By Jürgen Hasenauer, Dieter Küper, Jost E. Laumeyer and Ian Welsh

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5. Gate positioning

Correct gate location

Gate positioning – Besides causing processing problems, the wrong choice of the type of gating system and gate location can have a considerable effect on the quality of a moulded part. Design departments should, therefore, not underestimate the importance of gate location.

Apart from carrying out design calculations for plastics parts, designers must pay particular attention to mould gating. They have to choose the correct gating system and the number and location of gating points. The different types of gate and gating locations can have a considerable effect on part quality.

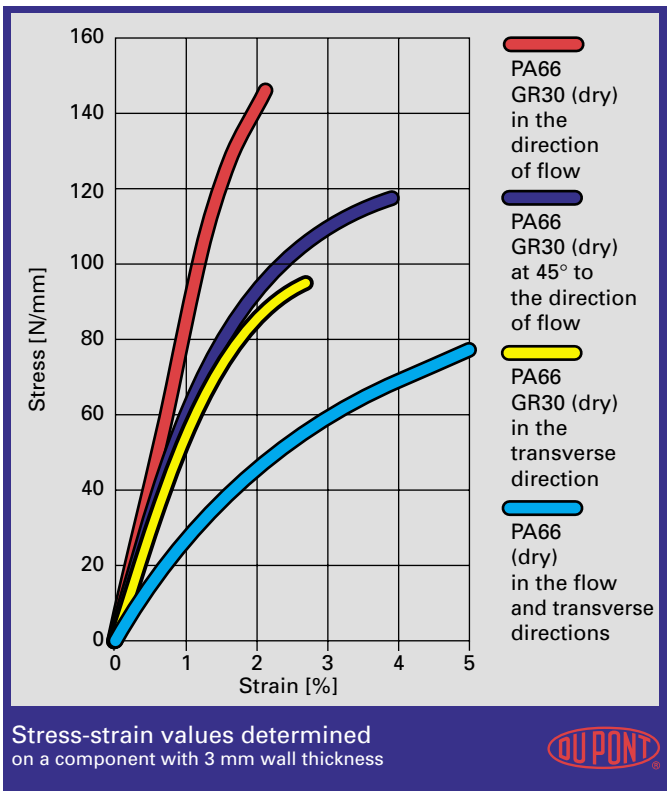

Fig. 1

Fixing the gate location also determines the following characteristics of a plastics part:
– filling behaviour
– final part dimensions (tolerances)
– shrinkage behaviour, warpage
– mechanical property level
– surface quality (aesthetic appearance).

Moulders have little scope to rectify the undesirable consequences of incorrect gating by optimizing processing parameters.

Orientation determines part properties

In the injection moulding process, the long polymer molecules and fibrous filling and reinforcing materials are oriented mainly in the direction of flow of the polymer melt. This results in directional dependency (anisotropy) of the part's properties. For example, strength properties in the flow direction are considerably higher than in the transverse direction (Fig. 1). Here the influence of the reinforcing fibres is significantly greater than the effect on strength of molecular orientation alone. Fibre orientation also causes differential shrinkage in the longitudinal and transverse directions, which can lead to warpage.

Quality reduction as a result of weld lines and trapped air

Weld lines occur when two or more melt streams unite in the mould. This happens, for example, when the melt has to flow around a mould insert or when parts are gated at several points (Fig. 2a+b). In addition, different wall thicknesses in a part can also lead to separation of melt fronts and so cause weld lines. Air entrapment (air bubbles) occurs when air that should be expelled from the mould is enclosed by melt streams and cannot escape. Weld lines and air entrapment are often manifested as surface defects. Apart from the fact that they are ugly, as a rule they also considerably reduce the mechanical properties in the affected areas, particularly impact strength (Fig. 3-4).

