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Experimental investigation on an entrained flow type biomass gasification system using coconut coir dust as powdery biomass feedstock

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HIGHLIGHTS

- ▶ An entrained flow gasifier has been successfully tried with coconut coir dusts.
- ▶ The gasifier could attain temperatures in the range of 976–1100 °C.
- ▶ The gas yield and tar content were influenced by introduction of steam and preheat.
- ▶ The LHV and peak CGE of 7.86 MJ/Nm^3 and 87.6% respectively were obtained.

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ABSTRACT

Based on an entrained flow concept, a prototype atmospheric gasification system has been designed and developed in the laboratory for gasification of powdery biomass feedstock such as rice husks, coconut coir dust, saw dust etc. The reactor was developed by adopting L/D (height to diameter) ratio of 10, residence time of about 2 s and a turn down ratio (TDR) of 1.5. The experimental investigation was carried out using coconut coir dust as biomass feedstock with a mean operating feed rate of 40 kg/h The effects of equivalence ratio in the range of 0.21–0.3, steam feed at a fixed flow rate of 12 kg/h, preheat on reactor temperature, product gas yield and tar content were investigated. The gasifier could able to attain high temperatures in the range of 976–1100 °C with gas lower heating value (LHV) and peak cold gas efficiency (CGE) of 7.86 MJ/Nm^3 and 87.6% respectively.

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1. Introduction

Biomass is the collective form for all forms of plant materials including forest and agro-residues. It has environmental benefits, offer fuel flexibility and can be used as supplemental low cost fuel, especially residues, for use in combustion systems, i.e. gas turbine, gas engines and gas burners. Gasification of biomass is a thermochemical process and has the potential to convert lignocellulosic biomass into a gas or liquid intermediate suitable for further refining to valuable products. It is a less developed technology than biomass combustion. Because of this reason, there is an increased risk associated with the commercialization of gasification technology. Several studies indicate that the available biomass potential in India can be used for energetic and chemical processes very efficiently via gasification.

Several types of biomass gasifiers have been developed over the years including fixed bed, bubbling fluidized bed and circulating fluid bed gasifiers for solid biomass (McKendry, 2002; Dasappa et al., 2004; Corella et al., 2005; Sharma, 2008; MNRE Newsletter, 2008; Barman et al., 2012; Balu and Chung, 2012). These gasifiers operate at pressures ranging from atmospheric to 2.4 MPa and with typical operating temperatures in the range of 250–900 °C. The content of impurities in terms of tar and particulate matter in the raw product gas necessitates cleaning activity in order to meet both utility and environmental emission limits (Lin et al., 2011). The effect of bed temperature and steam flow rate on product gas yield in a fixed bed biomass gasifier was studied by Yan et al. (2010). It has also been reported in literature that introduction of steam could able to generate nitrogen free hydrogen-rich product gas with higher heating values in fluidized and steam-oxygen blown circulating fluidized bed gasifiers with a medium range heating values (Peng-mei et al., 2003; Kempegowda et al., 2010; Karmakar et al., 2011; Meng et al.,2011). A few studies on design, developmental and modeling aspects of cyclone type biomass gasifiers have been reported in literature (Gabra et al., 2001; Syred et al., 2004; Guo et al., 2009; Sun et al., 2009).

Fletcher et al. (2000) carried out CFD modeling of entrained flow gasification of biomass which may be considered useful in designing such systems. Henrich and Weirich (2004) have

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