

Study on the decomposition characteristics of tar derived from low temperature gasification of brown coal over coexisting char

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Abstract

Form the views of energy saving and environmental protection, low temperature (lower than the ash melting point) gasification has been developed to improve cold gas efficiency. Concerning the slag discharge, a circulating fluidized bed (CFD) reactor, including a fluidized bed (gasifier) and a riser (combustor), should be a proper substituted gasifier for the conventional one which has to operate at temperature higher than ash melting point for conveniently discharge slag, because the high density ash particles condensed at the bottom of riser can be discharged easily and the fly ash can also be separated form product gases by cyclone effectively in the CFD reactor for low temperature gaisifcation.

However, gasification at low temperature unavoidable results in the generation of refractory aromatic compounds, namely tar, which not only inhibit char gasification but also make it difficult to operate downstream facilities. Therefore a triple-bed combined circulating fluidized-bed reactor system, consisting of a downer (pyrolyser), a bubbling fluidized bed (BFB, gasifier), and a riser (combustor), is proposed. This reactor system was expected to decompose tar through an enhanced volatiles-char interaction at the downer and avoid the detrimental effects of tar on gasification and system operation.

This work is the first study using a drop-tube reactor to examine tar reforming over a char surface under reaction conditions expected in the downer reactor, where coal, char particles, and gas are co-currently flowing.

In the chapter 2, a Victorian brown coal (Loy Yang, LY) was co-fed with char prepared from the same coal in an atmospheric DTR at 900 and 950 °C in the presence of 50% steam to study in-situ reforming of tar derived from rapid pyrolysis of brown coal over a char surface. The effects of the char properties, char concentration in the blended sample, temperature, and feeding rate related to solid hold-up on tar decomposition were investigated. We found that the tar was significantly decomposed by the tar–char interaction in the DTR. Increasing the temperature, feeding rate, and char concentration enhanced the tar decomposition.

In the chapter 3, a four-lump kinetic model that includes 6 total kinetic constants is proposed to well understand the in-situ tar reforming process carried out in DTR. The effects of residence time, temperature, solid hold-up and steam partial pressure on the in-situ tar reforming performance are investigated. This four-lump kinetic model predicts the product yields well. The kinetic parameters are estimated at different operating conditions, and the quantitative correlation between the kinetic parameter and operating condition is established.

In the chapter 4, inexpensive raw materials, soda ash (Na_2CO_3) and slaked lime ($\text{Ca}(\text{OH})_2$), were selected as catalyst precursors to prepare the catalyst loaded coal by an ion-exchange procedure using a sub-bituminous coal (Adaro coal, Indonesia). These coal samples were rapid pyrolyzed and in-situ gasified in an atmospheric drop-tube reactor (DTR) at 850–1000 °C under a steam partial pressure of 0.05 MPa. The catalytic effects of Na and Ca from inexpensive materials on in-situ steam gasification of char from the rapid pyrolysis of low rank coal were investigated. The state of catalyst over char was also examined. The Na and Ca catalysts showed remarkable activity for gasification and inhibited the formation of primary tar effectively.

In this work, we demonstrated the potential of the downer part to decompose tar in the TBCFB reactor system by using a drop-tube reactor to simulate the reaction conditions expected in the downer. We hope our study can serve as an effective guide for design, simulation, and practical operation of *in-situ* tar reforming in the downer reactor in the future.