Eulerian-Eulerian modelling, with applications

Berend van Wachem

This lecture will focus on the Euler-Euler, or two-fluid modelling of multi-phase flows. The lecture will start with exploring the continuuum approach, the implications of the continuum hypothesis for multi-phase flows, and discuss the various types of averaging applied in multi-phase flows. Three types of averaging will be discussed in more detail: volume averaging (Ishii, 1975), ensemble averaging (Anderson and Jackson, 1967), and averaging in the framework of the probability density framework (Simonin, 1996).

A central issue with the Eulerian-Eulerian approach is the necessity of closure relations, such as the closures for the particulate "stresses" (representing particle movement and collisions). The classical theory is derived for elastic particle collisions and assumes a laminar flow. These will be presented in detail, and discussed in the framework of the Enskog equation (Lun et al., 1984). This framework leads to a fully closed set of governing equations, including an equation for granular temperature, which represents the amount of energy of the fluctuating particle motion. Also, extensions to account for the interaction of the particles with a turbulent flow will be presented.

The lecture will give ample practical modelling examples, of the modelling of fluidized beds (van Wachem et al., 2001), circulating fluidized beds (Benavides and van Wachem, 2008), and gas-solid flows in pipes and channels (Benavides and van Wachem, 2009). Finally, challenges and future research directions for closure models will be discussed.

References

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