Injection of flexible polyurethane foams: comparison of numerical simulation and experiment

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ABSTRACT :

Optimization of the manufacturing process, as well as part quality may be improved thanks to numerical modelling.

Flexible PU foams are produced by one shot process with a mixed of polyisocyanate, polyol and water with suitable stabilizers, catalysts and cell-size control agents. The chemical reactions begin immediately, water which reacts with isocyanate giving CO2 and creating the foam. Foam rise starting a few seconds after mixing and being completed in a matter of minutes. The expansion of the foam leads to the full cavity filling. The curing reaction leads to the solidification of the foam. The kinetics of the two reaction must be precisely tuned so that curing does not occur too early, preventing the foam to expand, or too late, which can lead to foam collapse.

For the numerical simulation of foam expansion and mold filling, we used REM3D® software.

It is based on a 3D finite element resolution of the compressible flow equations, of the energy equation which includes the enthalpy of the reactions, and of the reactions kinetics equations. The material data have been determined using a Foamat device and additional rheometric data obtained with DSC and rheology experiments. The computation gives the evolution of the flow front position, temperature, pressure and foam density.

Injection foaming of a polyurethane formulation in different mold geometries has been performed.

A center gated square mold with different thicknesses has been instrumented with pressure and temperature transducers. The latter are located at specific positions in the thickness of the cavity, allowing to monitor the arrival of the foam on the transducers and the temperature increase due to the chemical reactions. The density of the foam has been determined at different positions, the cell microstructure has been observed by SEM (Scanning Electron Microscope) and cell size quantified by image analysis.

In the same way, some experiments have been carried out on a complex mold, industrial one. The mold is installed with an angle of 5 degree with respect to the horizontal position. The flow front of incomplete foaming has been studied

Temperature and density are compared with the numerical results and the agreement is correct.

Numerical simulations for the more complex situations are promising.