–60ºC for aerobic condition. This evidence has supported by their findings (Bach et al., 1984; McKinley and Vestal, 1984) [13]. On the other hand maximum yield in case of anaerobic condition was found at 25ºC.Moisture as variable impacts metabolic and physiological activities of micro organism as it serves as medium for transport of dissolved nutrients [20]. Too much moisture is not desirable as it inhibits the decomposition by making the process anaerobic due to water logging (Schulze et al., 1962; Tiquia et al., 1996).Many investigators have found that 50–60% moisture content is suitable for efficient composting[13,19] . Liang et al.2002 [21] found in his study that 50% is the minimal moisture requirement and even higher decomposing rate can be obtained by having 60-70% moisture. By increasing the moisture content higher temperature requirement can be offset.

C. Factors influencing the final briquette quality during pressurization

It is important to understand the factors that govern compacting. Chaney et. al., 2005,[22] said that some principle factors are the design of die, the method of load application, loading rate , maximum pressure applied, the time for which that pressure is maintained and material characteristics, for example particle size and moisture content. Usually briquetting needs higher amount of pressure for compression. But natural decomposition process can be used to break fibers down and it facilitates bonding [22]. The minimum pressure requirement is about 1Mpa or less. After compression in a die of a hand press, the briquettes relax and try to come to its original shape. It decides the stability and durability. The stable briquettes have less post die expansion [23] found that the relaxation behavior of briquettes mostly depend on the type of residue. For most types of biomass, maximum rate of relaxation occurred after 10 minutes of removal from die followed by a decreasing relaxation for next 2 hours. Chin et al. [23] propose the following relationship between the relaxed densities and applied die pressure:

$$\rho = a \ln P + b$$

where ρ is the relaxed density, P is the compaction pressure and a, b are empirical constants.

Dwell time during compression is decisive for stability of product. Chin et al., 2004 found that with increase in dwell time, maximum length reduction can be obtained as well as smaller post die relaxation. According to Chaney et al. [22], a hold time greater than 40 seconds does not require rigorous control of this variable can yield briquettes of repeating density. Particle size of biomass feedstock is crucial for briquetting. Kaliyan and Morey (2006) [24]indicated that generally, the finer the grind, the higher the quality of compact in case of dry briquetting. Moisture content plays an important role in briquetting of biomass materials. If the moisture content is too high there is a decrease in density and stability. On the other hand, Bellinger et al. [26] showed that energy required to form briquettes is less when there is higher moisture content in the feed stock. Higher moisture in biomass feedstock is desirable for wet briquetting.

Particle size of biomass feedstock is crucial for briquetting. Kaliyan and Morey (2006) [24]indicated that generally, the finer the grind, the higher the quality of compact in case of dry briquetting. In wet briquetting too same trend is followed. Density of briquettes influences its durability which in turn represents handling characteristics. Durability represents the handling characteristics. Durability for briquettes is measured by following ASAE S269.2 method [25]. According to Saptoadi et al., 2008, briquettes should not be more than 100 g for proper burning [27]. Moreover, a centre hole in briquettes facilitates easier burning of briquettes. Particle size also plays important role in combustion as the voids between particles will be less and less space is available for mass diffusion e.g. water, volatile matter etc [27].

D. Parameters influencing drying of wet briquettes

After the decomposed biomass material are given suitable cylindrical shape with centre hole by a piston press, it should be removed carefully from die and moved aside to dry with minimum handling[25, 28]. It should be ensured that these are placed at a windy place so that briquettes could get even air flow across their whole surface. Fuel briquettes generally take three to six days to dry direct sunlight and in cloudy condition it may increase up to eight to then days.

III. ECONOMIC VIABILITY OF WET BRIQUETTING

Before setting up any enterprise, the cost benefit analysis is a must. Then we can forecast the profitability of the enterprise. Sometimes a project even if it looks good may turn out to be fruitless in terms of economic analysis. To be a successful project, it must overcome economic barrier. Therefore, to understand fully the financial feasibility of briquette production, we need to do some preliminary feasibility exercise. The main objective of economic analysis is to compare the cost of briquette production per day per family to cost f fuel wood usage per day per family [28].

Table 1: Parameters for economic analysis

Parameters	**Values**
Daily wood requirement for a family of 4 members	7
Cost of wood per kg(Taking average), Rs	5
Worker cost per day ,Rs	150
Requirement of worker for the project	6
Maintenance and equipment cost added to worker cost,%	15
Briquettes used per family at an average	12-15

Daily fuel wood cost for the family= Rs 35 per day
Labour cost per day per person=Rs 150
Total labour cost for 6 labors = Rs 900 which will be producing briquettes between 750-1000 briquettes.
Adding 15% for other minor costs, such as equipment and maintenance = Rs 1035.
This is then divided by the 50 families who would be served by this production to arrive at a daily cost of fuel briquettes of Rs 20.7 per day per family.
Therefore, in comparison to the Rs 35 a day for fuel wood, the cost of making fuel briquettes at Rs 20.7 provides a feasible margin for the group to begin briquette production.

Moreover, the cost of production of each briquette can be determined by

$$\text{Cost of briquette} = \frac{6 \times \text{Average Daily Labour cost}}{\text{Average daily Production of 1000 briquettes}}$$

So, in this case the cost of each briquette comes around Rs 0.9. Also it has been noticed from extensive studies an ideal family having 4 to 5 members uses 12-15 briquettes per day. So, total fuel cost of a family is around Rs 18 which is about Rs 17 cheap than that of wood.

IV. RESULTS AND DISCUSSIONS

Wet briquetting depends on the decomposition of biomass materials such as various crop residues. From the above studies we come to opinion that decomposition of finely chopped biomass at anaerobic condition is faster. Moreover, by keeping biomass materials in heap condition at sun will enhance decomposition. However, during compaction of briquettes, wet biomasses need to be kept on pressing at least for 40 seconds and compaction pressure should not be less than 1 Mpa for the purpose to yield good quality briquette. During drying of briquettes, wet briquettes should be placed at windy places so that air circulates around its surfaces. The studies also indicate that briquette should be dried up to 8% moisture content otherwise it will cause severe smoke formation during burning. It has also come to notice that briquettes weighing above

100 gm shows problem during burning and handling. Therefore optimum weight should be less or equal to 100 gm. A cylindrical shaped briquette with a central hole burns at ease .

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