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EFFECT OF HOLE SIZES ON LIQUID MIXING AND TRAY EFFICIENCY

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Effect of hole sizes on tray performance has been investigated. Positive dependence of liquid mixing, mean rean residence time (MRT) and Murphree Tray Efficiency (E_{ML}) on the hole sizes has been demonstrated.

Key words: Sievetray, Tray efficiency, Distillation tray.

INTRODUCTION

Many attempts have been made by the earlier workers to establish the behaviour of a distillation tray. The reported data is very much contradictory due to the fact, that different systems and tray geometry have been used. Some workers did not include downcomers in their studied, hence different liquid patterns were existed than experienced on an industrial tray.

Almost no data has been reported on the influence of hole sizes on the liquid mixing and tray efficiency. Therefore it was decided to undertake this study in order to provide data for a better tray design.

EXPERIMENTAL

The pilot plant consisting of a large stainless steel column with large perspex windows and external downcomers, pumps, tanks and measuring instruments. Two trays 60 cm x 60 cm dimension with 3.175 mm and 9.5 mm perforation diameter were used. The upper tray was used as test tray. Once through air and liquid flow rates were practiced.

Dye injection (Nigrocine) technique was selected for the measurement of mean residence time and extent of liquid mixing on the tray. The dye was injected at tray inlet-weir and its concentration in solution agaisnt time was measured at tray outlet weir, with the help of a photoelectric cell and recorded by an ultra violet recorder. Areas under the tail of the distribution curves were calculated by the method described by Sater and Levenspiel [1].

For tray efficiency measurement, O_2-desorption from a semi saturated solution of aqueous glycerine (50% by wt.) was practised. O_2 was injected into the solution via porous ceramic diffuser and a 60 feet long, 2 inch dia copper pipe. The concentrations of dissolved O_2 at tray inlet and outlet-weir were measured with the help of O_2 detection cells and were recorded by a multiple points recorder continuously. Sampling techniques and instruments used have been fully described elsewhere [2].

RESULTS AND DISCUSSION

Effect of two holes sizes i.e. 3.157 mm and 9.5 mm on the performance of a sieve tray under identical operating conditions was investigated. It is presumed that, since the physical conditions on the tray are unchanged, therefore any change in the results noticed, could be attributed to the change in the hole sizes only.

In Figure 1 are plotted measured values of variance (δ^2) (which is a measure of the degree of liquid mixing on the tray) against the MRT of the liquid. A comparison is also shown between the variances measured for 3.175 mm diameter and 9.5 mm diameter holes using different trays.

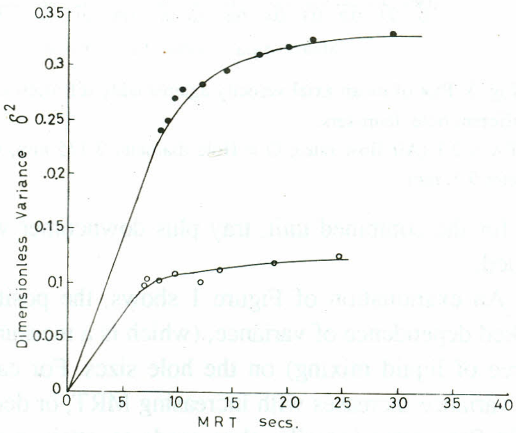

Fig. 1. Plot on mean residence time (MRT) against dimensionless variance (δ^2) for different hole diameters.
FA = 2.1 (Air flow rate); O = Hole diameter 3.175 mm; ● = Hole diameter 9.5. mm.

The effect of liquid flowrates on the mean residence time for both the hole sizes investigated is plotted in Figure 2. Calculated values of eddy diffusion coefficients against the mean axile velocity for both the perforated diameter i.e. 3.175 mm and 9.5 mm diameter are shown in Figure 3.

