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Experimental performance of Tar Removal by a Quench coupled with adsorption technology

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Abstract

The effective removal of tar is one of the main obstacles to the large-scale industrialization of biomass gasification process. In this research, a quench coupled with adsorption technology (QCAT) has been developed and patented to ease this barrier, which contained the quench column, the 1st adsorption column and the 2nd adsorption column. For this research, an analysis method of light and medium biomass gas tar was established to determine the light PAH tar (2-4 ring) and light aromatic tar (1 ring) compounds as well as their concentrations; the removal performance and the mechanism of the real tar which produced by the gasification were researched. The results showed that the quench column was used to remove the heavy tar; the 1st adsorption column was able to remove pyridine and the light PAH aromatic tar (2-4 ring) without naphthalene; the 2nd adsorption column was used to remove the light aromatic tar (1 ring) as well as naphthalene. The tar removal rates of the light aromatic tar and light PAH tar were almost 99.9% in the effective time of the experiment. The outlet gas of the 2nd adsorption column reached application requirement.

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Keywords:biomass gasification; real tar; quench; adsorption

1. Introduction

Biomass is the only one that can provide heat and power or act as carbon source for the production of fuels and chemical products as the fourth largest energy all over the world[1], which does not contribute

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to the production of CO_2 in the atmosphere[2]. Biomass gasification plays an important role in the biomass utilization process. However, the large-scale commercialization of biomass gasification is obstructed by the tar, which contains benzene, naphthalene, phenol and other aromatic hydrocarbons. Condensation and deposition of tar cause the clogging of pipes and engines, which increase the cost due to more frequent maintenance and repair of engines and heat exchangers.

Many kinds of tar removal technologies for biomass gasification have been investigated so far. Research at ECN (The Energy research Centre of The Netherlands) has culminated in the patented OLGA (Oil-based GAs washer) process[3-4], which can eliminate the total tar by 99% and reduce the tar dew-point in producer gas to below 0°C. Shunsuke Nakamura et al.[5] has investigated tar removal technologies by bio-oil in a pilot-scale gasification plant. The results show that the bio-oil scrubber and the char bed were effective for tar removal and both of them removed about 60% of tar from biomass syngas.

In this paper, QCAT was investigated based on coupled quench processing and adsorption separation, to provide fundamental basis for deep removal of real tar from biomass syngas.

2. Experimental section

2.1 Main materials and reagents

Main raw materials and reagents are shown in Table 1.

Table 1 Main raw materials and reagents

Name	Specification	Manufacturer
Wood chips	≤20 mesh	Self-production
Ceramic ring	3*5*10mm	Ceramics (Tangshan) Co.,Ltd.
AD-1	12~24 mesh	—
AD-2	8~20 mesh	—
Activated carbon sampling tube	18cm, O.D of 6mm	Labor Protection Science Research Institute Beijing

2.2 Main instruments and equipment

Main instruments and equipment are shown in Table 2.

Table 2 Main instruments and equipment

Name	Specification	Manufacturer
Gasifier	1~4.5kg/h	—
Elemental analyzer	Vario EL III	Elementar Analysensysteme GmbH
Thermogravimetric analyzer	The STA 449 F3 Jupiter	NETZSCH Scientific Instruments Trading
GC-MS	Trace ISQ	Thermo Fisher Scientific

2.3 Experiment equipment and testing process

For this research, the purification system of real biomass tar removal by QCAT has been established, and the schematic diagram and objects are shown in Fig. 1 and Fig. 2 respectively.