In-mold Coating of Thermoplastic Parts-Process Modeling and Simulation

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ABSTRACT

For thermoplastic parts like automotive body panels, the current industrial practice is to paint them for protection against outdoor exposure or to improve surface appearance. Painting is environmentally unfriendly and costly. Furthermore, a non-environmentally friendly adhesion promoter typically needs to be used before painting. Therefore, In-mold coating is a very promising alternative to painting as it is environmentally benign and lower in cost. In-mold coating (IMC) is carried out by injecting a liquid low viscosity thermoset material onto the surface of the thermoplastic substrate while it is still in the mold. The coating then solidifies and adheres to the substrate. The goal of our research work is to develop a computer simulation tool to predict the fill pattern and the pressure distribution to enable the identification and screening of potential IMC nozzle locations. A Hele-Shaw based mathematical model has been developed to simulate the coating flow during the IMC process assuming the coating to be a power law fluid. The continuous deformation of the thermoplastic substrate caused by the coating injection is analyzed by means of the PVT relationship of the substrate. A computer code based on the Control Volume based Finite Element Method (CV/FEM) has been developed to predict the fill pattern and pressure distribution during the coating flow. A packing module is being added to further improve the pressure prediction and achieve desired coating thickness. Current coating systems react by the free radical mechanism and adhering to the general industrial practice, it is assumed that enough inhibitor is added to the coating to prevent reaction until all the coating is injected. Therefore neglecting chemical reaction during filling gives a good approximation. Recent market trends show an increased interest for developing coatings for low molding temperature thermoplastics like TPO. This would require the coating system to be mix-activated, as a result of which, chemical reaction can no longer be neglected . A more realistic approach is to include viscosity changes due to chemical reaction in the flow simulation. We are improving the current flow models to include both, an improved constitutive equation for IMC as well as chemical reaction during flow. Various modeling results will be presented and process windows discussed.