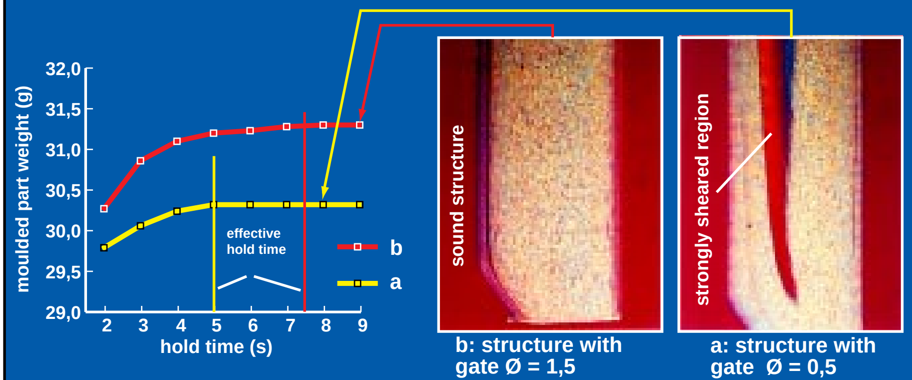
ENGINEERING POLYMERS: THE 'TOP TEN' MOULDING PROBLEMS

By R. Wilkinson, E. A. Poppe, Karl Leidig, Karl Schirmer

Chapter 2. Feed system too small

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

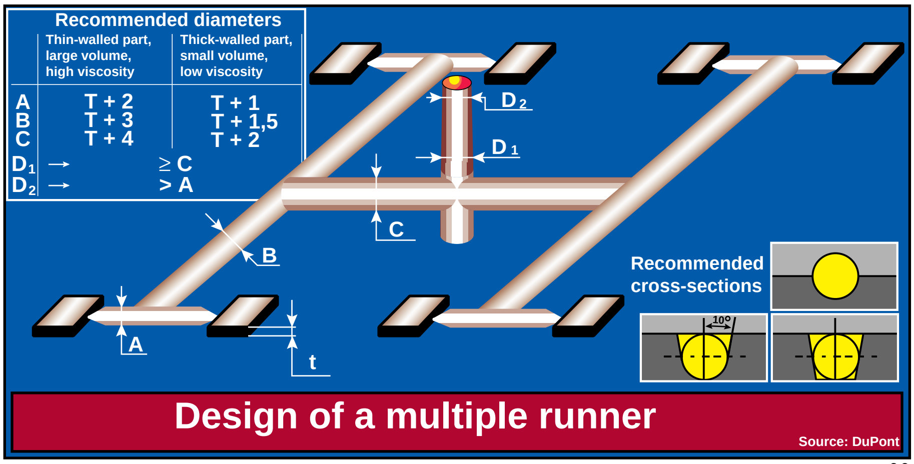
	Gate diameter (three-plate mould)	Maximum attainable weight (at 80 MPa holding pressure)	Maximum effective hold time	Required injection pressure (up to 1,4 s mould filling time)	Shrinkage
a:	ø 0,5 mm	30,32 g	5,0 s	170 MPa	1,7 %
b:	ø 1,5 mm	31,30 g	7,5 s	70 MPa	1,3 %



Effect of gate diameter on the quality of a moulded part (1,5 mm) of PA 66

Source: DuPont

2.1



Design of a multiple runner

2.2

Parts made of engineering polymers nowadays are designed with the help of complex methods such as computer-aided design, finite element analysis and mould-flow calculations. Though they are unquestionably useful, they sometimes fail to take enough account of the importance of the correct design of the feed system. This article considers the basic elements of correct feed system design for semi-crystalline polymers. But these elements need to be applied in combination with a correctly positioned gate and the right hold time. These subjects will be dealt with in the following chapters of this series.

A Distinguishing Feature of Semi-Crystalline Resins

Semi-crystalline thermoplastics undergo volume shrinkage during the transition from the molten to the solid (crystalline) state. This shrinkage, which may be as much as 14 per cent, depending on the type of resin, has to be compensated during hold time by the supply of additional melt into the mould cavity. That can only be done if the gate cross-section is adequate to ensure the presence of a fluid centre during the holding phase.

