Abstract

A multi-stage fluidized bed reactor (MFBR) with downcomer was designed and fabricated to study the stable operating range in respect of gas and solids flow rate, mechanism of gas-solid contacting and measure the overall pressure drop, holdup under different flow rates. Experiments were conducted on reactor to measure the gas pressure drop at gas flow rates ranging from 31.2 x 10^{-2} to 56.4 x 10^{-2} $kg/m^2\cdot s$ and solids flow rate ranging from 35.4 x 10^{-3} to 141.5 x 10^{-3} $kg/m^2\cdot s$ under various weir heights. The solids taken for investigation was hydrated lime and sand. The regime in each bed was bubbling regime whereas solids regime in each downcomer was like moving bed. The pressure drop due to lime particles decreased with increase in the gas flow rate and increased with increase in solids flow rate. The minimum pressure drops occurred in each stage at high gas flow rate corresponding to lowest solids flow rate (35.4 x 10^{-3} $kg/m^2\cdot s$) is 57.1, 103.3 and 143.5 N/m^2 at 0.03, 0.05 and 0.07 m weir height respectively. The maximum pressure drops occurred in each stage at lowest gas flow rate (31.2 x 10^{-2} $kg/m^2\cdot s$) corresponding to maximum solid flow rate (141.5 x 10^{-3} $kg/m^2\cdot s$) are 98.4, 139.6 and 185.1 N/m^2 at 0.03, 0.05 and 0.07 m weir height respectively. Similar trend also observed in case of sand particles. At ambient condition, the percentage removal efficiency of sulfur dioxide (η_{SO2}) by hydrated lime particles was maximum at top stage and minimum at bottom stage. It was observed that lowering the superficial gas velocity at a particular solid velocity had higher sulfur dioxide removal efficiency of 65% at 0.07 m weir height and 62% at 0.03 m weir height, which was due to higher gas residence time. A mathematical model has been proposed and EGPF model agreed well with experimental data.

Keywords:
Hydrodynamics; multi-stage fluidized bed; air pollution control; sulfur dioxide removal; pressure drop; hold-up; minimum fluidization velocity; residence time; flue gas