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An Experimental Investigation On Sawdust Gasification In A Fluidized Bed

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ABSTRACT

The present study investigates the effect of sawdust gasification in a fluidized bed gasifier. Two scenarios were investigated in this study. In the base case scenario, a total of 10 experiments consisting of five different temperatures in the range of (650 to 850°C) in 50 degrees intervals were conducted. The influence of Steam to biomass (S/B) ratio (0 to 2) was investigated as another scenario. In a bubbling fluidized bed gasifier air and steam were used as a fluidizing and gasifying agent. The gasifier used for this study was 108 mm ID and 1400 mm high (H), and it was fed with saw dust at a flow rates of 5-20 kg/h. The behaviors of saw dust under the various parameters were studied and the optimum parameters were obtained. The results showed that higher temperature contributed to more hydrogen production, but too high a temperature lowered gas heating value. Compared with biomass air gasification, the introduction of steam improved gas quality. However, excessive steam would lower gasification temperature and so degrade fuel gas quality.

Keywords : Gasification; Biomass; Fluidized bed; Gas yield; S/B ratio; Saw dust

Introduction

Biomass gasification, a century old technology, is viewed today as an alternative to conventional fuel. Biomass is widely considered to be a major potential fuel and renewable resource for the future [1]. Energy from biomass is an attracting more and more attention worldwide because it is a potentially CO - neutral and renewable energy source. Biomass refers to all organic materials that are originated from plants and its being traditionally used as energy source especially for cooking and heating particularly in the developing countries [2-4].The technology of biomass air gasification seems to have a feasible application and has been developed actively for industrial applications. However this technology produces a gas with a low heating value (46 MJ/m3) and an 814 vol. % H2 content only [5]. Biomass oxygen-rich air gasification is one effective way of producing medium heating value (MHV) gas, but it needs a large investment for oxygen production equipment and this disadvantage impedes its popularization. In the present work, a small scale bubbling fluidized bed was developed and low temperature steam (150ºC) and air were used as the biomass gasification agent to investigate the effects of some critical parameters on gasifier performance of saw dust gasification.

Materials And Methods

Materials

The sample of biomass used in this study was saw dust which was procured from local timber mill in Ambattur near Chennai, Tamil nadu, India. The results of ultimate and proximate analyses of biomass are given in Table 1. Chemical formulas of the biomass tested were calculated based on the results of the ultimate analyses as $CH_{1.41}O_{0.53}$.

Table 1 Property analysis of biomass sample

Characteristics		Parameters %	
Moisture content (Wt. % wet basis)	: 7.83		
Proximate analysis		**Ultimate analysis**	
Volatile matter	: 75.84	Carbon (C)	: 54.04
Fixed carbon	: 16.39	Hydrogen (H)	: 6.36
Ash	: 0.77	Oxygen (O)	: 38.1
		Nitrogen (N)	: 0.52
		Sulphur (S)	: 0.21
Higher Calorific value (kJ/kg)	:		20,728

Facility

The schematic diagram of an experimental set up is shown in Fig.1. The main elements of the installation are: the fluidized bed gasifier, a steam generator, cleaning and sampling system, temperature control system. Table 2 describes the main design and operating features of the bubbling fluidized bed gasifier. The fuel gas composition was analyzed using Siemens make Online Gas Analyzers viz. Oxymat 61 (Estimates O_2 using paramagnetic principle), Ultramat 23 (Estimates CO, CO_2, and CH_4 using Non Dispersive Infrared multilayer technology) and Calomat 61 (Estimates H_2 using thermal conductivity principle). Chromel Alumel (K type) thermocouples were used for measuring the temperature at different zones (T1 to T10).

Experimental procedure

At the beginning of the experimental work, the fluidized bed was charged with 3 kg of silica sand as bed material, which is used to help in stable fluidization and better heat transfer. Then the electric furnace was turned on to preheat the fluidized-bed reactor; meanwhile, steam generator was turned on for the preparation of steam for the test. After the bed temperature reached the desired level and was kept steady, the air blower was turned on to force the air through the distributor.

When the bed temperature again turned steady, the screw feeder was turned on at the desired rotate speed and the test began. Typically, it took 30 min for the test conditions to reach a stable state. Five samples were taken at an interval of 5 min after the test ran in a stable state.

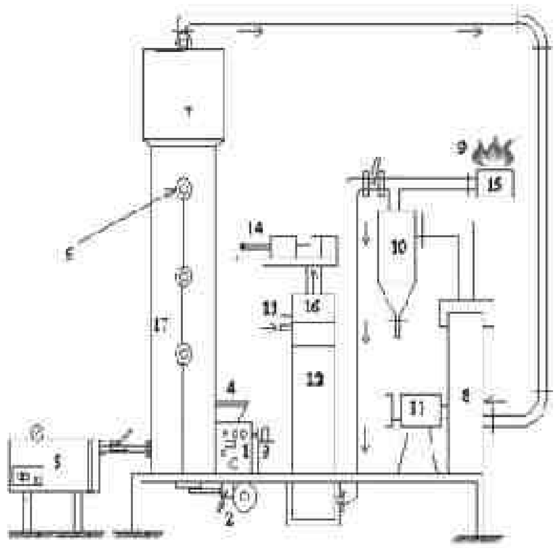


Figure 1. Experimental fluidized bed gasification system. 1 – control panel; 2 – air blower; 3 – Variable displacement drive motor; 4 – biomass hopper; 5 – steam generator; 6 – Thermo couple; 7 – free board; 8 – Suction blower; 9 – flare; 10 – cyclone; 11 – blower motor; 12 – water scrubber; 13 – water inlet; 14 – to gas chromatography; 15 – burner; 16 – dry filter; 17 – fluidized bed gasifier.

