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Progress in techniques of biomass conversion into syngas

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ABSTRACT

Biomass gasification is one of major biomass utilization technologies to get high quality gas. The high quality gas can be subsequently used for gas supply and power generation as well as syngas. Significant efforts have therefore been made in biomass-derived syngas production. The paper reviews the state-of-the-art biomass-derived syngas production techniques in terms of technical performance. Various kinds of gasification reactor are briefly introduced. Main technologies of syngas production can be divided into four approaches: partial oxidation and steam reforming of biomass pyrolysis oils, co-gasification of biomass and coal, coupled steam hydrogasification of biomass and reforming of methane, gasification of biomass-derived char. Each of these production processes are also analyzed in detail. Among these production technologies, the primary technology for syngas production is steam hydrogasification and reforming. Syngas has a higher H_2/CO ratio by using these two technologies: the steam hydrogasification and reforming technology and biomass-derived char technology.

1. Introduction

With fossil fuel depleting and increasing serious environmental problems, biomass energy as a clean and renewable resource has been paid more and more attention in the global sourcing strategy [1]. Because of the increasing energy demand and the limitation of the fossil sources, renewable energy sources should be used to the maximum. In order to achieve growth in economic development, it is essential to meet energy needs of all sectors, such as agriculture, industry and transportation [2]. Biomass gasification is one of major biomass utilization technologies to get high quality gas. The high quality gas can be subsequently used for gas supply and power generation as well as syngas. So it is regarded as one of the most attractive options for utilization of biomass. Syngas production from biomass is widely studied, since syngas could be further widely used for many purposes.

Many research institutes have involved in biomass gasification for many years. For example, in China, including Guangzhou Institute of Energy Conversion, Tsinghua University, Tianjin University, Huazhong University of Science and Technology, Xi'an Jiao Tong University, East China University of Science and Technology, Shandong Province Academy of Science, and so on. Syngas production technologies can be divided into four approaches: partial oxidation and steam reforming of biomass pyrolysis oils, co-gasification of biomass and coal, coupled steam hydrogasification of biomass and reforming of methane, gasification of biomass-derived char. In the gasification process, the gasification reactor is a critical component as is the main syngas production technology. In this paper, various kinds of gasification reactor are briefly introduced, such as, fixed bed, circulating fluidized bed (CFB), bubbling fluidized bed (BFB). And the main technologies of syngas production are summarized.

2. Gasification reactor type

Biomass gasification reactors are classified into two main types: fixed bed and fluidized bed. The sub-categories for the fixed bed type gasifiers are (a) updraft, (b) downdraft. And the sub-categories for the fluidized bed gasifiers are (a) bubbling fluidized bed (BFB) and (b) circulating fluidized bed (CFB).

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2.1. Fixed bed gasifier

2.1.1. Updraft gasifier

In the updraft gasifier, the material is fed from the top of the reactor and the air is introduced from the bottom of the reactor through a grate. Material and air move in opposite direction in the gasifier [3]. The "combustion" zone is essentially in the lowest part of the gasifier. In this zone, biomass is combusted and char is formed. During the process of combusting, the temperature of the lower part of the gasifier raises to about 750 °C. The hot gases pyrolyze the biomass and dry it in further in the upper part of the gasifier. Pyrolysis of biomass results in release of volatiles and formation of a sizeable amount of tar [4]. Some of the tar may be released with the outgoing gases. The humidity of the air used in the gasification plays an important role in controlling the temperature [5]. A schematic of the updraft gasifier is shown in Fig. 1 [5].

2.1.2. Downdraft gasifier

In the downdraft gasifier, the material and air move concurrently from top to bottom of the reactor. Since the exit of the produced gas is close to the combustion zone, tar formed during devolatilization of the biomass is thermally cracked to some extent [5]. Thus, the tar content of the produced gas from the downdraft gasifier is lower than that of the updraft gasifier [6,7]. Downdraft gasifier has been paid more and more attention due to the low tar content in the produced gas. Low tar content gas is always preferred for firing gas engines and turbines [5]. Fig. 2 shows a schematic of the downdraft gasifier [4].

2.2. Fluidized bed gasifier

Fluidized bed gasifier is widely used in recent years [5]. The advantages of these processes are: the temperature distribution in the reactor is uniform, conversion of carbon is high, tar production is low. The fuel type, feed rate, as well as particle size are flexible [8]. In the past two decades, significant experimental and theoretical research has already been carried out in design, development and scale-up of fluidized bed gasifiers [5]. Two kinds of fluidized systems are described.

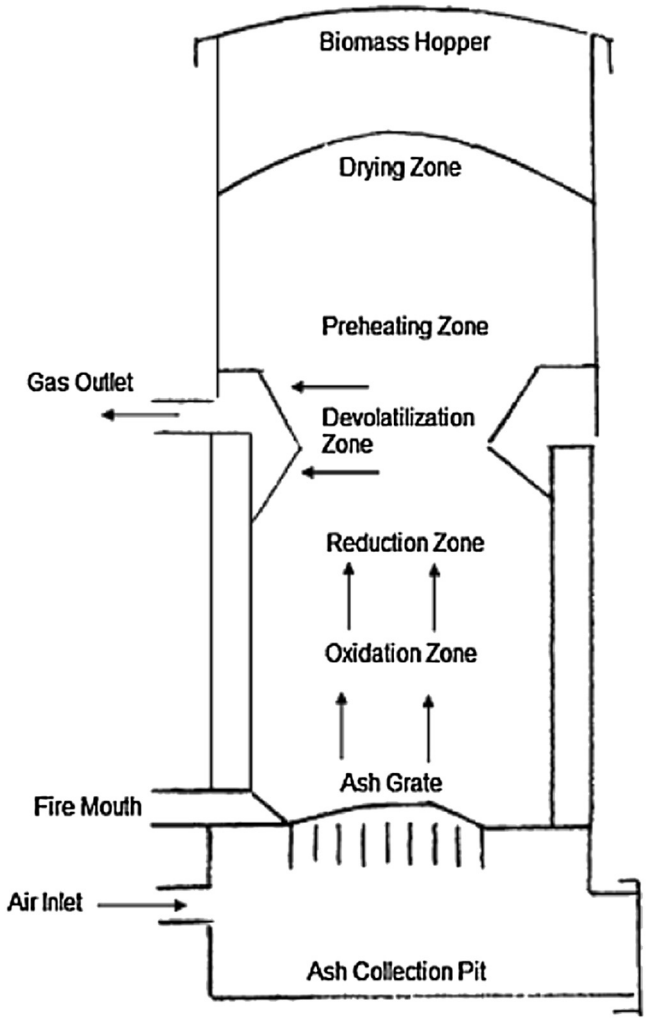

Fig. 1. The updraft gasifier.