Holding pressure value and timing has a critical impact on part quality. **John Goff** continues his discussion of the importance of getting this simple setting right

The value of holding pressure

Correct selection of optimum holding pressure value is vitally important if effective moulding performance is to be realised. Furthermore, that holding pressure should be used solely to counteract or compensate for the natural inherent shrinkage of the plastic in the mould if a dimensionally, visually and structurally compliant component is to be produced.

If the holding pressure value selected is too high, then excessive internal stress is created in the component and there is a high risk that it will fail to meet end-service requirements. A common issue that occurs when moulding clear components, for instance, is fracturing or presence of micro-cracks in the region of the gate during or shortly after its removal.

Sophisticated gate removal techniques are sometimes unnecessarily employed - for example, laser cutting - to overcome the presence of cracks caused as a consequence of excessive structural (molecular) compression in the gate region. That said, high holding pressures do need to be used on certain moulded components to achieve uniformity of surface texture or compliance with rigorous quality standards.

As a general rule, the actual holding pressure value selected should be between 20 to 70% of the injection pressure value. In situations where holding pressures are found to fall outside of this range, it is indicative of a problem elsewhere with the moulding process and an investigation should be carried out. For example, the design of the wall section of the component and/or its associated distribution in conjunction with the gate position may not be optimal, or it could be that the processing parameters selected to produce the moulding are not appropriate.

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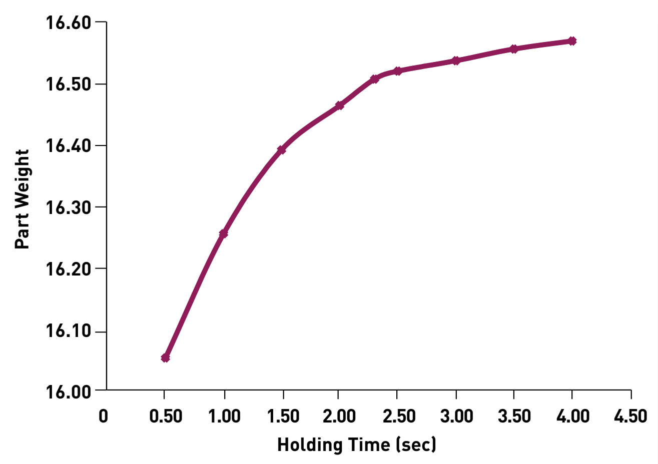
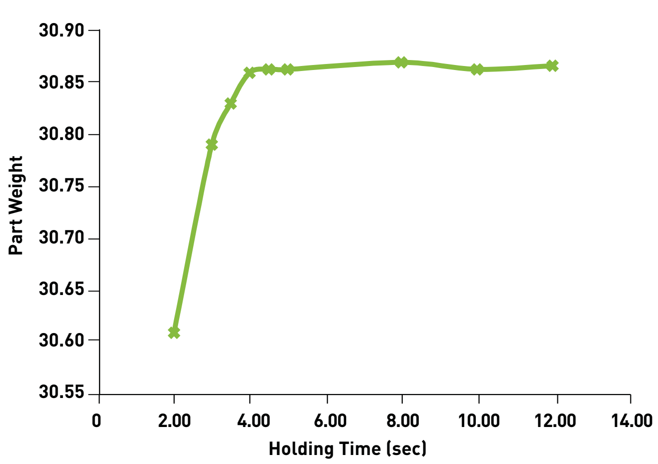
The value and timing of holding pressure is important in any moulding environment, not only cleanroom

Typical component quality issues arising from the selection of too high a holding pressure can include:

- Distortion of components on removal;
- Regions of dullness, scuff marks or poor surface finish, particularly in deep draw mouldings;
- Presence of glossy surfaces at the junction of thick and thin wall sections;
- Over-sized mouldings, particularly in the area close to the gate;
- Ejector pin marks.



OPTIMISATION OF HOLDING TIME AND GATE FREEZE OFF



OPTIMISATION OF HOLDING TIME AND GATE FREEZE OFF

These two charts show the use of part weight monitoring to optimise holding time. Onset of gate freeze can be easily identified

Problems are not only caused by selecting too high a holding pressure value. Too low a holding pressure value can often result in mouldings being undersized or displaying other problems. These might include flatness, warpage, sinking or voids.

