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Catalytic decomposition of biomass tars: use of dolomite and untreated olivine

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Abstract

Although biomass is getting increased attention as a renewable energy source, one of the remaining problems still to be solved is the reduction of the high level of tar present in the product gas from gasification of biomass. The purpose of the present work is to study the activity of olivine and dolomite for tar destruction. Some researchers investigated olivine as bed material for biomass gasification. But it is not yet known how tars behave in the presence of olivine and whether olivine has some activity towards tar destruction. A slipstream from a lab-scale atmospheric bubbling-fluidised-bed gasifier (located at ECN) is passed through a secondary fixed-bed reactor where the additives are placed. For easy understanding, the results are represented in terms of the following tar classes; GC-undetectable tars (class 1), heterocyclic compounds (class 2), aromatic compounds (class 3), light polyaromatic compounds (class 4), heavy polyaromatic compounds (class 5). The general observation is that the conversion of all tar classes increases as the temperature was raised from 800 to 900 °C for both additives. The water-soluble heterocyclic compounds can be easily converted by thermal treatment. At the temperature of 900 °C, the water-soluble heterocyclic compounds are completely converted. A 48% decrease in heavy PAHs is observed with pure sand. Addition of 17 wt% olivine to the sand leads to a 71% decrease of PAHs at 900 °C, whereas addition of 17 wt% (pre-calcined) dolomite converted 90%. Also improvement in conversion of other tar classes is observed when olivine and dolomite are added during hot gas cleaning. A total tar amount of 4.0 g m_0^{-3} could be reduced to 1.5 and 2.2 g m_0^{-3} using dolomite and olivine,

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respectively, at a temperature of 900 °C. Inspite of this reduction in total tar concentration, a limited impact on the tar dewpoint is observed.

Keywords: Biomass tar; Tar classification; Dolomite; Olivine

1. Introduction

In view of the worldwide concern about the depletion of fossil fuels and environmental problems associated with the use of these sources, renewable energy sources are getting increased attention. Biomass is considered as a potential source of renewable energy. Among all biomass conversion processes, gasification is one of the promising ones. One of the remaining problems still to be solved is the reduction of the tar present in the product gas. Tar is undesirable because of various problems associated with condensation, formation of tar aerosols and polymerisation to form more complex structures, which cause problems in the process equipment as well as the engines and turbines used in application of the producer gas. However, the minimum allowable limit for tar is highly dependent on the kind of process and the end user application. Considerable efforts have been directed towards tar removal from syn-gas.

Catalytic tar removal from the syngas is extensively reported in the literature. These catalysts include Ni-based catalysts, calcined dolomites and magnesites, zeolites and iron catalysts. The presence of additives not only influences the gas composition, but also the heating value of the product gas. The use of catalytically active materials during biomass gasification promotes the char gasification, changes the product gas composition and reduces the tar yield. Besides these, addition of active bed materials also prevents agglomeration tendencies and subsequent choking of the bed.

Dolomite and Ni-based steam reforming catalysts have been proven to be very active in terms of tar reduction. A lot is known on the behaviour of dolomite with respect to tar cracking. It has been tested as a primary [1–3] as well as secondary [4,5] measure, and it has been proven to be active in reducing tars produced in biomass gasifiers. However, besides good activity in terms of tar reduction, it has some critical limitations if used inside the gasifier. Dolomite is softer and thus gets eroded. Also, some dolomite particles break during the calcination and give rise to a large production of fines, leading to an increased carry over of solids from the bed.

Several nickel-based catalysts have been investigated and found to be very effective in terms of tar removal [3,6,7]. Ni-based catalysts are also very effective for NH_3 removal. Wang et al. [8] reported that NH_3 can be decomposed effectively over a Ni-based catalyst above 800 °C. Wang and his coworkers [9] reported 95% conversion of NH_3 along with 89% conversion of light hydrocarbons, which they defined as C_2H_6, C_6H_6, C_7H_8 and C_9H_8, over Ni-based catalyst in a secondary reactor at a temperature of 874 °C, pressure of 12 bar and a space time of 3 s. The main limitation of using Ni-based catalysts is severe deactivation of the catalyst. This deactivation occurs mainly when the catalyst is placed right after the gasifier; the high tar concentration has a devastating effect on catalyst activity. Steam reforming catalysts can however be used