Applicability of Dispersion Results to Packed Columns

W. G. MELLISH

Clarkson College of Technology, Potsdam, New York

With reference to the communication of Furzer and Ho (*1*) which showed quantitatively that longitudinal mixing (back mixing) of the phases is an important factor in the relation between HTU and packed height, they have chosen an illustration from Yoshida (*2*) using flow rates far below nominal industrial operating flow rates and have used dispersion coefficients from Sater and Levenspiel (*3*), and DeMaria and White (*4*) that were obtained from packed columns which were not operating with proper liquid distribution.

Furzer and Ho used a model developed by Miyauchi and Vermeulen (*5*), the equations for which were solved analytically by Hartland and Mecklenburgh (*6*). This is essentially the standard packed column mass transfer equation with a dispersion term added. Furzer and Ho then used data given by Yoshida to illustrate the results obtained by considering backmixing and obtained very good agreement between the predicted and measured height of a transfer unit for this data.

Yoshida's data for 15 mm. Raschig rings for benzene-toluene at flow rates of 5.0 lb. moles/(hr.)(sq.ft.) which would correspond to air and water flow rates of

air:

$$[5 \text{ lb. moles/(hr.)(sq.ft.)}]\ (28 \text{ lb./lb. mole}) = 140.\ \text{lb./(hr.)(sq.ft.)}$$

water:

$$[5 \text{ lb. moles/(hr.)(sq.ft.)}] \left(78 \frac{\text{lb.}}{\text{lb. mole}}\right) \frac{62.4 \dfrac{\text{lb.}}{\text{cu.ft.}} \text{ water}}{54.8 \dfrac{\text{lb.}}{\text{cu.ft.}} \text{ benzene}} = 445.\ \text{lb./(hr.)(sq.ft.)}$$

are well below loading as shown by the results of Shulman, Ullrich, and Wells (*7*) for 0.5 in. Raschig rings. For instance at a liquid rate of 500 lb./(hr.)(sq.ft.) water loading occurs at a gas rate of 500 lb./(hr.)(sq.ft.) air. It has been shown by many workers that axial diffusion is important at low gas and liquid flow rates but the question arises as to whether it is important at the industrially important flow rates at loading and just below.

Brittan and Woodburn (*8*) absorbed carbon dioxide into water by using a bed of ⅜ in. glass Raschig rings 35 in. deep in a 3.6 in. I.D. column. Adequate precautions were taken to guard against end effects. They found the gas axial dispersion to increase with increasing liquid rate and decreasing gas rate. They also found the difference in $K_l a$ between dispersion and no dispersion models to be about 3% for gas and liquid rates of 9.6 and 5,500 lb./(hr.)(sq.ft.) respectively. Therefore, it is logical to assume that at the usual industrial operating gas and liquid rates [around 250 lb./(hr.)(sq.ft.) and 2,000 lb./(hr.)(sq.ft.) respectively] for 0.5 in. Raschig rings, axial dispersion would be negligible. Like Furzer and Ho, Brittan and Woodburn used the dispersion data of DeMaria and White (*4*).

The communication of Furzer and Ho used dispersion coefficients from Sater and Levenspiel (*3*), and DeMaria and White (*4*). Sater and Levenspiel used a column 36 diam. long with 15 diam. between counters and 10.5 diam. between the liquid distributor and the first counter. DeMaria and White used a column 14 diam. long with sensing equipment at top and bottom. Scott (*9*) showed that for 0.5 in. rings most of the liquid flow occurs at the wall after 6 diam. for the best case of liquid injected into the center of the bed. Therefore, the data taken by Sater and Levenspiel, and DeMaria and White were really taken on an apparatus where most of the liquid flowed down the wall while most of the gas flowed up the center of the bed for the part of the bed where measurements were taken. A well designed packed column should have the liquid and gas flows distributed evenly across the column to facilitate interphase contact and to transfer as much mass as possible.

DeMaria and White commented that the response curves were distorted compared to what would be expected from the model used. They stated that the distortion was very pronounced for low gas rates and pure slugs of injected helium. It is questionable whether dropping the helium slug concentration to 15% and still using gas rates well below loading will give undistorted response curves. Ideally, a tracer gas of molecular weight near that of air should have been used with a column of no more than 6 diam. in length.

A comparison of the work of DeMaria and White with that of Sater and Levenspiel can be seen in Figure 11 of the latter's publication. The values of the Peclet number under the same conditions, including packing, differed by a factor of 10. This fact alone would tend to shed suspicion on the experimental method or apparatus.

CONCLUSIONS

The work of Furzer and Ho, and Hartland and Mecklenburgh is a remarkable and noteworthy treatment of back-mixing in packed columns. A dispersion model was proposed as an alternative explanation to the conventional explanation based on liquid distribution. It should be noted, however, that this is mostly applicable to the rare situations where the flow rates used are well below loading. Also, the dispersion coefficients should be evaluated for the usual packed column where packing size to tower diameter is at least 1 to 8 and the column is not so high as to preclude even liquid and vapor distribution at all points in the column (6 diam. for 0.5 in. Raschig rings).

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