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Mold cooling redefined

Additive manufacturing as a way to optimize injection molds

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The continuous increase in the production output of modern injection molds lead to the challenge that certain mold components cannot be produced in standard manufacturing processes or can only be produced at an increased cost. The common trend is towards more compact injection molds, while at the same time additional functions such as more efficient injection systems or sensors for process monitoring have to be integrated into the mold concept. The main challenge for mold making is to transfer the proven reliability of existing mold concepts to the new generation of injection molds while integrating modern mold components. This increases the cost-effectiveness of the mold and ensures reliable operation with high product quality.

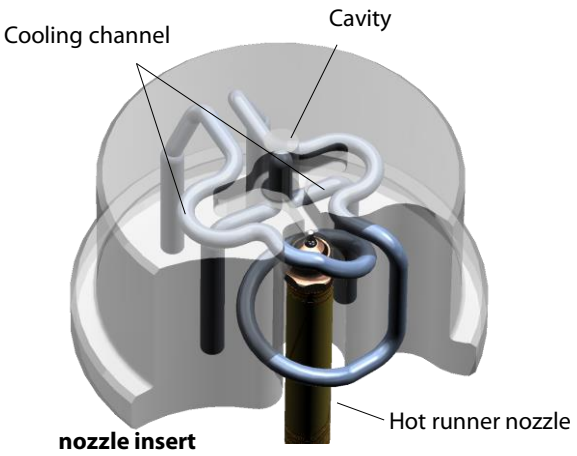

Figure 1: Additive manufactured mold insert

The challenge in mold making

The integration of these modern mold components can change the thermal and mechanical operating conditions, which makes it necessary to optimize the original mold concept. For example, replacing an open hot runner system with a valve gate system changes the thermal situation of the forming parts and can have a negative impact on cycle time or component quality. A homogeneous temperature distribution in the mold insert reduces shrinkage and distortion of the molded plastic part and is therefore just as important as a high cooling rate.

In the example, a hot runner nozzle with valve gate was implemented in the mold insert. Due to the changed thermal situation, the cooling had to be optimized. A cooling geometry adapted to the application is only possible by using the additive manufacturing process, whereby the cooling capacity can be positioned with the greatest influence on heat dissipation.

Additive solutions

SCHÖTTLI AG addresses these challenges right at the design stage and defines solutions for optimizing the performance of the injection mold. Therefore, we do not only achieve the best possible component quality, but also offer cost-efficient solutions by reducing the cycle time. Although additive manufacturing often lags behind conventional manufacturing processes in terms of cost-effectiveness, it has become an alternative solution for manufacturing specific mold areas or complex cooling channels. The experience from various projects in additive mold making helps us to weigh up the potential for improvement against the costs and to advise our customers in the best possible way.

