Dynamic relaxation processes in compressible multiphase flows

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Phase changes and heat exchanges are examples of physical processes appearing in many industrial applications involving multiphase compressible flows. Their knowledge is of fundamental importance to reproduce correctly the resulting effects in simulation tools. A fine description of the flow topology is thus required to obtain the interfacial area between phases. This one is responsible for the dynamics and the kinetics of heat and mass transfer when evaporation or condensation occur. Unfortunately this exchange area cannot be obtained easily and accurately especially when complex mixtures (drops, bubbles, pockets of very different sizes) appear inside the transient medium.

The natural way to solve this specific trouble consists in using a thin grid to capture interfaces at all spatial scales. But this possibility needs huge computing resources and can be hardly used when considering physical systems of large dimensions.

A realistic method is to consider instantaneous exchanges between phases by the way of additional source terms in a full non-equilibrium multiphase flow model. In this model initially introduced by (Baer & Nunziato, 1986), each phase obeys its own equation of state and has its own set of equations and variables (pressure, temperature, velocity, energy, entropy,…). In this context the multiphase mixture instantaneously tends towards a mechanical or thermodynamic equilibrium at each point of the flow. For example, when considering pressure and velocity relaxation effects, a single pressure and single velocity model is solved intrinsically (Kapila et al., 2001; Saurel et al., 2008).

In addition this strategy allows to mark the boundaries of the real flow behavior and to magnify the dominant physical effects (heat exchanges, evaporation, drag,…) inside the medium.

First the numerical treatment aimed to solve the non-equilibrium compressible multiphase flow model will be presented. This numerical method named Discrete Equations Method has shown its ability to solve multiphase compressible flows in very different configurations (Abgrall & Saurel, 2003; Saurel et al., 2003; Chinnayya et al., 2004; Le Métayer et al., 2005; Saurel et al., 2007; Le Métayer et al., 2011) such as mixtures with several velocities or interface problems. Then a description of the various relaxation processes will be given as well as a presentation of physical examples.

Key words: compressible multiphase flows, relaxation procedures