Large eddy simulation of colliding monodisperese particles in forced isotropic turbulence

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ABSTRACT

An investigation of the collision rate of monodisperse, solid particles in a turbulent flow was a subject of several studies in recent years. Wang *et al.* 2000 performed numerical simulation (DNS) of such a system for small particles whose size was comparable or smaller than the Kolmogorov length scale. Similar DNS simulations for particles larger than the Kolmogorov scale were carried out by ten Cate 2002.

Direct numerical simulations (DNS) are of little use for practical problems due to the computational cost involved. Therefore we look at alternative options such as the large eddy simulation (LES). In the present paper we report results for the LES carried out for a system similar to the one presented by ten Cate 2002.

In recent years the lattice-Boltzmann (lB) method attracted particular attention as a very useful tool to deal with the simualtions of two-phase flows. Its relative simplicity and the manner in which interactions between more than one phase can be prescribed, makes the lattice-Boltzmann (lB) method better suited to deal with multi-phase flows than methods classically used for CFD like FEM or FVM. In this work the lattice-Boltzmann scheme proposed by Eggels and Somers 1995 was used.

The case considered here is so called box turbulence with periodicity imposed in all directions. The domain sizes in the calculations performed were 32^3 and 64^3 grid points for the LES computations, while the original refference DNS was carried out on a 256^3 points grid. The homogeneous turbulence in our "periodic box" is generated by the random spectral forcing (Alvelius 1998). The refference Reynolds number based on the amplitude of the forcing was $R_f = 505$. Unresolved scales in the LES calculations are accounted for by the classical Smagorinsky sub-grid scale (SGS) model. Initially single phase calculations for DNS and LES cases were performed to evaluate the

lattice-Boltzmann code. Turbulence energy and energy dissipation spectra obtained for the DNS two-phase cases illustrate clearly the difference between single and two-phase simulations with characteristic shape in the region of the small scales.

The two-phase simulations were carried out for several volume and mass fractions (up to 10%). To describe the behaviour of the dispersed phase the Lagrangian approach is used. In performed LES computations particles are treated as point particles driven by the flow of the continues phase transmitted primarily by the drag force. At this stage only the one-way coupling is considered. DNS calculations follow the approach of ten Cate 2002 where particles are treated as fully resolved spheres. The radius of the single particle was set as four times larger than the Kolmogorov scale. The random character of the collisions implies that only by using some statistical tools and approaches we can try to adequatly evaluate their properties. As an illustration, distributions of the particle relative radial and transverse velocities associated with the collision kernel will be presented. Another quantitiy that provides some usefull information especially when related to different mass and volume fractions, is the averaged collision time. Obtained LES results are compared with corresponding DNS computations.

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