Optimum Sizing of Biomass Based Power Plants, Life Cycle Assessment and Techno Economic of Different Crops for M.P. (India)

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Abstract — This concept paper studies a Optimum sizing of ***Biomass based Power Plants, life cycle Assessment and Techno Economic of Different Crops for M.P. (India).Gasifier based electricity generation system having power rating of 10 KW installed at Energy park in Rajiv Gandhi Technological University Bhopal(India).The system was used to test biomass briquettes using various agricultural waste from fields of crops named (soybean) stalks , (arhar) stalks , (masoor) stalks , cotton stalks, mustered ,wheat, gram, etc. The agricultural biomass is characterized by physical and proximate analysis of briquettes made of above mentioned stalks in single and mixed composition of waste stalks .Further preparing a comparison of the best sizes of briquettes and mixed composition used to feed a gasifier generating producer gas running gas engine powering AC generator .Experiment with briquetting of waste stalks collected from fields into different cylindrical briquettes with diameter 90 mm and height varies from 40 mm ,60 mm, 80 mm used as fuel in gasifier of 10 KW capacity producing producer gas for a gas generator producing power at standard voltage and frequency for a connected grid of load determining the optimum size and composition of agricultural waste briquettes for commercial electricity generation for rural areas .***

The calorific value and proximate analysis of each selected crop in single and mixed form of each type of briquette is calculated .Experimental results indicate that the best composition briquettes made of 50-50 ratio of soybean-cotton stalks and Soybean-arhur stalks in size of 90mm diameter 60mm height as compared to other composite mixture briquettes. .The overall efficiency is being calculated on the basis of mass of fuel used as compared to wood and thus benchmarking the results for future considerations. Optimum size of Different composition both homogeneous and mixed form came out to be 90x60-90x80 for all the briquettes compressed by a pressure 110KPA .The best power production capability of crops from producer gas generated by a pilot down draft gasifier is of Composite briquette #2 (Soybean +Cotton Stalks) and cotton stalks of 7.25 and 7.06 KW respectively having outlet gas temperature varies from 400-500° C.

Keywords —Gasification, Downdraft gasifier, agricultural waste, pyrolysis, briquette, Proximate analysis,

1. INTRODUCTION

Gasifiers are relatively simple devices. The mechanics of their operation, such as feeding and gas cleanup, also are simple. The successful operation of gasifiers, however, is not so simple. No neat rules exist because the thermodynamics of gasifier operation are not well understood. Yet, nontrivial thermodynamic principles dictate the temperature, air supply, and other operating variables of the reactors that we build. It is a tribute to the persistence of experimentalists that so much progress has been made in the face of so little understanding.

Nevertheless, it has been the experience in related fields (such as oil, gas, and coal combustion) that once the mechanisms at work are understood, we present a summary of the underlying processes that occur during biomass gasification. We will attempt to keep the explanation simple because each fundamental process.

1. Biomass Thermal Conversion Processes
2. Introduction Thermal conversion processes for biomass involve some or all of the following processes:
3. **Pyrolysis**: Biomass + Heat → Charcoal, oil, gas
4. **Gasification**: Biomass + Limited oxygen → Fuel gas
5. **Combustion**: Biomass + Stoichiometric' oxygen → Hot combustion products

Thermal processes typically have high throughputs and can, in principle, operate on any biomass form. (Biological processes only operate on some of the components of biomass, usually the cellulose.) Cellulose is a linear polymer of anhydroglucose units; hemicelluloses is a mixture of polymers of 5- and "stoichiometric," that quantity required for a complete chemical reaction

6-carbon anhydrosugars, and lignin is an irregular polymer of phenyl propane units. In biomass, these three polymers form an interpenetrating system, or block copolymer, that varies in composition across the cell wall. Nevertheless, in large samples, there is a relatively constant atomic ratio of $CH_{1.4}O_{o.6}$ (The ratios will vary slightly with species. Coal is typically about $CH_{0.9}O_{0.1}$ but varies more widely in composition.

EXPERIMENTAL SETUP

Fig: 1 Downdraft gasifier

Fig: 2 Gas Generator

Following reaction zone and process in the gasifier
Devolatilization zone: Biomass → char + volatile + tar
Devolatilization reduction: Volatile → Gas1 (CO, CO_2, H2, CH_4 etc.)
Char Combustion: Char→ Gas2 (CO, CO_2)
There is also 10kWe downdraft gasifier available at Energy Park in Rajiv Gandhi Technical University, Bhopal (M.P.) for investigation and analysis of different woody biomass in the area of the research and development.

Dimension of gasifier

S.NO	Part of gasifier	Dimension
1	Inner shell diameter (D1)	22cm
2	Outer shell diameter (D2)	26cm
3	Thickness of shell	0.7cm
4	Height of gasifier (H1)	115cm
5	Insulation diameter	32cm
6	Air nozzle diameter (di)	3cm
7	Length of air nozzle	10cm
8	Gas outlet diameter at inner shell (dg)	7 cm

Table 1

MATERIALS AND METHOD

Fig: 3 Different crops in MP

Feed materials & Briquettes formation The agricultural residues has been procured from different farms near Sehore and Mandideep, Madhya pradesh Agricultural residues selected for study was glycine max (soybean) stalks , cajanus cajan (arhar) stalks , lens culinaris (masoor) stalks , cotton stalks. The briquetting machine used to create the briquettes is Jumbo 90 situated in village Dapri near Mandideep having a production capacity of 1000Kg/hr.The Agriculture waste residue of soybean stalks, arhar stalks, masoor stalks, cotton stalks are grounded separately in crusher to achieve the particle size of 10mm-30mm .The Compressing power of briquetting machine is being derived from RAM & DIE technology powered by Dc Motor of 55KW 1450rpm applying a compressing pressure of 100 MPa.

