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Grape Stalk Briquettes as an Alternative Feedstock of Biomass Gasifiers

Dilip R. Pangavhane*[1] and Shrikant Tare*

Abstract – *Biomass gasifiers are used for sustainable development by using the agricultural waste as a feedstock. Grape stalk are the major agricultural by product available from the grapes garden. Hence thousands tons of grape stalk are available as agricultural waste, which can be used as feedstock to the biomass gasifiers. But the grape stalks cannot be used directly because of their low energy value. So these grape stalks are to be converted into some other suitable form of fuel which has comparable high energy value. This suitable form may be the briquettes from grape stalk. This paper reports the development of a low-density biomass gasification system (92.048 MJ/hr) for direct thermal applications. Initially, ultimate and proximate analysis of grape stalk is carried out in order to determine the calorific value of stalk. Analysis was done to determine its gross calorific value. The system was tested under laboratory conditions and the Gross Calorific Value of the gas produced was within the range 5-6MJ/Nm^3. The GCV of briquette was found to be greater than that of grape stalks. Gasification output capacity, especially in the high output ranges, was controlled only by availability of adequate feed materials rather than other technical consideration.*

Keywords – Biomass, gasification, grape stalk briquettes, gross calorific value, and sustainable development.

1. INTRODUCTION

The process of gasification to produce combustible gases from organic feeds was used in blast furnaces over 180 years ago. The contemporary interest in small-scale gasifier research and development, for most part dates from 1973 oil crisis. The research and development activity of biomass gasification-power generation technology used in India and elsewhere however, all of them use wood, wood waste or rice husk cotton stalk, sugarcane leaves and bagasse as fuel for gasification. Waste rice husk from rice mill is fed to gasifier, the gas produced is cleaned and stored in a gas tank and used to drive gas engine. Similar experiments were performed on various biomass like wood blocks/chips, sugarcane leaf-bagasse, wheat straw and husk, rice straw and husk, groundnut shells, cotton straw, coconut shell husk, corn cobs, vegetable waste, hazelnuts shells, almond residue *etc.* as biomass feedstock [1]-[9] depending on its availability. India produces about 320 million tones of agricultural residues comprising of mainly rice husks, paddy straw, sugarcane leaves and bagasse, rice and wheat husk and its residues, grapes stalk [1]-[4], which can be used for the biomass gasifier projects for the decentralized power supply in India.

The worldwide grape production fell from 60 million tonne during the mid 80s to 55 million tonne in 1995. Thereafter, it has increased to 63 million tonne by 2000-2001. India is credited with achieving the highest productivity of grape *i.e.* average productivity of 25 tonne per hectare as against the world average of 8 tonne per hectare and also the record yield of 100 tonne per hectare. Thus taking into consideration the approach of the government in promoting production of grapes, there is no doubt that the bio-waste (grape-stalk) from grape farming would be available in a very large quantity. But unfortunately, this bio-waste is not utilized 100%. This will increase the availability of grape stalk and its efficient utilization for energy generation will become commercially important. This will not only save valuable oil and foreign exchange but also prove the way for self reliant and sustainable growth of rural farmers in this area. The use of producer gas from indigenously available agricultural residues is an attractive alternative to meet the energy demands of the industries. The gasifier can handle fuels like sugarcane leaves and bagasse, bajra stalks, sweet sorghum stalks and bagasse, *etc.*

Grape stalk are the major agricultural by-products available from the grapes garden. Hence thousands tons of grape stalk are available as agricultural waste, which can be used as feedstock to the biomass gasifiers. Thus, grape-stalks can be used in gasification systems to produce combustible gas for clean energy production. But the grape stalks cannot be used directly because of their low energy value. So these grape stalks are to be converted into some other suitable form of fuel which has comparable high energy value. This suitable form may be the briquettes from grape stalk. The main objective of this research study was to investigate the gasification characteristics of grapes stalk converting into briquettes and find out its suitability as a alternative feed stock for the biomass gasifier. This paper reports the development of a low-density biomass gasification system (92.048 MJ/hr) for thermal applications. Initially, ultimate and proximate analysis of grape stalk is carried out in order to determine the calorific value of stalk. Analysis was done to determine its gross calorific value. The system was tested under laboratory conditions and the gross calorific value (GCV) of the gas produced was within the range 5-6MJ/Nm^3 . The GCV of briquette was

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found to be greater than that of grape stalks. Gasification output capacity, especially in the high output ranges, was controlled only by availability of adequate feed materials rather than other technical consideration.

