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Industrial Application of Biomass Based Gasification System

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Abstract: The use of renewable energy sources is becoming increasingly necessary and thrust towards wider application of renewable energy devices at domestic, commercial and industrial levels not only resulted in greater awareness but also significant installed capacities. This study deals with the thermal performance of gasification system installed at M/S Phosphate India Pvt. Limited, Udaipur for heating and concentrating Phosphoric Acid. The biomass consumption rate of the gasifier was found to vary from 100-120 kg h^{-1}. The average air and gas flow rate was 92.69-99.20 and 204-210.26 m^3 h^{-1} respectively. The temperature at 20mm above the grate varied from 800-1143°C. The gas outlet and flame temperature varied during the test from 380-440°C and 690-740°C, respectively. The quality of gas samples were analysed and heat value of the producer gas was observed 4.35 $MJNm^{-3}$

Key words: Wood · Open core · Downdraft gasifier · Thermal application

INTRODUCTION

Sustainable and renewable natural resources as biomass that contains carbon and hydrogen elements can be a potential raw materials for energy conversion [1]. Current energy supplies in the world are dominated by fossil fuels (some 80% of the total use of over 400 EJ per year). Nevertheless, about 10-15% (or 45±10 EJ) of this demand is covered by biomass resources, making biomass by far the most important renewable energy source used to date. On an average, in the industrialized countries biomass contributes about 9-13% to the total energy supplies, but in developing countries the proportion is as high as a fifth to one third. In number of countries biomass covers even over 50-90% of the total energy demand. A large part of this biomass use is however non-commercial and used for cooking and space heating, generally by the poorer part of the population [2].

Fossil fuel based technology has been primary source in India since last two decades to meet the thermal energy required in small as well as large industries. The number of small-scale industries that uses liquid fuels in the range of 100 liters per hour to meet the heat requirements is quite large [3]. These small-scale industries occupy an important place in the country's economy. India has more than 3 million small-scale industries in the organized sector and about 15 million enterprises in the unorganized sector. These units account for about 40% of the total industrial output in the country [4]. There is urgent need to introduce the energy efficient technologies at industrial level for effective fuelwood utilization. Many industries have various thermal applications where direct burning of fuelwood is employed. The direct burning of fuelwood is not an energy efficient process [5]. Hence, the need for introduction of suitable technologies to harness the wood energy was identified for design refinement to make the gadget technically sound and economically viable.

MATERIALS AND METHODS

The generation of producer gas in gasification system occurs in two significant steps. The first step involves exothermic reactions of oxygen in air with the pyrolysis gas under rich conditions. The second step involves the endothermic reaction of these gases largely CO_2 and H_2O with hot char leading to producer gas [6].

An open core, throat less down draft gasifier to produce 233 kW_{th} of process heat for for industrial use was designed and developed by Department of Renewable Energy Sources, College of Technology, Udaipur (27° 42' N, 75° 33' E) and installed at M/s

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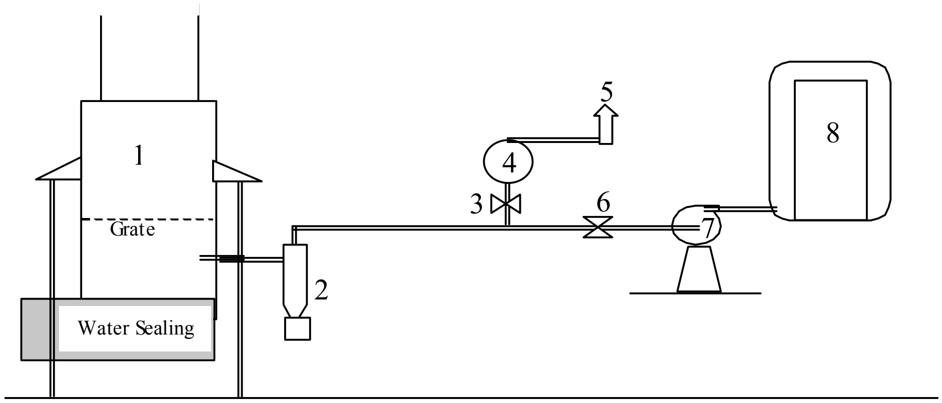

