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Influence of Mass loading and inter-particle collisions on particle dispersion in a recirculating flow geometry

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ABSTRACT

The effect of mass-loading and inter-particle collisions on the development of the polydispersed two-phase flow downstream a confined bluff-body is discussed here. Although the bluff-body flow configuration is one of the simplest turbulent recirculating flows, it is relevant for applications and forms the basis of numerous combusting devices. The present data are obtained for isothermal conditions by using a two-component phase-Doppler anemometer (PDA) allowing size and velocity measurements. A polydispersion of glass beads is introduced in the central tube flow. The statistical properties of narrow particle size classes are displayed and analysed in order to respect the wide range of particle relaxation times. The mean and fluctuating airflow in the presence of glass beads and the statistical properties of the dispersed phase motion have been discussed in a previous paper (Ishima et al. 1998). The data used here form the basis of a validated data set available for model testing.

The influence of mass loading on particle dispersion will be considered in this paper. The initial mass loading M_j of the inner jet is the ratio of the mass flux of particles to the mass flux of air in the jet flow. We propose a correction valid in confined complex 3D flows to ensure that the global mass flux per size class obtained by integration from the PDA data is conserved. The results are used to discuss the strong influence of flow regime on the dispersion of the glass beads. Particles recirculate at the lowest mass loading and the mass concentration of the dispersed phase in the recirculation zone and in the external shear layer is high. This property is interesting for flame stabilisation in two-phase combustion. On the contrary, the memory of the initial jet is detected far downstream at high mass loading and dispersion of particles is reduced dramatically. The signature of inertia effects on the local mean mass distribution of the polydispersion is discussed.

Finally, the effect of inter-particle collisions is considered. Recent applications of kinetic theory to binary mixtures of particles are used to analyse the probability of particle/particle collisions and to emphasise their influence in the stagnation region even at low mass loading. In a polydispersed situation, collisions will result in a redistribution of mean momentum and fluctuating kinetic energy between all colliding particle classes. These effects are observed in the present situation.