2. MATERIALS AND METHODOLOGY: GASIFICATION PROCESS

It is necessary to understand the basic gasification process along with the basic fuel characteristics for the development of energy efficient biomass gasifier.

2.1 Theory of Gasification Process

Biomass gasification is basically conversion of solid fuels (*i.e.* wood/wood waste, agricultural residues) into combustible gas mixture normally called producer gas. The process is typically used for various biomass materials and it involves partial combustion of such biomass. Partial combustion process occurs when air supply is less than adequate for combustion of biomass to be completed. The combustion products from incomplete combustion of biomass generally contain nitrogen, water vapor, carbon dioxide and surplus of oxygen. Thermochemical gasification is the conversion by partial oxidation at elevated temperature of a carbonaceous feedstock such as biomass or coal into a gaseous energy carrier. This gas contains carbon monoxide, carbon dioxide, hydrogen, methane, trace amounts of higher hydrocarbons and various contaminants such as small char particles, ash, tars and oils. The partial oxidation can be carried out using air, oxygen, steam or a mixture of these.

2.2 Zones of Gasification

The complete biomass gasification takes place in four gasification zones viz., drying, combustion, reduction and pyrolysis which are as shown in Figure 1 [6].

i. Drying Zone

In drying zone hot flue gases from pyrolysis zone comes to the drying zone thus increases the temperature of biomass and moisture is removed from the biomass. The following major reactions take place in combustion and reduction zone.

ii. Combustion Zone

The combustible substance of a solid fuel is usually composed of elements of carbon, hydrogen and oxygen. In complete combustion carbon dioxide is obtained from the carbon available in fuel and water is obtained from the hydrogen, usually as steam. The combustion reaction is exothermic and yields a theoretical oxidation temperature of 1450°C [2]. The main reactions, therefore, are:

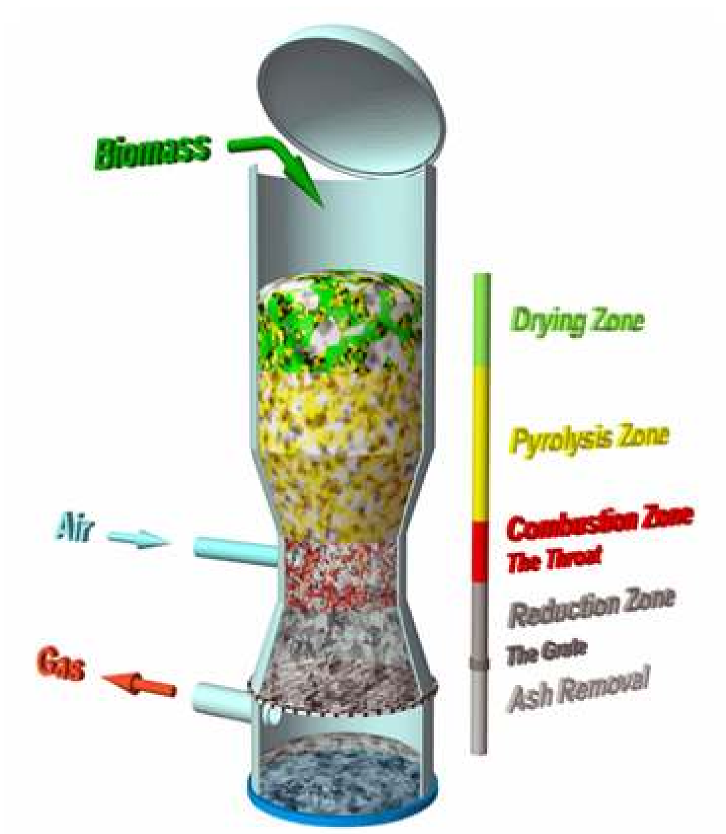

Fig. 1. Various zones of gasification.

$$C + O_2 = CO_2 \ (+ 393 \text{ MJ/kg mole}) \quad (1)$$

$$2H_2 + O_2 = 2H_2O \ (- 242 \text{ MJ/kg mole}) \quad (2)$$

iii. Reaction Zone

The products of partial combustion (water, carbon dioxide and uncombusted partially cracked pyrolysis products) now pass through a red-hot charcoal bed where the following reduction reactions take place.

