TIFR Centre for Interdisciplinary Sciences
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Colloquium

Direct Numerical Simulations: Applications to Commercial Designs

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In the present study, direct numerical simulations (DNS) were performed on single and a swarm of particles either settling under gravity or under the conditions of fluidization. The simulations have been carried out in the range of Reynolds number from 0.01 to 1800. The effect of the particle volume fraction on the drag coefficient has been studied and was found to be in good agreement with the correlations proposed by Richardson and Zaki. Further, when Re<1 the experimental measurements of suspension viscosity were also found to be in good agreement with the DNS simulations. In addition, the wake formation was simulated and the separation angle as well as wake size agreed with all the experimental data published in the literature. The onset of instability in the wake and its growth along with the dynamic behaviour of a settling sphere was examined at Reynolds number (Re) of upto 1800. It was found that, at the onset of instability, the sphere starts to rotate and gives rise to a lift force due to the break-up of the axi-symmetry in the wake which in turn triggers a lateral migration of the sphere. The values of lift and virtual mass coefficients have been estimated for single and multi particle systems over the entire Re range.

The turbulence in multiparticle system was found to be homogeneous, however, non-isotropic. It could be made isotropic by proper selection of particle shapes. It has further been shown that, along with homogeneity and isotropy, the Taylor Reynolds number could be increased even upto 2000. This high range of Re_λ, permits to understand the scaling laws of turbulence and also the origin of "vorticity". It may be pointed out that, getting Re_λ upto 2000 has been difficult in the published literature and gigantic water tunnels are being built for this purpose.

We extended the DNS simulation for the prediction of particle-fluid heat and mass transfer coefficients. These estimations are otherwise being done by empirical correlations. However, the estimations of various correlations differ even by a factor of 10 to 50. Such an uncertainty does not give confidence and the resulting designs have been expensive both on the counts of capital and operating costs. Further, by considering eight different applications (Froth Flotation, Chromatographic Separation, Pyrolysis, Biomass Stove, Continuous Cooker, Technologies for CNT, Titanium and New Generation of Atomic Power Reactor) it has been shown that, highly miniaturised and economical designs are possible by optimizing the flow field for a certain application. Most of these cases have been in successful commercial operation and, for the others, demonstration plants have been set-up.

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4:00 PM (Tea/Coffee at 3:45 PM)

Seminar Hall, TCIS