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Heat Transfer Experimental Characterization and Modeling of Innovative Structured Internals in Counter-Current Gas-Liquid Flow: Insight View on Distillation

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Heat Integrated Distillation Column (HIDiC) is based on technological innovations to improve energy efficiency of distillation operations, but due to the use of a compressor, an increase of the heat exchange surface area and the global heat transfer coefficient of the column internals are necessary to be transferable to industry [1].

With the help of 3D-printing, new structured column internals have been designed bringing a better mass transfer, hydrodynamic, wettability or less pressure drop [2]. However, there is a lack of literature studying experimentally heat transfer at a detailed level in conditions closed to distillation when gas and liquid are flowing in counter-current mode; and gives heat transfer parameters.

Objective of this paper is to measure the radial and axial temperature in a counter-current gas-liquid contactor (5 cm inlet diameter, 1 m tall) for air-water system. The experimental set-up was composed by 49 thermocouples monitoring in-situ temperature for different axial and radial positions. The heat flux was generated by "hot" liquid (around 70 °C) and gas while the wall of the contactor was maintained at a lower temperature cooling by tap water (around 20 °C). Different parameters have been studied like inlet gas and liquid superficial velocities in the range of 2 cm/s to 54 cm/s and 5.8 mm/s to 18.4 mm/s. Three interns 3D-printed (aluminum alloy) have been studied: one open cell foam (10 ppi); one Kelvin cell (5 CPI) and one TPMS (3 CPI) structures designed by our partner (Laboratoire de Génie Chimique, Toulouse France). It has been founded that the liquid velocity was the most influent parameters on axial and radial temperature profiles.

Experiment data was used for the column modeling using a 2D counter-current gas-liquid pseudo-homogeneous model containing four adjusted parameters (effective radial heat transfer conductivity, wall heat transfer and interfacial heat transfer coefficients) based on the works of Balakotaya et al and David et al [3]. The heat transfer parameters are found by fitting the simulation temperature profile to the experimental temperature profile (non-linear least square). Three different internal geometries were experimentally characterized.

This study will allow a better and a systematic characterization of the new column internals regarding to their heat transfer performance in counter-current gas-liquid configuration, as well as a better design of heat-integrated distillation columns, classical distillation columns and the packed bed catalytic reactors working in this flow configuration.

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