$$C + CO_2 = 2CO \ (- 164.9 \text{ MJ/kg mole}) \quad (3)$$

$$C + H_2O = CO + H_2 \ (- 122.6 \text{ MJ/kg mole}) \quad (4)$$

$$CO + H_2O = CO_2 + H_2 \ (+ 42 \text{ MJ/kg mole}) \quad (5)$$

$$C + 2H_2 = CH_4 \ (+ 75 \text{ MJ/kg mole}) \quad (6)$$

$$CO_2 + H_2 = CO + H_2O \ (- 42.3 \text{ MJ/kg mole}) \quad (7)$$

Reactions (3) and (4) are main reduction reactions and being endothermic have the capability of reducing gas temperature. Consequently the temperatures in the reduction zone are normally 800^0C -1000^0C. Lower the reduction zone temperature (~ 700-800^0C), lower is the calorific value of gas.

iv. Pyrolysis Zone

Wood pyrolysis is an intricate process that is still the research is going on to understand it completely [1]. The products depend upon temperature, pressure, residence time and heat losses. However following general remarks can be made about them. Up to the temperature of 200^0C only water is driven off. Between 200^0C to 280^0C carbon dioxide, acetic acid and water are given off. The real pyrolysis, which takes place between 280^0C to 500^0C, produces large quantities of tar and gases containing carbon dioxide. Besides light tars, some methyl alcohol is also formed. Between 500^0C to 700^0C the gas production is small and contains hydrogen. Due to this intricate process it is easy to see and observe that updraft gasifier will produce much more tar than downdraft one. In downdraft gasifier the tars have to go through combustion and reduction zone and are partially broken down which minimizes.

Since majority of fuels like wood and biomass residue do have large quantities of tar, downdraft gasifier is preferred over others. Indeed majority of gasifiers, both in World War II and presently are of downdraft type. Finally in the drying zone the main process is of drying of wood. Wood entering the gasifier has moisture content of 10-30%. Various experiments on different gasifiers in different conditions have shown that on an average the condensate formed is 6-10% of the weight of gasified wood [1]. Some organic acids also come out during the drying process of the biomass and these acid are adversely affecting on the gasifier which give rise to corrosion of gasifier materials.

2.3 Fixed Bed Gasification System

The fixed bed gasification system consists of a reactor / gasifier with a gas cooling and cleaning system. The fixed bed gasifier has a bed of solid fuel particles through which the gasifying media and gas move either up or down. It is the simplest type of gasifier consisting of usually a cylindrical space for fuel and gasifying media with a fuel feeding unit, an ash removal unit and a gas exit. It is made up of firebricks, steel or concrete. In the fixed bed gasifier the fuel bed moves slowly down the reactor as the gasification occurs. The fixed bed gasifiers are of simple construction and generally operate with high carbon conversion, long solid residence time, low gas velocity and low ash carry over. In fixed bed gasifiers tar removal is a major problem, however recent progress in thermal and catalytic conversion of tar has given credible options. The fixed bed gasifiers are being considered to be of average strength for small-scale heat and power applications. The gas cleaning and cooling system normally consists of filtration through cyclones, wet scrubbers and dry filters. Since there is an interaction of air or oxygen and biomass in the gasifier, they are classified according to the way air or oxygen is introduced in it.

There are different types of fixed bed gasifier with varying schemes for both reactor design and reaction media. The fixed bed gasifier can be classified according to the ways in which the gasifying agent enters the gasifier i.e. updraft or downdraft.

Downdraft

The schematic principle of downdraft gasifier [10] as shown in Figure 2a. It features a co-current flow of gases and solids through a descending packed bed, which is supported across a constriction known as a throat where most of the gasification reactions occur. The reaction products are intimately mixed in the turbulent high temperature region around the throat, which aids tar cracking. Some tar cracking also occurs below the throat on a residual charcoal bed where the gasification process is completed.

