Determination of the transition temperature at different cooling rates and its influence on prediction of shrinkage and warpage in injection moulding simulation

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In injection moulding simulation the phase change from melt to solid state is usually simplified by using a so called transition temperature (also known as no-flow-temperature). Above this temperature the polymer is assumed to behave like a fluid and below this temperature it is regarded as a frozen solid without any flow velocity. A common method to determine this material parameter is the Differential Scanning Calorimetry (DSC) with a cooling rate of typically 20 K/min. This cooling rate is much lower compared to the injection moulding process. It can be expected that the way of determining the transition temperature has an influence on the prediction of shrinkage and warpage with commercial injection moulding simulation tools. In the present work the transition temperature of several amorphous and semi-crystalline polymers was determined using DSC-runs at different cooling rates up to 100 K/min. The dependence of the transition temperature is described as a function of cooling rate. There was a weak influence of the cooling rate on the transition temperatures of the investigated amorphous polymers, but the transition temperatures of the semi-crystalline polymers were significantly shifted to lower temperatures with increasing cooling rate. The obtained transition temperatures of the selected semi-crystalline polymers were then used in injection moulding simulations with the commercial software package Autodesk Moldflow Insight to calculate the shrinkage and warpage of box-shaped test parts. The test parts were injection moulded and the dimensions of these boxes were determined using an optical 3D-scanner. Finally, the simulation results were compared with the experimental values of the injection moulded boxes.