

ENGINEERING POLYMERS: THE 'TOP TEN' MOULDING PROBLEMS

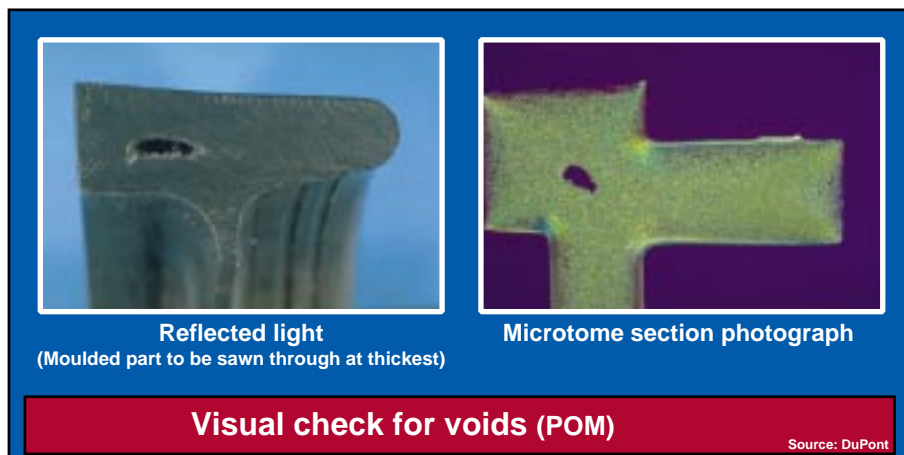
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Chapter 4: Hold Time Too Short

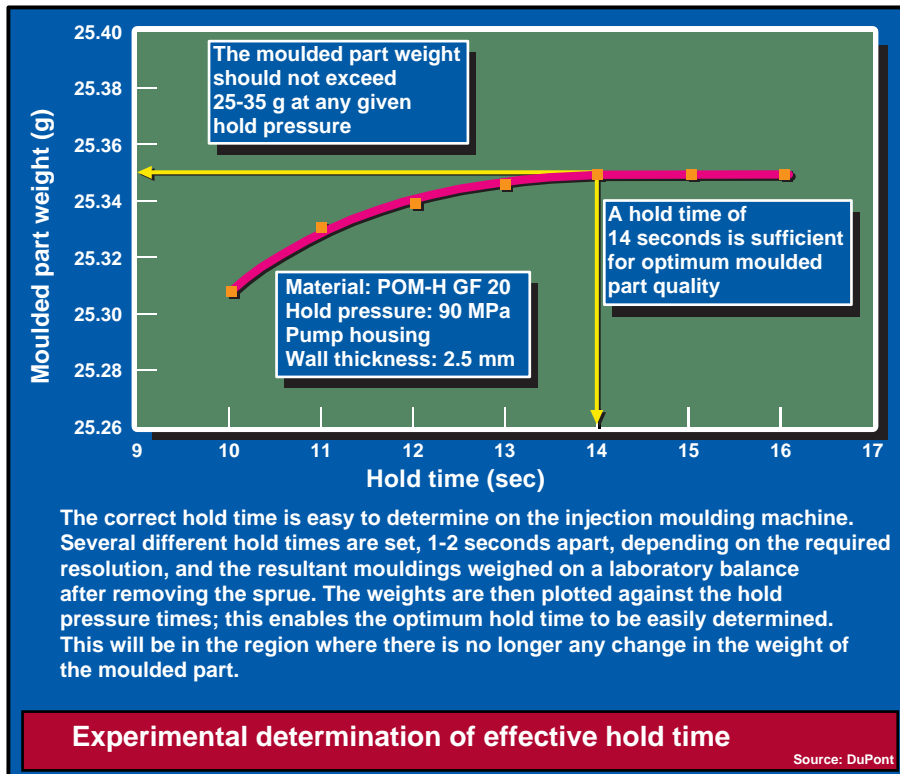
1. Moisture in the granules
2. Feed system too small
3. Wrong gate position
4. Hold time too short
5. Wrong melt temperature
6. Wrong tool temperature
7. Poor surface finish
8. Problems with hot runners
9. Warpage
10. Mould deposit

In practice many injection moulders, working from their experience of amorphous polymers, tend to use shorter hold pressure times and longer cooling times. Unfortunately, this approach also tends to be used for semi-crystalline polymers such as POM (acetal), PA (nylon), PBT and PET (polyesters). This article discusses the most important points to help machine setters choose the most suitable hold pressure time.



What exactly happens during the hold pressure phase?

Once the mould cavity has been filled, the polymer molecules start to crystallise, i.e. the molecule chains become aligned with respect to each other, resulting in higher packing density. This process starts in the outer zone and ends in the centre of the wall (see diagrams). The volume shrinkage caused by this can be as much as 14 %, as in the case of POM, and has to be made up again by further amounts of melt which are injected into the mould cavity during the hold pressure phase. If the hold pressure time is too short, it causes small voids to be formed (microporosity), which can have an adverse affect on moulded part properties in many ways.



