IFERP
ISSN (Online) 2456 -1304

International Journal of Science, Engineering and Management (IJSEM)
Vol 1, Issue 4, August 2016

A Study on Utilization of Biomass Waste Pellets as an Alternate Fuel

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Abstract— **In India, about 63 million hectares is covered by forest with a deforestation rate of around 3 lakh ha/year (Grover, 1996). In addition to the barren land (around 30 million hectares) available for forestation and forest residues, about 500 MT of agricultural residues are generated every year from agricultural lands(Source: Ministry of New and Renewable energy in association with Indian Institute of Science, Bangalore). Agriculture is the mainstay of rural India, constituting 70 % of total population and 198.9 million hectares of gross cropped area with a cropping intensity of 140.5 %(Singh S Y 2010). It also contributes significantly in India's economic sector with a share of approximately 13.9 % of India's gross domestic product (Mishra, 1996). Due to wide spread practices of agriculture, lots of agricultural wastes are generated which remains unutilized. Agricultural residues which account 33 % of total residues has surplus significance as concerned to global warming as its combustion has the potential to be carbon dioxide emission neutral. Low bulk densities of agricultural residues suggested them to opt for an effective transportation, storage and firing or usage of residues at the point of generation.**

I. INTRODUCTION

Agricultural activities create a number of waste products like dried leaves, branches/stalks, small twigs etc. Generally all this waste is directly burnt which is wasteful and also harmful to the environment. The total annual production of leafy biomass in India is of the order of 1130 million tons (R M Singh et al. 2009). This garden waste would land in dumping sites, or will be burned if not collected and processed contributing to the large scale contamination of land, water and air. Leaves accumulating in lawns, playgrounds add to the problem of municipal solid waste disposal. The burning of leaves adds to the air pollution and global warming.(Gajalakshmi et al. 2005)
Biomass is the most promising renewable energy because of its diverse quality of being used in any state of matter which makes it as the second largest renewable energy source on earth.

World's total energy consumption is around 12 % which is expected to increase in future.(Kaliyan and Morey, 2009). One of the major factors limiting the utilization of biomass for heat and power production is its low bulk density, resulting in inefficient and cost-intensive handling properties. The distances between biomass production sites, such as forest and agricultural land to industrial and residential areas, where the energy is needed, are often long and require significant logistics for transportation and storage (Rentizelas*et al.*2009). The bulk density of biomass is about 40 to 150 kg/m3 for grasses (Larsson *et al.* 2008) and about 150 to 200 kg/m3 for commercial woodchips (Robbins 1982). Pelletization of biomass increases the bulk density to about700kg/m3 (Sokhansanj and Turhollow 2004). Apart from density increase, pelletization offers several other benefits, such as a homogeneous shape and structure that is advantageous for automated feeding into boiler systems.
The objective of this research is to find the most suitable material of biomass pellets based on feedstock availability, including activity to find bio-pellet formulations, which characterize moisture content, density, ash content, and calorific value.In this study Palm fiber, palm leaves and Garden leaves were taken for the pelleting process.

II. MATERIALS AND METHODS

The biomass residues were procured from ICT campus, Institute of Chemical Technology, Matunga, Mumbai. Properties of the biomass were determined. The calorific value of the biomass sample was determined by Bomb calorimeter. Bulk density of the testing material was found out using the weight of a given sample in a known volume.

Determination of Moisture content

The moisture content of the raw biomass was determined by calculating the loss in weight of material

IFERP
ISSN (Online) 2456 -1304
International Journal of Science, Engineering and Management (IJSEM)
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using hot air oven drying method at 1050C for one hour and upto constant weight loss(DaraS.S., 1999).
Where w1= weight of crucible, g
w2=weight of crucible + weight of sample, g
w3= weight of sample + weight of sample after heating, g

$$\text{Moisture content (\%)} = \left(\frac{w_2 - w_3}{w_2 - w_1}\right) \times 100$$

Determination of Volatile matter

The dried sample left in the crucible was covered with a lid and placed in muffle furnace at 9500C for 7 minutes. The crucible was cooled in open air, then in a desiccator and weighed again. Loss in weight is reported as volatile matter on percentage basis.

$$\text{Volatile matter} = \left(\frac{w_5 - w_6}{w_5 - w_4}\right) \times 100$$

where w4= weight of empty crucible, g
w5=weight of empty crucible + weight of sample, g
w6= weight of sample + weight of sample after heating, g

Determination of Ash content

The ash content (ASTM-E830) of the material was determined in the muffle furnace at 7500C for 2 hours. The residual sample in the crucible was heated without lid at 7500C for one hour. The crucible was cooled in open air, then in a desiccator and weighed. Heating, cooling and weighing was repeated, till constant weight obtained. The residue reported as ash on percentage basis.

$$\text{Ash content} = \left(\frac{w_9 - w_7}{w_8 - w_7}\right) \times 100$$

where w7= weight of empty crucible, g
w8=weight of empty crucible + weight of sample, g
w9= weight of sample + ash, g

Determination of Fixed carbon

The fixed carbon percentage was calculated as
% of Fixed carbon = 100 - % of (Moisture content+ volatile matter+ash).
The fixed carbon was found out from the weight difference.

