SIMULATION OF SEGREGATION IN A FLUIDIZED BED BY CFD-DEM BY USING SIMILARITIES

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Segregation happens in a fluidized bed due to particles with different sizes and/or different densities. Segregation is important for a lot of processes such as gasification, combustion and drying, but there are still a lot of unknown features. CFD coupled with DEM (discrete element model) is a powerful tool to investigate segregation in fluidized beds, but the computational load by this approach is too heavy to perform simulations in large-scale. In this study, similarities are used to decrease computational load.

A fluidized bed consisting of jetsam and flotsam particles is simulated, i.e. large particles with small density and small particles with large density, respectively (Table 1). The dimensions of the fluidized bed are 1m height, 1m length and 0.037m depth. The number of real particles in the bed exceeds 1 billion, which is too large to track in a numerical simulation by computer. Therefore, in the imaginary system which is simulated the number of particles is reduced as described below.

The imaginary system contains imaginary gas and imaginary particles. Each imaginary particle with a diameter K times larger than that of the real particle replaces a group of real particles. It is deduced that the segregation behavior of the imaginary system is similar to that of the real system, if the physical properties of the imaginary system are adjusted such that Reynolds and Archimedes numbers equal those of the real system (Fig.2). Enlarging the imaginary particles by a factor K can decrease the number of particles and hence the computational load by a factor of K-4.5.

The similarity rules are validated by experiment (Fig.3). After mixing of flotsam and jetsam particles for sufficient time, the fluidized bed is shut-down in very short time. Then, samples are taken layer by layer with a vacuum cleaner, the particles separated by a sieve and their weights measured. The mass fraction along height as measured in this way is shown in Fig.4. The comparison between experiment and simulations shows reasonable accuracy.

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Table 1 Jetsam and flotsam properties

	diameter D_p [m]	density ρ_p[kg/m^3]	weight percentage[%]
jetsam particle	3.10E-04	2.61E+03	98
flotsam particle	9.50E-04	1.12E+03	2

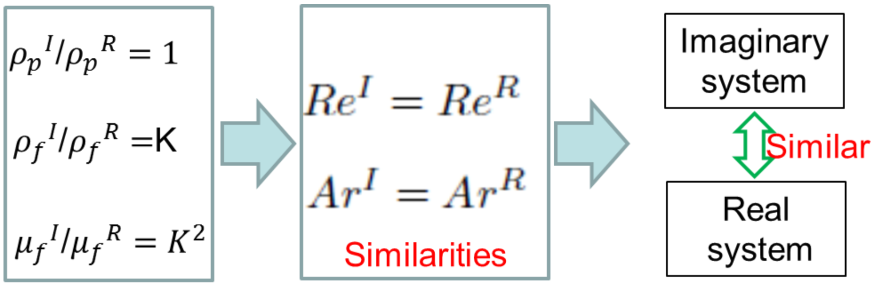
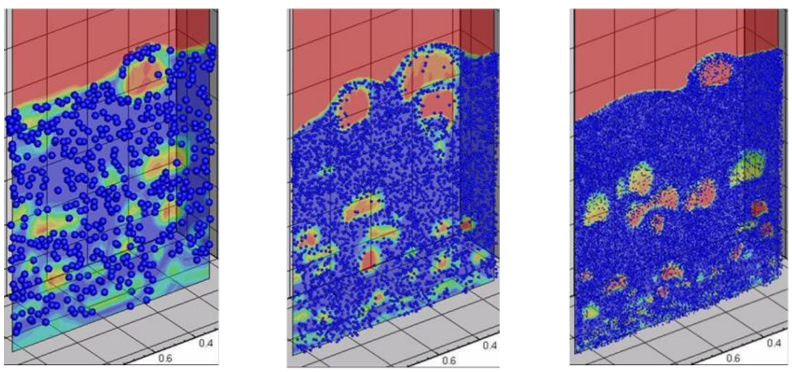


Fig.1 Conditions to achieve similarity between two systems
(here real and simulated system)

(Adjustment of particle density, fluid density and fluid viscosity to obtain same Reynolds and Archimedes numbers. $K = D_p^I / D_p^R$ denotes particle diameter ratio)



K=16 K=8 K=4

Fig.2 Flotsam particle distributions and void fractions as obtained for various multiplication factors K

(Only flotsam particles shown; contours of void fraction are shown simultaneously hear. It is found that fewer flotsam particles exist in the bottom of the bed.)

Fig.3 Early shot of concentration measurement (black: flotsam particles)

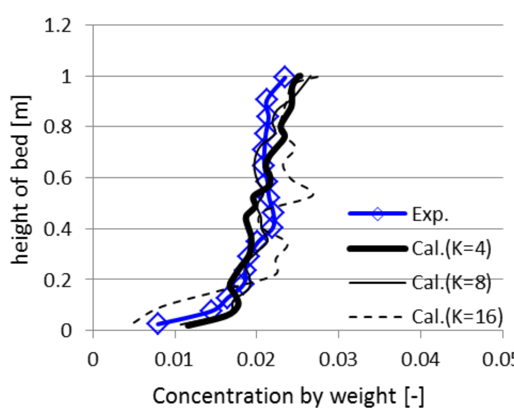


Fig.4 Concentration of flotsam particles along height