Waste Minimization by Way of Biomass Renewable Energy Resources

Gunjan Sharma[1], Leena Verma[1], Sunita Kumari[1], Sumit Dabhi[1], Dalip Kumar[2]
[1]*Department of Biotechnology, PGGCG-42, Chandigarh*
[2]*Department of Zoology, PGGCG-42, Chandigarh*

Abstract - The importance of energy for a nation's development cannot be over emphasized. This is because energy is the corner stone of economic and social development. As a result of the growing worldwide concern regarding environmental impacts, particularly climate change from the use of fossil fuels, the volatile fossil fuel market and the need for an independent energy supply to sustain economic development, there is currently a great deal of interest in renewable energy in general and biomass energy in particular. Biomass is one of the most common and easily accessible renewable energy resources and represents a great opportunity as a feedstock for bioenergy.Globally, 140 billion metric tons of biomass is generated every year from agriculture. This volume of biomass can be converted to an enormous amount of energy and raw materials equivalent to approximately 50 billion tons of oil. Biomass fuel that has gained national attention with rising fossil fuel prices. Biomass leaf pellets are one kind of fuels that contains as high calorific value as traditional fuels. Besides, as biomass pellets can be made from low cost material, there is a great demand in the market. The leaf pellets will burn fully, evenly and after burning with little smoke and ash. The various dimensions of biomass as source of energy and minimization of waste will be highlighted.

Keywords - Biomass, Waste, Renewable Energy, Pellet Biofuel

I. INTRODUCTION

The use of biomass as an energy source has been of great interest to members of the agricultural community in recent years because of its potential as a carbon and domestically producible type of fuel. Biomass can be grown in a variety of forms, such as fast growing trees, perennial grasses, and agricultural crop residues, fallen autumn waste leaves etc. Leaves a form of biomass is chemically composed mostly of hemicellulose, cellulose and lignin. On a dry-weight basis, all leafy cell walls consist mainly of sugar-based polymers (carbohydrates, 65–75 %) that are combined with lignin (18–35%). Pellets are among the fine fire fuels that can be easily produced from biomass such as leaves (Rowell M. R., 2005). The importance of energy for a nation's development cannot be over emphasized. This is because; energy is the corner stone of economic and social development (El-Saeidy *et al.*, 2004). Biomass is one of the most common and easily accessible renewable energy resources and represents a great opportunity as a feedstock for bioenergy (Phonphuak, N, Thiansem S *et al*., 2012). Biomass pellets are generally a superior fuel when compared to their raw feedstock. Not only are the pellets more energy dense, they are also easier to handle and use in automated feed systems. These advantages, when combined with the sustainable and ecologically sound properties of the fuel, make it very attractive for use.

Biomass in compact form results into a uniform solid densified fuel called briquettes or pellets. The pelleting of biomass improves its handling characteristics, increase the volumetric Calorific value reduces transportation costs and makes it available for a variety of application. It has higher density and energy content and less moist compared to its raw materials. Sometimes pelleting of biomass can be done using various techniques, either with or without binder addition (A.B.Nasrin, A.N.Ma,Y.M.Choo, S.Mohamad *et al.*,2008).

The pellets made from biomass can be used for domestic purposes (cooking, heating, barbequing) and industrial purposes (agro-industries, food processing) in both rural and urban areas. The end use of pellets 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 pellets. Being derived from renewable resources, the pellets has superior qualities as well as environmental benefits in comparison with coal and other fuels (Maninder, Rupinderjit Singh Kathuria, Sonia Grover *et al.,2012)* .This study was aimed at identifying conditions that allow the production of quality pellets from such a small scale machine. This work will benefit in setting guidelines for the effective operation of a small scale pellet mill and will allow being confident of results when producing pellets in a value added operation.

II. MATERIALS AND METHODS

The general manufacturing process of these leafy pellets is in a way the raw material, which is of different sizes, arrives at a reception area, where it is weighed and its moisture measured. In a first stage, the size of the material is reduced to 20-40 mm with a hammer splinter. Since the raw material has different levels of moisture, it is necessary to dry it until its moisture is lower than 15%. The reduction in moisture content is achieved by a rotary drier. The generation of hot air for the drying process comes from a biomass heating, composed of a burner, a combustion chamber, and a decanter of ashes. Magnets and screens are used to remove undesired particles before the dried material reaches a hammer mill. The pellets, 6 or 8 mm in diameter, are produced without any additives. The pelletizing process involves high temperatures, and attention has to be paid to proper cooling and heat removal before pellets leave the production plant, especially with regard to the storage stage.

