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Supplementary material

SUPPLEMENTARY MATERIAL TO

Pressure drop behaviour and mass transfer properties of a high specific area random type packing in a narrow packed column

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Rectifying tests

After initiation of the reboiler, at least 20 min was needed to completely warm the column. Then, the heating power of the reboiler was gradually increased to the specified power. Afterwards, about five minutes was needed for the condensed vapour to exit the condenser and start the reflux stream. Immediately after starting the reflux stream, one sample was taken from the top and one from the bottom of the column. Thereafter, the total reflux operation was continued and the second samples were taken after 20 min. From this point on, the sampling procedure was repeatedly continued until one hour every 20 min. Afterwards, the sampling period was increased to once an hour and the process was continued for six to seven hours. After collecting the samples, they were all cooled down to room temperature and analyzed using gas chromatography. Hence, the changes in the concentration of the top and bottom products were monitored during the total reflux experiment to recognize the steady state. Finally, the steady state results were used to calculate the value of HETP corresponding to the operating vapour loading factor. After the test, hot air was supplied to the column for at least 5 h in order to have a completely dry column. The column was then rested for at least 15 h to ensure that the dried column cools down to ambient temperature.

Subsequently, a fresh feed was added to the reboiler and the test was repeated. All of the operating steps were the same as previous test except that a new power was applied for heating of the reboiler. The experiments were conducted for various vapour loading factors. Finally, the variations of HETP versus vapour loading factor.

Pressure drop tests

A column with a height of one meter was employed for pressure drop measurements. To measure the dry pressure drop, a constant air flow at approximately atmospheric pressure was injected to the bottom of column. It is of great importance for the column and its internals to be completely dry when dry pressure drop is measured. Small amounts of liquid hold-up can greatly affect the final results. Pressure drop was measured using an accurate differential pressure transmitter with a maximum error value of 1 mbar (Sensys, DPLH 002R). Two

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accurate 250 mbar pressure transmitters with a maximum error value of 0.025 mbar (WIKA, S11), one at each end of the column, were used to cross check the observed pressure drop values. All of the sensors were connected to a central monitoring and control system to continuously monitor the operation of sensors.

At the beginning of experiments, air was injected to the column with a very small flow rate (0.00025 $m^3 s^{-1}$) corresponding to the value of 0.2 $Pa^{0.5}$ for the vapour loading factor. At least two minutes is required to ensure the aerodynamic stability which can be estimated by the constant pressure drop. Then, the experiment was continued for five minutes and the pressure drop values that were monitored for the specified flow rate of the inlet air were averaged to obtain a unique value. Indeed, the pressure drop sensors are accurate enough to record any small pressure fluctuations caused by air flow. Afterwards, the air flow was increased to a new upper value and this procedure was repeated again.

Wet pressure drop experiments were conducted in a similar procedure, although small differences were caused by liquid flow. For a specified liquid flow which was sprayed through the funnel type distributor, the different air flow rates were injected in the following procedure. First, a specified water flow was injected through the distributer for at least 5 min. Note that at least 5 min are required to ensure complete wetting of the packed bed. Then, air flow was initiated from the smallest investigated flow rate (corresponding to a value of 0.1 $Pa^{0.5}$ for vapour loading factor). When a constant value of pressure drop was observed and continued for about five minutes, air flow was increased to a new upper value and the procedure was repeated. Afterwards, this procedure was continued until the column was flooded, which could be recognized with a large increasing jump in the pressure drop. Finally, all of the pressure drop values that were monitored for each flow rate of inlet air were averaged to obtain a unique value. The obtained result from this test was a plot of wet pressure drop at different loading factors of air for a specified water flow. At this moment the experiment for the specified water flow was finished. Note that an another set of experiments for a new water flow rate could not be initiated immediately. In fact, if a new experiment is initiated immediately, the obtained results would be affected by the flooding phenomenon and the experiments would not lead to correct results. For instance, if the pressure drop for a water flow of 0.005 $m^3 m^{-2} s^{-1}$ and an air *F_factor* of 0.5 $Pa^{0.5}$ was observed to be 3 mbar, the same pressure drop at the same water and air flow rates could not be observed immediately after flooding. This may be caused by the over accumulation of packed column during the flooding. Therefore, the column and its internals should be completely dried before starting a new experiment. To do this, hot air was injected to the column for five hours. The column was then rested for at least 15 hours to ensure that the dried column cools down to ambient temperature. Then, a new set of experiments was performed for another water flow rate.