Samples of 4 homogeneous crop residue and 2 composite heterogeneous crop residue mixture (1.Soyabean & arhur & 2.Soyabean & cotton Stalks) were procured in 25 kg quantity each. Physical properties of crop waste briquette are basically the most important characteristics which decides the optimized performance and efficient operation of the gasifier.The physical properties of briquettes like moisture content in them, volatile matter content , ash content, carbon content, length and diameter, bulk density, were determined. To measuring length and diameter of briquettes, vernier caliper scale was used .observation recorded in the final reading is the average of five consequent readings

1. Proximate analysis of feed stalks The tests were performed at the RGPV Energy Department laboratory

Specification of the Briquetting plant

Model No.	Super 90
Technology	Ram and Die
Briquette diameter	90 mm
Briquette length	60-110 mm
Production capacity	1000 kg/h
Raw material size	1 mm to 10 mm
Finished product shape	cylindrical
Biomass type Agro residues	(cotton stalks, Gram stalks, soy bean stalks and other agro residues)
Driving motors rating & rpm/Current consumption on load	Main motor :3PH 55KW 75HP /1475/50A Coupling motor :3PH 2.20KW 3HP/1430/6A

Briquetting plant

Briquetting

Fig: 4 Technical Briquetting Machine

Moisture content The desired moisture content for our pilot gasifier is from 5-12% But we tried to keep it low in order of 8-10% The moisture of briquettes sample can be estimated by taking a small pre-weight sample with an initial mass Mi is placed in drying oven in which a temperature of 110o C is maintained After two hours mass is noted with an interval of 10 min until it becomes constant Me.

Volatile matter content The amount of volatile matter in briquette sample were calculated by heating moistureless briquette sample with an initial mass Mi in a closed crucible in an oven with a temperature of 600°c & 900o C for six minutes with 2 min interval and then its weight (Mf) is measured..

Ash content The use of moving grates in pilot gasifier has added the advantage of ability to operation with fuels having high ash content. The amount of ash in a sample briquette with higher percentage have the lower calorific value as compared to other lower ash content sample. The percentage of ash in composition is determined by heating a dried sample of briquette in a furnace which is kept at 800°C for 6 hours so that briquette sample burnt completely. Remaining ash residue in the crucible is weighted M_S.

Fixed carbon The final step of proximate analysis tests is the approximating of the amount of the fixed carbon [C] by using mass balance calculations. The amount of fixed carbon,

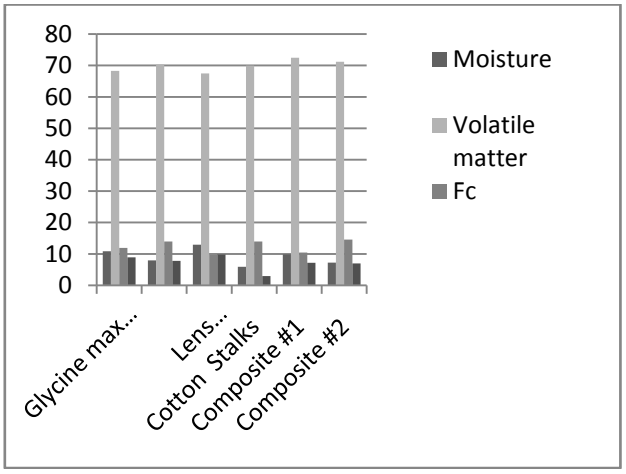
Bulk density of briquettes The bulk density of the briquettes is the ratio of its mass of sample briquette to bulk volume of the sample briquette .To measure the density of biomass briquettes sample, a standard measuring cylinder was filled up with briquettes and then the contents were weighted on weighing balance. Same observations are taken find out the loose stalks bulk density applying the same method.

Calorific value of feed stock The calorific value of biomass is dependent on the moisture content in it and its densification degree of briquetting .The calorific value of the different crop residues briquette were analysed by using Oxygen Bomb Calorimeter having Digital Beckman thermometer connected for accurate digital measurement. A sample of required briquette with a known mass is burned in presence of oxygen in a stainless steel high pressure vessel known as a bomb containing crucible. The heat liberated during combustion is measured from the difference of the rise in the temperature of water in the calorimeter containing the bomb crucible before and after complete combustion. The calorific value calculated from the above data is the gross calorific value of sample briquette taken.

The calorific value of sample briquette was calculated by using the following formula

$$\text{Kcal/kg} = (W + w) * (T1 - T2) / X$$

Where, W = weight of water in calorimeter (kg),
w = water equivalent,
T1 = initial temperature of water (^oC),
T2 = final temperature of water (^oC),
X = weight of briquette sample taken (kg)



CONCLUSIONS

The electricity is produced by direct combustion of biomass, advanced gasification. And pyrolysis technologies, which are almost ready for commercial scale use. As our study propagates toward concluding the data recorded into results showing that the Optimum size of Different composition both homogeneous and heterogeneous came out to be 90x20-90x40 for all the briquettes compressed by a pressure 110KPA .The best power production capability of crops from producer gas generated.

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