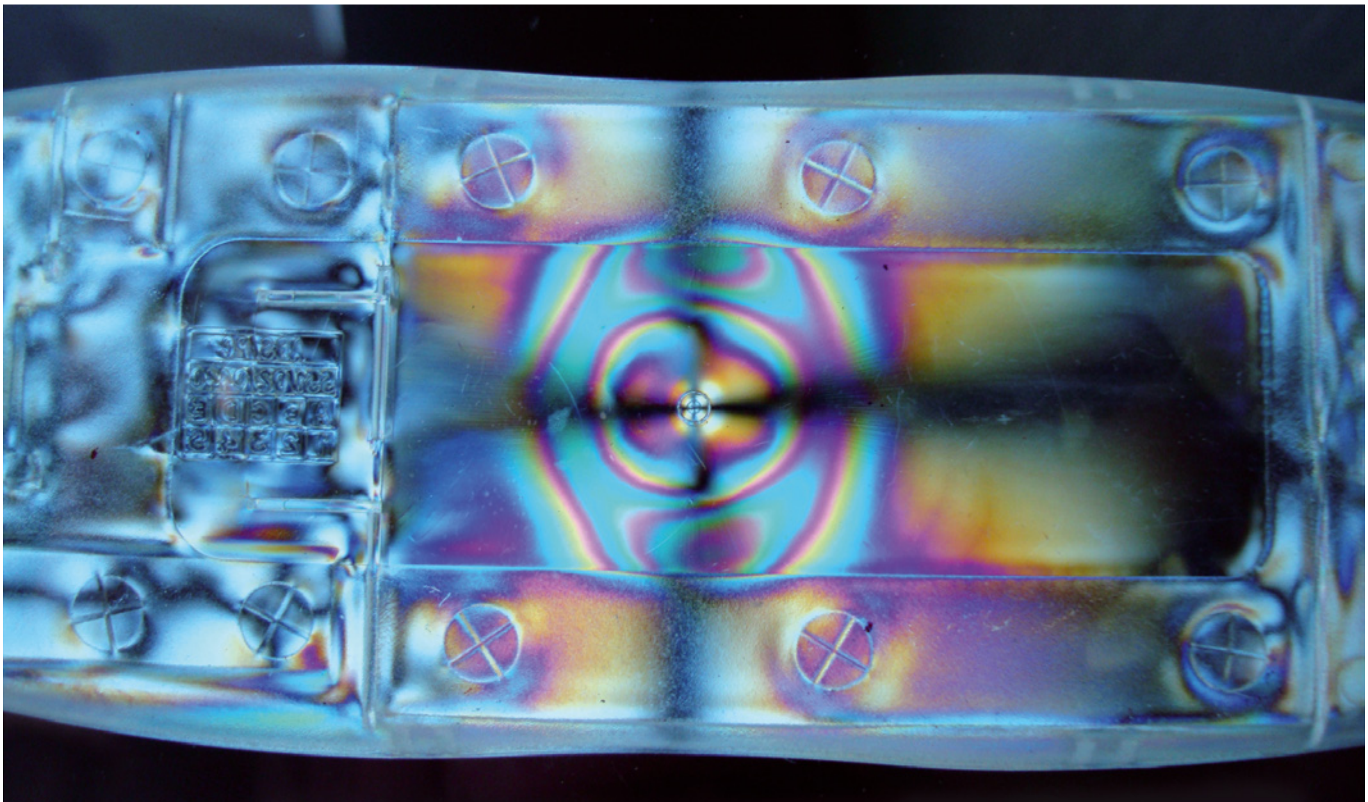


Figure 1, above: Birefringence examination showing the effect at the gate of over-packing through incorrect holding pressure selection

Holding on for improvement

In the 15th in his Moulding Masterclass series of articles, injection moulding expert John Goff discusses the critical importance of appropriate holding pressure selection

The compaction – or holding – phase of the injection moulding cycle is critical in achieving dimensionally, visually and mechanically capable plastics components. The most widely used method employed to initiate application of holding pressure on a modern machine is by stroke or volume (other modes of control include time, pressure and cavity pressure).