Design/Development/Simulation

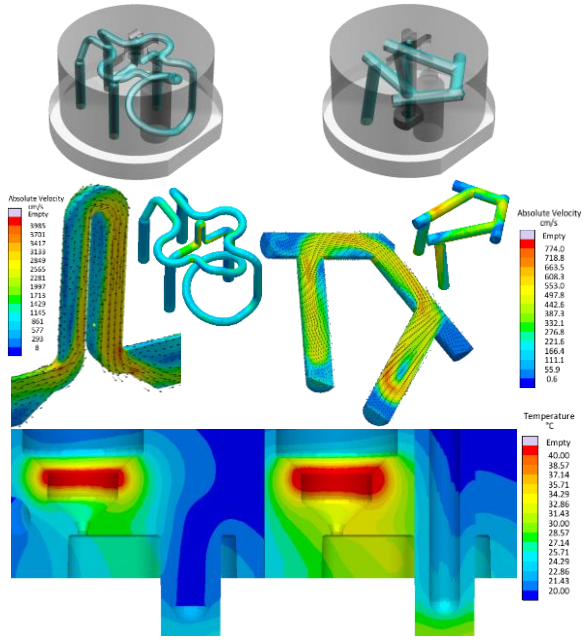

Figure 2: Design of the additive solution with CFD analysis

Conventionally manufactured mold components serve as a starting point to evaluate the effectiveness of the approaches. In many cases, the customer already provides practical experience that is useful for finding an appropriate solution. Within the scope of the conception, solution proposals are worked out and basic conditions such as process parameters are determined. Comparisons between existing and new solutions are first drawn on a theoretical basis with simulation data and a promising approach is then selected. This scientific approach leads to a fundamental understanding of the process, which is necessary for a meaningful and efficient approach. The example shows that the mold temperature can be significantly reduced by positioning the cooling channel closer to the heat source. Furthermore, Computational Fluid Dynamics (CFD) simulations can be used to calculate the pressure requirement and flow behavior in the cooling channels and optimize them with regard to optimal heat transfer. Figure 2 shows the thermal difference between a conventionally manufactured nozzle insert (right) and the additive manufactured insert (left). The more effective cooling in the optimized nozzle insert leads to a significantly lower mold temperature.

General manufacturing process

In laser sintering, metal particles are melted by laser energy and fused to form a printed part. The basic production process is shown in Figure 3. First, a base plate is inserted into the process chamber of the 3D printer (1). A powder storage (3) contains sieved metal powder which is conveyed to the powder reservoir of the process chamber. During building process (5), a squeegee is used to transfer the powder layer by layer to the process chamber where a laser beam, which is adjusted via a mirror mechanism, and the laser pulse melt the metal particles with a specific hatch pattern.