Fig. 2a

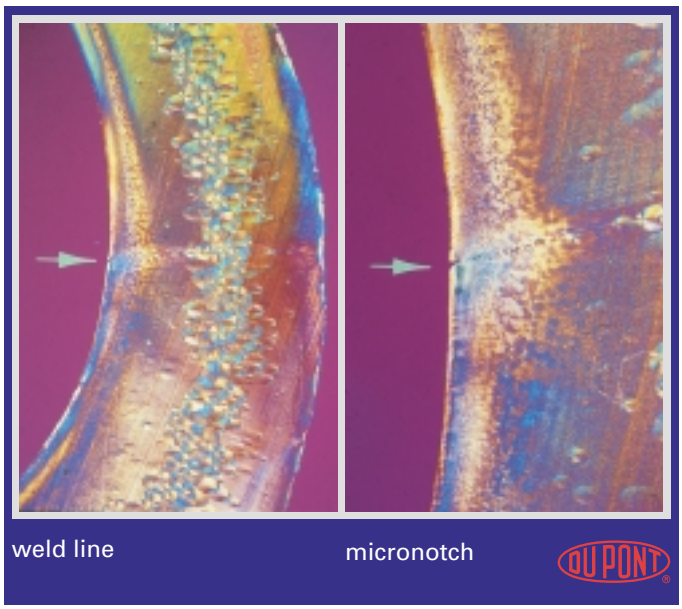

Fig. 2b

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Unsuitable gate positioning has adverse consequences

As gates always leave obvious marks, they should not be placed in areas which should have a high surface quality. In any gating region, high material stress (shear) takes place that considerably reduces the property levels of the plastics resin (Fig. 5). Unreinforced plastics have higher weld line quality than reinforced plastics. The quality-reduction factors in the weld line area are highly dependent on the type and content of filling and reinforcing material. Similarly, additives such as processing aids or flame retardants can have a detrimental effect. It is therefore difficult to estimate how much these factors will affect the part's final strength. In addition, weld line areas with high load-bearing capacity under tensile stress do not show equally good impact strength or fatigue endurance. With fibre-reinforced materials, fibres in the weld line area are aligned transversely to the direction of flow. This significantly lowers the mechanical properties of the part at this point (Fig. 6).