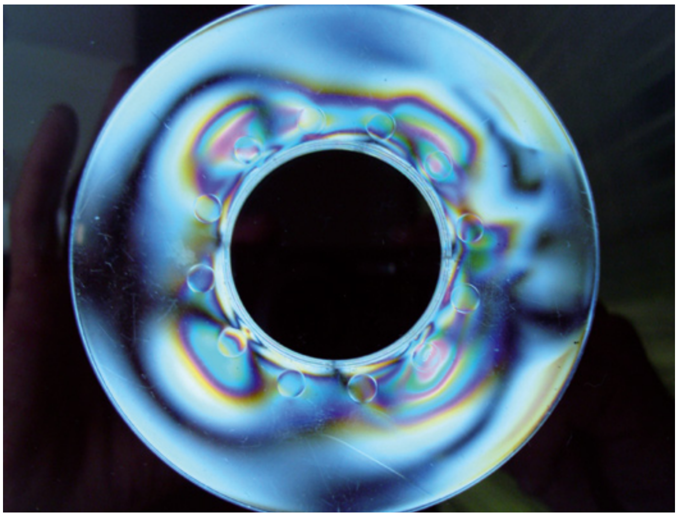
Selection is often related to the manner in which the moulding machine functions, so the machine may be instructed to initiate holding pressure upon reaching a certain specific injection pressure value during the final forward movement of the screw, or an external electrical signal may be taken from a temperature/pressure sensor located within the mould cavity.

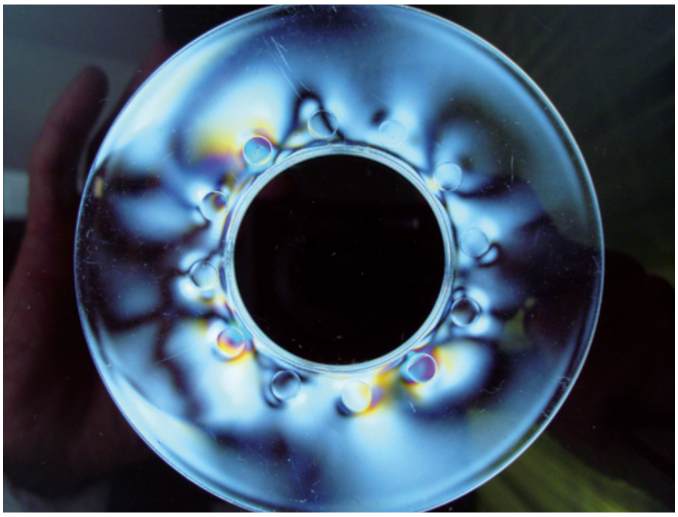
One of the main reasons stroke dependency is preferred is for its ability to be employed over a very large range of components without unnecessary complication and cost. Any melt viscosity variation encountered during a production run, for instance, can be accommodated by an increase or decrease in the actual injection pressure value during the forward movement of the reciprocating screw.

For this reason, the use of speed control is essential. Applied appropriately this caters for small changes in injection pressure while maintaining the required injection time value, allowing consistent component manufacture to continue. Furthermore, the time required for change of mode within the machine control system is minimal and shows excellent repeatability.

Stroke dependency accommodates changes in the melt viscosity well. While it is not always the most accurate mode of control, the fact it is robust and adaptable means continual production can be under-taken with relative ease (time and pressure control modes will be discussed later in this series).

As stated in previous articles, between 95 to 98% of the total moulding weight needs to be delivered into each cavity prior to the application of holding pressure. If not, the selected holding pressure value is required to





Birefringence stress tests showing effect on moulded in stress of using small gates (Figure 2, left) and large gates (Figure 3, right)

perform two functions:

- to push the outstanding material through the gate and molten core to the end of the mould cavity to achieve a complete (95-98% filled) moulding;
- and subsequently to introduce a further additional amount of molten plastic into each cavity to achieve a 100% fill to compensate for the shrinkage taking place as the molten core solidifies.

