Chaotic disintegration of suspension spray by a cross air flow

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Abstract

The aim of this experimental work is the characterization of chaotic disintegration of sprays generated by a cross air flow, in particular the description of droplet size distribution, average droplet size and the influence of the various process parameters on spray disintegration. These experiments will serve as a base for the development of phenomenological predictive model for typical spray parameters, in particular for the mean drop diameter of drops.

Introduction

Spray drying and spray microencapsulation are one of the most widely spread technologies for particle generation in pharmaceutical [1] food [2], detergents and chemical industries [3], and in powder generation for drug delivery [4].

The key element of these technologies is the primary spray atomization. It is well-known that the size distribution of atomized droplets coupled with the operating parameters of the spray dryer can influence not only the size but also the morphology of the particles obtained in spray dryers

The entire spray process consists of multiple physical phenomena: primary atomization, spray transport and wall interactions, as well as single droplet processes, i.e. evaporation during spray transport. The quality of the predictive tools in this field is highly related to the level of physical knowledge of the different elementary phenomena

In order to develop and validate theoretical models, estimation the size of drops generated as a result of the jet disintegration is essential. The effect of the properties of the feed fluid such as initial solid concentration, surface tension, density and rheology on the size distribution of the spray is investigated in this study.

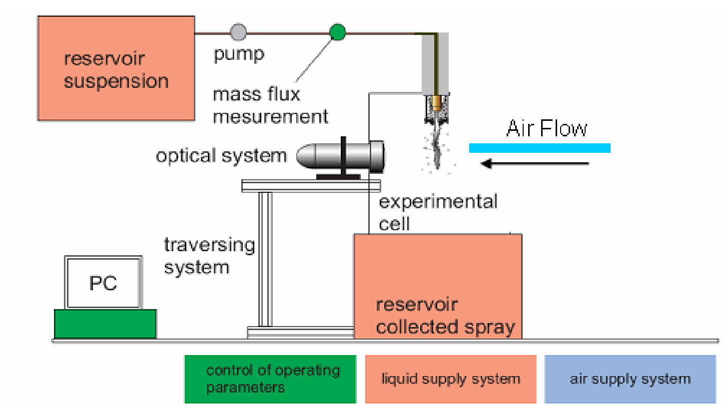

Figure 1. Experimental setup

Figure 2. Image of a disintegrating jet

Materials and Methods

An experimental rig has been built (see Fig. 1) to study chaotic disintegration of suspensions and other complex liquids. The liquid jet is ejected from a pressurized reservoir through a nozzle. The jet is then disintegrated by a continuous gas cross flow hitting it near the exit of the nozzle, as shown in Fig. 2. The geometry is chosen to be generically relevant to a wide variety of industrially applied atomization technologies.

An optical system consist of a high speed camera with back-lighting is used to capture the shadow images of the disintegrated spray. The images are analyzed to calculate average droplet size (primary and secondary droplets) and droplet size distribution; these results can be used then for numerical simulations and theoretical models appropriate to predict the size of drops generated as a result of the jet disintegration.

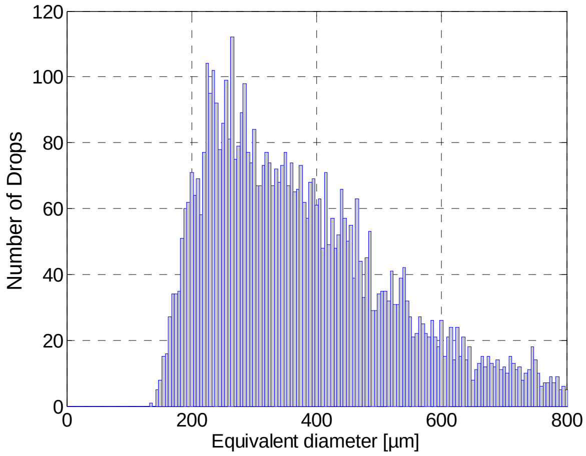

Figure 3. Droplet size distribution

The distribution of the drop diameters in the spray is determined by image analysis of the spray and then the mean drop diameter is estimated. Both pure liquid water and polymer suspension (Polyvinylpyrrolidone) have been investigated at various initial polymer concentration and different operating parameters. Different geometries of the nozzles are tested (diameter applicability to work with suspensions) to investigate airblast atomization. Two different air flow orientations are studied: axial air flow and cross air flow. These parameters will be applied to various liquid mixtures (surface tension, viscosity, solid concentrations, and size of the solid particles) and at different mass flow.

Fig. 3 shows the exemplary results obtained from an experiment with liquid flow rate of 240 l/min, the depicted droplet size distribution calculated for a sample number of images equal 500.

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