It is often found that when too low a holding pressure is selected it is because the mould cavity has already been overfilled during the filling phase of the moulding cycle, with the result that the component may not eject cleanly and/or scuff marks can be seen on the component. Where the holding pressure value selected is too low, screw bounce can often be readily seen. In many cases this easily avoidable setting error results in inconsistent component quality.

While it can be seen that holding pressure value selection is very important, how moulders go about determining the optimum holding pressure value varies considerably. Some employ the concept of overcoming the natural inherent visco-elasticity within the molten polymer by controlling screw bounce. Others will register the stability of the melt cushion value as a function of holding pressure, or plot component shrinkage, weight and surface flatness with the corresponding holding pressure value. Those utilising cavity pressure transducers may use the information displayed by the cavity pressure-time graph to achieve the most effective value.

Irrespective of the approach employed, it is important that the moulded component is compliant with the necessary quality control and end-service requirements. A well-trained moulding engineer will be familiar with many different strategies for determining the correct holding pressure as one approach does not fit all. These strategies will vary with the specific industries and applications.

These differences apply both to determination of the actual pressure value and the period over which that pressure is applied. When a cold feed system is employed within the mould tool the task is relatively straightforward. However, when a hot runner system is used it is not always possible to use the same procedure. Furthermore, the same approach cannot always be applied to all of the types and designs of hot runner systems commercially available.

As an example, when the hot runner system includes fixed or static probes (often called a thermal gate design) the required procedure would be different to that used for a valve-gated hot runner system, and different again for the thermally-actuated gate employed when using the Seiki Spear-type tip temperature control principle. Of all the most common commercially-available hot runner systems, only the latter type allows the gate to freeze off and solidify and subsequently re-melt upon optimisation of the applied heat energy and exposure time.

Hot runner confusion

The terminology associated with hot runner systems can often cause confusion within the injection moulding industry. Some processors/specialists will claim that the molten material contained within the gate orifice of a conventional thermal gate-type hot runner actually solidifies and freezes off.

However, with both thermal and valve gated systems, if material freeze-off occurs within the gate orifice, then the cavity will not be filled with molten plastic during the following cycle due to cold solid material blocking the gate orifice.

In reality, the polymeric material within the vicinity of the gate becomes partially solid as a consequence of the temperature reduction caused by the removal of heat energy via the cooling system within the gate bushing and adjacent plate. When this semi-solid (visco-elastic) material is compressed upon initiation of the injection phase, it is forced through the gate orifice due to the resultant applied shear. It is then carried into the mould cavity in the same manner as unplasticised granules.

In general, the size of the gate particle is much smaller when compared to the size of unplasticised plastic granules. Extensive studies have been undertaken to ascertain whether this semi-solid material re-melts or attains a temperature allowing it to flow and become homogeneous with the remaining molten material during cavity filling.

Determination of the gate freeze-off time for a cold runner feed system is related to the actual temperature value of the molten material within the gate orifice. The longer the selected holding pressure time, the greater the weight of the moulding. However, there comes a time value where no further molten material can be forced into the impression as the temperature of the material in the gate orifice has reduced to the point where it freezes off and solidifies. This point can be simply determined by measuring the size or weight of the moulded component and plotting it against holding time – see the charts on p52.

This same freeze-off point cannot be effectively determined, however, for either a thermal (static probe) or valve gate as the material does not completely freeze. This means that additional material can be forced into the moulding via the gate if the holding time is extended.

This amount of additional material is likely to be quite small in terms of the overall percentage increase in weight. More often, quality issues and concerns are the result of either the extent of molecular compression or the increase in component weight. The latter can be a particular problem as only a small increase in weight when producing millions of mouldings becomes quite significant in terms of material usage and costs.

More information

John Goff is managing director of G&A Moulding Technology. This is the sixteenth article in the Moulding Masterclass series. Recent articles can be accessed here, here and here.

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