Some Comments on an Analysis of Turbulent Flow in Concentric Annuli

LUIGI BIASI, GIANCARLO CLERICI, RICCARDO SALA, and ANTONIO TOZZI

A.R.S., Applicazioni e Ricerche Scientifiche, Milano, Italy

A theoretical analysis of turbulent flow in concentric annuli has been recently presented by Randhava (*1*). In this work, a simple expression for the velocity profile in the inner wall region is proposed:

$$U_1{}^+ = \frac{K}{\beta} \ln y^+ + A' \qquad (1)$$

The conventional logarithmic profile is accepted for the outer wall region:

$$U_2{}^+ = K \ln y^+ + A \qquad (2)$$

The maximum velocity radius is assumed as given by the Kays and Leung (*2*) correlation. Its knowledge together with the inner and outer radius fully determines the ratio of the wall shear stresses β. Constant A' is computed satisfying the condition

$$U_1{}^+ \,(19.7) = 13.2 \qquad (3)$$

Some comments can be added to the aforementioned paper.

1. The author points out that a variable mixing length constant is in disagreement with the experimental observations and therefore is unacceptable. From Equation (1) it seems that the assumed mixing length constant is β/K and therefore dependent upon r_m and the radius ratio.
2. The dimensional values of inner and outer velocities are not equal at the maximum velocity radius. Once a value of r_m is selected, the velocity profiles are completely determined. The velocity continuity requirement at r_m appears as a further condition which cannot be satisfied.

The latter remark suggests that the maximum velocity radius can be regarded as an unknown and obtained by imposing such a continuity condition. In this way, the following equation can be written:

$$U_{\tau 2}\,[K \ln y^+{}_{m2} + A] = U_{\tau 1}\left[K\left(\frac{U_{\tau 2}}{U_{\tau 1}}\right)^2 \ln\left(\frac{y^+{}_{m1}}{19.7}\right) + 13.2\right] \qquad (4)$$

Predictions of Equation (4) are compared in Table 1 with some experimental data of Brighton and Jones (*3*). The agreement with the experimental results seems to be satisfactory, with the exception of the slight dependence upon the Reynolds number which disagrees with the experimental observations.

TABLE 1.

		r_m (cm.)	
r_1/r_2	N_{Re}	Experimental	Equation (4)
0.0625	95,800	3.39	3.16
0.0625	194,000	3.25	3.23
0.0625	327,000	3.25	3.29
0.125	89,000	4.25	4.16
0.125	182,000	4.25	4.22
0.125	308,000	4.25	4.28
0.375	65,000	6.41	6.45
0.375	133,000	6.41	6.48
0.375	216,000	6.41	6.51
0.562	46,000	7.73	7.69
0.562	93,000	7.73	7.69
0.562	146,000	7.73	7.70

NOTATION

A = constant in Equation (2)
A' = constant in Equation (1)
K = mixing length constant
N_{Re} = Reynolds number
r = radial distance
U^+ = dimensionless velocity
U_τ = friction velocity
y^+ = dimensionless distance from wall
β = $(U_{\tau 1}/U_{\tau 2})^2$

Subscripts

1 = inner wall region
2 = outer wall region
m = position of maximum velocity

LITERATURE CITED

1. Randhava, S. S., *AIChE J.*, **15**, 132 (1969).
2. Kays, W. M., and E. Y. Leung, *Intern. J. Heat Mass Transfer*, **6**, 537 (1963).
3. Brighton, J. A., and J. B. Jones, *J. Basic Eng.*, **86**, 835 (1964).

A Penetration Theory Model for Vapor-Phase Mass Transfer on Distillation Trays

G. A. HUGHMARK

Ethyl Corporation, Baton Rouge, Louisiana

The University of Delaware Final Report of the AIChE Research Committee (*1*) summarizes mass transfer relationships for distillation trays which lead to the equation for the vapor phase:

$$N_G = 2a\left(\frac{D_G}{\pi t'_G}\right)^{0.5}\left(\frac{Z_f}{Z_f - Z_c}\right) t_G \qquad (1)$$

Equation (1) includes the penetration theory model for the mass transfer coefficient. Hughmark (2) assumed that the vapor residence time t_G is the plug flow residence time

$$t_G = \frac{Z_f - Z_c}{u_G} \qquad (2)$$

and that only one surface renewal occurred during this