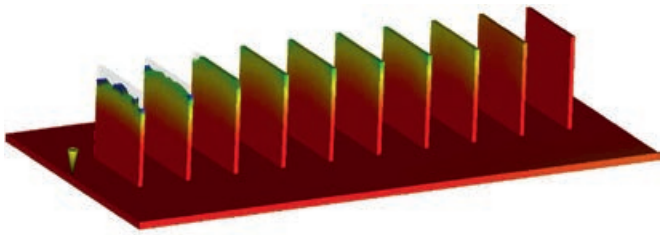
Understanding Flow Hesitation in Molded Medical Parts

Molded parts can be difficult to fill for a variety of reasons. Some, such as when the walls are too thin or the flow length too long, are obvious. Non-fill due to inadequate venting or poor processing is less obvious but still readily understandable. But when a thin feature fills when it is far from the gate, but not when it is close, the reason can be puzzling.

This last example is symptomatic of flow hesitation which can afflict molded medical parts with thin features such as ports and ribs that project from a thicker main wall. The remedies for flow hesitation can be counterintuitive. This article addresses the causes of flow hesitation and correction strategies.

The molding simulation plot below shows the flow front temperature distribution for a rectangular part with a series of half-thickness ribs spaced at equal intervals from the injection point (yellow cone) at the left. The three ribs closest to the injection point or gate failed to fill because the flow fronts became too cold. The ribs farther from the gate are progressively hotter and have no difficulty filling.

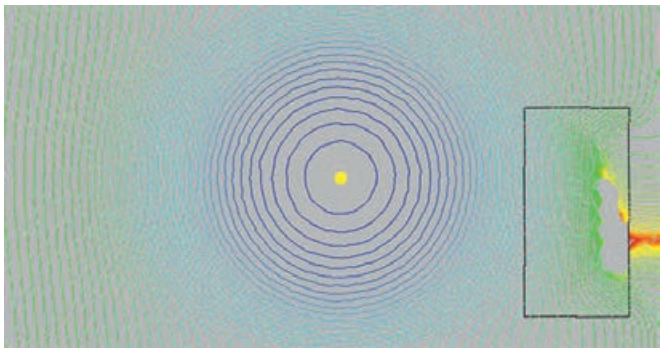


This example illustrates four key concepts about flow hesitation. First, plastic flow will favor the path of least resistance. In this example it is the path through the thicker main wall section. Flow progresses more slowly in the thin ribs as long as there are thicker sections left to fill. Second, slow moving flow fronts give up their heat more quickly than fast moving flow fronts. Frictional (shear) heating and heat carried through the inner wall layers to feed the advancing flow front help to keep the bulk temperature hotter in the faster moving flow path. Third, the melt viscosity climbs sharply as the material gets cooler, making flow more difficult and further exacerbating flow hesitation. Fourth, flow-hesitation-induced non-fill occurs because the flow front becomes too cold to progress, not because of inadequate injection pressure.

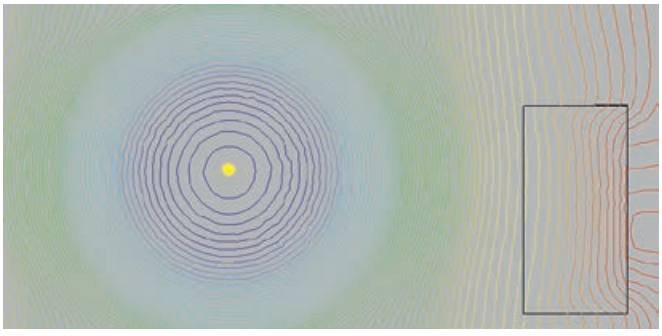
Filling the part 40 % faster enables all ribs to fill. The faster filling speed reduces the time the ribs nearest the gate hesitate waiting for the thicker main wall to complete filling. The shorter wait means the flow fronts in the ribs are hotter when flow finally diverts from the main wall to the thin ribs.

This assumes the part and feed system can tolerate a faster filling speed. Design permitting, increasing rib thickness would be another strategy to prevent flow hesitation problems. In this geometry, moving the gate to different locations is not a good option because it only changes which ribs fail to fill.

