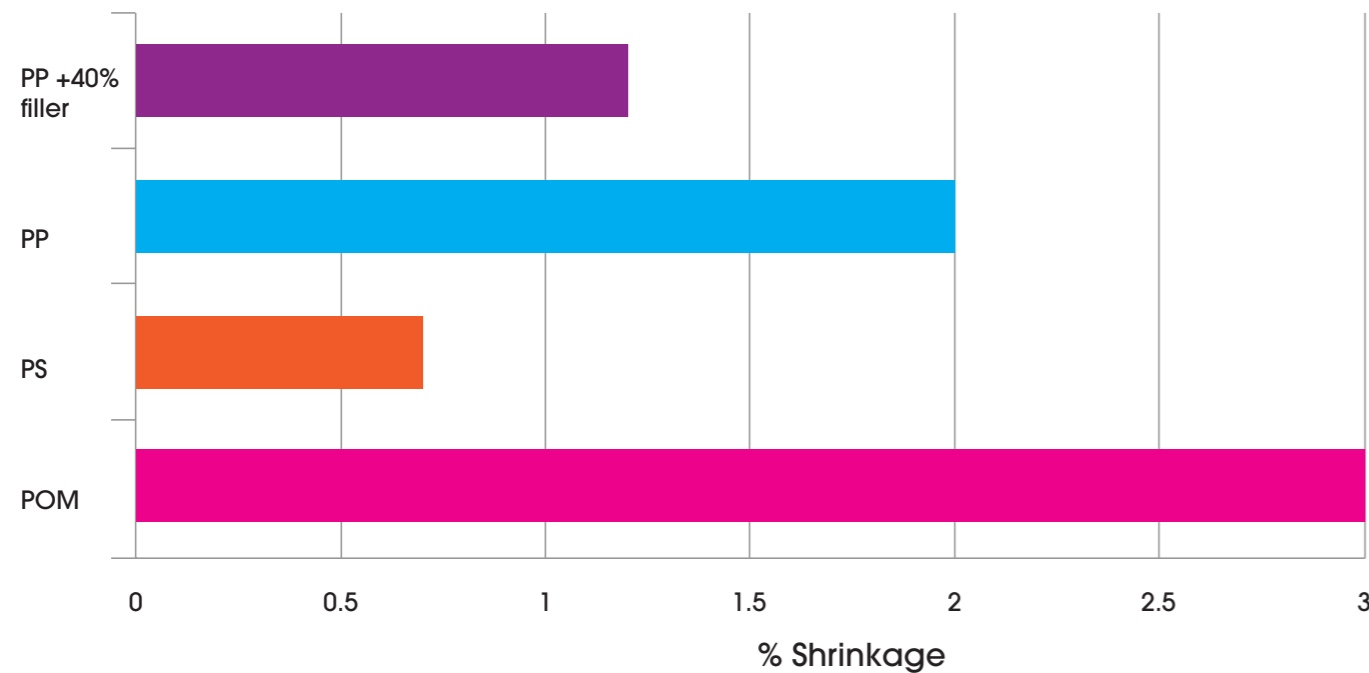


industry

know-how

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The shrinkage of polymers

One of the core values of Plastribution is its expertise - something that all of its suppliers and customers know they can rely on.

Industry know-how is a series of articles from Plastribution that shares this expertise to provide essential background on some of the common terminology and practices used within the plastics industry.

The shrinkage of polymers - a key factor in the quality and performance of components - is considered here, with a more detailed analysis available on the Plastribution website www.plastribution.co.uk.

Thermoplastics are subject to significant expansion and contraction during the extrusion and injection moulding processes.

When allowing for shrinkage, the amount of change can be influenced by the type of polymer selected.

Thermoplastics polymers can be divided into two distinct types:

- amorphous = indeterminate structure, no order or arrangement, e.g. polystyrene, polycarbonate, acrylic;

- semi-crystalline polymers = a structure containing both amorphous and crystalline components that are highly ordered, e.g. polyethylene, polypropylene, acetal.

When crystalline materials are cooled below their melting point, the molecules in the crystalline phase begin to arrange themselves in a more orderly way, meaning that they take up less volume than they would if they were amorphous.

The shrinkage rate of crystalline polymers is therefore greater than those of amorphous ones.

Typical shrinkage rates for an amorphous material are typically in the region of 0.4% to 0.7%, whilst for semi-crystalline polymers they can range from 1.0% to 3.0%

Moulded-in stress

During processing, polymers are forced into mould tools at high pressures and shear rates. As the polymer hits the relatively cooler metal of the mould tool it starts to cool.

If this happens too rapidly, the polymer chains may be excessively "frozen" in a state of tension. Because polymers are also relatively poor conductors of heat, uneven cooling (and therefore shrinkage) may occur, resulting in moulded-in stresses.

Once ejected the polymer chains will want to relax back to their original dimensions. This can result in warped mouldings, poor impact performance, poor service temperature performance and chemical resistance issues.

These issues can be alleviated by increasing the tool temperature, material temperature, gate size, injection speed or using a material with a higher melt flow index - or indeed a combination of all of these parameters.

Mould finishes can also increase moulded-in stress - in particular, care should be taken if grained finishes are to be applied to a tool after initial trialling has taken place.

Post-mould shrinkage

The majority of post-mould shrinkage occurs within the first 48 hours of manufacturing due to thermal contraction and crystallisation.

Any further relaxation of the polymer chains after this point will be dependent on service conditions. In semi-crystalline polymers, any additional post-moulding crystallisation will result in further shrinkage. It can therefore take up to 96 hours for highly-crystalline materials such as acetal to achieve component stabilisation.

To avoid large degrees of post-mould shrinkage, it is advisable to have a mould temperature on the high side. This will have the effect of increasing cycle times but will give the polymer chains more time to relax thus avoiding excessive post-mould shrinkage.

Annealing

As previously mentioned, as the plastic part cools down stresses can be introduced. If the parts are reheated to a suitable temperature, usually just below the HDT, and held for a pre-determined period of time, the polymer chains are given the opportunity to relax which can relieve the majority of the moulded-in stress.

It can be useful in certain cases to jig the part during annealing to retain the required dimensions if required.

Fillers

Fillers undergo only very limited thermal expansion and contraction during thermoplastics processing and therefore reduce the amount of shrinkage.

Consequently adding filler to a material will reduce the amount of shrinkage generally exhibited. 40% talc filled PP will shrink by 1.2% instead of a nominal 2.0%, ignoring any effects of heat transmission due to the presence of the filler.

Fibre fillers, such as glass fibre, have what is described as an aspect ratio (the variation in each dimension), whereby the higher the aspect ratio, the greater is the tendency of the fibres to align.

As a result of flow, the fibres can become aligned within the component, resulting in anisotropic shrinkage (lower in the direction of flow than across the direction of flow).

Careful attention to the above when designing tools or parts will greatly reduce the problems encountered due to shrinkage, irrespective of its cause.

If you would like to discuss any of the above points further then please do not hesitate to contact the Plastribution team on 0845 3454560 or sales@plastribution.co.uk. Or you can read the full article on our website at www.plastribution.co.uk

Plastribution is the UK's leading distributor of plastics raw materials, delivering reliability, know-how and true business partnership to the world's best polymer suppliers and our UK customers.

In the event that you require further information about the shrinkage of polymers, please do not hesitate to contact a member of the Plastribution team for further information by emailing sales@plastribution.co.uk or phone 0845 3454560

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