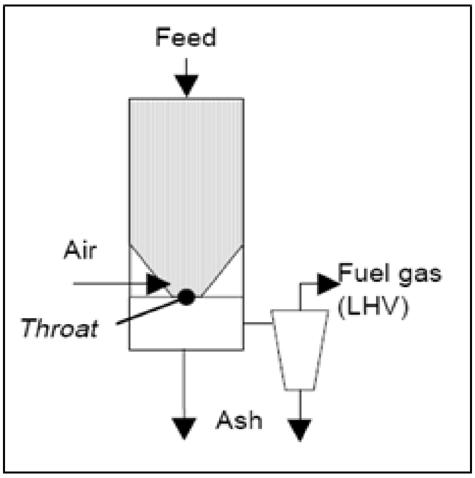

Fig. 2a. Downdraft gasifier.

This configuration results in a high conversion of pyrolysis intermediates and hence a relatively clean gas. Downdraft gasification is simple, reliable and proven for certain fuels; such as relatively dry (up to about 30 wt. % moisture) blocks or lumps with a low ash content (below 1 wt. %) and containing a low proportion of fine and coarse particles (not smaller than about 1 cm and not bigger than about 30 cm in the longest dimension).

Due to the low content of tars in the gas, this configuration is generally favoured for small-scale electricity generation with an internal combustion engine. The physical limitations of the diameter and particle size relationship mean that there is a practical upper limit to the capacity of this configuration of around 500 kg/hr.

Updraft

The updraft gasifier arrangement is as shown in Figure 2b. The downward moving biomass is first dried by the up flowing hot product gas. After drying, the solid fuel is pyrolysed-giving char, which continues to move down to be gasified, and pyrolysis vapours, which are carried upward by the upflowing hot product gas. The tars in the vapour either condense on the cool descending fuel, or it carried out of the reactor with the product gas contributing to its high tar content. The extent of this tar "bypassing" is believed to be up to 20% of the pyrolysis products. The condensed tars are recycled back to the reaction zones where they are further cracked to gas and char. In the bottom gasification zone the solid char from pyrolysis and tar cracking is partially oxidized with the incoming air or oxygen. Steam may also be added to provide a higher level of hydrogen in the gas. The product gas from an updraft gasifier thus has a significant proportion of tars and hydrocarbons, which contributes to its high heating value. The fuel gas requires substantial clean up if further processing is to be performed.

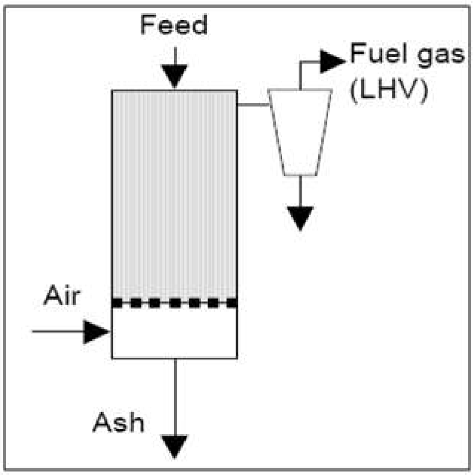

Fig. 2b. Updraft gasifier.

3. EXPERIMENTATION: FUEL CHARACTERISTICS

Almost any carbonaceous or biomass fuel can be gasified under experimental or laboratory conditions. However the real test for a good gasifier is not whether a combustible gas can be generated by burning a biomass fuel with 20-40% stoichiometric air but that a reliable gas producer can be made which can also be economically attractive to the customer. Towards this goal the fuel characteristics have to be evaluated and fuel processing done. A gasifier is very fuel specific and it is tailored around a fuel rather than the other way round. Thus a gasifier fuel can be classified as good or bad according to some parameters mentioned here.

3.1 Energy Content and Bulk Density of Fuel

The higher the energy content and bulk density of fuel, the similar is the gasifier volume since for one charge one can get power for longer time.

3.2 Moisture Content

In most fuels there is very little choice in moisture content since it is determined by the type of fuel, its origin and treatment. It is desirable to use fuel with low moisture content because heat loss due to its evaporation before gasification is considerable and the heat budget of the gasification reaction is impaired. For example, for fuel at 25°C and raw gas exit temperature from gasifier at 300°C, 2875 kJ/kg moisture must be supplied by fuel to heat and evaporate moisture. Besides impairing the gasifier heat budget, high moisture content also puts load on cooling and filtering equipment by increasing the pressure drop across these units because of condensing liquid. Thus in order to reduce the moisture content of fuel some pretreatment of fuel is required. Generally desirable moisture content for fuel should be less than 20%.

