6.3.3 Homogeneous flow friction

When the multiphase flow or slurry is thoroughly mixed the pressure drop can be approximated by the friction coefficient for a single-phase flow with the mixture density, ρ (equation 1, section 6.2.1) and the same total volumetric flux, j, as the multiphase flow. Then the ratio of the multiphase flow friction coefficient (based on j), $C_f(\alpha)$, at a particular void fraction, α, to the friction coefficient for the continuous phase flowing alone, $C_f(0)$, will given by

$$\frac{C_f(\alpha)}{C_f(0)} = \frac{(1 + \alpha\rho_D/\rho_C)}{(1-\alpha)^2} \tag{1}$$

where it is assumed that $\beta \approx \alpha$. An example of the comparison of this expression with measured friction coefficient ratios in horizontal disperse flows shows good agreement up to large volume fractions (Brennen 2005).

Thus a flow regime that is homogeneous or thoroughly mixed can usually be modeled as a single phase flow with an effective density, volume flow rate and viscosity. In these circumstances the orientation of the pipe appears to make little difference. Often these correlations also require an effective mixture viscosity. In the above example, an effective kinematic viscosity of the multiphase flow could have been incorporated in the expression 1; however, this often has little effect especially under the turbulent conditions.

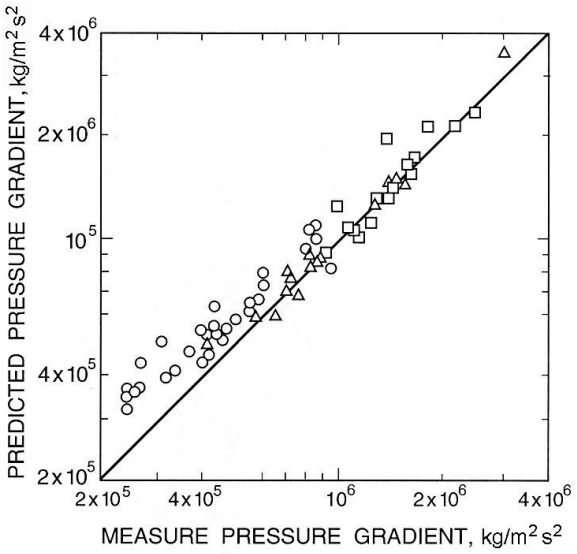

Figure 1: Comparison of the homogeneous prediction with measured friction coefficients in a $0.3cm$ diameter tube for steam/water flows with mass qualities, $\mathcal{X}$, ranging up to 0.5. Data from Owens (1961).

Wallis (1969) includes a discussion of homogeneous flow friction correlations

for both laminar and turbulent flow. Turbulence in multiphase flows introduces another set of complicated issues. Nevertheless the above-mentioned single phase approach to the pipe friction seems to produce moderately accurate results in homogeneous flows as is illustrated by the data of figure 1. The presence of drops, bubbles or particles can act like surface roughness, enhancing turbulence in many applications. Consequently, turbulent friction factors for homogeneous flow tend to be similar to the values obtained for single phase flow in rough pipes, values around 0.005 being commonly experienced (Wallis 1969).