Characterization of Poly-Dispersed Paint Droplet Trajectories in Systems with an Electrostatic Rotary Bell Atomizer

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Abstract

Charged poly-dispersed paint droplets can be produced by an electrostatic rotary bell atomizer. These droplets have different sizes and charge-to-mass ratios and thus experience mechanical and electrical forces that result in different trajectories. FLUENT software was used to determine the paint droplet trajectories and user-defined functions (UDF) were compiled to calculate the electrostatic field and the electrostatic forces acting on the charged droplets. Two methods of droplet size input were used, namely the multiple injection method and the Rosin-Rammler method, and droplet size distributions acquired from experiment were assumed. The droplet charge-to-mass ratios were considered to vary inversely with diameter. The paint droplet trajectories, the transfer efficiency and paint layer thickness distribution on a planar target surface were calculated. The results show that for the multiple injection method, the trajectories of individual sized droplets can be displayed and although the experimental size distribution can be directly entered, the data input and UDFs are complex. For the Rosin-Rammler method, the data input and UDFs are simpler, but the accuracy depends on how well this distribution fits the experimental data. The results show that poly-dispersed charged sprays expand spatially which results in more uniform droplet deposition. The smaller droplets concentrate at the inner part of the spray due to shaping air entrainment, while larger ones are at the outer part due to their higher momentum. It was found that the droplet charging improves the transfer efficiency for all droplet size ranges because of the electrical attraction when the droplets approach the target. The paint thickness distribution patterns are displayed under charge and no charge conditions.

Key words: electrostatic spray painting; numerical modeling; electrostatic rotary bell atomizer; drop size distribution; charge-to-mass ratio; droplet trajectory