If holding pressure is asked to realise both the above functions (because it is introduced too early in filling) it must invariably be higher in value. Quite simply, holding pressure should be used only for compaction (packing) purposes.

The manner and speed at which the frozen skin is forced against the adjacent metal surface is dependent upon the design of the component and its wall sectional thickness, the thermoplastics material being processed, and the surface temperature and related finish of the cavity/core. The hotter the mould surface, the more effective the applied holding pressure becomes in forcing the frozen layer into the respective detail machined within the mould cavity/core surfaces.

The two main process parameters that need to be addressed within the compaction phase are the holding pressure and holding pressure time. To achieve optimum selection of both values, isolation of one from the other needs to take place when selecting their values. Typically, it is the holding pressure time value which is adjusted to ensure the thermoplastics material solidifies appropriately in the gate or in its vicinity. This enables any incremental increase in the holding pressure value to be detected both visually and dimensionally on the resultant moulding.

Subsequent increases in the holding pressure value will result in a reduction in the amount of shrinkage, which in turn will produce mouldings of larger and heavier nature. It is important that the required amount of holding pressure is technically addressed as increases beyond a certain value may cause the moulding to:

- fail in service;
- be difficult to eject;
- display a non-uniform surface finish (patches of dullness and gloss);
- show areas of stress whitening;
- give rise to sharp edges, in the form of flash, around the split line;
- display dimensional variation;
- or show poor optical quality.

In previous articles, it was said that the selection of incorrect injection speed can have detrimental effects on the properties of an injection moulded component. For instance, slow injection speed can cause the molecular structure to become compressed, resulting in high levels of internal stress which can lead to possible failure in service.

This principle also applies when selecting holding pressure. During the compaction stage the molten core begins to cool and solidify, and the natural action for the molecular chains is to revert back from their stretched orientated state to their natural coiled configuration. The presence of holding pressure controls this reversion, particularly in the gate or in its vicinity.

When using a large sprue on a cold feed (runner) system or when a sprue gate is employed, the use of too high a holding pressure and/or too long a holding pressure time can cause the structure within the sprue to become highly compressed – over-packed. Upon opening the mould the sprue can separate from the moulding or feed system and remain within the bushing in the fixed half of the tool.

When using a sprue gate, in particular, the effect of over-packing can result in high levels of molecular compression. This can lead to radial cracks appearing in the area of the gate when the moulding is subjected to any load or comes into contact with chemicals or chemical vapours during its service life.

One method of measuring stress is to view the clear mouldings between polarised filters. The level of stress present within the moulding is depicted by the extent and closeness of the coloured birefringence bands. Figure 1 shows a moulded component where over-packing has occurred in the area of the gate (clearly identified by the extent of coloured banding in the gate area).

In general, the greater holding pressure value used, the greater the residual stress created within the component as a result of increased molecular compression. This relationship of stress level with the amount of applied holding pressure has been a topic of interest for many years.

Injection moulding trials using transparent, amorphous type thermoplastics allow us to view and categorise the extent of molecular compression present (the majority of these materials suffer from stress related processing issues). By viewing the transparent mouldings between polarised filters we can estimate the level of stress in each part by examining the coloured birefringence patterns. The level of stress present within the moulding is depicted by the extent and closeness of coloured bands.

In the circular transparent disc moulding in Figure 2, the extent and vividness of the coloured bands indicate the stressed areas (particularly in the vicinity of the four gates), with the black sections at the periphery of the moulding indicating minimal or no stress is present. The main quality issue with this example was the inability to produce the disc to the necessary flatness tolerance. Meanwhile, Figure 3 shows a second acceptable and dimensionally compliant moulding that possesses considerably less stress within it. This was produced using the same mould tool, thermoplastics material, injection moulding machine and ancillary equipment. The disc moulding contains four gates. Each larger gate shows less coloured banding, indicating lower stress levels in this region.

More information

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

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