ENGINEERING POLYMERS: THE 'TOP TEN' MOULDING PROBLEMS

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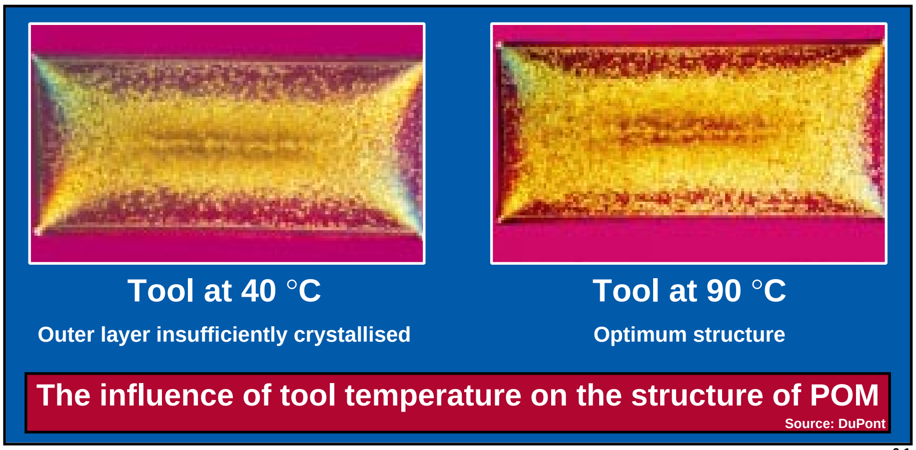
Chapter 6: Wrong Tool Temperature

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

When moulding semi-crystalline engineering plastics such as POM (acetal), PA (nylon), PBT and PET (polyesters), it is important to make sure that the surface temperature of the tool is correct. The basic requirements for optimum processing are in the design of the tool. Only if the tool design is right can the moulder produce good quality parts with the help of temperature control equipment. This calls for close co-operation in the tool design and planning phase, in order to avoid production problems at a later stage.



The influence of tool temperature on the structure of POM

6.1

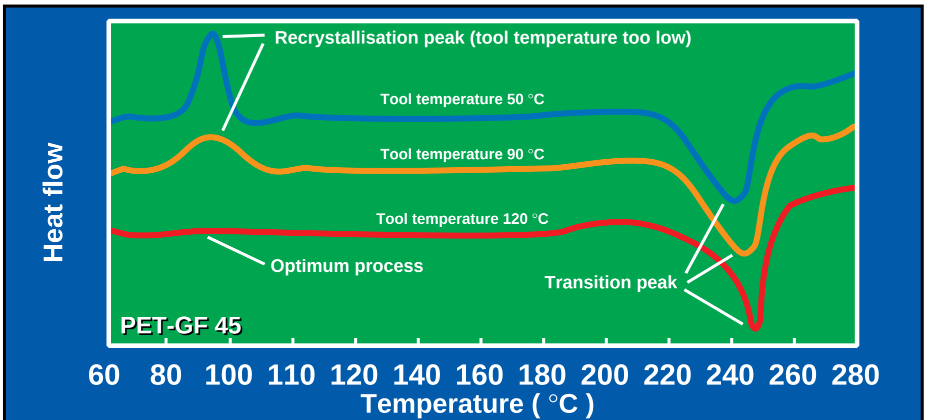
Possible Negative Consequences of the Wrong Tool Temperature

The symptom that is easiest to recognise is poor surface finish of moulded parts. The cause is often too low surface temperature in the tool.
The mould shrinkage and post-moulding shrinkage of semi-crystalline polymers are strongly dependent on tool temperature and the wall thickness of the part. Uneven heat dissipation in the tool can thus lead to differential shrinkage. This in turn can lead to inability to maintain part tolerances. In the most unfavourable circumstances shrinkage can be beyond correction, whether working with unreinforced or reinforced resins.
When dimensions of parts in high-temperature applications become smaller with use, this is generally due to mould surface temperatures that are too low. This is because with too low mould surface temperatures mould shrinkage may be lower, but post-moulding shrinkage is substantially higher.
If a long start-up phase is needed before the dimensions settle down, it is a sign of poor temperature control in the tool, since the tool temperature is probably rising for a long time until equilibrium is reached.
Poor heat dissipation in some regions of the tool can cause substantial lengthening of the cycle time, leading to increased cost of the moulding.
Incorrect tool temperatures can sometimes also be established from the moulded parts by means of analytical methods such as structural analysis (e.g in the case of POM) and differential scanning calorimetry (DSC) examination (e.g. with PET).

