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Numerical modelling of electrostatically supported spray painting processes

Q. Ye, A. Scheibe, J. Domnick

Fraunhofer-Institute for Manufacturing Engineering and Automation
Nobelstr. 12, D-70569 Stuttgart
Germany

Extended Abstract

A future successful implementation of the so-called *Digital Factory* as a sensible tool for planning and optimization tasks relies on powerful models for all relevant physical processes involved. This is especially true for the painting process, which produces a high percentage of fixed and flexible costs in automotive production. Within the painting process, which consists of several different process steps, spray painting plays an important role as the key step for the final technological and optical properties of the paint film.

In the current study we focus on the transport stage of the charged particles in the electrostatic painting process, where both aerodynamic and electrical forces play an equal important role. One essential requirement for a successful simulation of such spray painting is using suitable solver to model complicated turbulent flow and implementation of all relevant electrical effects including static electric field and space charge. Although today some commercial CFD (computational fluid dynamics) codes, in which different turbulent models are implemented, are available on the flow simulation for industry application, little commercial codes are available on modelling both complicated flow field and inhomogeneous electrical field with space charge. Most of the CFD codes depend on finite volume method, whereas the numerical models for solving space charge field are usually developed using finite difference and finite element method. Therefore there is a modeling gap for the application where both flow field and electrical field are equally important

Studies involving numerical simulation of the electric field with the space charge have been carried out based on some hybrid approaches [1-5], for instance, the finite-element method (FEM) combined with the method of the characteristics (MOC), Finite difference (FDM) with MOC, BEM (boundary element method)-FEM technique with MOC as well as FDM with FEM. Since the geometry of the spray gun and the work piece in the current study is quite complicated, the application of the above methods for the simulation of the electrical field will create difficulties. In a number of papers [6-10], the authors have successfully demonstrated that by appropriately extending Fluent, a commercial CFD code based on an unstructured finite volume mesh, the coating process of electrostatically supported high-speed rotary bells as well as powder paint application can be simulated.

In the current paper, the results of the numerical simulation for wet and powder paint spray painting processes with three different spray guns are showed. The practically relevant operating conditions, e.g. airflow rate, particle loading or high voltage were applied. The results confirm the applicability and reliability of the chosen models for the painting processes considered.