Experimental Investigation of Dynamics and Atomization of a Liquid Film Flowing over a Spinning Disk

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Abstract

Many intermediate and final products in chemical, pharmaceutical and food industry as well as in material processing are in the form of powder. Rotary atomizers are very common in the production of powder due to the possibility to create a spray with a narrow drop size distribution. In this technique a thin liquid film is formed and spreads radially over a spinning disk. In most of the cases the film is wavy. As the film flows over the disk edge, it disintegrates into droplets forming a spray. The influence of the liquid film hydrodynamics on the spray characteristics is not yet understood.

We have developed an experimental method for high-speed measurements of film dynamics and drop size distribution on a spinning stainless steel disk with a diameter of $d = 0.15$ m. Experiments are carried out in a wide range of mass flow rates and rotational speeds ($\dot{m} = 10 - 250\,\mathrm{kg/h}$, $f = 0 - 25\,\mathrm{Hz}$). The liquid jet is impinging at the center of the rotating disk. The local and temporal film thickness has been measured at different radial positions using a confocal chromatic sensoring (CHR) technique, which is based on chromatic longitudinal aberration of special optical probe. The sensor has been positioned above the disk and the radial position has been varied from $r = 2.5 \cdot 10^{-2}\mathrm{m}$ to the edge of the disk. The film thickness has been measured with a frequency of 4 kHz. The wave formation and the film development have been additionally captured using high speed video imaging. The drop formation at the disk edge and the drop size diameter have been observed by the shadowgraphy technique using an additional high speed camera.

The film flow on the rotating disk has been investigated in a wide range of parameters. The strongly wavy structure of the film flow has been observed for all sets of parameters. The development of waves depends on the nozzle-to-disk distance. At low mass flow rates the film thickness continuously decreases with increasing distance from the disk center, which indicates that the flow is dominated by viscosity and centrifugal force. At higher mass flow rates a maximum of the film thickness can be observed on the film thickness profile.

The comparison with correlations from literature shows a quantitatively good agreement for large dimensionless radii but only a qualitative good agreement for moderate values. First experimental results on the drop size distributions show the development of a bimodal distribution for small mass flow rates of the impinging liquid jet within the experimental range of parameters.

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