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Application of Flue Gas Recirculation in Fluidized Bed Combustor for Energy Efficiency Enhancement

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Abstract : For a fluidized-bed combustion system, excess air ratio (EAR) and superficial velocity are major operating parameters affecting combustion behaviors, and these 2 factors are dependent variables since both fluidizing gas and combustion-supporting agent are air. EAR will change when superficial velocity alters, so that the effect of superficial velocity and/or EAR on combustion behaviors cannot be examined under a specific condition. When stage combustion is executed, one can discuss the effect of EAR under a certain specific superficial velocity, but the flow rate of secondary air and EAR are dependent. In order to investigate the effect of excess air ratio on the combustion behavior of a fluidized combustion system, the flue gas recirculation was adapted by the author in 2007. We can maintain a fixed flow rate of primary gas or secondary gas and change excess oxygen as an independent variable by adjusting the recirculated flue gas appropriately. In another word, we can investigate the effect of excess oxygen on the combustion behavior at a certain primary gas flow, or at a certain hydrodynamics conditions. This technique can be used at a lower turndown ratio to maintain the residual oxygen in the flue gas at a certain value. All the experiments were conducted in a pilot scale fluidized bed combustor. The fluidized bed combustor can be divided into four parts, i.e., windbox, distributor, combustion chamber, and freeboard. The combustion chamber with a cross-section of 0.8 m × 0.4 m was constructed of 6 mm carbon steel lined with 150 mm refractory to reduce heat loss. Above the combustion chamber, the freeboard is 0.64 m in inner diameter. A total of 27 tuyeres with orifices of 5 and 3 mm inside diameters mounted on a 6 mm stainless-steel plate were used as the gas distributor with an open-area-ratio of 0.52%. The Primary gas and secondary gas were fixed at 3 Nm3/min and 1 Nm3/min respectively. The bed temperature was controlled by three heat transfer tubes inserted into the bubbling bed zone. The experimental data shows that bed temperature, CO and NO emissions increase with the stoichiometric oxygen of the primary gas. NO emissions decrease with the stoichiometric oxygen of the primary. Compared with part of primary air substituted with nitrogen, a lower NO emission can be obtained while flue gas recirculation applies as part of primary air.

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