COMMUNICATIONS TO THE EDITOR

Tables for the Calculation of Operating Parameters for Compound Solvent-Extraction Columns

TERRY R. JOHNSON
Argonne National Laboratory, Argonne, Illinois

The familiar Kremser-Brown equation (*1*) for simple countercurrent, extraction columns can be applied to columns that have a central feed by considering the compound column to be two simple columns. If the equilibrium and operating lines can be assumed to be straight lines, the Kremser-Brown equation can be used to relate the compositions of the streams entering and leaving the section below the feed and also to relate the stream compositions for the section above the feed. Material balances can then be used to combine the two relationships. If an extracting solvent containing a distributing solute is fed to the top of the column and pure scrub solvent is fed to the bottom of the column ($y_F \neq 0$ and $x'_F = 0$), the following relationship can be derived:

$$\frac{Ey'_1}{\overline{R}x_F} = f\left[1 - \left(\frac{R}{\overline{R}}\right)\left(\frac{y_F}{x_F K}\right)\right] + g\left(\frac{Ey_F}{\overline{R}x_F}\right) \quad (1)$$

An analogous expression for the case of an impure scrub solvent and a pure extracting solvent ($y_F = 0$, $x'_F \neq 0$) is

$$\frac{Ey'_1}{\overline{R}x_F + R'x'_F} = f + (1-g)\left[\frac{EK'x'_F}{\overline{R}x_F + R'x'_F}\right] \quad (2)$$

The general case, in which distributing components are fed to the top and bottom of the column as well as to an intermediate stage, is essentially the equation presented by Smith (*2*, *3*). The above equations can be deduced from Smith's by assuming the solute content of either the scrub or extracting solvent is zero. If both scrub and extracting solvents are pure, Equations (1) and (2) reduce to

$$\frac{Ey'_1}{\overline{R}x_F} = f = \frac{1-A}{1-A+AB} \quad (3)$$

Tables of functions that greatly facilitate the use of the above equations in hand calculations have been prepared and are available as a report (*4*) of Argonne National Laboratory. The parameters f and g have been tabulated as functions of the extraction factor, the scrub factor, and the numbers of extraction and scrub stages. Because recoveries are usually specified, tables of the extraction factor α as a function of f, β, n, and n' have been listed also. These tables are analogous to the familiar graph (*5*) that can be used to solve the Kremser-Brown equation. Problems involving two distributing components can be solved readily by hand calculations with the use of these tables combined with a straightforward, graphical technique that is also described in the report.

NOTATION

$A \; = \dfrac{\alpha - 1}{\alpha^{n+1} - 1}$

$B \; = \dfrac{\beta^{n'+1} - 1}{\beta - 1}$

K = y/x = distribution coefficient in extraction section

K' = distribution coefficient in scrub section

R = flow rate of raffinate solvent in extraction section

R' = flow rate of scrub solvent in scrub section

$\overline{R}$ = flow rate of feed solvent in principal feed

E = flow rate of extracting solvent

n = number of extraction stages

n' = number of scrub stages

f = $(1 - A)/(1 - A + AB)$

$g \; = \dfrac{1}{1 - A + AB}$

x = concentration in feed or scrub phase

y = concentration in extract phase

α = EK/R = extraction factor

β = R'/EK' = scrub factor

LITERATURE CITED

1. Kremser, A., *Natl. Petrol. News*, **22**, No. 21, 42 (May 21, 1930).
2. Smith, B. D., and W. K. Brinkley, *A.I.Ch.E. J.*, **6**, 446 (1960).
3. Smith, B. D., "Design of Equilibrium Stage Processes," pp. 252-293, McGraw-Hill, New York (1963).
4. Johnson, T. R., N. K. Clark, *U.S.A.E.C. Rept. ANL-7165*, Argonne Natl. Lab. (1966).
5. Souders, M., and G. G. Brown, *Ind. Eng. Chem.*, **24**, 519 (1932).