

## Introduction to Flows with Gas Dynamics

This section addresses the class of compressible flows in which a gaseous continuous phase is seeded with droplets or particles and in which it is necessary to evaluate the relative motion between the disperse and continuous phases for a variety of possible reasons. In many such flows, the motivation is the erosion of the flow boundaries by particles or drops and this is directly related to the relative motion. In other cases, the purpose is to evaluate the change in the performance of the system or device. Still another motivation is the desire to evaluate changes in the instability boundaries caused by the presence of the disperse phase.

Examples include the potential for serious damage to steam turbine blades by impacting water droplets (e.g. Gardner 1963, Smith *et al.* 1967). In the context of aircraft engines, desert sand storms or clouds of volcanic dust can not only cause serious erosion to the gas turbine compressor (Tabakoff and Hussein 1971, Smialek *et al.* 1994, Dunn *et al.* 1996, Tabakoff and Hamed 1986) but can also deleteriously effect the stall margin and cause engine shutdown (Batcho *et al.* 1987). Other examples include the consequences of seeding the fuel of a solid-propelled rocket with metal particles in order to enhance its performance. This is a particularly complicated example because the particles may also melt and oxidize in the flow (Shorr and Zaehring 1967).

In recent years considerable advancements have been made in the numerical models and methods available for the solution of dilute particle-laden flows. In this text, we present a survey of the analytical methods and the physical understanding that they generate; for a valuable survey of the numerical methods the reader is referred to Crowe (1982).