ChE letter to the editor

Dear Editor:

In their recent article titled "An Experiment to Characterize a Consolidating Packed Bed" (*CEE,* 31(3), p. 192, 1997), Gerrard, Hackborn, and Glass misinterpret the Kozeny equation for low gas flow through packed beds and consequently arrive at an incorrect result.

The Kozeny equation as written by these authors is

$$\Delta p = 5a^2(1-\varepsilon)^2 \mu h v / \varepsilon^3 \tag{1}$$

(Nomenclature and numbering of equations follow those of the article criticized, with the addition that numbers assigned to *corrected* equations have the letter "a" appended to them.) In this form of the equation, the term a signifies the specific surface of the particles in the packed bed, *i.e.,* particle surface area/particle volume, and is independent of the bed consolidation (assuming rigid particles). Therefore, in the authors' terminology,

$$a = a_o \tag{3a}$$

The specific surface of the packed bed, particle surface area/bed volume, is given by the product $a(1-\varepsilon)$. Unfortunately, the authors incorrectly assume that a alone signifies the specific surface of the bed, and hence they write

$$a = a_o h_o / h \tag{3}$$

which is *incorrect* for a as used in Eq. (1).

If instead of Eq. (3), one correctly substitutes Eq. (3a) and the authors' Eq. (2),

$$\varepsilon = 1 - \frac{(1-\varepsilon_o)h_o}{h} \tag{2}$$

into Eq. (1), the result is

$$\Delta p = \frac{5a_o^2 h_o^2 (1-\varepsilon_o)^2 \mu v h^2}{\left\{h - (1-\varepsilon_o)h_o\right\}^3} \tag{4a}$$

or

$$\Delta p = k v h^2 / (h - G)^3 \tag{5a}$$

where

$$k = 5a_o^2 h_o^2 (1-\varepsilon_o)^2 \mu \tag{6a}$$

and

$$G = (1-\varepsilon_o)h_o \tag{7}$$

Rearranging Eq. (5a) gives

$$\left(h^2 v / \Delta p\right)^{1/3} = k^{-1/3} h - k^{-1/3} G \tag{8a}$$

Thus it is $\left(h^2 v / \Delta p\right)^{1/3}$, and not $(v/\Delta p)^{1/3}$, that should be plotted against h in order to linearize Eq. (5a). That approximate linearlization was actually obtained by plotting $(v/\Delta p)^{1/3}$ instead of $\left(h^2 v/\Delta p\right)^{1/3}$ against h can be attributed to the fact that the maximum decrease in $h^{2/3}$ for the experiments performed was only $1-(0.41/0.61)^{2/3} = 23\%$.

The authors should note that if they were to substitute their Eq. (9),

$$a = 6(1-\varepsilon)/D_p \tag{9}$$

into Eq. (1), the right-hand side of the latter equation would then contain $(1-\varepsilon)^4$ in the numerator, which is clearly incorrect. The error arises from the misinterpretation of a, which is *not* the packed bed specific surface given by Eq. (9), but the particle specific surface given by

$$a = \pi D_p^2 / (\pi/6) D_p^3 = 6/D_p \tag{9a}$$

(Alternately, if we define a as the authors have done, then the $(1-\varepsilon)^2$ term in Eq. (1) would disappear.)

Professor Norman Epstein
Department of Chemical Engineering
The University of British Columbia

Dear Professor Epstein:

Thank you for pointing out the correction, which makes the fit even better.

Professor Mark Gerrard

ChE book review

Batch Distillation Simulation, Optimal Design and Control

by *Urmila M. Diwekar*

Published by *Taylor & Francis, 1101 Vermont Ave., N.W., Suite 200, Washington, DC 20005; 211 pages including index; $59.95 (1995)*

Reviewed by
Phillip C. Wankat
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Batch processes, and batch distillation in particular, are understudied in universities. The typical undergraduate separations textbook devotes a short chapter to batch distillation, and typical coverage in courses (*CEER*, **28**, p 15, 1994) is from one to three class periods. The average graduate student does no additional study of batch distillation. Yet, batch distillation is an increasingly important separation method in industry, and there is significant interest in batch distillation research.

Batch Distillation, which is "primarily designed to serve as a textbook for a graduate course," is very timely. The companion software MultiBatchDS (education edition from CACHE Corp.) was not available and is not reviewed here. A review of the book and the software from a consultant's viewpoint was recently published (*Chem. Engr. Progr.,* p. 77, June 1997).

If the software is available, this would be a good text for a graduate-level course. There are 38 homework problems in the book, which is probably sufficient for the first time the course is offered. With the exception that packed columns are not covered, the coverage is broad and most topics of interest are included.

Chapters 1 and 2 introduce batch distillation and analyze binary systems. These two chapters are a good resource for professors and undergraduate students, but some professorial guidance will be needed. For example. Eq. (1.6) and

Continued on page 81.