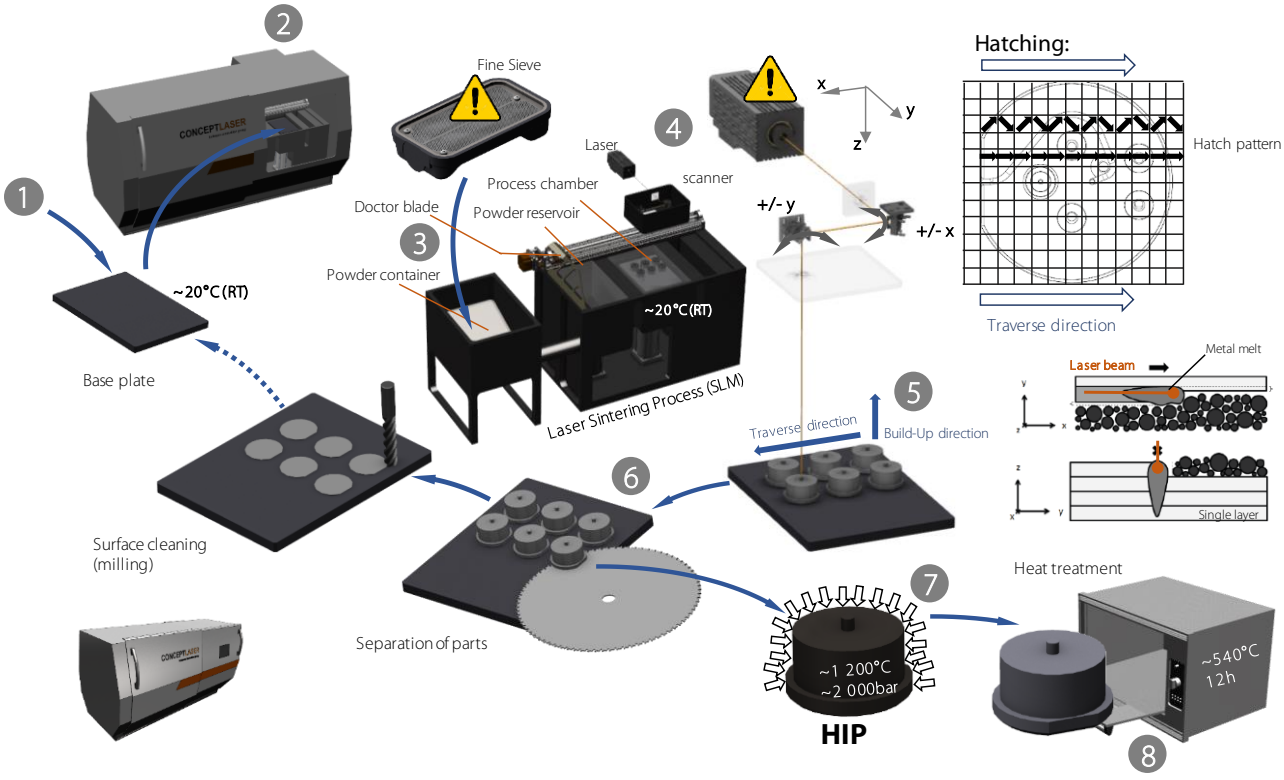

Figure 3: Process steps additive manufacturing

Optimal adjustment of the printing process requires expert knowledge, since poor powder material or inhomogeneous heat input can cause stress cracks, which can lead to a failure of the component under mechanical stress. The printed parts are separated from the base (6) and consolidated by using a compression method (Hot Isostatic Pressing). Using a heat treatment, the metal component reaches its final material-mechanical properties.
The experience gained by implementing several additive manufactured mold components have shown that this manufacturing method offers new possibilities for the design of a cooling channel. However, physical effects which often occur during the manufacturing process decrease the component quality. An additive manufacturer is an expert in its field of production – but the expertise of a mold maker is necessary to implement complex cooling channel geometries and determine the requirements for the component. We work closely with the additive manufacturer and combine the expertise of 3D printing with many years of experience in the Swiss mold making industry.
This cooperation results in components that meet the same quality standards as conventionally manufactured components but differ in important characteristics such as cooling capacity.

Flow measurements during sampling

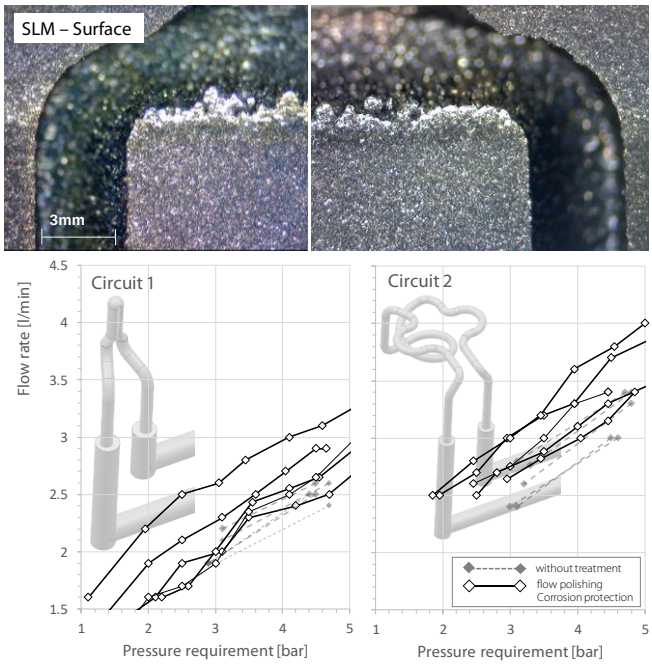

Figure 4: Flow tests of the nozzle inserts

The use of additive manufactured components in the mold correlates with the question of whether the higher manufacturing expenditure and production costs are economically justifiable. SCHÖTTLI records and documents all relevant process data, using comprehensive measuring technology that consists of pressure and flow sensors. The aim is to achieve a constant flow through all cooling channels to ensure an even cooling behavior and a homogeneous temperature distribution in the inserts. In this specific project, the influence of a surface post treatment on the coolant water pressure drop was also investigated. By means of flow polishing, the pressure drop could be reduced and the flow volume increased by approx. 10% at the same time. Figure 4 shows the individual circuits before and after surface finishing and the water flow, which correlates with the water pressure. It shows that during flow polishing, loose particles from the laser sintering process are released from the cooling channel surface, creating a more even surface. At the same time, the individual cooling circuits show a similar flow rate, which ensures a homogeneous temperature distribution in the mold insert.

A HUSKY valve gate system was implemented for the plastic part presented in this report. This system ensures the constant quality of the injection point; it also introduces more thermal energy into the mold insert. The position of the valve gate nozzle causes an inhomogeneous temperature profile, which can be compensated by the more effective cooling of the additive cooling channel located at the point of major heat input. With this solution, the cycle time of this specific part can be reduced by 6%.

SCHÖTTLI as a partner in additive manufacturing

SCHÖTTLI AG, a HUSKY Company, offers safe and efficient solutions for complex applications in the medical and pharmaceutical industry. In addition to developing new mold components, SCHÖTTLI also offers the possibility of analyzing existing mold concepts and optimizing them in terms of process efficiency. No matter what the demands are – SCHÖTTLI molds offer the highest part quality combined with the lowest costs per part.