Third International Conference on CFD in the Minerals and Process Industries
CSIRO, Melbourne, Australia
10-12 December 2003

EULERIAN MULTIPHASE MODELING OF PARTICLE-PARTICLE AND PARTICLE-TURBULENCE INTERACTIONS IN POLYDISPERSE GAS-SOLID FLOWS

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ABSTRACT

A multifluid modeling approach is presented for the numerical prediction of turbulent gas-solid flows which distinguished among multiple particle classes, on the basis of their physical properties (diameter, density). Separate transport equations for the first order moments (number density, mean velocity, kinetic stresses) of each particle classes are derived from a microscopic kinetic equation governing the joint fluid-particle PDF (Probability Density Function).

Such an approach allows to account simultaneously for the particle-turbulence interaction and for the inelastic collisions between particles. Special care in the closure derivation for collision modeling is made to account for the correlation between neighboring particles induced by turbulence interaction and for the non-equilibrium distribution of the particle velocities such as measured in dilute flows. Validation of the proposed approach is performed by using results from Discrete Particle Simulation (DPS) coupled with Direct Numerical Simulation (DNS), or Large Eddy Simulation (LES), of the gas turbulence in very simple flow configurations. As an example, a validation of the model is carried out from DPS+LES results for colliding particles suspended in an homogeneous isotropic stationary gas turbulent flow.

Finally, two practical models for the dispersed phases are derived in the frame of this general approach and implemented in the 3D codes Saturne_Polyphasique@Tlse developed in collaboration with EDF R&D. The Particle Kinetic Energy Model is based on the calculation of a transport equation for the particle fluctuating kinetic energy and a kinematic viscosity assumption for each classes while the Particle Kinetic Stress Transport Model is based on the calculation of separate transport equations for the particle kinetic stress tensor components. For both approaches, the turbulent momentum transfer between the gas and particle fluctuating motion for each classes is written in terms of the fluid-particle velocity covariance given by a separate transport equation. The gaseous phase turbulence is computed by means of k-epsilon eddy viscosity model (or R_{ij}-epsilon model) with additional terms which account for the modulation by the dispersed phases. Predictions of the proposed models are presented for particle-laden turbulent round jet, vertical pipe flows and confined bluff body flow.

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