Murphree efficiencies (E_{ML}) for the experimental test tray against liquid flowrate are given in Figure 4. Efficien-

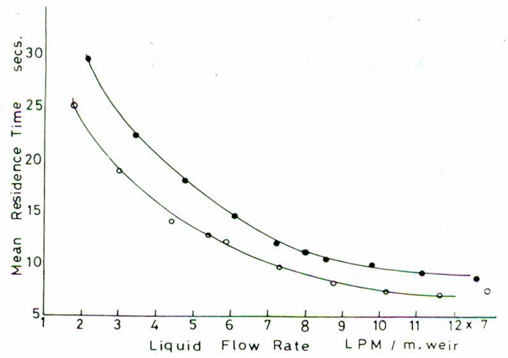

Fig. 2. A plot of liquid flow rate verses mean residence times (MRT) for different hole diameters.

FA = 2.1 (Air flow rate); O = Hole diameter 3.175 mm; ● = Hole diameter 9.5. mm.

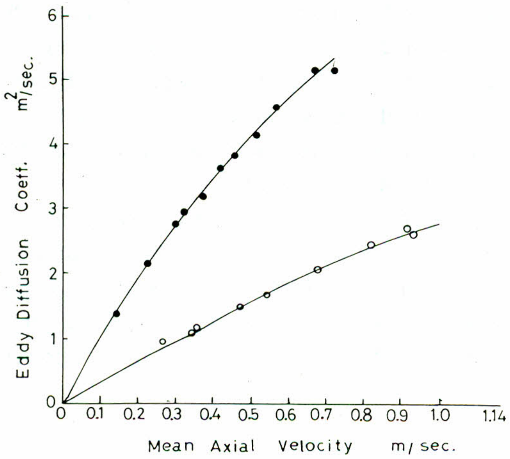

Fig. 3. Plot of mean axial velocity against eddy diffusion coefficient for different hole diameters.

FA = 2.1 (Air flow rate); O = Hole diameter 3.175 mm; ● = Hole diameter 9.5. mm.

cies for the combined unit, tray plus downcomer were not studied.

An examination of Figure 1 shows, the positive and marked dependence of variance, (which is a measure of the degree of liquid mixing) on the hole sizes. For each hole size variance increases with increasing MRT, or decreasing liquid flow rates initially, then tends to attain a constant value for higher MRT values i.e. above 10 seconds. At lower values of MRT (higher liquid flow rates), the values of variance becomes smaller, which mean an approach to plug flow. These results are comparable with the earlier reported work [3, 4].

Dependence of MRT on liquid flow rates and hole sizes is demonstrated in Figure 2. MRT decreases with increasing liquid rates and decreasing hole diameter. The values of MRT tend to be constant at higher liquid flow rates for each of the hole size investigated. This conclusion is supported by the earlier work [5].

Figure 3 shows the effect of hole sizes on the eddy diffusivity values. Though similar curves are obtained for both the hole sizes, yet there is a great effect of hole size. This mean that the hole sizes have a marked effect on the liquid mixing on the tray. This is supported by a similar effect on the variance. The eddy diffusion coefficient was calculated from the values of variance, MRT and the effective length of trays [3, 6].

Dependence of Murphree Tray Efficiency on liquid rate and hole sizes is given in Figure 4. For each hole size,

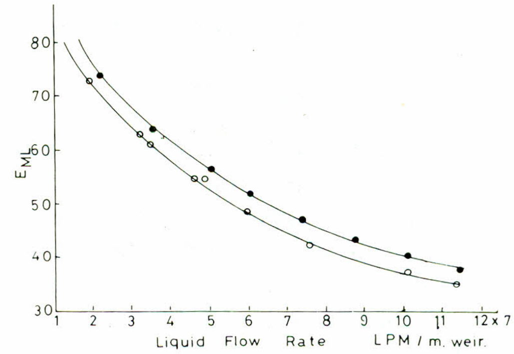

Fig. 4. Plot of liquid flow rates versees tray efficiency for different hole diameters.

FA = 2.1 (Air flow rate); O = Hole diameter 3.175 mm; ● = Hole diameter 9.5. mm.

E_{ML} decreases with increasing liquid flow rates and approaches a constant value at higher E_{ML} liquid flow rates (i.e. low MRT values). Increase in with hole sizes is not so marked, but is still positive i.e. about 7% at 40 LPM/M-weir liquid rates. This conclusion is in agreement with earlier reported work [7].

Symbol

MRT = Mean residency time (secs)

E_{ML} = Murphree tray efficiency

δ^2 = Dimensionless variance.

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