3.3 Dust Content

All gasifier fuels produce dust. This dust is a nuisance since it can clog the internal combustion engine and hence has to be removed. The gasifier design should be such that it should not produce more than 2-6 g/m3 of dust. The higher the dust produced, more load is put on filters necessitating their frequent flushing and increased maintenance.

3.4 Tar Content

Tar is one of the most unpleasant constituents of the gas as it tends to deposit in the carburetor and intake valves causing sticking and troublesome operations. It is a product of highly irreversible process taking place in the pyrolysis zone. The physical property of tar depends upon temperature and heat rate and the appearance ranges from brown and watery (60% water) to black and highly viscous (7% water). There are approximately 200 chemical constituents that have been identified in tar so far. Very little research work has been done in the area of removing or burning tar in the gasifier so that relatively tar free gas comes out. Thus the major effort has been devoted to cleaning this tar by filters and coolers.

3.5 Ash and Slagging Characteristics

The mineral content in the fuel that remains in oxidized form after complete combustion is usually called ash. The ash content of a fuel and the ash composition has a major impact on trouble free operation of gasifier. Ash basically interferes with gasification process in two ways:

a) It fuses together to form slag and this clinker stops or inhibits the downward flow of biomass feed.

b) Even if it does not fuse together it shelters the points in fuel where ignition is initiated and thus lowers the fuel's reaction response. Ash and tar removal are the two most important processes in gasification system for its smooth running.

Various systems have been devised for ash removal. In fact some fuels with high ash content can be easily gasified if elaborate ash removal system is installed in the gasifier. Slagging, however, can be overcome by two types of operation of gasifier:

1) Low temperature operation that keeps the temperature well below the flow temperature of the ash.

2) High temperature operation that keeps the temperature above the melting point of ash.

Many agricultural residues and fuels have, therefore, been gasified. However the operating experience is very limited and most of the work has been on laboratory scale. Table 1 lists the characteristics of various fuels.

Table 1. Gasification characteristics of various fuels

Sr. No.	Fuel	Treatment	Bulk Density	Moisture Content	Tar produced (g/m)	Ash content	Gasifier	Experience
1	Bean straw	Cubed	440 kg/m^3	13 %	1.97	10.2	Downdraft	Severe slag formation
2	Coconut shell	Crushed (1-4 cm)	435 kg/m^3	11.8 %	3	0.8	Downdraft	Excellent fuel, no slag formation
3	Corn cobs	complete	304 kg/m^3	11%	7.24	1.5	Downdraft	Excellent fuel, no slagging
4	Corn fodder	Cubed	390 kg/m^3	11.9 %	1.43	6.1	Downdraft	Severe slagging and bridging
5	Cotton stalks	Cubed	259 kg/m^3	20.6 %	5	17.2	Downdraft	Severe slag formation

3.6 *Briquette Preparation*

The availability of agricultural and agro-industrial residues is increasing day by day due to increase in agricultural production. In spite of very high-energy potential of these residues, it cannot be used in small/medium gasifiers due to its looseness. The ideal way is better to convert these residues into high density and high-value solid fuel i.e. briquettes. The laboratory briquette machine consists of a holder block wherein a taper die with a wearing ring and a split die are fitted. Diameter and length of punch are 50 and 350 mm, respectively. The material used for both, taper die and punch is high carbon chromium steel. The complete briquetting machine consists of briquetting press (extruder), material handling equipment material chopper / crushers.

4. RESULTS AND DISCUSSION

Initially before carrying out the gasification the characteristics of the grapes stalk were determined in the laboratory to find out its suitability as efficient feedstock. The dried grapes stalks were crushed in the laboratory crusher and chopper mill to convert into small particles. With the help of extruder machine (briquetting press) the crushed pieces were converted in to small briquettes of different diameters with sufficient quantity required for experimentation. The sample photographs of the manufactured briquettes are shown in Figure 3.

The briquettes were tested to determine the physical properties (particulate size, absolute density and bulk density) of grape stalk as a feedstock under the actual operating conditions of the gasifier in the laboratory and are given in Table 2.

