Tool-optimization by powerful cooling systems

MÜHLBEYER cares for the heat budget by designing tools

To achieve short cycle times in injection molding processing without loosing molding quality, the tempering of the tools has to be thought through and at least protected by simulation. The example of a connector for electric vehicles shows clearly that the effort involved in an early phase of component development is worthwhile.

For the production of precise injection-molded parts an exact tool which is adapted to the component, a good material preparation and an optimal adjustment of the process parameters at the injection molding machine is necessary. Apart from the process parameters in the filling and cooling phase, the temperature of shaping tool surfaces mainly affects the component properties. Depending on the type of plastic, the temperature can strongly influence properties such as degree of crystallization, warpage, shrinkage and surface texture.

Measures against hotspots

In order to keep cycle time in check a weighed tempering of the tool is required. Greatest demands on the cooling system are, for example, narrow webs, double-walled regions, eyes, domes, cylindrical moldings with small diameters and high-grade breakthroughs. To counter such a component characteristic only with a standard cooling usually leads to so-called hotspots, since at these locations in the cavity a large volume of hot plastic melt opposes a low cooling capacityner.

The most commom way to react to these problem areas is to provide a separate intensive cooling system. Depending on the geometry of the injection molding, various materials and techniques for direct or indirect cooling are available to the tool builderg:

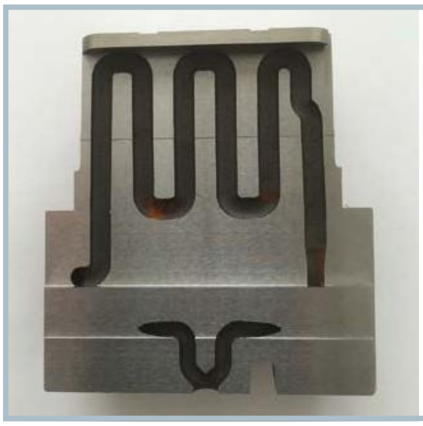
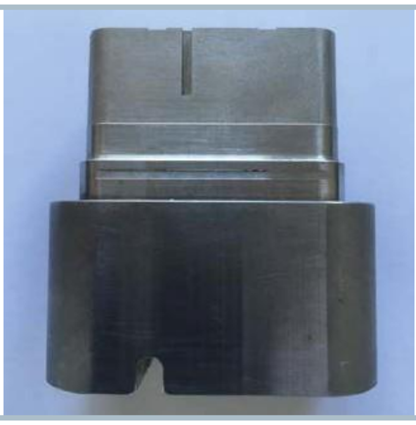
Cooling with a tempering medium – for example:

- spiral core
- bubbler
- baffle plates
- intelligently arranged cooling channels, whether produced by conventional means of drilling or by alternative methods of production

Heat dissipation with good heat conducting materials – for example:

- Heat pipes
- copper pins in high cores
- copper inserts in form inserts
- copper alloy or a special heat-conductive steel for shaping components
- holding plates rinsed with water

Special ways, especially to create complex three-dimensional cooling channels, are the vacuum soldering and


Picture 1. Injection molded connector strip (right). The laser sintering technique was used to produce the tool core with contoured cooling channels © MüHLBEYER

Thermal tool design

The specialists for thermal tool design take into account the following parameters:

- cooling and cycle time
- position and size of the temperature control channels
- favoring a turbulent flow in the design of the temperature control channels
- temperature profile in mold and tool
- throughput and temperature of the temperature control medium
- homogeneity or error of temperature on the mold wall
- heat flows
- pumping, cooling or heating power of the temperature control unit with regard to losses of pressure in the temperature control channels
- simulation and variation of individual parameters such as material, temperature, processing variables etc.

the additive production in the laser sintering process (**picture 1**). Mold inserts are either assembled from several plates or built up in layers from metal powder. The selection of the appropriate temperature control medium (water, CO_2) and the possible consideration of special processes such as pulse cooling or dynamic temperature control are also part of the design of the cooling system.

Important values of experience

To design high-performance cooling systems requires a high level of expertise and a wealth of experience. Preliminary, intermediate and post-treatments of the different materials must be down to reach, for example, the strength of the material and to achieve high tool life. If you use combinations of different materials, it is very important that they join together. Experienced tool builders also know that the outer layer of copper alloys has to have a hardness of 52 HRC and that a tool component made of a particularly heat-conducting steel must generally be equipped with corrosion protection.
With "CMold"(C means Cool) Mühlbeyer Werkzeug und Formenbau GmbH, Bad Friedrichshall, offers in collaboration with the customer the most suitable and economically efficient variant of cooling system. For this purpose, a project team for thermal tool design uses a catalog of defined criteria (**information-box at the top**). By means of fill and delay simulations, possible hot spots can be found and counter-measures against the hotspots can be initiated even before the tool is constructed.

Optimization of the cooling system by simulation

An example for this purposeful approach is a connector for electric vehicles (**picture 2**). The injection molding simulation with Autodesk Mold flow, carried out in an early development phase, shows hotspots and, consequently, an intolerable warpage on the domes (**picture 3**). This imbalance in the heat distribution of the injection mold has to be counteracted with a powerful cooling system.