Fig. 1: Schematic of gasifier layout with dryer

1	Gasifier	4.	Testing Blower	7.	Main Blower
2.	Cyclone	5.	Testing Burner	8.	Dryer
3.	Valve No. 1	6.	Valve No. 2		

Table 1: Technical detail of gasifier

Type	:	Down draft throat less open core
Feed stock	:	Sized wood
Consumption rate	:	120 kg h^{-1}
Rated capacity	:	233 kW_{th}
Equivalence ratio	:	3:1
Grate cross sectional area	:	0.8 m^2
Ash removal unit	:	Manual
Fuel feeding	:	Manual
Gas discharge	:	By electric suction blower

Table 2: Physical and thermal properties of feed stock Babul wood (*Prosopis juliflora*)

S. No.	Characteristic		Biomass (Babul wood) (*Prosopis juliflora*)
1	Size (mm)	:	25-40
2	Length (mm)	:	35-85
3	Bulk density (kg m^{-3})	:	395
4	Angle of slide (deg)	:	15
5	Moisture content (% wb)	:	10.20
6	Volatile matter (% db)	:	83.42
7	Ash content (% db)	:	1.05
8	Fixed carbon (% db)	:	15.53
9	Calorific value ($MJkg^{-1}$)	:	16.30

Phosphate India Private Limited, Udaipur, a chemical industry manufacturing of phosphoric acid. In this study attempt has been made to evaluate the performance of gasifier for actual use. The technical specification of design gasifier for thermal application is given in Table 1.

SYSTEM OPERATION AND MEASUREMENTS

The gasifier was operated according to the procedure prescribed by the Ministry of New and Renewable Energy [7]. Proximate analysis of fuel was carried out before the test by using the method suggested by ASTM [8]. The calorific value of feed stock was calculated by Digital Bomb Calorimeter (Advance Research Instrument Company). Initially 30 kg of charcoal pieces (15-40 mm long) were loaded up to the air nozzle level and 10 kg of wood saving was loaded for easy firing. Then fuel wood was loaded up to the top of gasifier. The flare blower was started, drawing air for gasification through top of reactor and through air tuyeres. By holding flame at the air tuyeres one by one ignited the fuel bed, which sucked in the flame to ignite the bed. After some time, the producer gas obtained became combustible and was ignited at the testing burner. The main blower was started after quality gas was recorded at flare burner to turn the producer gas for actual operation in the oven. The gas was sucked by blower after closing the valve No. 1 and the opening valve No. 2. The gasifier was operated with feed stock of Babul wood (*Prosopis juliflora*) to evaluate the performance of the system. Physical and thermal properties of feedstock is presented in Table 2.

The fuel consumption rate (FCR) was measured by recharging the gasifier on an hourly basis by filling the gasifier volume to predetermine level that was at the top of gasifier hopper. The grate was operated at regular interval to remove ash accumulated on the grate. K-type thermocouples and digital multi channel temperature indicator were used to measure temperature inside the gasifier. Water filled U tube manometer was used to measure the pressure drop across the gasifier Junkar's gas calorimeter (make-INSURF) was used to calculate the calorific value of producer gas by combustion of a known volume of gas to heat steadily the flowing water and measuring the rise in temperature of a measured volume of water.

RESULTS

For evaluating the thermal performance of designed gasifier on thermal application, the system was operated for 50 h continuously. The temperature inside the reactor was measured at 20mm, 120mm, 220mm, 420 mm, 620 mm above the grate and is shown in Fig. 2. The temperature at 20 mm above the grate varied from 800-1143°C. The variation in temperature above 120mm and 220 mm the grate was observed 525-920°C and 410-762°C, respectively. The gas outlet and flame temperature varied during the test from 380-440°C and 690-740°C

