Drag Reduction in Two-Phase Gas-Liquid Flows

D. D. Kale
Department of Chemical Technology
University of Bombay
Matunga, Bombay 400 019

A considerable amount of drag reduction is observed in various flow regimes for two-phase gas-liquid flow of drag reducing fluids. [Greskovich and Shrier (1971), Rosehart et al. (1972), Otten and Fayed (1976), Sylvester and Brill (1976), Thwaites et al. (1976) and Attal (1978)]. Various attempts have been made to correlate the amount of drag reduction, but comparison with single phase flow of drag reducing fluids has not been done in a satisfactory manner.

It is well known that single phase flow of drag reducing fluids exhibits a diameter effect. In order to account for this, a plot of percent drag reduction versus friction velocity, u^*, in the absence of a polymer additive gives a simple method of estimating the amount of drag reduction for a given flow rate and pipe diameter. For two-phase flow no such comparison has been made.

A parameter u^*_{TP} may be defined as,

$$u^*_{TP} = \sqrt{\frac{D\Delta P_{TP}}{4L\rho_L}}$$

similar to that for single phase flow, where ΔP_{TP} is the pressure drop for given gas-liquid flow rates without the polymer.

In the above formula, density of the liquid, ρ_L, is used for simplicity instead of the density of the gas-liquid mixture.

Figures 1–3 compare published data for single phase and two-phase gas-liquid flow of drag-reducing liquids. Otten and Fayed (1976) reported data for various concentrations of carbopol using 25.4 mm ID acrylic pipe as a test section, while Rosehart et al. (1972) used pipe of 25.4 mm ID and various concentrations of Polyhall. In both these works slug flow regime was observed. Attal (1978) reported data for various concentrations of polyacrylamide (Separan AP 30) using a pipe of 13 mm and 19 mm ID, covering mainly bubble and plug flow regime.

The comparison of data in Figs. 1–3 over a wide range of bubble, plug and slug flow regimes for the three different types of polymer additives is certainly quite encouraging, and the method outlined above seems to correlate both single phase and two-phase flow drag reduction data reasonably well.

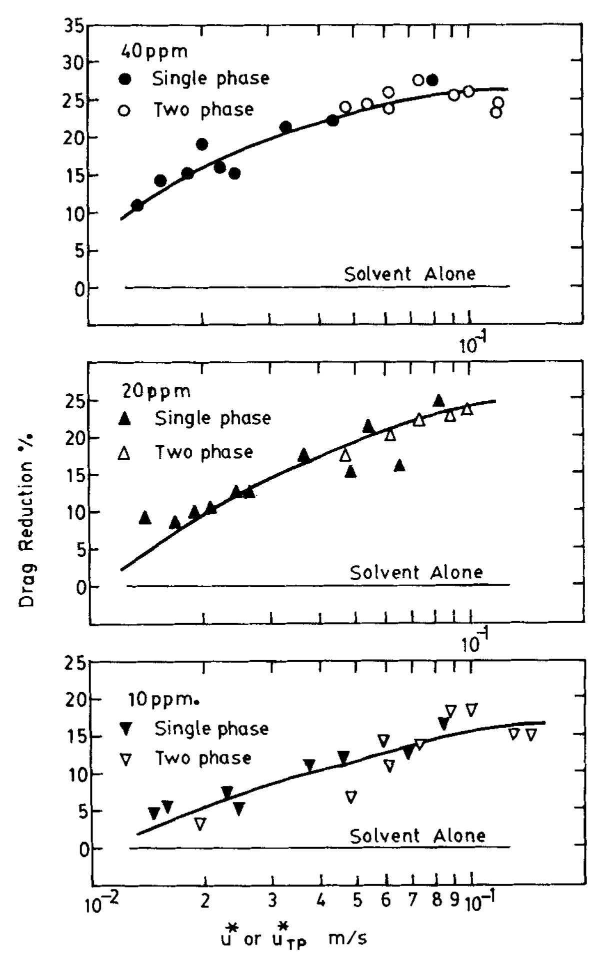

Figure 1. Single phase and two-phase flow draw reduction for carbopol 941, [Otten and Fayed (1976)].