Material	Crystallisation time per mm wall thickness
POM - H	7,5 - 8,5 $\frac{s}{mm}$
PA 66	3,5 - 4,5 $\frac{s}{mm}$
PA 66 (impact modified)	3,0 - 4,0 $\frac{s}{mm}$
PA 66 GF 30	2,5 - 3,5 $\frac{s}{mm}$
PET GF 30	3,0 - 4,0 $\frac{s}{mm}$
PBT	3,5 - 4,5 $\frac{s}{mm}$
PBT GF 30	2,5 - 3,5 $\frac{s}{mm}$

Crystallisation rate for a wall thickness of 3 mm Source: DuPont

4.3

How to find out whether the hold time is too short

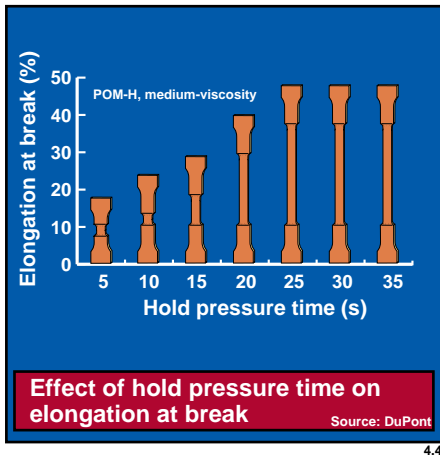
Parts made in this way often show excessive shrinkage, warpage, sink marks, voids and, in some cases, enormous loss of mechanical properties. In addition, there may be considerable dimensional variations. In some cases a misguided attempt is made to compensate for these shortcomings by increasing the cooling time. This results in unnecessarily long cycle times.

One way of recognising the effects of inadequate hold pressure times, for unreinforced moulding compounds, consists of cutting through the moulded part at a point where there is maximum wall thickness. The polished cut surface can then be checked for voids and pinholes. A magnifying glass or reflected-light microscope are sufficient to form a first opinion. A more elaborate method consists of preparing microtome sections (see diagram). In these, even the finest defects can be made visible with a transmitted-light microscope.

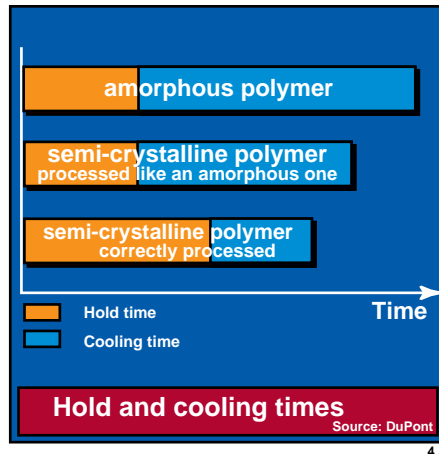
With reinforced moulding compounds, defects can be easily detected on a fracture surface where there is maximum wall thickness. If the hold time is too short, there will be a foam-like structure in the fracture region and an enlarged fracture photomicrograph will show exposed fibres which are not embedded in polymer. Another method consists of preparing a photomicrograph of a polished section, in which pinholes can be detected with a microscope.

The effective hold time can be determined on the injection moulding machine by weighing a number of mouldings (see description). This is the best way of determining the hold pressure time for a given moulding under practical conditions.

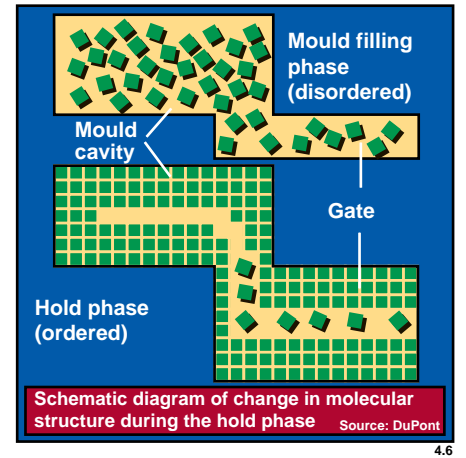
A guideline for the optimum hold time can also be obtained by using actual figures as comparison (see table). These apply only for a given wall thickness and cannot be applied to other factors such as temperature, nucleating additives and pigments, mould filling time, etc. For thinner walls, the figures will be lower, for thicker ones higher.



4.4



4.5



4.6

Correct setting procedure

To obtain optimum moulded part properties, the hold time should be determined by the weighing method, and the cooling time should be reduced to the required minimum (which is usually just above the plasticising time). This presupposes that the gate has been correctly positioned and designed (cf. parts 2 and 3 of this series, *Plastverarbeiter* 46 [1995] 6 and 7). It is also important to keep the pressure constant during the hold time. The correct pressure varies between 60 and 100 MPa, depending on the material used.