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More transparent LSR processes with Virtual Molding  As LIM processes can be quite challenging a thorough understanding of not only the part, but of the whole mold and process are essential for molders to stay competitive. With the help of the Virtual Molding approach one can look into the process up-front and make secure decisions on material, mold and process.

Products out of Liquid Silicone Rubber (LSR) are steadily gaining popularity because of their good physiological properties and thermal stability. The demand is especially growing in the medical, infant care and design markets. However, the production of LSR products in Liquid Injection Molding (LIM) can be quite challenging.

Molders are faced with a range of error sources such as venting problems, flashing, a high reject rate or an optimized cold runner design. Additionally, LSR offers only a small process window to achieve good results because of its rheological properties and curing kinetics. To face these challenges and to find the optimal process window molders often seek assistance from simulation. While some questions regarding the optimization of the part and runner design can be answered with classical simulation, reliable predictions of achievable part quality and process stability are only possible with Sigmasoft Virtual Molding.

In classical simulation only the part and maybe the runner are taken into account under the assumption of a homogenous mold temperature and ideal boundary conditions (Figure 1, left). This makes it suitable for a first estimation but seldom delivers reliable more-in-depth results. The Virtual Molding approach not only takes all geometries and their material properties into account (Figure 1, right), but all process parameters as well. Thus, all interactions between the mold components and the material are considered. With

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Summary

More Transparency in the LSR Process with Simulation

LIM processes mean that the processors are faced with some challenges, so a thorough understanding of the component, tool and process is indispensable in order to remain competitive. With the help of the Virtual Molding approach, the process can be viewed in detail and in advance. Decisions regarding material, tools and process are thereby secured. The silicone used in this product has been provided by Momentive. The designer article by CVA Silicone consists of Silopren LSR 2670. The production took place at the Fakuma on a full electric e-mac 100 injection molding machine with integrated e-pic handling of angels. The interlaced geometry of the molding with a volume of more than 70 cm³ requires very stable flow and cross-linking properties to ensure a reliable injection molding process.

diagram

the calculation of not only several cycles but also of the heating-up of the mold the real process is reproduced at the computer. With this the molder can evaluate and optimize part, mold and process without expensive trial-and-error procedures and wasting resources at the machine.

Upfront evaluation

When the whole process and mold are taken into account, it becomes much easier to elaborate analyze the process and to find optimization potentials otherwise unnoticed. The evaluation possibilities and optimization potentials presenting themselves with this approach are shown in more detail on the example of the design article “Ursula” – a carry mesh for bottles (Lead figure). The main characteristics of the carry mesh are a volume of 72 cm³ and its highly complex, interlaced geometry, which leads to a maximum flow length of 619 mm just inside the part (Figure 2). Additionally, the material has to pass a cold runner system of about 375 mm length. To ensure process capability stable rheological properties and curing kinetics as well as a sophisticated heating and cold runner design are essential.

As a first step the right material for production was to be determined. Two different LSR materials were a possible choice for the process. A first quick evaluation under the classical simulation approach with a homogenous mold temperature of 180 °C led to the assumption that both materials could be used equally for the task (Figure 3, top). However, a second calculation with the Virtual Molding approach showed this was not the case. When the heating up of the mold as well as 25 cycles to reach a thermal steady state were taken into account, one of the materials could not completely fill the cavity because of premature curing (Figure 3, bottom left). In contrast the second material still ensured a good filling behavior and part quality (Figure 3, bottom right) and was hence chosen for production.

Figure 1: Simulation setup under the classical (left) and Virtual Molding approach (right).

Figure 2: An interlaced geometry and a maximum flow length of 619 mm make the carry mesh challenging for production.

Figure 3: Evaluating the possibility to fill the part under the classical (top) and Virtual Molding approach (bottom) for materials one (left) and two (right).
The reason for this varied outcome is the temperature distribution inside the mold. While the classical approach assumes a homogeneous temperature, the real mold shows quite high temperature variations. Taking a closer look on the movable half after the thermal steady state is reached reveals that just inside the cavity the difference is already bigger than 30 °C (Figure 4). The hot areas at the top of the cavity cause the one material to quickly reach a curing degree of over 20 % at the flow front. With an Alpha Gel at 10 % the material cannot flow any longer in this state. Whereas for the second, more stable material the curing degree also rises, but not to the extent resulting in impaired filling behavior.

The temperature distribution inside the cavity does not only influence the filling but also the curing of the carrier mesh. During further evaluation it becomes apparent that the curing reaction is first started at the top of the cavity (Figure 5, left) and then moves from the outside to the center of the part (Figure 5, middle and right). To receive a smoother curing behavior and more balanced filling the molder could try changes for the power settings or a different assembly of the heating cartridges. Both options can be safely
evaluated on the computer before making changes on the real mold.

**Validation of the simulation**

After the evaluation on the computer was done and when the production of "Ursula" started the congruence of the calculated results and reality was checked. For this purpose short shots (partial fillings) done during starting up the process should be compared to the simulated results during filling. As the carry mesh has a volume of 72 cm³ a short shot of every 10 cm³ was planned. These short shots were brought face to face with the corresponding results, when the same amount of material was inside the cavity.

Figure 6 shows the comparison for the short shots with 10 cm³, 40 cm³ and 60 cm³. Because of the slightly unsymmetrical filling, the results can be easily compared with the short shots, as the areas which are rushing ahead of others can be identified without problems. The pictures show that the simulation correlates closely with reality.

This validation proves the reliability of the Virtual Molding approach and shows it is a valuable tool for LSR molders to make sure their processes are not only delivering a good part quality, but also that they have a stable process in an optimal process window. With this knowledge they not only increase profitability and energy efficiency, but also become more confident to virtually test new ideas, as the outcome is known much faster and the trial is less risky.

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