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SOLIDIFICATION DURING THE FILLING STAGE OF INJECTION MOLDING: A SIMULATION-ORIENTED STUDY

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The solidification dynamics during the injection molding process exerts an important influence on the final part properties. However, getting experimental information about polymer solidification throughout the injection molding cycle is still a challenge.
To overcome the practical issues, the process simulation can be used to get useful information, especially for identifying the most influencing parameters.
The no-flow temperature (NFT) is a parameter used in most of injection molding simulation packages as a mean to determine whether the polymer flows or it is solid. With this simple parameter it is possible to take into account the rheological solidification of the polymer, i.e. the high viscosity of the melt hinders the flow. However, for semicrystalline polymers, a better knowledge on the crystallization kinetics, especially at high cooling rates, is needed to achieve a comprehensive picture of the process.
A sensitivity analysis regarding the filling stage was carried out on two different packages (VISI Flow and Moldflow) to estimate the influences of NFT on process performance, as the frozen layer fraction and the filling pressure. The NFT resulted very influent on frozen layer, while does not affect appreciably the filling pressure. These results suggest an influence on the shrinkage and warpage estimation.
A simple correlation for NFT estimation, derived from Cross-WLF equation, is proposed for both amorphous and semicrystalline polymers. The new parameter proposed considers the variation in the apparent zero shear viscosity of the polymer on temperature, thus allowing to take into account both polymer properties and cooling rate.
A set of Dynamic Mechanical Analysis (DMA) experiments were carried out on polyamide 6 (PA6), to outline the influence of crystallization on melt hardening. At a constant melt hardening value, a linear relation between temperature and time was discerned. To show the influence of cooling rate on the onset of crystallization, an example of PVT measurements at different cooling rates are presented.