Raw materials for pellets production: Leafy biomass (different sized leaves) was used to manufacture pellets in this research. The raw materials used are leaves of Eucalyptus, Cassia fistula, Polyalthea (pseudoashoka), starch as additive and water for desired moisture level. Fresh materials were collected from college campus and chipped with specific machinery used for that purpose, and transported to the pelletizing plant where raw material is passed through standard pelletizing process, where the material was processed to obtain pellets.

Description of the Pelleting Process: The process of manufacturing fuel pellets involves placing ground biomass under high pressure and forcing it through a round opening called a "die." When exposed to the appropriate conditions, the biomass compacts together, forming a solid mass. This process is known as "extrusion." Some biomass (primarily wood) naturally forms high-quality fuel pellets, while other types of biomass may need additives to serve as a "binder" that holds the pellet together. However, the creation of the pellets is only a small step in the overall process of manufacturing fuel pellets. These steps involve feedstock grinding, moisture control, extrusion, cooling, and packaging. Each step must be carried out with care if the final product is to be of acceptable quality. The following properties of pellets were selected and determined.

PHYSICAL PROPERTIES OF PELLETS:-

1. Pellet dimensions- The pellets were cylindrical in the shape. In order to determine dimensions and unit mass, 5 biomass pellets were selected in each experiment. The length (L) and diameter (d) of pellets were measured using a vernier caliper. The mass of pellet was weighed using a precision digital balance.

2. Bulk density- Bulk density was calculated as the ratio of the material mass to the container volume. The pellets were leveled to the top surface of the container and were weighed using digital balance. The container volume was calculated by measuring its length and diameter.

Bulk density= m_b/V_b

V_b is the volume of the container (cm^3); m_b is the total mass of the pellet (gm.)

3. Pellet durability-Pellet durability was determined by mass loss of sample. Some pellets were randomly selected and weighed using digital precise balance. The initial mass was recorded. They were then put into a vibrator. After 10min they were weighed again and final mass was recorded. Pellet durability was calculated using the following equation.

$$P_d = 100 - (m_i - m_f)/m_i \times 100$$

Where P_d is pellet durability (%); m_i is initial mass of sample (g); m_f is the final mass of Sample (gm.)

4. Pellet quality-As stated quality pellets should have moisture content below 10% and be mechanically strong with a good density. The simplest way to test pellet quality is to place a pellet in glass of water, if the pellet sinks to the bottom, the pellet has a high density, and was formed under sufficient pressure. However if the pellet floats it will be a poorer quality pellet with a lower density, lower mechanical durability and more likely to crumble and to produce fines. For the quality pellets the results should be between 0.6-0.7kg/lt, poor quality pellet will crumble easily and will produce excessive fines.

III. PROXIMATE ANALYSIS OF THE PELLETS

Proximate analysis, which is a standardized procedure that gives an idea of the bulk components that make up a fuel, was done to determine the average of the percentage volatile matter content, percentage ash content of the pellets.

1. Percentage volatile matter-

The percentage volatile matter (PVM) was determined by pulverizing 2g of the pellet sample in a crucible and placing it in an oven until a constant weight was obtained. The pellets were then kept in a furnace at a temperature of 550°C for 10min and weighed after cooling in a desiccator. The PVM was then calculated using the Equation below:

$$PVM = A - B/A \times 100$$

Where A is the weight of the oven dried sample and B is the weight of the sample after 10min in the furnace at 550°C.

2. Percentage ash content-

The percentage ash content (PAC) was also determined by heating 2g of the pellet sample in the furnace at a temperature of 550°C for 4h and weighed after cooling in a desiccator to obtain the weight of ash (C). The PAC was determined using the Equation below:

$$PAC = C/A \times 100$$

A=the weight of the oven dried sample; C= weight of ash.

RESULTS AND DISCUSSIONS

IV. DETERMINATION OF PROPERTIES OF BIOMASS LEAF PELLETS

1. Pellet Dimensions –

The dimensions of the pellets, both diameter and length, are also important factors with respect to fuel feeding properties and to combustion. Thinner pellets allow a more uniform combustion rate than thicker ones; the shorter the pellets, the easier the continuous flow can be arranged. Visual observations of the pellets tested showed differences between them. Most of the pellet samples obtained had a diameter of about 1.36cm.However differences were detected in relation to their length and ratio length/diameter.

Length-average length of pellet is measured using vernier caliper that is 3.4cm.

Diameter- average diameter of pellet is measured using vernier caliper that is1.36cm

Mass- average mass of pellet is measured using vernier caliper that is 2.51gm.

