FLOW CHARACTERISATION OF COAL AND INERT PARTICLES IN A CIRCULATING FLUIDISED BED USING AN ELECTROSTATIC SENSOR ARRAY

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Abstract:

Coal is an abundant fossil energy resource that represents about 70% of the world's proven fossil fuel resources. The negative effect of direct coal combustion is mostly related to its low energy conversion efficiency and serious pollution to the environment. Coal gasification is an effective way to reduce the emission of CO₂, which is a major contributor to climate change and global warming, especially from low-rank coals such as lignite and sub-bituminous coal. Circulating fluidised beds (CFBs) have been widely adopted to improve the energy conversion efficiency of coal gasification. In the gasification process, inert particles, such as sand, are circulated in the bed to transfer heat from the combustor to the gasifier. Therefore, the flow characteristics of coal and inert particles in CFBs should be investigated to achieve an in-depth understanding and subsequent optimisation of the coal gasification process.

In fluidisation processes and granular flow systems, tribo-electrification is inevitable due to the collision, friction and rolling between particles and particles and between particles and wall. This phenomenon may result in undesirable particle agglomeration and affects the hydrodynamics of the fluidisation process. Although electrostatics can cause problems the coal gasification process, it can be utilized to measure the particle flow dynamics in the fluidised bed. There have been limited reports on the use of electrostatic sensing techniques for the characterisation of particle flow dynamics in CFBs. In this study, an electrostatic sensor array is introduced for the first time to measure the flow characteristics of coal and inert particles. However, the structure of the sensor array has a significant impact on the performance of the sensor. By taking the sensitivity distribution and the spatial filtering effect into consideration, the structure optimization of the sensor array is conducted. Then using the optimized sensor, the velocity profile of coal and inert particles in the CFB is obtained by cross correlating the signals from upstream and downstream sensors. By considering the charging mechanism and the features of the signals from the sensor array, the concentration distributions of coal and inert particles are then determined. The design, implementation and practical evaluation of the electrostatic sensor array for this particular application are presented. Experimental results obtained on a CFB model rig are presented and discussed.

Keywords: coal gasification, circulating fluidised bed, electrostatic sensor array, coal particle, inert particle, velocity profile, solids concentration distribution

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