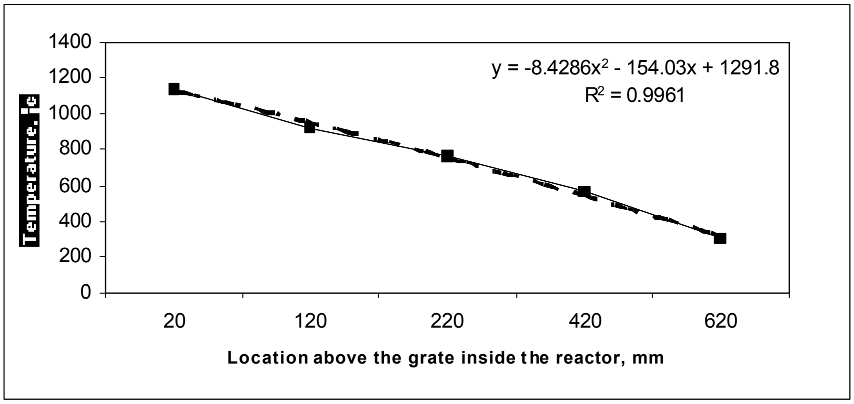

Fig. 2: Temperature profile of the reactor

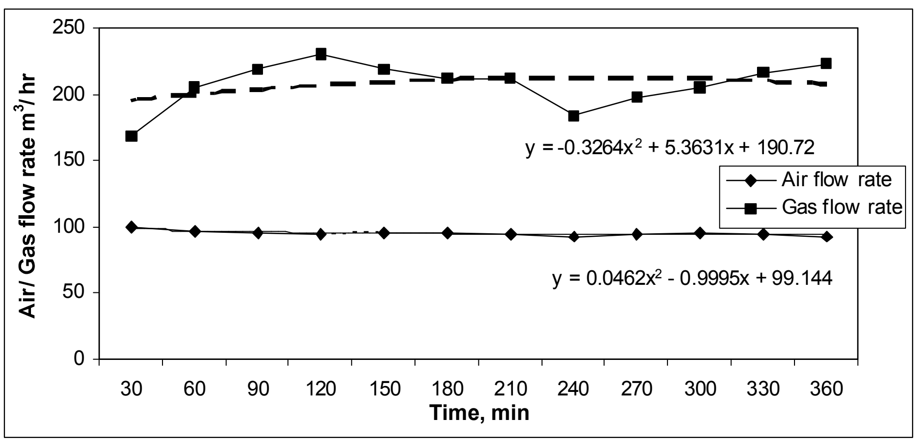

Fig. 3: Gas and flame temperature across reactor for wood gasification

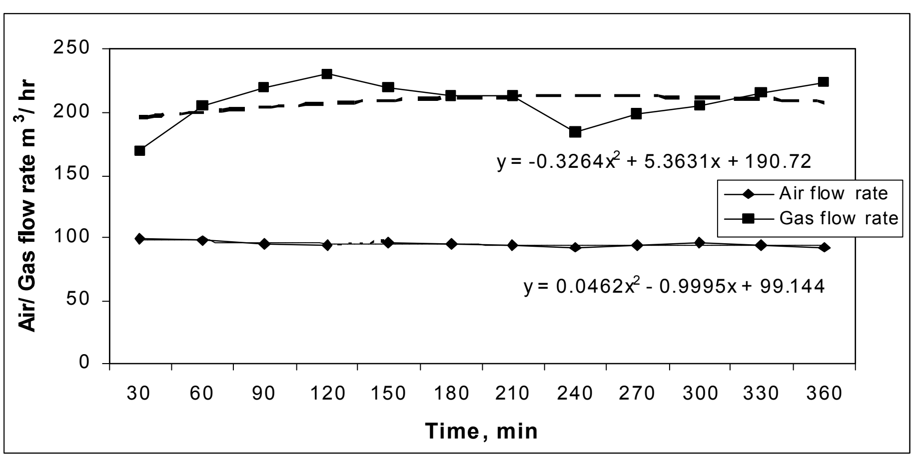

Fig. 4: Air and Gas flow rate distribution across reactor for wood gasification

Table 3: Performance of gasifier at M/s phosphate India limited

S. No.	Parameters	Babul wood (*Prosopis juliflora*)
1.	Fuel consumption rate, kg h^{-1}	112.00
2.	Producer gas flow rate, Nm^3 h^{-1}	210.00
3.	Calorific value of producer gas, $MJNm^{-3}$	4.35
4.	Cold gas efficiency, %	68.00
5.	Gas production, m^3 kg^{-1}	2.65

respectively as shown in Fig. 3. The air and gas flow rate observed was in the rage of 92.7-99.20 m^3h^{-1} and 204-210.26 m^3 h^{-1} respectively as shown in Fig. 4. There was no problem found in the operation of gasifier and combustible producer gas was recorded after 10 minutes of flaring. The calorific value of producer gas varied in the range of 4.2-4.6 $MJNm^{-3}$ and cold gas efficiency in the range of 65-70% as shown in Table 3.

CONCLUSIONS

The performance of the designed system for process heat at industrial level was has demonstrated technically feasible. Biomass based open core down draft biomass gasifier system perform constantly well in industries for thermal application which not only a means of energy conservation, but also. There is huge scope to conserve fossil fuel and reduction in greenhouse gases as well.

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