Simulation and Experimental Verification of Two Cavity Balance in Injection Molding

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Abstract

Injection molding of two cavities of different sizes leads to filling imbalance and possible defects, since the smaller cavity fills first, but is not packed until the larger cavity is filled. SigmaSoft PIM simulation was applied to alter the gate and runner geometry of two similar sized cavities in order to balance the fill rates of the 2 cavities. The optimized geometries were produced and tested, and the verification of the simulation is compared to the experimental results. The material used in simulation and experimental verification is a WC-10Co grade powder. The agreement between simulation and experimental results was good, though experimental optimization was still required.

Background:

Multi cavity tooling is used in injection molding to increase the number of parts per molding cycle and increase the production rate. However, the savings from the increased production rate must offset the increased tool cost for the additional cavities. For this reason, the tooling cost for additional cavities is typically justified only for high volume parts [1]. Molding two or more similar parts in one molding cycle is a method to increase production rates without increasing tooling cost. The challenge lies in the loss of control over the molding conditions of each cavity. The shared runner system between the parts has a controlled volume of feedstock flowing through it based on the injection molding machine filling parameters. However, the rate of filling of the cavities may be very different from each other. Once an imbalance of pressure is generated between the cavities, the fill rates will not be equal between the cavities. The smaller cavity will typically reach a near filled condition first, causing the fill speed to approach zero for the smaller cavity, meanwhile the fill speed for the larger cavity rapidly increases. Once the larger cavity is filled, packing begins for both parts. A pause in filling can be very detrimental since freezing will begin during the pause, before packing pressure is applied, reducing the effective packing time. This may cause poor surface finish, or poorly packed areas leading to voids or cracks. An uncontrolled increase in speed for the larger part may cause jetting, which may lead to trapped air, resulting in voids in the part. Upon initial examination, a tempting solution is to increase the runner volume in the section that feeds the smaller cavity, thus balancing the total shot volume (runner + cavity) of the 2 paths. However, this would cause material to reach the gate of the larger cavity first, where pressure would build from the decrease in cross section, and flow would rapidly decrease or stop until feedstock reached the gate of the smaller cavity. At that point both cavities would begin filling, however freezing may have already occurred at the larger cavity's gate, making the filling of the larger cavity slower and packing time before freeze-off shorter. This could then lead to a larger imbalance in filling between the two cavities. A better solution is to alter the gate geometries to reduce the filling speed of the smaller cavity compared to the larger one.

Standard multi cavity molds of more than 2 branches in the runner system commonly have uneven filling due to cavity temperature differences, and branching effects on the melt stream, even though the runner lengths and cavities are nominally the same. These imbalances are commonly corrected by trial and error method of adjusting gate orifices, but may be corrected by specialized geometries placed at the runner branching points [2]. US patent 7597827 [3] describes a method to balance the filling of multi cavity