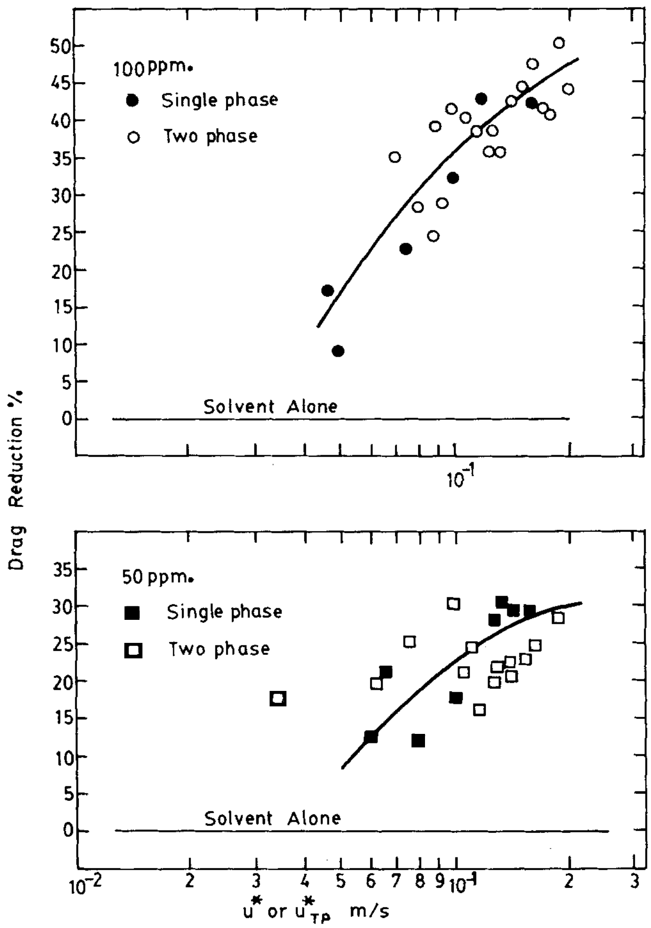

Figure 2. Single phase and two-phase flow drag reduction for polyacrylamide, Separan AP 30 [Attal (1978)].

Notation

D = pipe diameter
$\Delta P_{TP/L}$ = pressure drop per unit length, L
u^* = friction velocity, $\sqrt{D\Delta P/4L\rho}$
u^*_{TP} = parameter
ρ_L = liquid density

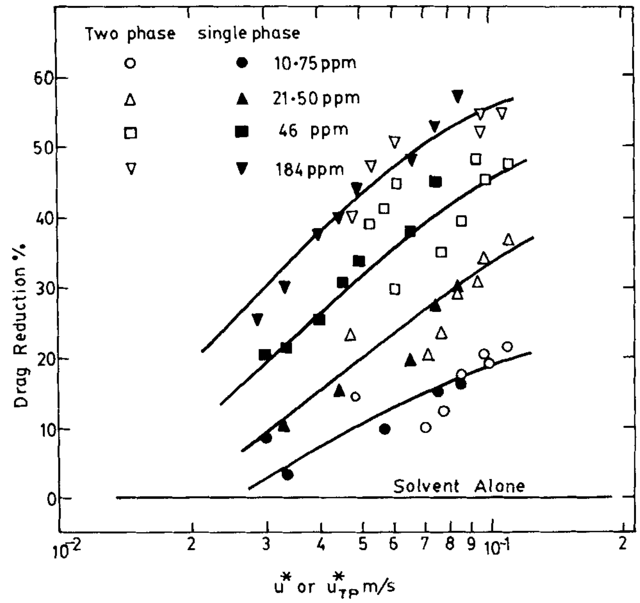

Figure 3. Single phase and two-phase flow drag reduction for polyhall [Rosehart et al. (1972)].

Literature cited

Attal, H. G., "Transport Phenomena in Drag Reducing Fluids—Studies in Two-Phase Flows," M.S. Thesis, University of Bombay (1978).
Greskovich, E. J., and A. L. Shrier, "Drag Reduction in Two-Phase Flows," *Ind. Eng. Chem. Fund.*, **10**, 646 (1971).
Otten, L., and A. S. Fayed, "Pressure Drop and Drag Reduction in Two-Phase Non-Newtonian Slug Flow," *Can. J. Chem. Eng.*, **54**, 111 (1976).
Rosehart, R. G., D. S. Scott, and E. Rhodes, "Gas-Liquid Slug Flow with Drag-Reducing Polymer Solutions," *AIChE J.*, **18**(4), 744 (1972).
Sylvester, N. D., and J. P. Brill, "Drag Reduction in Two-Phase Annular-Mist Flow of Air and Water," *AIChE J.*, **22**(3), 615 (1976).
Thwaites, G. R., N. N. Kulov, and N. M. Nedderman, "Liquid Film Properties in Two-Phase Annular Flow," *Chem. Eng. Sci.*, **31**, 481 (1976).

Manuscript received Apr. 21, 1986, and revision received July 15, 1986.