Bioresource Technology 119 (2012) 15–21

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

Influence of particle size on performance of a pilot-scale fixed-bed gasification system

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HIGHLIGHTS

- The effect of particle size on the gasification performance of a gasifier was investigated.
- Peach prunings were used at five different size fractions.
- As particle size increased, the gas yield increased while the tar and dust content decreased.
- More kinds of hydrocarbons were detected when smaller particle size were used.
- The gas produced by the smaller particle size showed a better combustion performance than the larger one.

ARTICLE INFO

Article history:
Received 14 November 2011
Received in revised form 18 April 2012
Accepted 18 May 2012
Available online 30 May 2012

Keywords:
Biomass gasification
Fixed bed
Pilot-scale
Particle size

ABSTRACT

The effect of particle size on the gasification performance of a pilot-scale (25 kg/h) downdraft fixed bed gasification system was investigated using prunings from peach trees at five different size fractions (below 1, 1–2, 2–4, 4–6 and 6–8 cm). The gas and hydrocarbon compositions were analyzed by gas chromatography (GC) and gas chromatography/mass spectrometry (GC–MS), respectively. With increasing particle size, gas yield increased while tar and dust content decreased. The lower heating value of the gas decreased slightly with particle size. At a smaller particle size, more hydrocarbons were detected in the producer gas. Hydrogen and carbon dioxide contents increased with the decrease in particle size, reaching 16.09% and 14.36% at particle size below 1 cm, respectively. Prunings with a particle size of 1–2 cm were favorable for gasification in the downdraft gasifier used in this study.

1. Introduction

Among biomass energy conversion technologies, biomass gasification technology is regarded as an ideal technology for the treatment of wood chips and lignocellulose agricultural wastes for fuel gas production (McKendry, 2002b). Down-draft gasifiers are commonly used in China due to its easy operation and flexibility for different types of biomass materials. Biomass properties (particle size, moisture content, ash content) and gasifier operation conditions (temperature, space resident time, equivalence ratio) can influence the producer gas quality. Much work has been devoted to assessing the influence of these factors (Di Blasi et al., 1999; Dogru et al., 2002; Karmakar and Datta, 2011; Midilli et al., 2002). Among these parameters, biomass particle size can greatly affect gasification performance. For a fixed bed gasifier, there is a limitation in the range of biomass particle size. Feedstock with particles that are too small may have a high pressure drop problem as well as a high proportion of dust in the gas, causing an eventual shutdown of the gasifier. Larger particle sizes give rise to reduced reactivity of the feedstock, resulting in start-up problems, and causing bridge problem which prevent the feed from moving down (McKendry, 2002b). Additionally, the preparation, particularly the reduction of biomass to a required size, is associated with an energy cost. Therefore, it is important to determine the effect of biomass particle size on the operation of a gasification system.

Many studies have been carried out to investigate the effect of particle size on gasification performance in different types of reactors. Hernández et al. (2010) studied the effect of particle size and residence time in an entrained flow gasifier using three types of biomass materials (grapevine pruning, sawdust wastes and marc of grape) and concluded that reduction in the fuel particle size leads to an improvement in gasification performance. Rapagn and Latif (1997) conducted a study on steam gasification of almond shells in a fluidized bed reactor to evaluate the effect of particle size as a function of temperature on product yield and gas composition. They found that as particle size decreased, there were no differences in product yield and distribution of gas, char and tar

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http://dx.doi.org/10.1016/j.biortech.2012.05.085