IN-MOLD COATING FOR THERMOPLASTIC SUBSTRATES: FLOW MODELING AND RHEOLOGY

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In-mold coating (IMC) operation is performed by injecting a coating material onto the surface of the substrate with the mold closed. The coating flows by compressing the substrate under pressure. Most thermoplastic products need to be coated with some kind of surface finish determined by the kind of item and its application. The main reasons for applying a surface coating are: a) to protect the surface from the environment and thereby increase its lifetime, and b) to provide a decorate surface that is also easy to keep clean. Moreover, parts for the automotive industry are often required to have a “class A” surface finish on internal and external prominent surfaces. Few plastic parts have this required surface finish following demolding. Due to inherently low surface energy of thermoplastics, they are generally difficult to paint or coat. Therefore, it is desirable to have a method by which a coating could be applied to a thermoplastic part in the mold, resulting in a surface finish suitable for end use application, or one which would require less surface preparation treatment than heretofore utilized. As a primer, IMC would be used in place of adhesion promoters that are currently applied to plastic parts prior to painting, making the process more environment-friendly.

There are key issues that need to be addressed for a successful IMC operation. The location of IMC nozzle should be located such that total coverage is achieved and the potential for air trapping is minimized. The selected location should be cosmetically and be accessible for ease of maintenance. This necessitates the use of fill patterns. To avoid leakage of the coating material, the generated hydraulic force must never exceed the clamping force. Therefore it is imperative that we predict the pressures generated during coating injection. A Control Volume Finite Element Method (CV/FEM) based simulation tool has been developed to accurately predict the fill pattern and pressure distribution during the coating flow using the Carreau viscosity model and considering slip at the wall, which is needed due to the micro flow characteristics of the coating operation. In the case of IMC flow (as compared with injection molding), the gap-wise dimension h of filling space is not fixed. It is equal to the change in thickness of the substrate and is a function of time.

The rheological and slip parameters used in the simulations are measured by using a micro slit rheometer built in our laboratory. To verify the simulation results, an experimental result for a fully coated ABS part and a short shot are included here from among the various runs conducted using the IMC pilot facility. A coating flow rate value of 1.12E-06 m^3/s was used for the simulations. The experimental IMC pressures for a full shot of coating are compared with those obtained using the 2D simulation tool in Fig.1. Fig.2&3 illustrate the pressures and the corresponding fill pattern comparisons for a coating short shot. It can be seen that the two-dimensional slip and Carreau model based simulation code predicts the pressures better than the power law/no slip based code. The fill patterns also show good correlation.

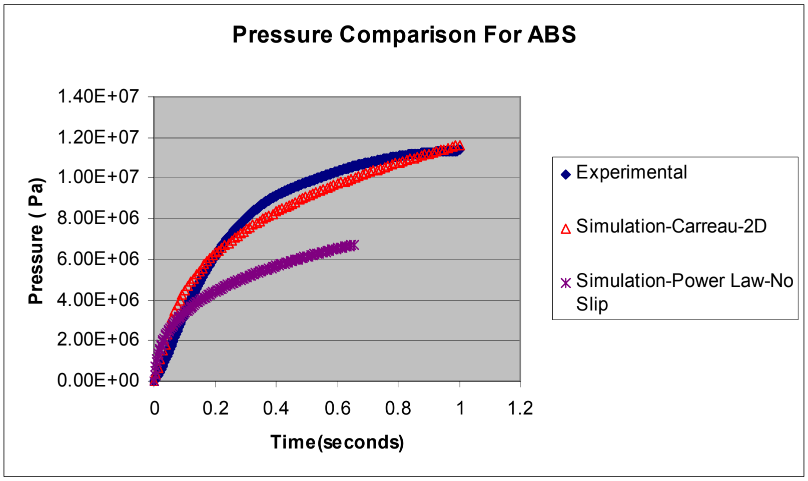

Fig.1. Pressure comparison for ABS full shot

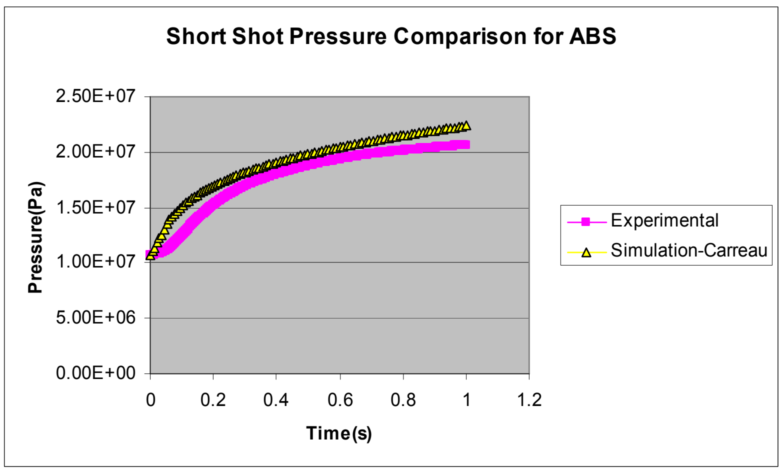

Fig.2. Pressure comparison for ABS short shot

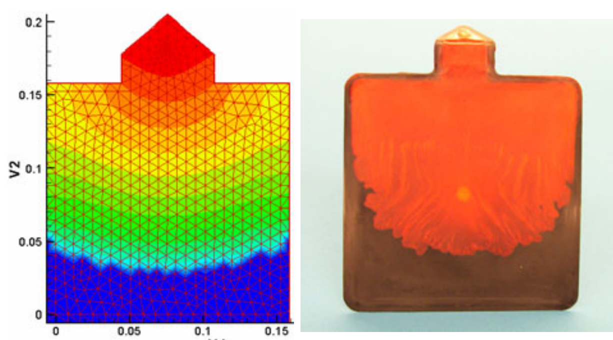

Fig.3. Fill pattern comparison for ABS full shot