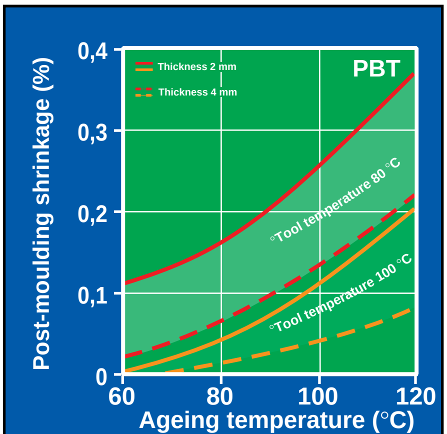
Recommendations for Setting the Correct Tool Temperature

Tools are becoming more and more complex, and as a result it is getting ever more difficult to create the proper conditions for effective mould temperature control. Except in the case of simple parts, mould temperature control systems are always a matter for compromise. For this reason, the following list of recommendations should be seen as rough guidelines only.

- Temperature control of the shape to be moulded must be taken into consideration at the tool design stage.
- When designing moulds that have a low shot weight and large mould dimensions, it is important to allow for good thermal transfer in the construction.
- Be generous when in dimensioning flow cross-section in the tool and in the feed pipes. Do not use fittings that cause a major restriction to the flow of the mould temperature control fluid.
- Use pressurised water as the temperature control medium, if possible. Provide flexible pipes and manifolds that are capable of withstanding high pressures and temperatures (up to 8 bar and 130° C).



The influence of tool temperature on DSC curves
Source: DuPont
6.2

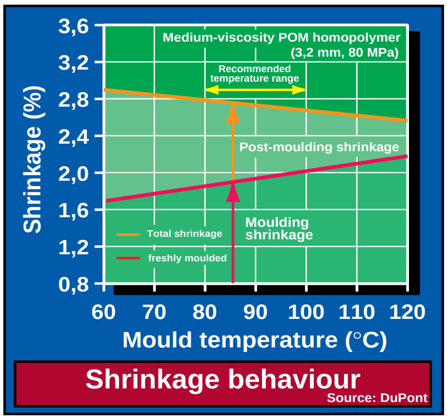


Post-moulding shrinkage
Source: DuPont
6.3

- Specify the performance of the temperature control equipment to match the tool. The tool-maker’s data sheets should supply the necessary figures for flow rates.
- Use thermal insulation plates between both halves of the tool and the machine platens.
- Use separate temperature control systems for the moving half and the fixed half of the mould.
- Use separate temperature control systems for any side actions and the core, so that you can work with different start-up temperatures to get the mould running.
- Always connect different temperature control circuits in series, never in parallel. If circuits are in parallel, small differences in the flow resistance cause different volumetric flow rates of the temperature control medium, so that bigger temperature variations can occur than with circuits connected in series. (This series connection will work properly only if there is less than 5° C difference between mould inlet and mould outlet temperatures.)
- It is an advantage to have a display showing the supply temperature and return temperature on the mould temperature control equipment.
- For purposes of process control it is recommended to have a temperature sensor built into the tool, so as to be able to check its temperature during actual production.

Thermal equilibrium is established in the tool after a number of shots on cycle, normally a minimum of 10 shots. The actual temperature at equilibrium will depend on many factors. This actual temperature of the surfaces of the tool in contact with the plastic can be measured either by thermocouples within the tool (reading 2 mm from the surface) or more commonly by a hand-held pyrometer. The surface probe of the pyrometer needs to be fast-acting, and the tool temperature needs to be measured in a number of places, not just once on each side. Corrections may then be made to the set temperatures of the control units to adjust the mould temperature to what it should be. The data sheets for the various raw materials always give the recommended tool temperature. These recommendations always represent the best possible compromise between a good surface finish, mechanical properties, shrinkage behaviour and cycle times.

Moulders of precision parts and of parts that have to meet exacting optical or safety-oriented specifications generally tend to use higher tool temperatures (giving lower post-moulding shrinkage, shinier surface, more uniform properties). Technically less critical parts which have to be produced at the lowest possible cost can probably be moulded at somewhat lower tool temperatures. However, moulders should be aware of the drawbacks of this option and they should test the parts thoroughly, so as to be sure that they still meet the customer’s specifications.



Shrinkage behaviour

Source: DuPont

6.4

Material	Recommended tool temperature
POM - H	90 °C
PA 66	70 °C
PA 66 GF 30	110 °C
PA 6	70 °C
PA 6 GF 30	85 °C
PBT	80 °C
PBT GF 30	80 °C
PET GF 30	110 °C

Tool temperatures

Source: DuPont

6.5