Radial segregation of settling suspension in horizontally rotating cylinder

Akshat Jain[1], Anugrah Singh[1] and John F Brady[2]

[1]*Dept. of Chemical Engg., Indian Institute of technology Guwahati, Guwahati, India**

[2]*Department of Chemical Engineering, California Institute of Technology, Pasadena CA 91125, USA*

Suspension of solid particles in viscous fluid rotating in a horizontal drum or cylinder is often encountered in many mixing and segregation devices. In mixing application, homogeneous dispersion of particles is desired, while on the other hand phenomena of segregation provide an effective way to separate particles caused simply by rotation of cylinder [1]. A great deal of experimental and theoretical work has been done in the past to understand the axial and radial patterns in mono- dispersed neutrally buoyant suspension in fully filled cylinder [2-3] but there are very limited studies on the dynamics of settling suspensions in rotating cylinder [4]. We report experimental and simulation studies on the radial segregation of non-neutrally buoyant suspension in rotating cylinder. It is observed that the interplay between hydrodynamic and gravitational forces on the particles leads to instabilities resulting into a segregation pattern in which the heavier particles occupy the central region and the lighter particles are confined around the heavier particles. The final pattern is independent of initial configuration of the particles. The experiments were conducted by taking equal volume percentage of heavier (steel balls) and lighter (glass beads) particles in glycerol-water mixture. The cylinder was rotated at very low speed to keep the Reynolds number small. Figure 1 (a) shows the initial configuration of particles. The particles that appear to be solid black are the steel beads and the lighter ones are the glass beads. The final steady state configuration is shown in figure 1(b) where the segregation pattern is clearly observed with heavier particles surrounded by lighter ones. The Stokesian dynamics simulations were performed for similar conditions as mentioned above. Figure 2(a) shows the initial distribution of particles in the cylinder and figure 2(b) shows the final segregation pattern. It is clear that the simulations also display segregation of heavy particles in the inner core surrounded by the light particles. We have also conducted simulations for different ratio of particle densities. It was observed that the segregation of heavier particles increases as we increase the density ratio. This can be explained on the basis of difference in trajectories of a light and a heavy particle. The heavier particles have shorter trajectories as compared to the lighter ones; which allows these particles to separate from the lighter ones. Lighter particles prefer to stay is a highly mobilized region. As we go on decreasing the density ratio, the difference in trajectories of heavy and light particle reduces and so is the decrease in segregation.

*Electronic address: anugrah@iitg.ernet.in

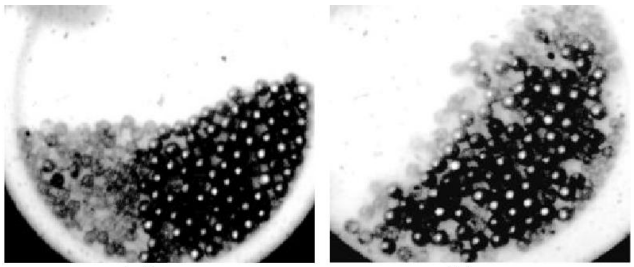

Figure 1: Initial distribution (a) and final configuration (b) of particles in experiments.

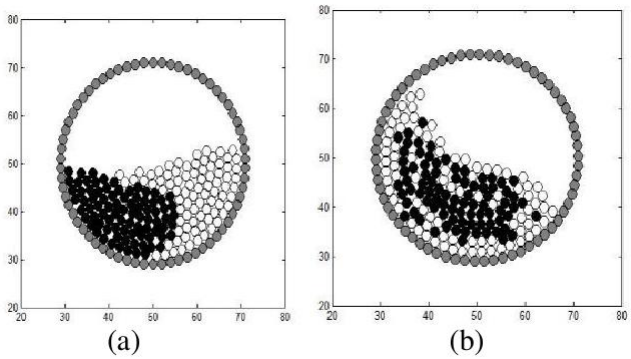

Figure 2: Initial distribution (a) and final configuration (b) of particles in Stokesian dynamics simulations.

References

[1] M. Tirumkudulu, A. Mileo and A. Acrivos, Particle segregation in monodisperse sheared suspensions in a partially filled rotating horizontal cylinder, Phys. Fluids., **12**, 1615 (2000).

[2] J. Breu, C.A. Kruelle and I. Rehberg, Pattern formation in a rotating aqueous suspension, Europhys Lett., **62(4)**, 491 (2003).

[3] W. R. Matson, M. Kalyankar, B. J. Ackerson and P. Tong, Concentration and velocity patterns in a horizontal rotating suspension of non-Brownian settling particles, Phys. Rev. E, **71(3)**, 031401 (2005).

[4] A. Ashok Kumar and A.Singh, Dynamics of bi-dispersed settling suspension of non-colloidal particles in rotating cylinder Adv. Powder Technology, **21(6)**, 641 (2010).