Numerical Modelling of Electrostatic Spray Painting Process with a Rotating Bell Cup for Automotive Painting

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ABSTRACT

In this study, the electrostatic coating process employing a rotary bell sprayer is simulated by developing a 3D Eulerian-Lagrangian algorithm under the framework of the OpenFOAM package. The efficient evaluated algorithm contains models for spray dynamics, atomized droplet trajectory tracking, unsteady airflow field, electric field, charging of sprayed droplets, wall film dynamics and boundary layer over the target. By setting a simulation condition that strongly matches the practical applications, the obtained results validate against experimental ones with suitable accuracy. The discussion contains an analysis of recirculation flow, primary and secondary breakup process, overspray phenomena, the toroidal vortical flow and flow field characteristics in various operational conditions, e.g., air and paint flow rate, rotational speed, electrical charge and size distributions of droplets. The overspray phenomenon is rare in the droplet dispersal plume when electrostatic spraying is used, resulting in a significantly thicker film on the body. The electrostatic spraying process examined in the condition benefits from using the control ring or retractable blades electric conductor combined with the conventional electrostatic rotary bell sprayer (ERBS) to produce a denser electric field pattern over the rotary bell sprayer. These findings are critical for the coatings industry to optimize the operating conditions.

Keywords: Electrostatic rotary bell sprayer (ERBS), OpenFOAM, Droplet breakup, Coating film thickness, Electrostatic painting simulation, Particle trajectories.