Int. J. Multiphase Flow Vol. 6, pp. 273–274
Pergamon/Elsevier, 1980. Printed in Great Britain

LETTER TO THE EDITOR

Choked Foam Flows in a Convergent–divergent Nozzle

Sandhu & Jameson (1979) have presented interesting experimental data for choked foam flows in a convergent–divergent nozzle, and have compared these data with a theory which they based partially on the assumption of a flat voidage profile in the flow. They conclude that their data are compatible with isothermal gas behaviour and no relative motion between the phases at low gas concentrations, and with relative motion between the phases (a velocity ratio up to 1.5) together with isentropic gas expansion at higher gas concentrations.

A simpler interpretation of the data can be made if it is assumed that the gas concentration profile is not flat. "Slip" between the phases may then be due solely to the concentration of gas in higher velocity regions of the flow, not to relative motion between the phases.

The theory of choked flows in such systems differs from that of Sandhu and Jameson. The key feature is the use of a distribution parameter, C_0, developed by Zuber & Findlay (1965), which is a coefficient dependent on the shape of the concentration and velocity profiles. A flat concentration or velocity profile results in a distribution parameter value of unity; peaked profiles give values greater than unity. Typically, $C_0 \simeq 1.2$ for low voidage flows.

Critical flow expressions for flow where "slip" is due to concentration and velocity profile effects are given in Beattie (1976) and Beattie & Thompson (1976). For isothermal gas behaviour,

$$U_m \surd(\rho_L/P_t) \simeq \left(1+\frac{1}{\delta_t}\right)\left(\frac{\delta_t}{1-(C_0-1)(1+2\delta_t)}\right)^{1/2} , \qquad [1]$$

where U_m is the mixture velocity, and P_t and δ_t are the throat pressure and gas/liquid volume flow ratio, respectively.

Figure 1 indicates that the data are consistent with a non-flat concentration profile such that $C_0 \simeq 1.06$ for all gas concentrations. This value, which is rather low, is consistent with the view

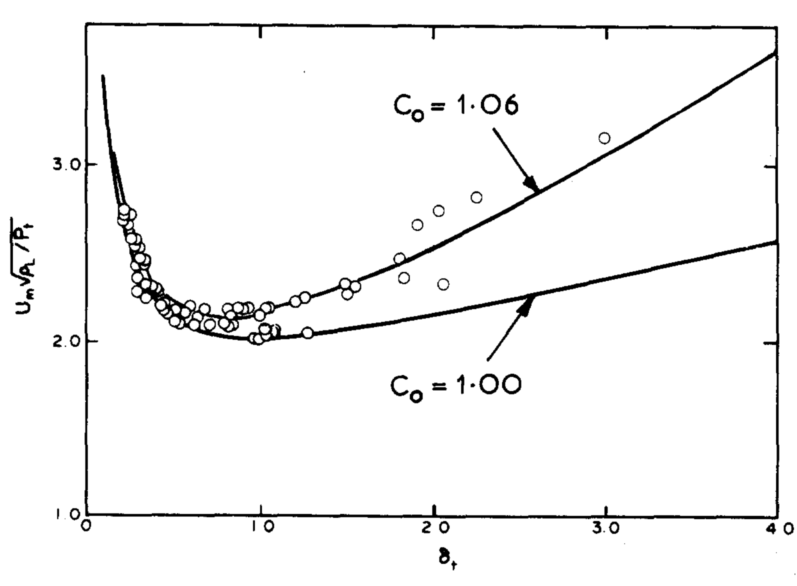

Figure 1. Experimental and theoretical dimensionless choking velocity as a function of throat volume ratio (adapted from Sandhu & Jameson 1979: figure 9); ——, [1].

of Sandhu and Jameson that their flows were comparatively homogeneous. This can be further seen by considering velocity ratio values. For flows in which Sandhu and Jameson require a velocity ratio k of 1.5 for agreement with their theory, the present model gives $k = 1 + (C_0 - 1)(1 + \delta_t) \simeq 1.1$.

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REFERENCES

Beattie, D. R. H. 1976 Pressure pulse and critical flow behaviour in distributed gas–liquid systems. *Proc. 2nd Int. Conf. Pressure Surges, BHRA Fluids Engineering*, Cranfield, England.

Beattie, D. R. H. & Thompson, J. J. 1976 The effect of flow velocity on two-phase propagation phenomena. *Proc. 2nd Int. Conf. Pressure Surges, BHRA Fluids Engineering*, Cranfield, England.

Sandhu, N. & Jameson, G. J. 1979 An experimental study of choked foam flows in a convergent–divergent nozzle. *Int. J. Multiphase Flow* **5**, 39–58.

Zuber, N. & Findlay, J. A. 1965 Average volumetric concentration in two-phase flow systems. *J. Heat Transfer* **87**, 453–468.