Chapter 13

DRIFT-FLUX MODEL

The basic concept of the drift-flux model is to consider the mixture as a whole, rather than two phases separately. It is clear that the drift-flux model formulation will be simpler than the two-fluid model, however it requires some drastic constitutive assumptions causing some of the important characteristics of two-phase flow to be lost. However, it is exactly this simplicity of the drift-flux model that makes it very useful in many engineering applications. As it is the case with the analyses of two-phase flow system dynamics, information required in engineering problems is often the response of the total mixture and not of each constituent phase (Tong, 1965). Furthermore, detailed analyses on the local behavior of each phase can be carried out with less difficulty, if these mixtures responses are known.

Another important aspect of the drift-flux model is concerned with the scaling of systems that has direct applications in the planning and designing of two-phase flow experimental and engineering systems. The similarities of two different systems can be studied effectively by using the drift-flux model formulation and mixture properties. The most important aspect of the drift-flux model is the reduction in the total number of field and constitutive equations required in the formulation in comparison with the two-fluid model. The drift-flux model is expressed in terms of four field equations: the mixture continuity; momentum; energy equations; and the gas continuity equation.

It can be seen, therefore, that the drift-flux model follows the standard approach used to analyze the dynamics of a mixture of gases or of miscible liquids. It is generally accepted that the drift-flux model is appropriate to the mixture where the dynamics of two components are closely coupled. This suggests that the same argument may be used for the macroscopic two-phase flows. The usefulness of the drift-flux model in many practical engineering systems comes from the fact that even two-phase mixtures that are weakly coupled locally can be considered, because the relatively large axial
dimension of the systems usually gives sufficient interaction times. The advantages of using the drift-flux model for the studies of system dynamics and instabilities caused by the low velocity wave propagation, namely, the void propagation, are demonstrated by Zuber (1967) and Ishii and Zuber (1970). However, there are some questions in applying the drift-flux model to the problems of acoustic wave propagations, choking phenomena and high frequency instabilities, as it has been discussed in detail by Bouré and Réocreux (1972), Bouré (1973) and Réocreux et al. (1973).

In the drift-flux model formulation we have only four field equations and, thus, one energy and one momentum equation have been eliminated from the original six field equations. Then, the relative motion and energy difference should be expressed by additional constitutive equations. In other words, the dynamic interaction relations are replaced by the constitutive laws. Furthermore, it is important to formulate the model based on the mixture center of mass in order to preserve the additive characteristic of the extensive variables, as explained in Chapter 4.

In this chapter, we develop a general formulation of the mixture model (Ishii, 1975) then discuss various special cases (Ishii, 1977) that are important in practical applications. Since we have carried out the detailed analysis on the field and constitutive equations for two-fluid model in Chapter 9, we recall and use these results for the establishment of the drift-flux model formulation whenever it is helpful. The following diagram summarizes the establishment of the drift-flux model formulation. Here we see the special importance of the kinematic, mechanical and thermal relations between the two phases. It is evident that the elimination of one of the two momentum equations from the formulation requires the kinematic relation between the phases, therefore, the relative velocity should be given by a constitutive law. Similarly, by using only the mixture energy equation for the balance of energies in a two-phase flow, thermal relation between the phases should be given.

1.1 Drift-flux model field equations

Formulation Based on the Center of Mass and Drift-flux Velocities

The most general forms of the four basic field equations for the drift-flux model have been given in the Section 1.3 of Chapter 5. In this section, first we put these equations into more realistic form by using some of the analysis on the constitutive equations for the two-fluid model. Then we discuss some appropriate simplifications which are important for practical applications. Here, we formulate the model based on the mixture continuity, momentum and thermal energy equations plus the continuity equation for one of the phases. These equations can be reduced to the following forms