Table 2 Main design and operating features of the bubbling fluidized bed gasifier

Geometrical parameters	ID: 0.108 m; total height: 1.40m
Feedstock capacity	: 5 -20 kg / hr
Feeding equipment type of fuel)	: screw feeder (depending on the
Gasifying agents	: Air, steam
Range of temperature	: 600 -900ºC
Fuel gas treatments	: Cyclone, water scrubber

Results And Discussion

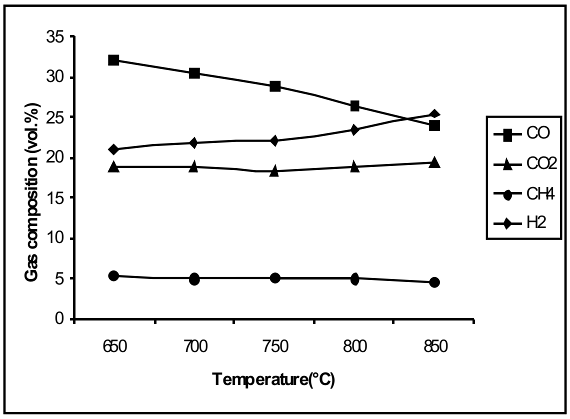
Effect of operating parameters

The various factors influencing the gas composition and heating value of fuel gas were investigated in this paper. The major factors influence the gas compositions were bed temperature and steam to biomass ratio.

Effect of reactor temperature

In gasification, bed temperature is one of the most important operation parameters which affect both the heating value and producer gas composition [6-8]. The following sections describe the effect of bed temperature in fluidized bed steam gasification in terms of gas composition and gas yield. Operating temperature in fluidized bed gasification was found to have a strong influence on the gas composition. The rise in temperature gave rise to a significant increase in H2 content by 1020% and a reduction in heavier hydrocarbons by 35%, while the CO amount decreased slightly in the range 730 and 850 °C and then remained constant. Similar trends were observed from Ajay Kumar et al [9]. Fig. 2 shows the effect of temperature on gas composition on saw dust gasification.

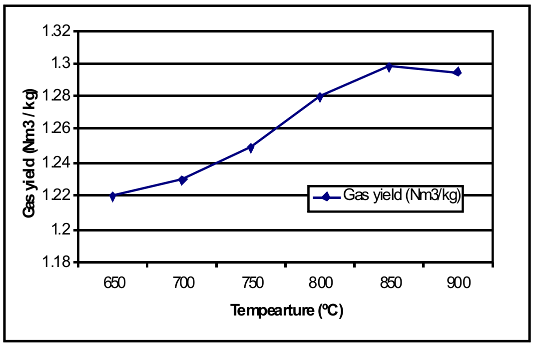
Fig. 2 Effect of temperature on gas composition



Influence of temperature on gas yield

The influence of temperature on gas yield of saw dust is shown in Fig.3. It is noted from the figure that the increase of temperature leads to increase the gas yield up to the temperature of 850°C. As the temperature increases, more amount of solid fuel is converted into gaseous products thereby increasing the product gas yield. This is in agreement with the studies conducted by the other researcher, Sheeba et al., 2009.

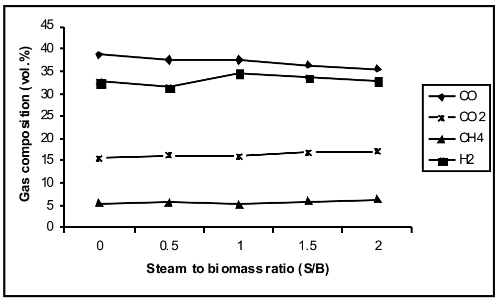
Fig. 3. Effect of temperature on gas yield



Effect of steam to biomass ratio (S / B)

The effect of S/B was minimal at all temperature set points, which suggest that the steam did not react with the syngas to increase the hydrogen content at these operating conditions[10-12]. The experimental investigation on saw dust at various steam to biomass ratio on gas composition are described in Fig.4. The similar result was achieved by the Franco et al 2003, the author investigated the steam gasification in fixed bed with pine saw dust was used as fuel. The tests were performed at four different temperatures ranges from 600 °C to 900 °C, and the S/B was varied from 0 to 2.80. In each test, the fuel flow rate was kept constant at 5 g/min. The author concluded that, When S/B is 1.43, the dry gas yield and carbon conversion efficiency reach its maximum value with 2.53 Nm3 / kg and 92.59%, respectively.

Fig. 4 Effect of Steam to biomass ratio on gas composition



While if the S / B is regarded as a function of the H2 content, the optimum value of S / B is 2.10. From the serious investigation of Guo et al [11], the introduction of steam, gas temperature gradually degrades, but it greatly improves gas yield, LHV, carbon conversion, especially H2-content up to 11.23 vol %.When excessive stream was introduced, gas quality lowered. Thus, there exists an optimal value for S/B, it is 1.2 in this test.

Conclusions

Temperature was the most important factor in this process. Higher temperature favored hydrogen production and gas yield but did not always favor gas heating value. Too high a temperature lowered gas heating value. ER had complex e□ects on tests results and there existed an optimal value for ER, which was di□erent according to di□erent operating parameters. In the present study, the optimal value of ER was found to be 0.23. This experimental study has confirmed that the addition of steam to biomass gasification is favorable for improving gas quality. However, excessive steam would lower gasification temperature and so degrade product gas quality.

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