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LETTERS TO THE EDITORS

Discussion of "Drift flux model for large diameter pipe and new correlation for pool void fraction"

KATAOKA and Ishii [1] proposed a correlation of pool void fraction based upon the drift flux model and with the assumption that the distribution parameter, C_0, and the drift flux velocity, V_{gj}, are both independent of the voidage, α. This letter will show that the assumption contradicts the previously existing correlations, some of which Kataoka and Ishii refer to.

My own correlation [2] is representative as well as being simple and accurate. Firstly, it is noted that individual data sets for large diameter pools and for, say, steam and water at one pressure all agree that $\alpha/(1-\alpha)^{0.5}$ is a linear function of the gas superficial velocity, j_g, to the power of two-thirds. Now the drift flux theory with the liquid velocity zero gives

$$\frac{j_g}{\alpha} = C_0 j_g + V_{gj}. \tag{1}$$

Therefore

$$V_{gj} \propto \frac{\alpha^{0.5}(1-C_0\alpha)}{(1-\alpha)^{0.75}} = F_1(\alpha). \tag{2}$$

Figure 1 plots F_1 vs α for two arbitrary choices of C_0. The variation of V_{gj} with α when assuming that C_0 is constant is apparent. Of course, the correlation, which was for vapour–liquid systems, was more general and was of the form

$$\frac{\alpha}{(1-\alpha)^{1/2}} = K j_g^{+2/3} P^n \tag{3}$$

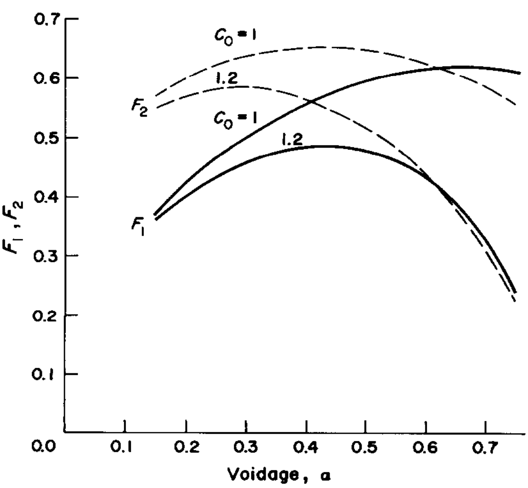

FIG. 1.

where

$$j_g^+ = \frac{\rho_f^{1/2} j_g}{(\Delta\rho g\sigma)^{1/4}} \tag{4}$$

$$P = \frac{\rho_g v_f^2 (\Delta\rho g)^{1/2}}{\sigma^{3/2}} \tag{5}$$

ρ_f and ρ_g are the densities of the liquid and gas, $\Delta\rho$ the density difference between the phases, v_f the kinematic viscosity of the liquid, σ the surface tension and g the acceleration due to gravity. Both K and n are constants and it was shown that there were two large bodies of data for large pools, each from several groups of workers, which had the different values of $K = 1.7$ and $n = 0.107$ and of $K = 11.2$ and $n = 0.2$. Thus the two data sets were different but, for steam and water, agreed satisfactorily over a wide range of pressures.

It was also found that a data set from Filimonov *et al.* [3] for a 63 mm bore tube and for water at pressures of 111, 141 and 180 bar agreed with a correlation

$$\frac{\alpha}{(1-\alpha)^{1/2}} = 21.3 j_g^{+0.79} p^{0.237}. \tag{6}$$

According to criterions by Sterman [4] and Bartolomei and Alkhutov [5], this system should be regarded as a large pool, though a 63 mm diameter tube at lower pressures would be regarded as a small pool with results depending upon the tube diameter.

