Int. J. Heat Mass Transfer. Vol. 12, pp. 663–664. Pergamon Press 1969. Printed in Great Britain

LETTERS TO THE EDITORS

COMMENTS ON "HEAT TRANSFER AND PRESSURE DROP IN HORIZONTAL ANNULAR TWO-PHASE TWO-COMPONENT FLOW"

R. H. PLETCHER and H. N. MCMANUS, JR., *Int. J. Heat Mass Transfer* **11** (7), 1087–1104 (1968).

IN A RECENT article Pletcher and McManus [1] presented interesting correlations of data for heat transfer during air–water flow in pipes. The line in their Fig. 20 is given almost exactly by

$$\frac{\bar{h}}{\phi_L} = 5000\left\{X\left(\frac{\dot{W}_a}{\dot{W}_L}\right)^{0.4}\right\}^2. \qquad (1)$$

The Martinelli parameter X can be written

$$X = \left(\frac{\dot{W}_L}{\dot{W}_a}\right)^{0.875}\left(\frac{\rho_a}{\rho_L}\right)^{0.5}\left(\frac{\mu_L}{\mu_a}\right)^{0.125} \qquad (2)$$

where a smooth tube surface is assumed. Substituting equation (2) in (1) gives

$$\frac{\bar{h}}{\phi_L} \propto \left(\frac{\mu_L}{\mu_a}\right)^{0.25}\left\{\left(\frac{\dot{W}_L}{\dot{W}_a}\right)^{0.475}\left(\frac{\rho_a}{\rho_L}\right)^{0.5}\right\}^2$$

which is approximately proportional to

$$\left(\frac{\mu_L}{\mu_a}\right)^{0.25}\frac{\dot{W}_L}{\dot{W}_a}\frac{\rho_a}{\rho_L}$$

i.e. to

$$\left(\frac{\mu_L}{\mu_a}\right)^{0.25}\frac{Q_L}{Q_a}$$

where Q_L and Q_a are the volume flowrates of water and air respectively. The writer therefore suggests that plots of $\bar{h}/\phi_L$ against Q_L/Q_a or $Q_L/(Q_a + Q_L)$ and $\bar{h}$ against $Q_L/(Q_a + Q_L)$ might give a more meaningful correlation of the data than the type of plots used in Fig. 20.

1. R. H. PLETCHER and H. N. MCMANUS JR., Heat transfer and pressure drop in horizontal annular two-phase two-component flow, *Int. J. Heat Mass Transfer*, **11**, 1086–1104 (1968).

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REJOINDER

CHISHOLM has made an interesting and correct observation concerning the parameter, $X(\dot{W}_a/\dot{W}_L)^{0.4}$, used to correlate data in [1] for heat transfer to horizontal annular water–air flow. For the results in [1], the Martinelli parameter X was actually computed according to

$$X = \left(\frac{\dot{W}_L}{\dot{W}_a}\right)^{0.4}\left(\frac{\rho_a}{\rho_L}\right)^{0.5}\left(\frac{\mu_L}{\mu_a}\right)^{0.125} \qquad (1)$$

(see [1] for nomenclature) which results from computing the single phase turbulent flow friction factor according to an equation of the form

$$f \propto \frac{C}{Re^{0.2}} \qquad (2)$$

where C is a constant. Thus, the parameter $X(\dot{W}_a/\dot{W}_L)^{0.4}$ can be reduced to

$$\left(\frac{\mu_L}{\mu_a}\right)^{0.1}\left(\frac{Q_L}{Q_a}\right)^{0.5} \qquad (3)$$

without making the approximation indicated by Chisholm. Q_L and Q_a are the volume flow rates of water and air respectively.

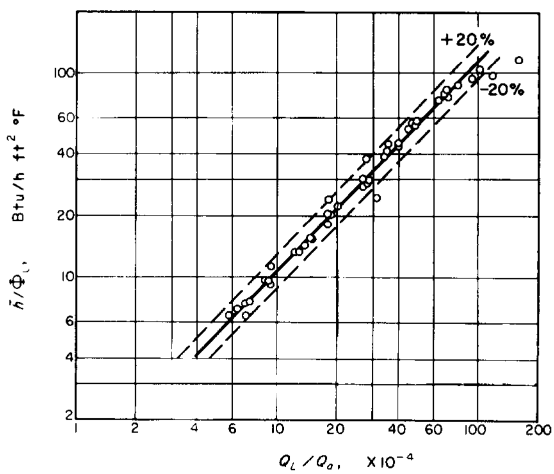

FIG. 1. Correlation of measured average heat-transfer coefficients from [1] based on Q_L/Q_a.

Since $(\mu_L/\mu_a)^{0\cdot 1}$ was relatively constant over the range of the data, the ratio of the maximum to minimum value being about 1·1, it is expected that a reasonably good correlation of the data would be obtained by using $(Q_L/Q_a)^{0\cdot 5}$ or (Q_L/Q_a) as a parameter. Figure 1 shows the data in Fig. 20 of [1] plotted according to $\bar{h}/Q_L$ vs. Q_L/Q_a as suggested by Chisholm. The authors consider Q_L/Q_a to be an equivalent and perhaps more convenient parameter than $X(\dot{W}_a/\dot{W}_L)^{0\cdot 4}$ for correlating the data of [1] but they see no physical basis for considering it a more "meaningful" parameter as suggested Chisholm. Experiments involving a variety of substances in addition to water and air would be required to determine the true dependence of $\bar{h}$ upon μ_L/μ_a. The authors gave special attention to the possible use of X as a heat transfer correlating parameter since pressure drop data has been successfully correlated with X for many two-phase systems other than water and air. Regarding some of Chisholm's other suggeststions, $Q_L/(Q_a + Q_L)$ is nearly equivalent to Q_L/Q_a since Q_L/Q_a is small for annular flows in general and was generally less than one per cent for the data of [1]. Less spread of the data is obtained by plotting $\bar{h}/\phi_L$ rather than $\bar{h}$ so the former is preferred.

1. R. H. Pletcher and H. N. McManus, Jr., Heat transfer and pressure drop in horizontal annular two-phase, two-component flow, *Int. J. Heat Mass Transfer* **11**, 1087–1104 (1968).

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