GASIFICATION KINETICS OF LIGNITE CHAR WITH CO_2 AND H_2O IN A FLUIDIZED BED

F. Scala
scala@irc.cnr.it
Istituto di Ricerche sulla Combustione (IRC-CNR), P.le Tecchio 80, Napoli, Italy

Commercial use of lignite is forecast to grow substantially in the future, since lignite reserves are abundant in the world. The use of lignite is appealing for some recently proposed techniques, namely chemical looping combustion and sorption enhanced gasification. In fact, these processes require that fuel gasification is carried out at a low temperature, so that fuels with highly reactive chars, like low-rank coals or biomass, are best suited.

Fluidized bed (FB) gasification is acknowledged to have great flexibility in conversion of solid fuels into synthesis gas. Unfortunately, gasification is capital-intensive and the produced syngas has a high dust and tar content. The production of unburned carbon fines is well known to affect the reliability and efficiency of FB gasification.

To design or model a FB lignite gasification process, accurate kinetic expressions of the char gasification reactions are needed. In fact, contrary to FB combustion which is mostly controlled by oxygen mass transfer around the particle, FB gasification is mostly controlled by the intrinsic kinetics of the carbon reaction with CO_2 or H_2O. Carbon gasification has long been studied and numerous works have been reported in the literature, especially for CO_2 gasification. Most of these studies were performed in devices (TG, drop tube, fixed bed) and/or conditions (particle size, heating rate) which differ from those relevant in a FB. Comparatively fewer studies were performed in FBs, especially for steam gasification. Noteworthy, FBs are very well suited for kinetic studies because of the accurate control of operating conditions and uniform temperature.

Lignite char is known to be more reactive than high-rank coal char. One reason is the catalytic activity of some ash constituents. However, very limited activity was reported on lignite FB gasification. In this work char from an Italian lignite was studied under both CO_2 and H_2O gasification conditions in a lab-scale FB apparatus at different bed temperatures (750-900°C) and gas compositions. Carbon conversion was measured by following the outlet CO and CO_2 concentrations. A kinetic model for both CO_2 and H_2O gasification was developed, that could predict the evolution of conversion vs time. Both reactions followed a Langmuir–Hinshelwood (L-H)-type equation. Similar activation energies were found for the two reactions. Interestingly, the structural parameters of the two expressions were identical, suggesting that CO_2 and H_2O attack the same carbon surface sites.

10.4405/profic2014.B26