Introduction to Drift Flux Methods

In this chapter we consider a class of models of multiphase flows in which the relative motion between the phases is governed by a particular subset of the flow parameters. The members of this subset are called *drift flux models* and were first developed by Zuber (see, for example, Zuber and Findlay 1965) and Wallis (1969) among others. To define the subset consider the one-dimensional flow of a mixture of the two components, A and B. From the definitions (Nac4), (Nac5) and (Nac14), the volumetric fluxes of the two components, j_A and j_B, are related to the total volumetric flux, j, the drift flux, j_{AB}, and the volume fraction, $\alpha = \alpha_A = 1 - \alpha_B$, by

$$j_A = \alpha j + j_{AB} \quad ; \quad j_B = (1-\alpha)j - j_{AB} \tag{Nqa1}$$

Frequently, it is necessary to determine the basic kinematics of such a flow, for example by determining α given j_A and j_B. To do so it is clearly necessary to determine the drift flux, j_{AB}, and, in general, one must consider the dynamics, the forces on the individual phases in order to determine the relative motion. In some cases, this will require the introduction and simultaneous solution of momentum and energy equations, a problem that rapidly becomes mathematically complicated. There exists, however, a class of problems in which the dominant relative motion is caused by an external force such as gravity and therefore, to a reasonably good approximation, is a simple function only of the magnitude of that external force (say the acceleration due to gravity, g), of the volume fraction, α, and of the physical properties of the components (densities, ρ_A and ρ_B, and viscosities, μ_A and μ_B). The drift flux models were designed for these circumstances. If the relative velocity, u_{AB}, and, therefore, the drift flux, $j_{AB} = \alpha(1-\alpha)u_{AB}$, are known functions of α and the fluid properties, then it is clear that the solution to the types of kinematic problems described above, follow directly from equations (Nqa1). Often this solution is achieved graphically as described in the next section.

Drift flux models are particularly useful in the study of sedimentation, fluidized beds or other flows in which the relative motion is primarily controlled by buoyancy forces and the fluid drag. Then, as described in section (Nel), the relative velocity, u_{AB}, is usually a decreasing function of the volume fraction and this function can often be represented by a relation of the form

$$u_{AB} = u_{AB0}(1-\alpha)^{b-1} \quad ; \quad j_{AB} = u_{AB0}\alpha(1-\alpha)^{b} \tag{Nqa2}$$

where u_{AB0} is the terminal velocity of a single particle of the disperse phase, A, as $\alpha \to 0$ and b is some constant of order 2 or 3 as mentioned in section (Nel). Then, given u_{AB0} and b the kinematic problem is complete.

Of course, many multiphase flows cannot be approximated by a drift flux model. Most separated flows can not, since, in such flows, the relative motion is intimately connected with the pressure and velocity gradients in the two phases. But a sufficient number of useful flows can be analysed using these methods. The drift flux methods also allow demonstration of a number of fundamental phenomena that are common to a wide class of multiphase flows and whose essential components are retained by the equations given above.