KL 6.1

Polymer Melt Rheology at High Shear Rates Using a New Micro-Rheology Technique

W. Friesenbichler, G.R. Langecker, I. Duretek, S. Schuschnigg
Institute of Plastics Processing, University of Leoben, A-8700 Leoben, Austria

Small and micro-injection moulded parts with a mass less than 1 g and wall thicknesses < 0,5 mm are increasingly being used e.g. in medical technology, optics electronics, sensors etc. When these parts are injection moulded, high shear rates of 10,000 s^{-1} to 1,000,000 s^{-1} occur. In order to obtain proper simulation results which correlate well with actual practice, however, exact material data and in particular rheological data at high shear rates are required. This data cannot be measured using standard capillary rheometers. In literature rheological measurements up to a shear rate of 10,000,000 s^{-1} were carried out without taking into account the temperature rise due to shearing, and respectively the measured data for a number of thermoplastics are presented in the form of apparent viscosity curves.

A special slit-die system for micro-rheology measurements was constructed and optimised in several steps, using actual measurements and 3D FEM simulations of the melt flow in the die gap. The slit-die system consists of a die body and split die inserts with two different gap widths (0.1 and 0.15 mm) and 4 different die lengths per gap width.

The rheological experiments with the slit-die system were performed using a standard high-pressure capillary rheometer as well as a fully electric injection moulding machine. Using the injection moulding machine viscosity measurement is possible up to a shear rate of approx. 2,000,000 s^{-1}. A software package has been developed for the rheological evaluation of measured values and the approximation of true viscosity curves which takes into account the temperature rise due to shearing at shear rates > 5,000 s^{-1} (2 °C to 50 °C depending on shear rate) by temperature correcting the pressure values measured. The measured viscosity curves using the new micro-rheology technique were compared with the measured values from standard high-pressure capillary rheometer equipment.