Similarly the ultimate analysis (carbon, hydrogen, oxygen, nitrogen, sulfur and ash content) and proximate analysis of grape stalk was also carried out in order to determine the calorific value of grape stalk and the results are shown in Table 3 along with other biomass as gasifier feedstock used by the researchers.

Proximate analysis of biomass contents such as moisture content, volatile matter, fixed carbon and ash content. The carbon content determined through this method is not the actual carbon content in the biomass but only non-volatiles. This method developed for coal gives char product in relatively simple and economical manner. It indicates the quality of coal and is used as an index for its characterization.

Fig. 3. Briquettes from grapes stalks.

Table 2. Physical and chemical properties of grape stalk briquettes.

Sr. No.	Description	Value
1	Bulk Density	340 (kg/m^3)
2	Absolute density	250 (kg/m^3)
3	Moisture	8.86 %
4	Volatile matter	96.8 %
5	Fixed carbon	0.05 %
6	Ash	3.15 %

Table 3. Proximate and ultimate analysis of grape stalks compared with other biomass as feedstock.

Sr. No.	Description	Parameter	Values			
			Grapes Stalk	Hazelnut shells*	Gasified Forestry Waste**	Sugarcane Leaves***
1	Proximate analysis % Wet basis (average of four samples)	Moisture	8.86 %	12.45%	12.10%	4-33%
		Volatile matter	96.8 %	62.70%	77.70%	77.4%
		Fixed carbon	0.05 %	24.08%	19.65%	14.9%
		Ash	3.15 %	0.77	2.66%	7.7%
		Gross Calorific Value	15.9 ((MJ/kg)	17.36 (MJ/kg)	3.59 (MJ/kg)	16-17.6% (MJ/kg)
2	Ultimate analysis % Dry basis (average of four samples)	Carbon	34.4 %	46.76%	45.80%	39.75%
		Hydrogen	0.438 %	5.76%	6.0%	5.5%
		Nitrogen	1.11 %	0.22%	0.30%	0186%
		Oxygen	63.965 %	45.83%	47.90%	46.84%
		Sulphur	0.087 %	0.67%	NA	NA

GCV denotes gross calorific value in kJ/kg, and carbon (C), hydrogen (H), sulfur (S), ash (A), oxygen (O) and nitrogen (N) are used by percentage elemental mass. The GCV of grape-stalk was experimentally determined at 15.9 MJ/kg and theoretically calculated at 16.7 MJ/kg; the experimental value will be used in all calculations of the work.

The fuel moisture content greatly affects both the operation of the gasifier and quality of the produced gas. Generally the moisture content of most biomass varies between 8 and 15%, in this study the moisture content of grapes stalk briquettes was around 8.86%.

From the Table 3, it is found that the proximate and ultimate analysis values lies very closer with effective results as other biomass used as feed stock for biomass gasifier by [6], [11] and [12]. However it is also found that the gross calorific value of the grape stalk is also comparatively good with other biomass. Hence with above obtained values grape-stalk can be thought as an alternate fuel for biomass gasifier in rural areas, especially where it is available. Thus, grape-stalks can be used in gasification systems to produce combustible gas for clean energy production with less percentage of sulfur with higher calorific value.

5. GASIFIER DEVELOPMENT AND TESTING:

5.1 System Design:

The laboratory type of downdraft gasifier was developed for testing of the grapes stalk briquettes. The main parts of the gasifier like hopper, cover plate, reactor parts are assembled together for testing. The schematic of the designed system of complete gasifier assembly is presented by Figures 4 and 5. The flanges of hopper, gas collector and throat are connected with nuts and bolts.

i. Capacity of the Gasification System:

Biomass-based close core down draft gasifier has been designed for multiple uses with following assumptions and details of biomass:

Hot gas efficiency of the gasification system: 60%
Specific gasification rate (SGR): 3900 kg/hr-m^2
Calorific value of gas (CVg): 5-6 MJ/Nm^2
Calorific value of feedstock (CVf): 15.9 MJ/kg
Gas output from grape stalk briquette: 2.2 M^3/kg

ii. Feed stock Consumption Rate:

As the system was designed for the laboratory purpose was determined by FSR = (PGout x CVg)/(gasification eff. x CVf).

iii. Dimensions of the Reactor Shells:

Reactor cross sectional area was calculated by FCR/SGR.

iv. Height of the Gasifier Reactor:

