PREFACE

Multiphase flow occurs in a vast number of problems whose solutions are crucial both to our understanding of Nature and to our ability to successfully design and implement engineering processes. It usually involves a mixture in which gaseous, liquid and solid phases are present, often in conditions far from thermodynamic equilibrium. A common special case referred to as two-phase flow is characterized by the presence of only two phases of matter, e.g., liquid with solid particles or gas bubbles, or gas with solid particles or liquid droplets. Multiphase flow components can differ not only in continuum physical properties such as density or viscosity, but also in velocities and temperatures. A good example of multiphase flow with such temperature and velocity differences would be shock-accelerated gas seeded with solid particles. Phase transformations occurring within multiphase flows further complicate the picture and expand the range of relevant physical processes from that characterizing homogeneous single-phase flow. Interaction of solid and liquid particles with gas, their acceleration or deceleration, heating or cooling all lead to non-trivial aerodynamics on the particle scale. For liquid droplets, evaporation, breakup or coagulation are also important, which in turn affects the parameters of the gas phase. Initially evenly distributed inclusions in the carrier phase (particles in liquid or gas, drops in gas, or bubbles in liquid) can migrate between flow areas in accelerated or sheared flow. In the flow of gas with solid and liquid particles, as well as in vapor-liquid flows moving in channels, tubes, and nozzles of jet engines, particles can collide, fracture, and so on. In multiphase pipe flows, films can form on the walls, leading to deposition of droplets and particles on them, and resulting in complex heat exchange between the vapor, droplets and film. Solid or liquid particles can fall on the walls, settle on them or be reflected and re-enter the stream. During the interaction of particles with walls, erosion of the latter may also be important.

In multiphase flow, a complex interaction of the phases takes place, accompanied by a variety of physical phenomena. Accordingly, processes of diffusion, viscous interaction, turbulence evolution, sound propagation, radiation, and shock propagation are substantially different in multiphase media and in the flow of homogeneous mixtures.

A full description of a multiphase continuous medium uses the laws of conservation of mass, momentum and energy for each of the phases and the mixture as a whole, written in the integral or differential forms, using the concept of a multi-velocity continuum with interpenetrating motion of components. The multi-velocity continuum is a collection of N continua, each of which corresponds to its component of the mixture and fills the volume occupied by the mixture. For each of these constituent continua, density, velocity, and other parameters are determined in each flow. Then at each point of the volume occupied by the mixture, N densities, temperatures, and velocities must be determined. The complete description of the motion of a multiphase medium must also include thermal and caloric equations of state, making it possible to describe the stress tensor and internal energy through the remaining parameters of the mixture and some physicochemical constants. When solving specific problems, it is also necessary to use the relationships that determine the parameters of mass, force, and energetic interaction between the phases. Among such relationships are, for example, the relationships that allow us to determine the rate of condensation of the liquid phase, the drag forces on particles in the flow, the laws of coagulation and break-up of liquid particles, the rate of crystallization, and so on.

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