ENGINEERING POLYMERS: THE 'TOP TEN' INJECTION MOULDING PROBLEMS

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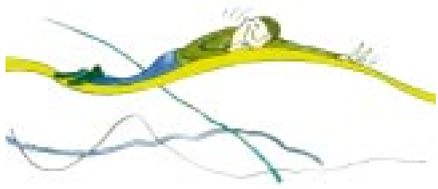


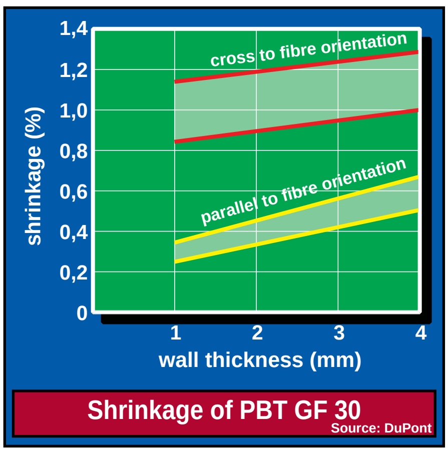
Part 9: Warpage

1. Moisture in the granules
2. Feed system too small
3. Wrong gate position
4. Hold time too short
5. Wrong melt temperature
6. Wrong tool temperature
7. Poor surface finish
8. Problems with hot runners
9. Warpage
10. Mould deposit

Partially crystalline substances such as POM (acetal), PA (nylon), PBT and PET (polyesters) tend to warp far more than amorphous ones. This point should be taken into consideration already when designing moulds and mouldings. If this is not done, it is almost impossible to rectify at a later stage. This article discusses the causes of warpage and steps that can be taken to prevent and reduce it.

What are the main causes of warpage?

Shrinkage is relatively high in partially crystalline materials and is influenced by a number of factors. In the case of unreinforced materials, warpage is greatly influenced by wall thickness and mould surface temperature. It follows that major differences in wall thickness and unsuitable mould temperatures will cause the moulding to warp. Totally different shrinkage characteristics will be evident in the case of glass fibre reinforced materials, due to orientation of the glass fibres. The effect of wall thickness differences on shrinkage is relatively slight. Here, the main cause of warping is the difference between fibre orientation longitudinally and at right angles to the direction of flow. Warpage is essentially due to wall thickness distribution, gate location, flow restrictions and by-passes, as well as the inherent rigidity of the moulded part.
These different causes of warping, depending on whether the material is fibre-reinforced or not, frequently result in contrary warping phenomena in the same part.



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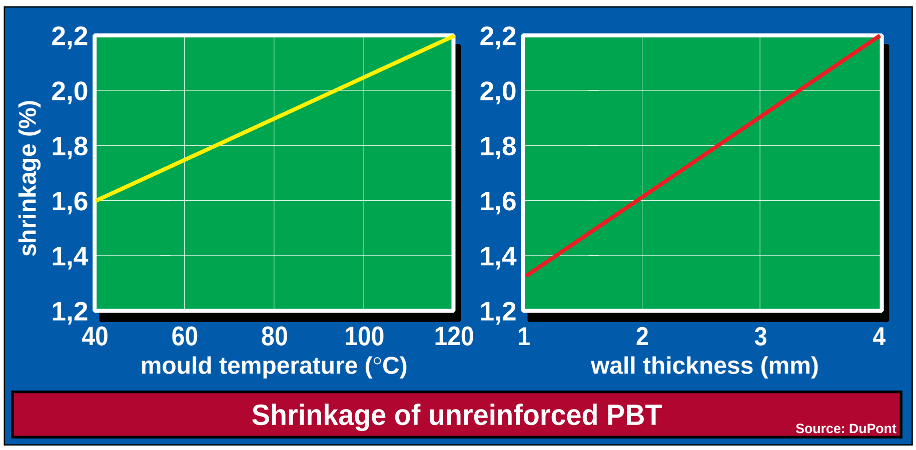

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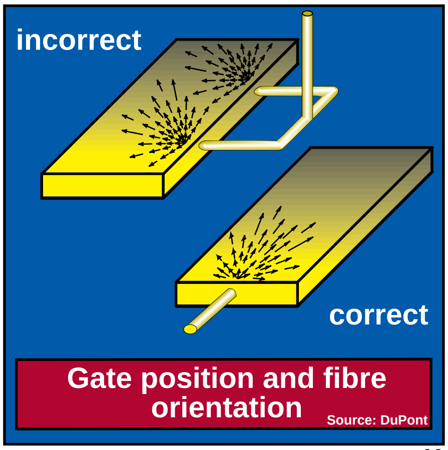

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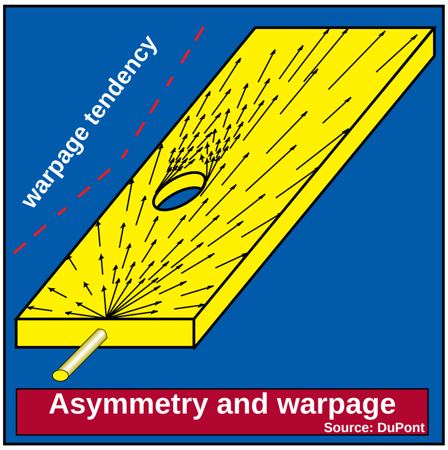

