A Cool Innovation

Virtual Design of Challenging LSR Manufacturing Processes

In a joint project at Fakuma 2018, a number of partners portrayed the transition from virtual to actual production of a pot holder. Sigma Engineering supported the entire development process of the complex part injection molded from a silicone elastomer. Not only were the ideal process settings determined, but the mold gating and heating concept was also optimized.

A project presented at Fakuma shows the route from the virtual part and process design to the actual product, a pot holder of heat-resistant LSR (© Momentive)

Two tradeshow booths with one theme: the virtual and actual challenges faced by the fully automatic production of pot holders of a liquid silicone rubber (LSR) could be experienced at first hand by visitors to Fakuma at two stations. This a joint project by a coalition of five companies:

- Momentive Performance Materials GmbH, Leverkusen, Germany,
- Sigma Engineering GmbH, Aachen, Germany,
- Wittmann Battenfeld GmbH, Kottingbrunn, Austria,
- Emde Moldtech GmbH, Oberbachheim, Germany, and
- ACH Solution GmbH, Fischlham, Austria.

Though it may sound like a banal product, it is an impressive part. The pot holder with a shot weight of 83 g demonstrates the filling of a honeycomb structure with up to 1 mm wall thickness at a maximum flow-path length of 135 mm (**Fig. 1**). This complex molding is manufactured from a Silopren LSR 2650, an LSR material that, according to Oliver Franssen, Senior Global Marketing Leader of Momentive, is heat stable up to 3200 °C (however only for 45 s in this extreme case). These properties even qualify it for use in the heat shield of the Ariane 5 launch vehicle.

Without a simulation, the mold design would have been difficult to solve, according to the project partners. To run through various filling and geometry scenarios, and ultimately determine the optimum process configuration, Sigma Engineering with its Sigmasoft software made use of "virtual molding" and its enhancement "Autonomous Optimization." As was shown at the Sigma booth, the simulation is already used to support development right from part design, and, in a continuation, helped to answer key questions, such as which gating via the cold runner is most efficient or which heating concept is advisable for uniform temperature control.

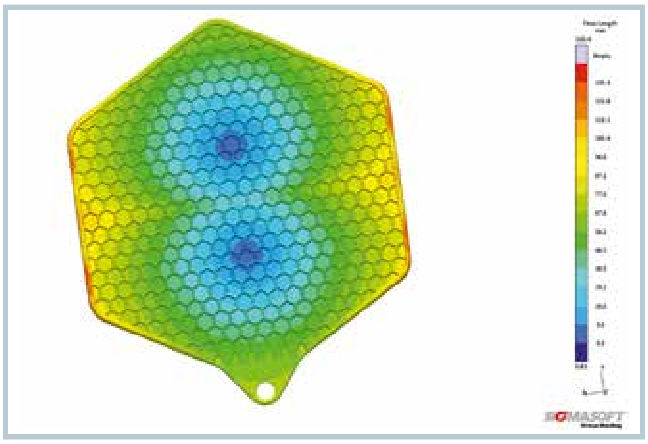

Fig. 1. The maximum flow-path length from the two injection points is 135 mm (orange/red on the color scale). The pot holder has a fine honeycomb structure with an averaged wall thickness of 1 mm (© Sigma Engineering)

Appropriate Corrections to the Mold Concept

For such complex parts, uniform filling without premature crosslinking is crucial to quality. In a virtual design of experiments (DoE), the number and best positions of the cold runner nozzles were first determined. In a single simulation, an arbitrary number of variants can be computed and, compared and assessed with the aid of predefined target parameters, e.g. the pressure demand and the risk of air inclusions. In this way, an originally planned gate point on the hanger of the pot holder was distributed between two centralized injection points. Partial fillings document the accuracy of the predictions.

Oliver Franssen explains the reason for this: "The intricate hexagonal honeycomb structure is surrounded by a 7 mm-high, 1 mm-wide rim. The LSR flows through this channel faster along the path of least resistance, from where it then surges backward into the honeycomb structure. As a result, air inclusions occur at four points according to the simulation. As the ideal solution, Sigmasoft calculated an oval as a gating component formed by two injection points. Together with a small lateral grinding in the mold, through which the air escapes, it ensures complete filling of the cavity.

In the virtual checking of the mold concept and the simulation of series production, besides the geometries, the steel grades for the cavities and the cold runner were also established, and the position and capacity of the heating cartridges taken into account. All details were simulated in a dynamic environment, in which the cold LSR is injected into the hot mold in each cycle, and the cycle time took less than a minute. In the virtual optimization, the temperature difference within the cavity was successfully reduced to 10 °C at most (starting from approx. 40 °C) by reworking the heating concept. The mold was ultimately constructed by Emde, based on the simulation results.

Compact Mold and System Design

Those who wanted to experience the leap from mold design and virtual process optimization to actual production then had to walk through to the neighboring hall, to the Momentive booth. Here, the pot holders were produced on a SmartPower 90/350 servohydraulic injection-molding machine from Wittmann Battenfeld. The machine with 900 kN clamping force was equipped with a W818 robot from Wittmann for removal and deposition of the parts. The mold and the cold-runner block from Emde were combined with a metering pump and a mixing unit (type: MaxiMix 2G) from ACH Solution, and, like the robot, is connected to the B8 machine control system.

Wittmann Battenfeld had prepared the entire manufacturing cell in it its technology center. Its chief features are its high efficiency and compact design. Thus, the required footprint of the only 4.20 m-long injection-molding machine and the metering pump are very small compared to most industrial solutions, according to the project partners (**Fig. 2**). The metering system control unit, which is accessible from three sides – the pump does not need columns, and is mounted floating, so to speak – can provide a reliable, consistent A/B feeding and complete emptying of both drums of a kit. According to Oliver Franssen, the small cold runner is mounted directly on the machine nozzle and guided through the machine platen, to permit a compact mold design and only low thermal contact with the hot mold.

In live operation, the system operated with a cycle time of 50 s, 35 s of which is heating time. Proof of the successful intermeshing of simulation and production: "The mold operated within the cycle time and temperature settings predicted in the simulation right from the first shot," according to Franssen. ■ *CD*

Fig. 2. The production cell developed by Wittmann Battenfeld combines a servohydraulic SmartPower 90/350 injection-molding machine and a pump and mixing unit from ACH solution on a compact footprint (© Hanser/F. Gründel)

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