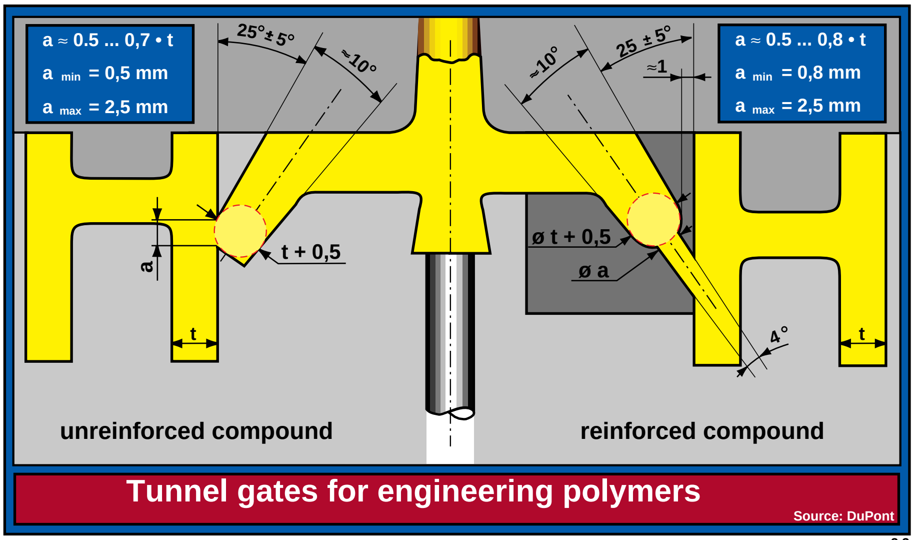
Recognising the Results

If the gating system is too narrow (see example), the holding pressure cannot remain effective beyond the desired holding pressure time. In that case, volume shrinkage cannot be adequately compensated, resulting in the formation of voids and sink marks, (especially in the case of unreinforced compounds), as well as pinholes (if the compounds are reinforced). These symptoms can be observed under the microscope. The dimensional stability of the resultant mouldings will also vary considerably, and there will be excessive shrinkage and an increased tendency to warp.

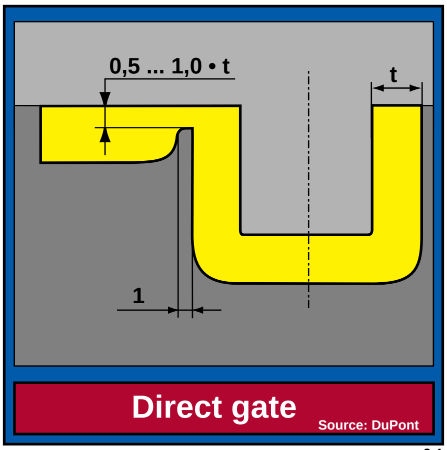
Voids and pinholes adversely affect mechanical properties since they act as notches and drastically reduce elongation at break and impact strength. In the case of fibre-reinforced compounds, the fibres will be damaged and become shorter if the gate is too narrow; this, in turn, will further weaken the moulding.

High injection pressures and long mould filling times can be a further indication that the gates are too narrow. This can be recognised, for example, by the fact that different injection rate settings have little effect on the actual mould filling time.

If the gate is too narrow, this can also cause surface defects. Excessive shear can result in additives such as impact modifiers, pigments, flame retardants and fibres separating. Gates that are too small will also tend to cause jetting, resulting in streaks, dull spots and a 'marbled' effect, and the formation of a kind of halo near the gate. There is also an increasing tendency for mould deposits to form.



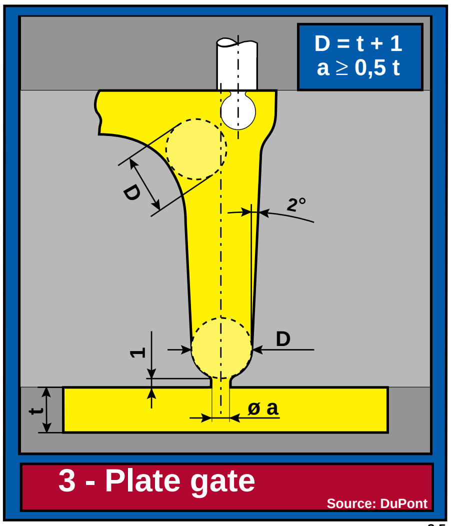
Tunnel gates for engineering polymers
Source: DuPont
2.3



Direct gate
Source: DuPont
2.4

Design of the feed system

In designing the feed system, the first point to be considered is the wall thickness (t) of the moulded part (see diagram). Nowhere should the diameter of the runner be less than the wall thickness of the injection moulding. Starting out from the gate, the runner diameter at each branch point can be widened so that an almost constant shear rate is maintained.
To prevent the inevitable cold slug reaching the moulding from the injection nozzle, the gate should always be extended so that the cold slug can be intercepted. This extension should have roughly the same diameter as the gate to ensure that the cold slug really is retained.
When moulding partially crystalline, unreinforced polymers, the minimum gate thickness should be 50 per cent of the wall thickness of the moulded part. This would also be adequate for reinforced compounds. To minimise the risk of damage to the fibres and also bearing in mind the higher viscosity of these compounds, the gate thickness should be up to 75 per cent of the wall thickness of the moulded part.
Gate length is especially crucial. This should be ≤1 mm to prevent premature solidification of the sprue. The mould will heat up near the gate, so that the holding pressure is at its most effective.
To summarise the basic rules:
• always provide a means of intercepting the cold slug;
• make the runner diameter bigger than the moulded part wall thickness
• gate thickness should be at least 50% of the moulded part wall thickness.
These principles take only the crystallising behaviour of engineering polymers into account. If one wants to estimate mould filling behaviour, data about flow lengths of the polymer can be used and, if needed, flow calculations must be carried out. There are probably certain applications where, for various reasons, gate design does not follow these recommendations. Here, one will generally have to compromise between quality and cost-effectiveness.



3 - Plate gate
Source: DuPont

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