Precision Moulding of Polymer Micro Components

Experimental Process Analysis and Simulation Validation

Micro injection moulding is a process which enables the mass production of polymer micro products. Micro injection moulding introduces additional design freedom, new application areas, unique geometrical features, and sustainable economical benefits, as well as material properties and part quality that cannot be accomplished by the conventional injection moulding process.

In order to produce high quality injection moulded micro parts, a crucial aspect to be thoroughly analysed and optimized is the filling of the cavity by the molten polymer. As a result, the relationships between filling performance and the different process parameter settings have to be established. Characterization of the filling phase during micro injection moulding is a challenging task, mainly due to the dimensions of the cavity (typically in the sub-millimetre range, and even down to a few micrometres) and the filling time of the cavity (in the order of few tens of milliseconds).

To this respect, a series of experimental investigations were carried out on the influence of the main μIM process parameters (melt temperature, mould temperature, and injection speed) on the polymer melt flow within micro cavities and the results of this research will be presented.

Experiments were conducted on a micro-injection moulding machine especially designed for the production of micro polymer components. A new approach based on calibrated optical measurements of flow markers was developed for the characterization of the melt flow. In-line pressure measurements were also performed to characterize the process in terms of injection time depending on the process factors. The process quality in terms of repeatability was assessed over a broad range of the investigated process parameters.

In polymer micro manufacturing technology, software simulation tools adapted from conventional injection moulding can provide useful assistance for the optimization of moulding tools, mould inserts, micro component designs, and process parameters. Simulation tools can work adequately from a qualitative point of view currently available numerical values cannot be calculated as precisely as necessary.

However, a proper implementation strategy employed during the set-up of the simulation can greatly improve the quality (i.e. the accuracy) of the simulated results. Methods developed for the validation of commercially available injection moulding simulation software will be presented. As a result, software predictions in terms of injection time, injection pressure and flow pattern of micro injection moulded parts can be improved by using optimized implementation strategies suitable for micro moulding applications.