No. 1419

Quantification of Crystal Particle Collision Aiming to Develop Model of Secondary Nucleation

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Summary

Particle collision with impeller blades in industrial processes often causes attrition and breakage of the particles. In these industrial processes, solid particles exhibit wide variation in diameter and specific gravity. This study clarified the effects of particle properties on particle collision with impeller blades using Euler–Lagrangian simulations of particles suspended in a stirred vessel.

A flat-bottomed cylindrical stirred vessel with four baffle plates was used. The vessel had inner diameter of 100 mm and a liquid level of 100 mm (H). The fluid was presumed to be water. A 50-mm-diameter, six-blade, paddle-type impeller was submersed at a height of H / 3. The impeller rotational speed, n, was 6 s^{-1}. Large Eddy Simulation (LES) was used for turbulence simulation. The Lagrangian particle motion equations for each particle were calculated based on the instantaneous local fluid velocity obtained using the LES simulation. For the LES coupled with the DEM, we used commercial CFD software (R-flow; R-flow Co. Ltd.).

Results are summarized as follows. Particles caught up in fluid flow come from little above the front of blade. Some of the particles veered from the fluid flow, and then collide with blade face. On the front face of impeller blade, many of particle collisions occur along the blade edge. Collision velocity in normal to blade face increases toward the blade edge or tip. The probability density of the normal component of collision velocity shows the log–normal distribution. The mode value is less than one-tenth of the blade tip speed.

Collision frequency with the front face $F_{coll,f}$ increases with particle diameter and slightly decreases with particle density. Particle distribution in a vessel changes with particle diameter and density. So, the collision frequency is also affected by the number of particles suspended around the impeller, N_{imp}. Relation between the collision frequency of a particle suspended around the impeller $F_{coll,f}/N_{imp}$ and settling velocity of a particle u_t with variation of particle size and density are investigated. Results show that $F_{coll,f}/N_{imp}$ is increased, as the settling velocity u_t increases regardless of particle size and density.