Determination of Calorific Value

After the evaluation of the moisture content, about 1g mass of each fuel sample was accurately weighed into the crucible and a fuse wire (Nickel, whose weight is known) was stretched between the electrodes. It was ensured that the wire was in close contact with the fuel. To absorb the combustion products of sulphur and nitrogen, 2 ml of water was poured in the bomb. Bomb was then supplied with pure oxygen through the valve to an amount of 25atm. The bomb was then placed in the weighed quantity of water, in the calorimeter. The stirring was started after making necessary electrical connections, and when the thermometer indicates a steady temperature, the fuel was fired and temperature readings are recorded after 1/2 minute intervals until maximum temperature was attained. The bomb was then removed; the pressure slowly released through the exhaust valve and the contents of the bomb were carefully weighed for further analysis. The heat released by the fuel on combustion was absorbed by the surrounding water and the calorimeter. The gross heat of combustion of each residue was analysed in the laboratory with the bomb calorimeter and calculated using equation (www.parrinst.com).

CV = CΔT – (e1 + e2 + e3) m Where, C = heat capacity of the bomb calorimeter = 15kJ/oC ΔT = change in temperature variation m = mass of sample (g) e1 = Correction of heat of formation of nitric acid [however, flushing the bomb with oxygen prior to firing, displaces all nitrogen, thereby eliminates nitric acid formation, hence, e1 = 0] e2 = Correction of heat of formation of sulphuric acid [% of sulphur in sample x 57.54(J/g) x mass of sample (g)] e3 = Correction of heat of formation of fuse wire [length of fuse wire consumed in (cm) x 9.66(J/cm)]
Based on the proximity analysis elemental composition of the biomass samples were estimated using the following equations.

C = 0.637 F C + 0.455 VM
H = 0.052 F C + 0.062 VM
O = 0.304 F C + 0.476 VM

(The H and O atom compositions depend on the required no. of molecules of water used in the process/ obtained by moisture analysis of the sample)

ISSN (Online) 2456 -1304

International Journal of Science, Engineering and Management (IJSEM)
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Table 1 Properties of samples

Properties	Garden leaves	Palm leaves/fibers
Bulk Density Kg/M3	115.5	278.6
Moisture content %	8.97	18.5
Volatile matter %	67.92	62.7
Ash content %	6.82	4.4
Fixed carbon %	16.29	14.4
Carbon %	41.28	39.38
Hydrogen %	5.05	4.636
Oxygen %	37.28	34.22
Calorific Value kcal/kg	1986	3865

Pellet Production Process

The feed materials were open dried to a moisture content of 7-8% for palm fibers and 6-7% for garden leaves. To increase the durability of the pellets, the biomaterials were shredded. The shredded material was fed into roller and dye type pelletizing machine.

Figure 1 Pelleting Machine (Roller and Die)

Figure 2 Biomass Waste And Pellets

Table 2 Properties of Pellets

Properties	Garden leaves	Palm leaves/fibers
Bulk Density Kg/M3	323.6	458.8
Volatile matter %	74.9	68.6

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Ash content %	6.37	4.8
Calorific Value Kcal/Kg	3056	4125.94
Fixed carbon %	18.73	26.6
Carbon %	46.01	48.16
Hydrogen %	5.62	5.002
Oxygen %	41.35	28.94

III. CONCLUSION

The large volume of agricultural by-products being generated which constitute environmental hazard calls for effective utilization of these high grade biomass materials for Pellets. The briquetting Technology is one of the promising methods to recycle the loose biomass waste and converted into value added products. Based on the results from the experiment there is a lot of potential heat energy from the palm leaves/ fiber residues that can be utilize as an alternative to the fossil fuel energy for the purpose of combustion. Study is in progress to increase the heating value of the low density biomass by blending with other wastes. Waste-to-energy conversion technology not only extends the life of landfill but also provide an alternative energy resource by utilizing unused waste products. This will not only enhance the employment opportunity in rural areas but also will be a good source of supplementary income to farmers.

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