Shah, Umesh, MESc, “Numerical investigation of electrostatic fine powder coating process with CFD”, The University of Western Ontario, September 2004 (co-supervisor: C. Zhang).

Abstract

Powder paint coating is the process where the paint powder is directly applied to part surfaces with the aid of an electrostatic charging. It is superior to liquid paint in that (1) it eliminates the use of petroleum-based solvents that are both expensive and harmful to the environment, and (2) it allows overspray paint powder to be recycled and reused. In powder coating, the particle size greatly affects the quality of coating and the use of finer particles of size 15 µm or lower can greatly enhance the surface quality providing glossy look and uniform thickness. However, only coarse paint powders of 30-60 µm have been used so far for powder coating since finer powders make the powder extremely difficult to flow. The research team at the Powder Technology Research Centre at this university has developed a novel technique, which can effectively fluidize very fine particles. With the development that allows the use of fine powder-coating process to potentially replace the liquid painting, for high-end surface finishing, it is very important to study the flow field of sprayed fine powder and air inside the coating booth to understand the performance of the coating process and to design appropriate operating parameters and geometric parameters of the coating booth for a given spray gun.

The overall objective of the study presented is to simulate the powder coating process in an experimental coating booth and an industrial coating booth and to determine the differences between the performances of fine paint particles and coarse paint particles under various operating conditions. The complete electrostatic powder coating process is modelled using the commercial computational fluid dynamics code, Fluent v6.1. The air and powder particle flows in a coating booth are solved as a three dimensional turbulent continuous gas flow with solid particles as a discrete phase. The continuous gas flow is calculated by solving Navier-Stokes equations including the standard k- turbulence model with non-equilibrium wall function and the discrete phase is modeled based on the Langrangian approach. Since the solid phase volumetric fraction is less than 0.1%, the effect of particle-particle interaction on particle trajectories is not taken into account. In addition to drag force and gravity, the electrostatic force including the effect of space charge due to the free ions is considered in the equation of motion and implemented using user defined scalars and user defined functions.

The numerical results agree well with the experimental data. It shows that the numerical model predicts quite accurately the particle velocities and average particle diameter accumulation at different locations inside the coating booth. The investigation of the performance of fine powder coating in comparison of coarse powder coating shows that the finer particles of size 15 µm or lower can give very smooth and uniform surface finish, which may serve the requirement of automotive top clear coat. This also provides useful information about optimum operating conditions such as the airflow rate, the applied external voltage and the powder-spray rate. The numerical model can also be used to optimize the gun-booth design for a better coating efficiency and coating quality.