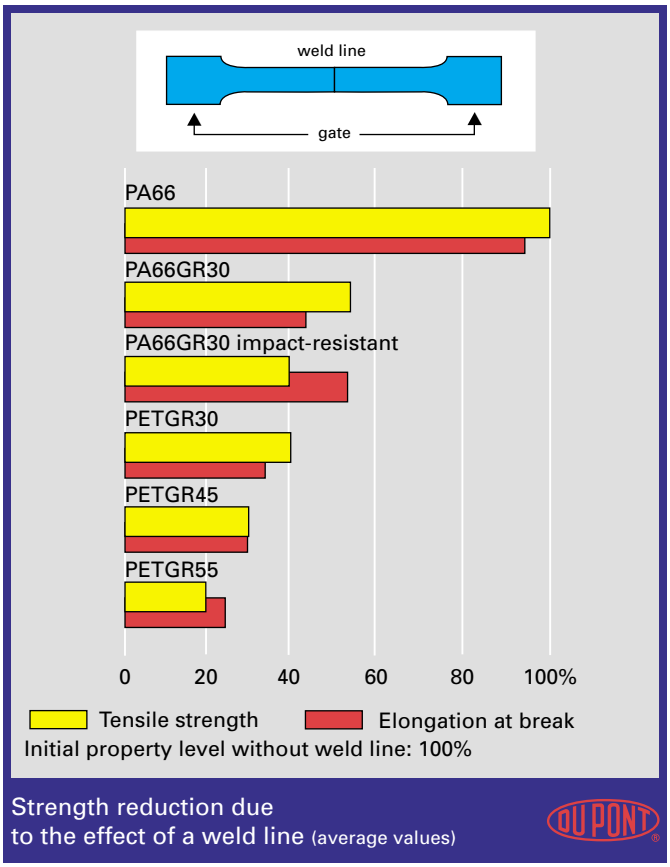

Fig. 3

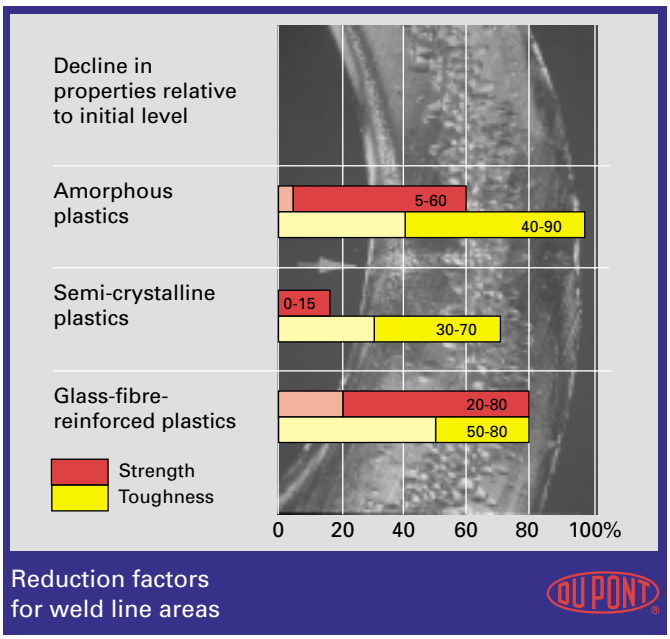

Fig. 4

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Correct gate positioning

Complex mouldings usually cannot be produced without weld lines. If the number of weld lines cannot be reduced, they should be placed in non-critical parts of the moulding in terms of surface quality and mechanical strength. This can be done by moving the gate location or by increasing/ reducing part wall thickness.

Basic design principles:

– do not gate parts in highly stressed zones
– avoid or minimise weld lines
– avoid leaving weld lines in highly stressed areas
– with reinforced plastics, gate location determines part warpage
– avoid air entrapment by providing adequate vents.

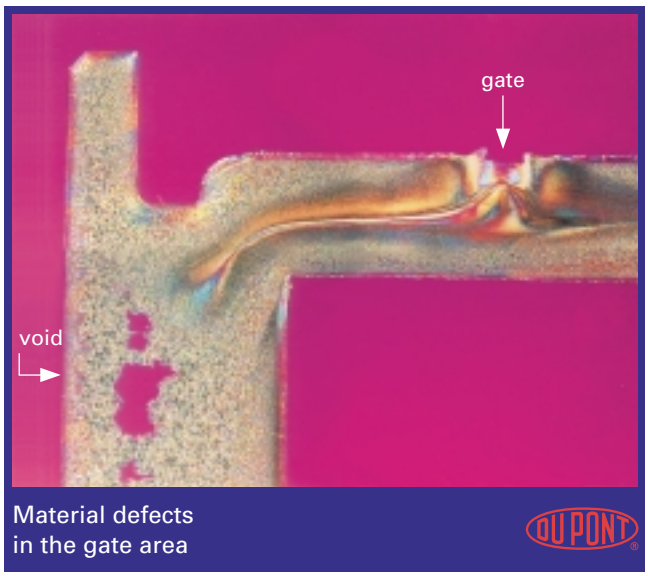

Fig. 5

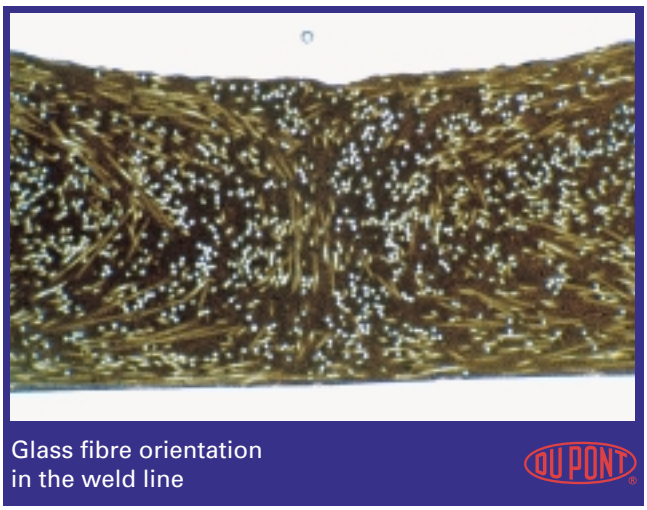

Fig. 6

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