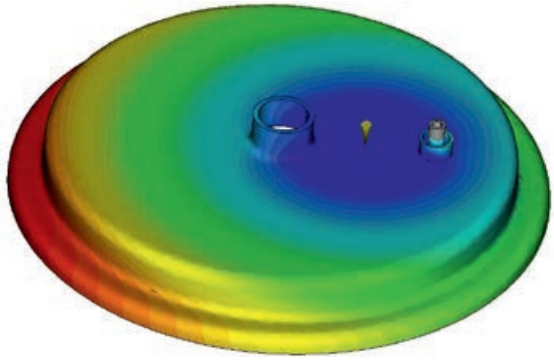
The next example is an 80 mm by 40 mm rectangular part with a main wall thickness of 1.0 mm. On one side is a recessed rectangular area with a wall thickness of just 0.6 mm. The filling contour plot shows the predicted filling pattern resulting from a gate positioned in the middle of the part. The contour lines show the position of the flow front at equal time intervals, so the wider the spacing the faster the flow front speed. The tight spacing of green and yellow contour lines in the 0.6 mm thick region indicates severe flow hesitation bordering an area that failed to fill. A review of the temperature plots revealed that the melt in the thin region became excessively cold while waiting for the thicker main wall to finish filling.



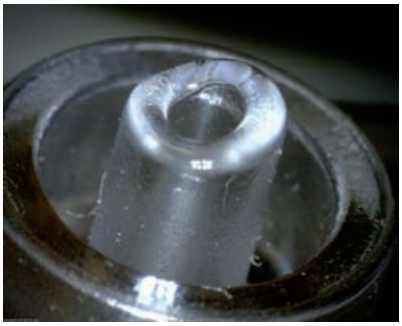
Normally a centrally located gate is preferred since it minimizes flow distance and provides symmetrical filling. In this case, it created problems. Contrary to common logic, the gate needs to be moved off center and away from the thin wall section to correct flow hesitation, as shown below.



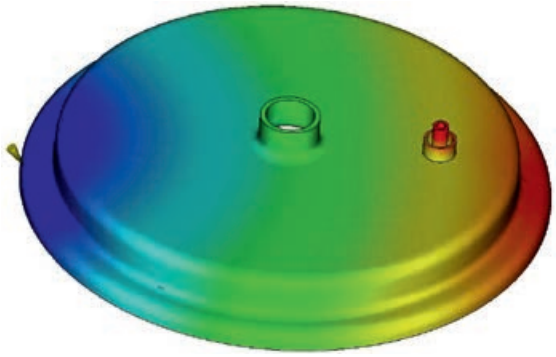
The final example is a 200 mm diameter cap with a 2.0 mm wall thickness and a center hole. Off to the side there is a port feature consisting of a circular rib and an inner tubular section. The walls of the rib and port are just 0.75 mm thick. When gated into the center hole, the port failed to fill. The filling pattern plot below shows that moving the gate closer to the port does not facilitate filling. Note that the injection location is indicated by the yellow cone, and the gray area in the port is the region that failed to fill.



This close-up photo shows actual non-fill due to flow hesitation in the port of a similar medical part.



Moving the injection location to the far edge opposite the port allowed the port to fill as shown in the following plot. Filling hesitated about halfway up the port until the main wall finished filling. Flow then diverted to quickly fill the last remaining feature, the top of the port. Review of the flow front temperature plot and the surface stress plot revealed a potential for problems caused by elevated stresses at the point of hesitation in the port. Increasing the filling speed by 50 % brought the stresses down to acceptable levels.



Flow hesitation occurs when flow in thin sections slows or pauses until thicker walls sections finish filling. This can lead to incomplete filling or elevated molding stresses in the affected feature. Often faster filling can raise the flow front temperature and reduce the time of hesitation enough to correct the problem. When processing adjustments are not enough, the counterintuitive step of moving the gate farther away from the thin feature can often fix the problem. Other options include increasing the thickness of the offending feature or adding more gates so the main wall sections can fill faster. Faster filling of the main wall reduces the duration of hesitation in the thin feature. Filling simulation is a great tool for identifying potential problem features and testing corrective options before the part or mold designs are finalized.

Typical value
These values are typical values only. Unless explicitly agreed in written form, they do not constitute a binding material specification or warranted values. Values may be affected by the design of the mold/die, the processing conditions and coloring/pigmentation of the product. Unless specified to the contrary, the property values given have been established on standardized test specimens at room temperature.

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