
PHOTO: AXEL

In the third of his articles on process optimisation, moulding expert **John Goff** looks at the critical issue of plasticization

Achieving perfect plasticization

Let's look at the foundation for a good injection moulding process. To achieve the required accuracy for a moulded component, conversion of the solid polymer into a liquid melt has to be correct. Selecting the wrong process parameters for this critical element of the process is often the sole cause for an injection moulding process that is running inconsistently and ineffectively.

Commonly called plasticization/plastification, this conversion needs the correct use of the two main heat energies to be effective, ie conductive and frictional. Moulders regularly compensate conductive energy for the lack of frictional energy, sometimes with reasonable success, in particular with amorphous materials such as PS, HIPS, ABS, PC, PC/ABS and PSU.

However, problems can arise, particularly when processing semi-crystalline materials such as PP and PA 66. Unplasticized granules are often the main issue with shorts appearing for no apparent reason; partial or total loss of the melt cushion resulting in undersized, underpacked parts with poor visual quality; or even short components.

Quite often, the lack of frictional energy stems from the inability of the moulding machine's screw motor to generate the necessary screw rotation speed (rpm). If this is the issue, then various options are available:

- Increasing the set barrel temperatures. This is quite common and success is variable, depending upon whether the material is amorphous or semi-crystalline, the shot capacity on the moulding machine and the cycle time being used.
- Increase screw back pressure to achieve the required flowability of the polymer melt. The ratio of energy input is 70:30 in favour of frictional energy, compared to the conductive energy, however it must be clearly understood that lack of either heat source cannot be truly compensated by the other. Furthermore, too much frictional energy shortens the dwell time of the material, preventing the conductive heat energy being dispersed within the material while it passes along the screw, resulting in a varying state of plasticization on arrival at the front of the screw. The situation is made even worse when a large percentage of the barrel capacity is used, together with increased screw rotation to achieve screw recovery time within the selected cooling time.

The photos overleaf show the results of using fast screw rotation and low screw back pressure values compared to a melt obtained using an optimised screw recovery and screw back pressure setting and a more controlled screw recovery time. The tests were carried out using the same barrel capacity of 65-70% with POM.

Injection moulding machines are typically purchased with a general purpose screw (GP). However, the screw

Converting plastic pellets into an homogenous melt is fundamental to achieving a consistent and high-quality injection moulding process

Melt obtained using fast screw rotation and low screw back pressure (left) compared to the much more homogenous melt obtained using an optimised screw recovery and screw back pressure setting and a more controlled screw recovery time (right)

geometry, mixing capability and back flow valve technology have a critical impact on the melt homogeneity. They will therefore be discussed in more detail in further articles in this series.

The importance of melt homogeneity is often overlooked when there are problems with part quality and dimensional inconsistency. However, the cooling of the colder and hotter regions of an inhomogeneous melt during the melt solidification process interferes with the formation of the molecular structure. This introduces unwanted internal stresses, particularly with semi-crystalline polymers. Such stresses will cause dimensional changes, leading to subsequent warpage and physical weakness within the component.

Process inconsistencies can be seen when viewing the information displayed on the injection moulding machine and will highlight large variances from shot to shot for particularly consequential variables. As stated in the first article, it is the consequential variables that highlight how well the controllable variables have been selected and the effectiveness of their interaction.

The following are variables that are instrumental in achieving a uniform (homogeneous) melt:

● **Barrel temperature settings:** Raw material suppliers/distributors of thermoplastic materials offer a recommended melt temperature range, with an optimum or more precise value that provides opportunities to achieve better process control. From my experience, it is surprising how often this information is not used and at G&A Moulding we find that a group of new trainees will initially select a wide range of temperature values.

A further complication is that certain moulding machines offer a different number of temperature zones along the screw and barrel assembly. This brings us back to the fact that the main objective of any screw and barrel assembly is to supply sufficient conductive heat energy to support the major frictional element to achieve melt plasticization.

As stated, the shot capacity of the moulding machine and the cycle time employed will also influence the actual temperature value selection. When too much heat energy is applied through adiabatic means, the actual recorded temperature value often overrides the set temperature value due to the extent of excess. Therefore, the highest set temperature along the screw and barrel assembly should coincide with the compression section of the Archimedean screw and usually the first section of the melting zone.

● **Screw rotation speeds:** Screw speed values have and always will play an important part in the preparation of an homogeneous melt and the use of rpm can be acceptable if the value used has a direct correlation to the material being processed, the diameter and type of screw, the design of the screw and the cycle time.

Frequently the screw speed selection is either too fast or too slow and based upon what the cycle time requires. Raw material suppliers are still cautious in offering recommended screw speed values for their grades despite the significant contribution that screw speed makes in converting solid granules to a liquid melt.

Screw speed values have for some time been quoted in mm/sec and it is disappointing that many moulders still do not correlate screw speed and rpm with screw surface speed in mm/sec, taking into account the diameter of the screw.

To be continued... This is the third part of John Goff's series of articles looking at process optimisation and troubleshooting. The first and second parts can be see **here** and **here**.

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