The height of the gasifier reactor was decided on the basis of required holding capacity of feed stock and duration of the operation.

v. System Description:

The dimensions and specification of the designed laboratory type biomass gasifier are:

a. Feed stock consumption rate: 10 kg/hr
b. Diameter of the gasifier: 2 feet
c. Height of gasifier: 2 m
d. Grate:
   Type: Circular
   Material: Cast steel
   Sealing: Water trough
   Cyclone: Medium efficiency
e. Blower:
   Type: Centrifugal type, air tight
   RPM: 2800
   Air flow rate: 100m^3/hr
   Impeller material: SS-304
   Gas outlet: 0.10m below the grate
f. Grate Agitator:
   Type: Combing action
   Materials: SS-304
g. Biomass Size: 50mm (Ø) x 100mm (L)

vi. Gas Cleaning System:

The cleaning of the gas is tricky and critical process, as the 65% of producer gas contains the particles above 60µm size. To clean this gas dry type cyclone filters (fine mesh and cotton) were used which are useful for particle size of 5µm in size. After passing the gas through this dry filter it was directly used for thermal application *i.e.* heating purpose without going for fine filtration.

vii. Instrumentation:

The temperatures at various points were measured by using PT-100 thermocouples with digital temperatures indicators.

The portable infrared gas analyzers (Model 2015 SPI The Technovation) Figure 6 was used for measuring the various constituents of the gases. It has a specially designed sampling configuration and NDIR infrared gas analyzers which makes it feasible to accurately measure gases that absorb infrared wavelengths of electromagnetic energy.

6. TESTING OF BIOMASS GASIFIER

In the testing of biomass gasifier the biomass (grapes stalk) briquettes of approximately 5 kg was fed in the hopper. After this the blower was switched on due to which the negative pressure was created inside the system. By taking the advantage of negative pressure inside the reactor, it was ignited with external means. After few minutes, the biomass inside the reactor started burning i.e. partial combustion process. With the help of instrumentation the various parameters were measured.

During testing on gasifier, it was observed that the product gas flow rate was intermittent. Also for the analysis of gas, sophisticated equipments such as briquetting machine, gas analyzer, gas cleaning system *etc.* were used for efficient conduction of the test. This will help in carrying out the analysis more effectively. Figure 5 shows the actual flame of burning the produced gas at gasifier exit. The system was tested with various intermittent trials.

Fig. 4. Gasifier assembly.

Fig. 5. Testing on biomass gasifier.

Fig. 6. Gas analyzer.

7. GASIFIER SYSTEM PERFORMANCE:

The available grape stalks were crushed in to the crusher and the briquettes were prepared from the briquetting machine. The gasification system was tested on the prepared single size grape stalk briquettes for heating the water. The detailed grapes stalk briquettes gasification results which include chemical analysis of the produced gas, calorific value (GCV), wet feed rate, wet product gas flow and air fuel ratios are summarized in Table 4.

From the above Table 4 it is observed that the air gasification of grapes stalk briquettes in a laboratory biomass gasifier having good specific gasification rate, flow rate with good gas outlet temperature and higher calorific value. The air fuel ratio has vital important effect on the gasifier performance because it regulates the fuel consumption rate [13]. In this study higher air fuel ratios were obtained at lower wet feed rates

Table 4. Gasifier system performance.

Sr. No.	Description		Value
1	Biomass consumption rate(kg/hr)		10
2	Air required (kg per kg of biomass)		5
3	Amount of gas produced (m^3 per kg of wet biomass)		2.2
4	specific gasification rate (kg/hr per square meter throat area)		3900
5	Gas characteristics	Flow rate (Nm^3/hr)	22
6	Process parameters (^{0}C)	Gas outlet temperature	350-400
		Gas temperature at burner inlet	275-300
7	Gross calorific value of the gas (MJ/Nm^3)		5-6
8	Gasifier performance (energy content of gas) (MJ/hr)		50-150

8. CONCLUSION

Biomass gasification offers the most attractive alternative energy system for agricultural produces. The Gasification from Grape stalk briquettes may be used as alternative biomass materials as the feedstock to the biomass gasifier in rural areas of Maharashtra state of India. Gasification output capacity, especially in the high output ranges, can be controlled only by availability of adequate feed materials rather than other technical consideration.

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