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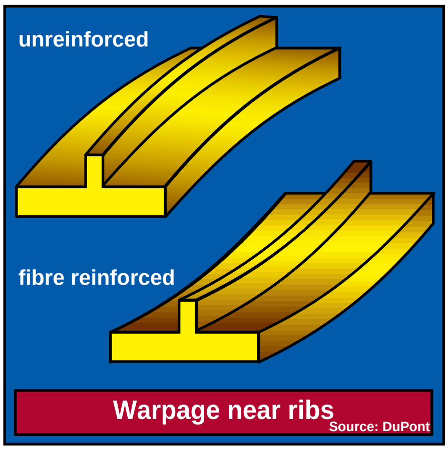

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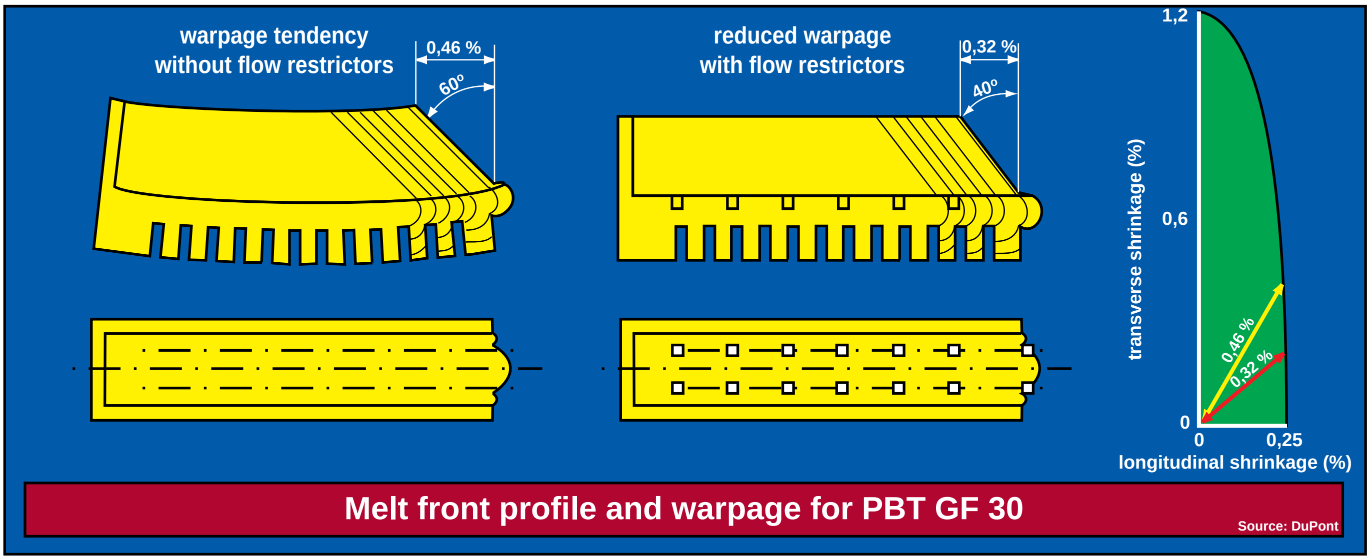
How can warpage be prevented?

Unreinforced materials require uniform wall thicknesses. Melt accumulations should be avoided as far as possible. Multi-point gating can be used to achieve a high pressure gradient and thus reduce shrinkage differences to a minimum. The mould heating system should be designed so that heat is dissipated as evenly as possible (see No. 6 of this series of articles).
With glass fibre reinforced materials, the symmetry of the moulded part is as important as uniform wall thickness. Asymmetrical parts hinder melt flow and thus orientation, and eventually cause warpage. In the case of asymmetrical parts it is therefore necessary to achieve a balance by incorporating blind cores at the mould planning and design stage. The position of the gate is also important – every by-pass and every weld line is a potential cause of warping.

What possibilities are open to the moulder?

Assuming that the moulded part, the gate and the mould have all been correctly designed, the moulder can control warpage up to a point via the holding pressure and mould temperature. The use of several heating circuits to optimise heat dissipation is normal practice.
In the case of reinforced materials, changing the injection rate or lowering the mould temperature is a slight help. If the possibility of subsequent warpage has not been foreseen at the mould and moulded part design stage, this cannot be subsequently rectified by modifying moulding conditions.



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What can be done when warping has occurred?

The most important step, especially in the case of glass-fibre-reinforced materials, is to carry out a mould filling study, i.e. by partly filling the mould in several stages. By studying the melt front profile, fibre orientation can be reconstructed. By referring to the shrinkage curve for the reinforced material, measures can be taken to reduce warpage, e.g. by incorporating flow aids or flow restrictors. These alter the melt front profile, thereby influencing warpage.

This method requires a great deal of practical experience and, at the same time, increases the amount of knowledge to enable precautionary measures to be taken in future. It also has its limitations, due to the properties of the raw material and physical conditions. For crystalline polymers, it is not possible to obtain the same flatness as for amorphous polymers. In this connection, mention should be made of low-warpage, semi-crystalline polymer blends. These represent a compromise between properties and warpage, due to chemical modification or the combination of different reinforcing components. The last, and also the most expensive method consists of modifying the mould. If there already is experience with similar mouldings, correctable inserts are the best solution for critical parts.