1 Flow regime transition criteria

This chapter presents a review of the existing methods for identification of flow patterns in two-phase flow in pools, adiabatic and nonadiabatic channels, rod bundles and porous structures. An attempt is made to extend this information to be applicable in three-phase flow modeling. In addition the influence of the dynamic fragmentation and coalescence of flow regimes is introduced.

1.1 Introduction

Transient multiphase flows with temporal and spatial variation of the volumetric fractions of the participating phases can be represented by sequences of geometric flow patterns that have some characteristic length scale. Owing to the highly random behavior of the flow in detail, the number of flow patterns needed for this purpose is very large. Nevertheless, this approach has led to some successful applications in the field of multiphase flow modeling. Frequently modern mathematical models of transient flows include, among others, the following features:

1. Postulation of a limited number of idealized flow patterns, with transition limits as a function of local parameters for steady-state flow (e.g., see Fig. 1.1);
2. Identification of one of the postulated idealized steady-state flow patterns for each time step;
3. Computation of a characteristic steady-state length scale of the flow patterns (e.g., bubble or droplet size) in order to address further constitutive relationships for interfacial heat, mass, and momentum transfer.

Various transfer mechanisms between mixture and wall, as well as between the velocity fields, depend on the flow regimes. This leads to the use of regime-dependent correlations for modeling of the interfacial mass, momentum, and energy transfer. The transfer mechanisms themselves influence strongly the flow pattern’s appearance. That is why the first step of the coupling between the system PDEs (Partial differential equations) and the correlations governing the transfer mechanisms is the flow regime identification.

We distinguish between flow patterns appearing in pool flow and in channel flow. In pool flow, \( \gamma_r = 1 \), there is no influence of the walls on the flow pattern. In channel flows characterized by \( \gamma_r < 1 \), however, this influence can be very strong resulting in patterns like film flow, slug flow etc.
Some flow patterns can be trivially identified by knowing only the values of the local volume fractions of the fields, $\alpha_i$, and the consistency of the fields that is $C_i$, for example the single-phase flows or flows consisting of three velocity fields with an initially postulated structure. For two interpenetrating velocity fields additional information is necessary to identify the flow pattern. There are analytical and experimental arguments for flow pattern identification which will