The challenge of determining optimal hotrunner settings is simplified if broken down into distinct sections, according to moulding expert **John Goff**

Hotrunner optimisation

One question regularly asked is: How do I obtain the optimum temperatures for a hot runner system in order to achieve effective mould tool performance? A simple protocol has been derived at G&A Moulding Technology that divides the hot runner into distinct sections.

Most hot runner systems, either single or multi-level configuration, can be typically broken down into the sprue or entry bushing, the distribution manifold, and the feed bushings (commonly known as drops, thermal tips or probes). When selecting the temperatures for each section of the hot runner system, reference to the actual melt temperature value achieved upon exit from the screw and barrel assembly must be considered.

It is common with most types of hot runner system for the entry section to be independently controlled with its own heater and thermocouple combination. When this is not the case, in general, the dimensions of the bushing should allow unrestricted flow of the molten material into the distribution manifold and the skin temperature of the entry channel should be as close to the derived melt temperature as possible.

For this reason, it is imperative that the actual melt temperature is measured so that an accurate correlation can be obtained. Often the temperature value selected for the entry bushing is either identical or similar to that used for the distribution manifold unless certain criteria dictate otherwise – for example, the dimensions (length/surface profile) of a snorkel incorporated with a stack mould tool.

When comparing the difference in the mass of metal in both the entry bushing and distribution manifold, they are usually very different. Furthermore, the thermocouple is often located within the wall of the bushing itself, enabling the heat energy dissipated by the electrical resistance element and directed to the entrance channel to be effectively monitored, resulting in a usual skin temperature of 2 to 10°C of the set temperature. Correlation of this value to the derived melt temperature needs to take place to ensure good control. Some processors confirm comparability by manually measuring the polymer temperature within the bushing.

In comparison, the skin temperature of the inner surface of the manifold channels can be up to 20 to 25°C lower than the derived melt value for the same temperature setting as the entry bushing. This ΔT can be due to various reasons: positioning of the thermocouple, the geometry and layout of resistance elements, and heating capacity. Regardless of whether the skin temperature is 5 to 25°C lower, the set temperature value needs to be established to compensate for this temperature disparity.

Hot runner manufacturers often quote temperature variances across a distribution manifold to be within 5°C or lower. This variance is the surface temperature and is not to be confused with the inner channel skin temperature or to the set temperatures measured by the thermocouple. Most direct or externally heated manifold hot runner systems encounter this ΔT issue and some systems will have a greater ΔT than others.

If one considers the temperature requirements of the tips (drops), then the set temperatures should reflect the actual temperature of the melt passing through and around the gate entry. In order to control the temperature at the gate, cooling channels are strategically positioned either within the impression plate or in and around the gate bushing. Effective cooling is essential to ensure minimal gate vestige, the overcoming of poor gate scars, differences in surface gloss in and around the gate area, and the presence of fibres attached to the moulding upon separating the mould halves. Poor gate cooling can lead to increased cycle times and lower performance capability.

The values selected at the gate are often much higher than the measured melt temperature as the increase in the set temperature value is essential to prevent premature freeze-off taking place behind the gate aperture, which will cause inconsistency in component manufacture and/or process cycle repeatability. It is often the case that the temperature of the coolant passing in and around the gate plate/bushing is set at too low a value because it is the temperature that is being used for the remainder of the mould tool.

Interestingly, the lower the coolant temperature, the more significant is the extent of imbalance between impressions within a multi-impression mould tool. Good moulding practice recommends the gate/feed plate assembly should be separately controlled at a temperature value which allows comparable temperatures to the measured melt value to be selected. In fact, if the plate temperature is correct, then slightly lower tip values can be used without moulding quality issues or output issues being encountered.

More importantly, correct temperature selection is critical for the static thermal probe type hot runner system where the detachable tip assembly, in its expanded position, must be accurately positioned to ensure the concentric conically-shaped gap in the gate entry allows the correct volume of molten polymer to flow unrestricted into the cavity. The higher the selected tip temperature, the greater the tendency for the tip to expand further into the gate orifice.

In practice, when increasing the tip temperature, greater flowability occurs due mainly to the increasing shear being applied to the molten material as a consequence of the smaller available gap. Such flowability is achieved without any temperature control and often leads to the production of mouldings with quality issues due to the lack of control. Furthermore, the use of high tip temperatures induces increased wear to the external profile of the detachable tip, leading to a reduction in the overall tip height and position. This often results in poor gate cosmetics.

In terms of importance, the distribution manifold temperature is the highest priority. A key factor in selecting the optimum value is that, at each incremental temperature setting, reference is made to a measurable process parameter or moulding attribute.

As part of the selection process for a designated hot runner system, the use of CAE to predict the loss in injection pressure at a given temperature and flow rate provides the basis for the channel geometries. By determining the extent of pressure loss and part volume, as well as the variability incurred over a number of consecutive shots for each incremental setting, invaluable information for achieving the optimum value can be derived. Upon determining the optimum manifold temperature value, refinement of the tip/probe values can then follow if required.

About the author:

John Goff is CEO of UK-based injection moulding process consultancy G&A Moulding Technology (**www.gandamoulding.co.uk**), which provides consultancy services on all aspects of process setting, optimisation and control, including hot runner technology, and developed and markets the Pro-Op process optimisation software tool.

This is the 28th instalment in his Moulding Masterclass series. You can read the most recent instalments in this series **here**, **here**, and **here**.