2. Bulk density- Pellets made with waste tree leaves showed bulk density values similar to the bulk density of pellets from fresh logging residues, The bulk density is of importance with regard to pellet storage and transport, because the necessary storage and transport capacity decreases with an increasing bulk density.

Bulk density=Material mass/container volume

Material mass=257.18gm.

Container volume=$\pi r^2 h$ =3.14×(3.35)^2×10

Bulk density =257.18/3.14×(3.35)^2×10 = 0.729gm/cm^3

3. Pellet durability- Pellet in a test tube is tested over a vibratory shaker. Initial and final mass of

Pellet is tested after shaking continuously for 10min.

Pellet initial mass=2.51gm.

Pellet final mass after using a vibrator=2.20gm.

$P_{d=}$100-(m_i-m_f)/m_i×100 (m_i is the initial mass of pellet, m_f is the final mass pellet)

P_d=100-(2.51-2.20)/2.51×100=87.65%

The test pellet is durable with specific hardness and crushing resistance.

4. Pellet quality-

Weight of the container(100ml)=47.13g

Weight of the container filled with pellet(100ml)=117.42g

Weight of the container filled with water(100ml)=167.46g

Weight of the container filled with pellets-weight of the container = (117.42-47.13)=70.29g

Again, weight of the container filled with water-weight of the container =167.46-47.13 =120.33g

Pellet quality=weight of pellet/weight of water =70.29/120.33 =0.5841g/ml

This value is closer to the standard value depicting that pellet is near the quality range that varies within 0.6-0.7gm/ml.

PHYSICAL PROPERTIES OF LEAF PELLETS

PARAMETERS	VALUE
Length	3.4 cm
Diameter	1.36 cm
Mass of pellet	2.51g
Volume	4.936 g/cm^3
Bulk density	0.729 g/cm^3
Pellet durability	87.65%
Pellet quality	good

Proximate Analysis of Biopellet:-

The results of the proximate analysis of the formed pellets are following:

1. Percentage volatile matter- Some part of the biomass is released when the biomass is heated (up to 400 to 500°C). During this heating process the biomass decomposes into volatile gases and ash. Biomass typically has high volatile matter content (up to 80 percent). From the given sample:-

PVM= A-B/A×100

Weight of the oven dried sample (A) =2.24g

Weight of the sample after 10min in furnace at 500°C (B) =0.42g =2.24-0.42/2.24×100 =81.25%

However, for the leaf pellet produced, a volatile content of 81.25% was recorded. The high volatile matter content indicates that during combustion, most of the formed pellets will volatilize and burn as gas in combustion chambers.

2. Percentage Ash Content- Pellets from the leaves of trees generated a higher percentage of ash content than pellets from wood or sawdust. In any case, it was observed that values exceed the usual ash content of wood, whose values are between 0.4 and 0.8 % for softwood and between 1 and 1.3 % for hardwood, or values given in the literature on sawdust pellets with values lower that 0.5%. In order to maintain a high operating comfort for end users in the residential heating sector, high ash content must be avoided.

Percentage ash content =C/A×100

Weight of oven dried sample (A) =2.24g

Weight after cooling to obtain weight of ash(C) = 0.44g = 0.44/2.24×100 =19.64%

Ash, which is the inorganic matter left out after complete combustion of the biomass was found to be 19.64%. This is the percentage of impurity that will not burn during and after combustion. The low ash content indicates that it is suitable for thermal utilization whereas higher ash content in a fuel usually leads to lower calorific value.

TABLE-2 PROXIMATE ANALYSIS OF LEAF PELLET

PARAMETERS	VALUES (%)
Volatile matter	81.25%
Ash content	19.64 %

V. CONCLUSION

The use of bio pellets is mainly for replacing coal substitution in industrial process heat applications. The pellet has superior qualities as well as environmental benefits in comparison with coal and other fuels. The biomass pellet was successfully produced from leaves. The average length of pellet is 3.4cm. The average diameter of pellet is 1.36cm. The average mass of pellet is 2.51gm. The test pellet is durable with specific hardness and crushing resistance. Pellet quality is good that is 0.5841g/ml. This value is closer to the standard value depicting that pellet is near the quality range that varies within 0.6-0.7gm/ml. Percentage Volatile content of Biopellet is 81.25%. The high volatile matter content indicates that during combustion, most of the formed pellets will volatilize and burn as gas in combustion chambers. Percentage Ash content is 19.64%. The low ash content indicates that it is suitable for thermal utilization whereas higher ash content in a fuel usually leads to lower calorific value.

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