EFFECTS OF LIQUID PULSATION ON THE PERCENT USE OF AN ION-EXCHANGE BED

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Ion exchange can be intensified by oscillating the liquid in a long bed of material, which considerably increases the time between two regenerations.

The rate of ion exchange is determined either by external diffusion or by internal diffusion [1]. Internal diffusion processes are the more rapid; use of hydrodynamic features allows one to accelerate the external diffusion considerably and to bring the rate near to that for internal diffusion [2].

Kinetic equations have been given [3] for KU-2 cation exchange resin in a short bed with liquid pulsating, and it was shown that such motion provides an efficient means of accelerating the ion exchange; an appropriate pulsation velocity \( \omega A \) resulted in an internal-diffusion state.

In industrial practice, a given degree of exchange is obtained by operating with a long bed; periods of ion exchange alternate with ones of exchanger regeneration, and the first period ends when a certain level of breakthrough begins. Completion of this period does not mean that the exchanger in the bed has been fully utilized; the degree of utilization is related to the mode of exchange. This is maximal if the diffusion is of internal type, and breakthrough will set in later than in external diffusion. The ratio of exchange times to breakdown characterizes the relative increase in the exchange duration \( \alpha \). If, for instance, it is possible in some way to raise \( \alpha \) to 2, this means that a bed of exchanger of given quality and given length will operate twice as long before breakthrough than when the other mode of operation is employed, and the exchange capacity will be much better utilized. Pulsating motion corresponds to this requirement.

It might seem that solution to the problem consists in increasing the speed of the liquid and thus transferring the process to the internal-diffusion range; but this method is sometimes inapplicable, because it leads to a considerable reduction in the dimensionless length \( \omega^* \):

\[
\omega^* = \frac{\sigma H (D_{ie} + \Gamma D_{ie})}{u R^2 m}
\]

and hence to transformation of the bed into a short one, which offers little protection. The method of oscillating the liquid is better also in that it enables one to increase the Biot number without altering the dimensionless length of the layer.

Rosen [4, 5] has considered mass transfer in the motion of a liquid through a layer of spherical particles, while particles of other shapes have been considered in [6]. Apart from exact solutions, which are troublesome for direct use, approximate solutions have also been derived that enable one to determine the relative liquid concentration \( \Delta = c_1/c_0 \) at the exit from the layer with a set degree of accuracy.

We use the approximate solutions of [4-6] to find \( \alpha \):

\[
\alpha = \frac{1 + \sqrt{\frac{4}{15} \omega^* \text{erf}^{-1}(2\Delta - 1)}}{1 + \sqrt{\frac{4}{3\omega^*} \left( \frac{1}{\text{Bi}^*} + \frac{1}{5} \right) \text{erf}^{-1}(2\Delta - 1)}}
\]
In (2)

$$Bi^* = \frac{kR}{D_{2c} + \Gamma D_{1a}}.$$  \hspace{1cm} (3)

We see from (2) that for certain values of \(Bi^*\) and \(\omega^*\) the denominator becomes 0, and \(\alpha \to \infty\); for a layer with a given \(\omega^*\) we can determine the \(Bi_{\text{min}}^*\) for which \(\alpha \to \infty\).