Proceedings of the 4th International Conference of Fluid Flow, Heat and Mass Transfer (FFHMT'17)
Toronto, Canada – August 21 – 23, 2017
Paper No. 140
DOI: 10.11159/ffhmt17.140

Enhancement of Mass Transfer in Spray Reactors through the Mono-Disperse Droplet

M. K. Cho, J. W. Lee
Department of Mechanical Engineering, POSTECH
77 Cheongam-Ro Nam-Gu, Pohang, South Korea
mkcho@postech.ac.kr; jwlee@postech.ac.kr

Extended Abstract

Capture of gas or vapor by chemical absorption using spray droplets has long been used in a variety of fields [1,2]. Mass transfer performance using droplets generated with common spray nozzles in a spray reactor is degraded because of fundamental characteristics of common spray nozzles that generate droplets of highly non-uniform size in highly non-uniform spatial distribution. It is proposed by Choi et al. [3] that the performance of spray reactor can be improved by optimized injection of droplets. In this study, an improved nozzle plate was developed that injects uniform-size droplets vertically downward and that uniformly across the whole reactor cross-section, and performance of reactor equipped with the improved nozzle plate was tested for CO2 capture using aqueous ammonia sorbent.

The nozzle plate has large number of contoured nozzle holes on a single plate and generates droplets of 300μm diameter with a narrow size variation of geometric standard deviation σ_g~1.2 regardless of the liquid flow rate. Nozzle plate vertically ejects aqueous ammonia from the top of reactor of 1m height and 0.1m diameter, and 15% (vol%) CO2 gas mixture was supplied from the bottom forming a counter current configuration. CO2 concentration was checked at the gas inlet and outlet by a gas analyser and then CO2 capture efficiency was calculated. The loss of droplets to the reactor wall by conical ejection with typical spray nozzles was almost negligible due to the vertical injection of rather large droplets. Mol-to-mol flow-rate ratio of NH3 to CO2 was varied in the range of 5-20 by varying the gas flow rate with the liquid flow fixed. The CO2 capture efficiency increased from 60% to 92% as the mol-to-mol flow ratio increased from 5 to 20. Very high efficiency of 92% was attained with 8% (wt%) ammonia concentration at 20 mol-to-mol NH3/CO2. It is the best-ever efficiency with spray reactor for the CO2 capture using ammonia solution. CO2 capture efficiency was much higher and effective mass transfer conductance was almost twice than typical spray reactors.

A novel type spray tower with various weak points of conventional spray reactors was developed and tested experimentally. Capture efficiency reached over 90% that is the best performance ever reported. And the droplet conditions used in this study is proper to apply for larger systems. Further enhancement of mass transfer capacity is expected with larger-system via the longer contact time.

References

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