Li Z-N, M.E.Sc., “Numerical Simulations of Fine Powder Coating Systems”, The University of Western Ontario, April 2003.

Abstract

Powder coating is environmentally friendly and more economical than liquid coating since it eliminates the problem associated with solvent emission, reduces the extra cost of solvent and allows easy recycle of over sprayed powder. In powder coating, the size of particles strongly affects the quality of the finishing of the painted part, with the quality being enhanced with decreasing particle size. However, when using finer powder, the particle size less than 35 mm, there exist flow problems due to particle agglomeration, so that the finishing quality of powder coating is still inferior to liquid coating. Recently, this university has developed a technology that can penetrate the agglomeration of the fine paint powders of 10-20 mm in size in the coating process. Separate experiments have shown greatly improved surface finish with the finer paint powder.

This thesis reports on a research project that studies the effect of paint powder size on the particle flow and its distribution in an experimental spray booth and an industrial spray booth using FLUENT as a modelling tool. Many parameters in a powder coating process affect the process efficiency and coating quality, for example, the size of the painted part, the distance between the painted part and the spray gun, the air flow rate and particle loading for the spray gun, the location of the pattern adjuster sleeve of the spray gun, and the suction pressure. How to improve the quality of coating finish and enhance the particle transfer efficiency are the two main goals to achieve in a powder coating process. The particle transfer efficiency is used in this study as a parameter to evaluate the performance of the powder coating system. In this thesis, numerical simulations are conducted for the different parameters mentioned above with and without electrostatic field and with different particle sizes The numerical simulations can provide detailed information on particle concentration, air velocity distributions, and particle trajectories inside the coating booth as well as the particle transfer efficiency. This information can be used for a parametric study of the coating booth to optimize booth geometry, the gun to the painted part distance, air flow rate and particle loading, suction pressure and particle size, in order to increase the process efficiency and coating quality. The numerical simulations are conducted in this investigation with an experimental powder coating booth and an industrial powder coating booth.

In the simulation the air flow field is obtained by solving three-dimensional Navier-Stokes equation with standard k-e turbulence model and non-equilibrium wall function. In addition to solving transport equations for the continuous phase, the air, a discrete second phase is solved in a Lagrangian frame of reference. The second phase consists of spherical particles, the powder, and is dispersed in the continuous phase. It is assumed that particle-particle interaction can be neglected. The trajectories of particles are calculated by solving the particle motion equations using Lagrangian method. The electrostatic field is established by solving the Laplaceequation.