VISCOSITY MEASUREMENTS FOR POLYMER MELTS AT HIGH SHEAR RATES - HOW TO CORRECT DISSIPATIVE HEATING

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In order to obtain proper simulation results for injection molding which correlate well with running production rheological data at high shear rates are essential which cannot be measured performing isothermal measurements with standard capillary rheometers. In non-isothermal rheological measurements, where shear rates of 100,000 to 1,000,000 s^{-1} and more occur, severe temperature increase due to viscous dissipation can be observed in the range of high shear rate (Friesenbichler et al. (2005, 2011). In literature viscosity curves are reported for this range calculated without taking into account the temperature rise due to viscous dissipation which leads to an underestimation of viscosity.

Achievements during the 1970s were made by Daryanani et al. (1973) who experimentally verified viscous dissipation in non-isothermal flow of polymer melts and suggested a method for correcting the viscosity due to frictional heat. Cox and Macosco (1974) calculated the effect of viscous dissipation in non-isothermal flows and verified the increase in melt temperature by means of an IR pyrometer. In the 1990s Aggassant et al. (1991) and Hay et al. (1999) developed new methods how to calculate temperature increase in non-isothermal melt flow due to dissipation and compression. These methods were further developed by Friesenbichler et al. (2005, 2011) for correcting the measured viscosity values due to dissipation.

The approach for viscosity correction presented in this contribution was applied for measurements with slit-die systems for micro-rheology and injection molding machine rheology and standard rheological measurements. The evaluation technique for viscosity data starts with rheological evaluation of measured values which subsequently will be corrected for viscous dissipation for each data point. Final result will be the true viscosity curve which takes into account the temperature rise due viscous dissipation at shear rates > 5,000 s^{-1}. The increase of melt temperature was calculated for a low viscous PP with 2 °C up to 50 °C depending on shear rate. Measured viscosity curves using the correction method will be presented for polypropylene, polystyrene and EPDM rubber. For rubber compounds with complex rheological behavior practical conditions in terms of material preparation and shear rate are of crucial importance because of filler-filler interactions. As a consequence such measurements should be carried out using a rubber injection molding machine and the correction methods mentioned above.