Now Behringer [6] obtained data for 57–82.5 mm diameter tubes with water at pressures from 1 to 40 bar and Fig. 2 shows that this data correlates very well with

$$\frac{\alpha}{(1-\alpha)^{1/2}} = 8.1 j_g^{+0.79} p^{0.18}. \tag{7}$$

Moreover, it is easily shown that equation (6) is a good extrapolation of equation (7) to higher pressures, if P is not set to a simple power. From either equation (6) or equation (7) and with equation (1)

$$V_{gj} \propto \frac{\alpha^{0.266}(1-C_0\alpha)}{(1-\alpha)^{0.633}} = F_2(\alpha). \tag{8}$$

Figure 1 plots F_2 for two arbitrary choices of C_0 and again the variation of the drift flux velocity with voidage is clear.

It must be concluded that, because of the functional relationship between the gas superficial velocity and the voidage, the distribution parameter and the drift flux velocity cannot both be assumed to be independent of voidage. The accuracy and consistency of the data allow this statement to be made unambiguously.

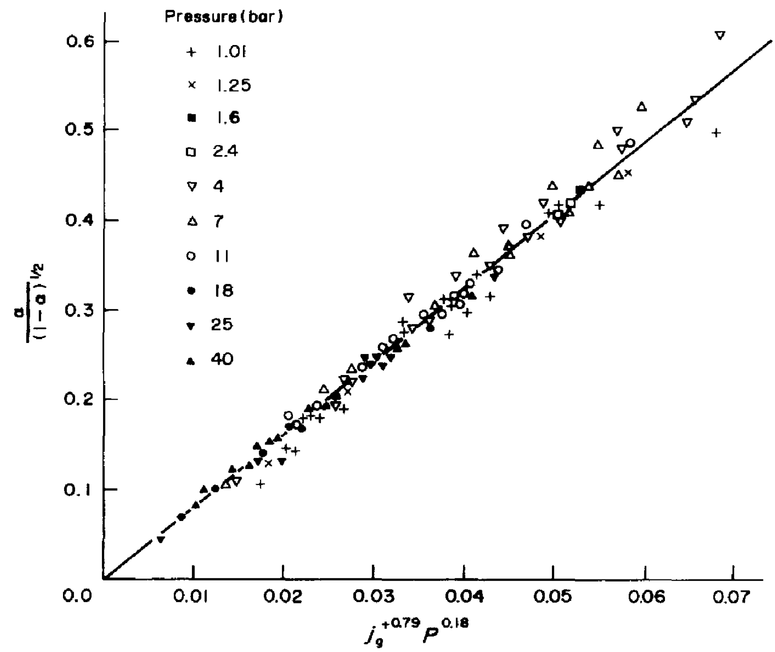

FIG. 2.

Acknowledgement—This work was carried out at the Central Electricity Research Laboratories and is presented by permission of the Central Electricity Generating Board.

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Reply to 'Discussion of "Drift flux model for large diameter pipe and new correlation for pool void fraction"'

THERE are several ways in correlating experimental data. The mathematical expression in one correlation may differ considerably from that in another correlation. In comparing correlations, one should take into account the uncertainties of constants and exponents in the correlations.

Gardner's correlation has one constant and three exponents which are determined by experimental data. His correlation may be written as

$$\alpha = K(1-\alpha)^l j_g^{+m} p^n. \quad \text{(A)}$$

Here, K, l, m, and n have uncertainties which are given by

$$K = K_0 \pm \Delta K, l = l_0 \pm \Delta l, m = m_0 \pm \Delta m, p = p_0 \pm \Delta p. \quad \text{(B)}$$

As was done by Gardner, if one substitutes equation (A) into the drift flux relation, one obtains

$$V_{gj} = F(\alpha, K_0 \pm \Delta K, l_0 \pm \Delta l, m_0 \pm \Delta m, p_0 \pm \Delta p). \quad \text{(C)}$$

Due to the uncertainties, ΔK, Δl, Δm, and Δp, the value of V_{gj} given by equation (C) has also uncertainty. Therefore, in the V_{gj}–α plane, equation (C) is represented not by a single line but by a band with certain width. The consistency between Gardner's correlation and ours should have been discussed in such a band. By the way, the lines, F_1 and F_2 in his Fig. 1 have nothing to do with uncertainty consideration as mentioned above, because in that figure, the strong depen-