CLEANING OF SYNTHESIS GAS BY A MULTISTAGE DUAL-FLOW SIEVE PLATE COLUMN WET SCRUBBER

ABSTRACT

The demand for energy has been increasing day by day and the energy production from synthesis gas (syngas) can meet the present and future global energy needs. The syngas is a mixture of carbon monoxide and hydrogen. The syngas can be produced from gasification of carbonaceous fuels but the gasifier syngas also contains particulate matter (PM) and hydrogen sulphide (H_2S) which need to be addressed to protect the energy production equipment and environment. Plate scrubbers are medium level energy wet scrubbers which are widely used in various chemical process industries for individual and simultaneous removal of particulate matter and gas pollutants. Plate without down comer is called as dual-flow plate and its free area is 20% more than normal tray with down comer. The sieve plate columns have advantages of simple design and easy maintenance. In present study, a lab scale multi (three) stage dual-flow sieve plate column has been designed and developed to remove air pollutants from gasifier syngas. The hydrodynamics of the multistage dual-flow sieve plate column have been studied by observing the effect of gas flow rate ($8.297x10^{-4}$ -$27.65x10^{-4}$ Nm^3/s) and liquid flow rate ($20.649x10^{-6}$ - $48.183x10^{-6}$ m^3/s) on pressure drop, liquid holdup and froth height. The maximum pressure drop observed was 2798.76 Pa. The performance of the multistage dual-flow sieve plate column was investigated for particulate scrubbing at different operating conditions and achieved a maximum efficiency of 99.27% for $25x10^{-3}$ kg/Nm^3 inlet PM loading at gas and liquid flow rates of $27.65x10^{-4}$ Nm^3/s and $48.183x10^{-6}$ m^3/s respectively. A mathematical model was developed to predict the particulate removal efficiency in the scrubber. The water scrubbing of H_2S for 50-300 ppm was studied experimentally and 78.88% efficiency achieved at 300 ppm H_2S inlet concentration. The simultaneous scrubbing of particulate and H_2S was carried out and observed that the removal efficiency of the H_2S in presence of particulate matter has been increased. The maximum percentage removal of H_2S in presence of $25x10^{-3}$ kg/Nm^3 particulate matter was observed as 87.45% for 300 ppm inlet H_2S concentration at $27.65x10^{-4}$ Nm^3/s gas flow rate and $48.183x10^{-6}$ m^3/s liquid flow rate. The process parameters were optimized to maximize the particle laden H_2S removal efficiency using response surface methodology.

Keywords: Air pollution control, hydrodynamics, performance, hydrogen sulphide, wet scrubber, particulate matter, gasification