Experimental and computational investigation of droplet-particle interactions

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Abstract title	EXPERIMENTAL AND COMPUTATIONAL INVESTIGATION OF DROPLET-PARTICLE INTERACTIONS
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Abstract:

Spray drying is an essential unit operation for the production of powders from liquid slurry. Important events occurring inside the spray dryer are droplet drying and interactions between droplets and fine particles, leading to bouncing collisions, coalescence, agglomeration, and satellite droplet formation. In recent years, there has been growing interest to use computational fluid dynamics (CFD) for exploring such phenomena inside spray dryer systems. Researchers have extensively investigated single droplet-droplet and single particle-particle interactions using numerical and experimental methods. However, the literature on droplet-particle interactions with a quantitative description of agglomeration in spray drying is scarce, and mainly qualitative.

The main objective of this research is to develop a simulation tool that can provide the particle size, velocity and mass flux distribution for a section of a large scale spray dryer. These results ought to be used as boundary conditions for coarse grained simulations. Specifically, we are developing an Euler-Lagrange model with a stochastic approach for the outcome of collision, coalescence and agglomeration events between droplets and particles in a spray dryer.

In this paper, we describe supporting experiments for the interaction between a single droplet and a single particle. The experiments consist of dropping a single spherical particle on a single droplet, using a syringe. The important parameters determining the outcome of the interaction are the impact contact angle, the size of the droplet relative to the particle, and the characteristic Reynolds and Weber numbers upon impact. Depending on these parameters, we classify different types of collision events.

The purpose of this study is to obtain an experimentally validated model for droplet-particle interactions. To reach this point, two main problems need to be solved. The first is to obtain accurate high-speed image series for all binary interaction categories. The second is to develop a theoretical model, based on experimental data, which predicts droplet and particle velocities and sizes after impact for each category. The model will be applied in an Euler-Lagrange simulation with stochastic treatment of the collision probabilities, based on particle concentration and relative velocity. Such a simulation can predict the distribution in the sizes of dried and partially wetted particles and droplets, as well as their mass fluxes, in spray dryer systems. This will be useful in the design of more efficient spray dryers that can produce higher throughputs.

Images

Back