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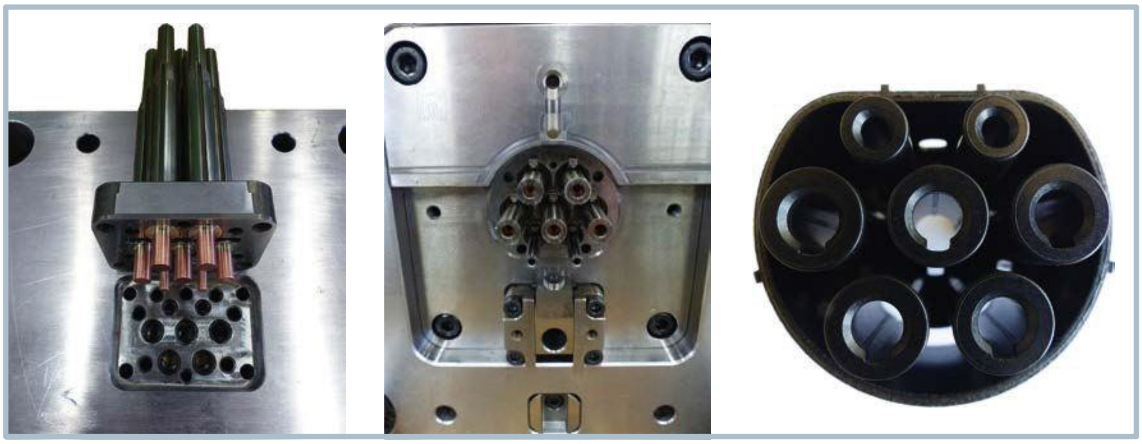
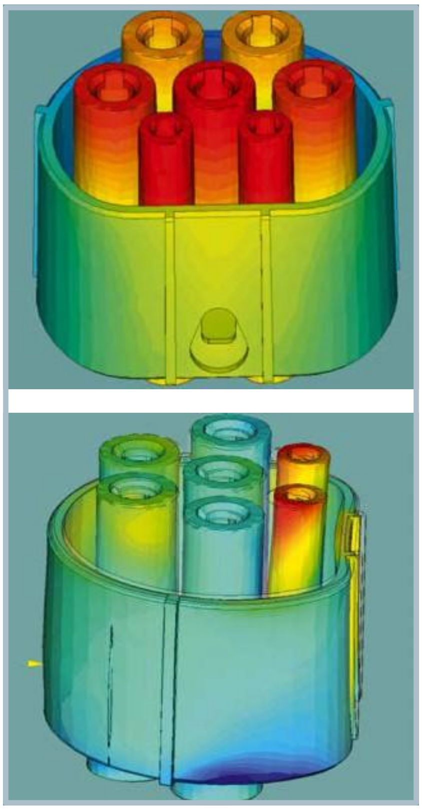


picturei 2. The Injection molding tool for this E-Mobility connector (right) contains continented cooling domes equipped with copper pins (©Mühlbeyer)



picture 3. In the filling simulation for the connector the distortion was shown in color in relation to the drawing-compatible injection-molded component for easy comprehension. The blue areas are warp-free, green-colored have a warpage of 0.1 mm, yellow means 0.2 mm warpage; red spots have a delay of 0.3 mm and correspond to the hot spots (©Mühlbeyer)

The Autor

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Profile

Mühlbeyer Werkzeug- und Formenbau GmbH is specialized in long-life and maintenance-friendly injection molds with powerful cooling systems, for example for the manufacture of plug-in connectors. The company, located in Bad Friedrichshall, near Heilbronn, produces among other tools multi-cavity and floor tools for plastic parts with a shot weight of up to 300 g and injection molding tools for plastic-metal-hybrid-components. Since its beginnings more than 30 years ago, the company has evolved from pure moldmaker to a broadly based system supplier for injection molding.

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As soon as the tool concept, which is conceived in a first approach, is structurally established with the provided sprue system and cooling system, a practically-oriented simulation is performed. Both the individual process phases such as filling, holding pressure and cooling phase as well as component characteristics such as shrinkage and warpage are simulated.

It is found that the assumed uniform tool temperature prevails only in theory. Specifically, the nuclei of the domes are assumed to be hotter than measured in the initial simulations.

On the basis of the new results, the mold construction, including the cooling system, is once again optimized – by continually cooling the cores with copper pins.

Now the realistic tool temperature can be simulated over the cycle time. The tool temperature control is tested using analytical equations and finite elements programs of the simulation program.

Triple of benefit

Thermally balanced injection molds shape the production of injection molded parts cheaper and safer. Optimized cooling on the contoured surface of a tool is worthwhile in three ways. Firstly, it shortens the cycle time by 10 to 40%, because molds can be taken out of the mold earlier due to more effective cooling. Secondly, it extends the tool life because the contouring surface is subjected to substantially lower thermal stresses and the tool is thereby spared. Finally, due to a nearly constant temperature level at the cavity surface, the molding quality is increased by promoting a uniform microstructure formation. In this way, internal stresses in the molded part as well as distortion and dimensional deviations, which require subsequent tool corrections, are avoided.