Quality Assurance for Multiple Cavities

Automating Injection Molding with Process Control – with the Example of a Cube Mold

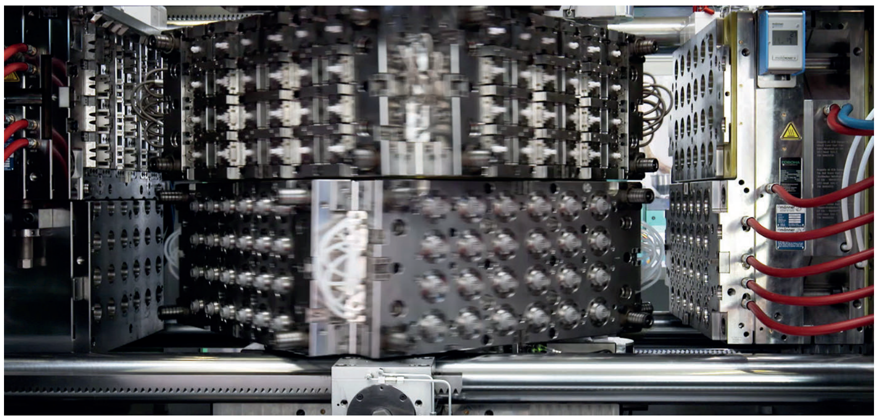
The Reversecube two-part cube mold is used to produce 60 million multicomponent parts per year on one production line and in the same process. The cycle times must be kept very short while at the same time maintaining stable processes and a high part quality. Sensor-based monitoring and automatic process control is therefore deployed in the form of Fillcontrol from Priamus. It consists of hot-runner balancing, viscosity and compression control as well as automatic holding pressure changeover.

Plastic parts are becoming more and more challenging and the requirements for functionality and dimensional accuracy are increasing. A design unsuitable for injection molding or fluctuating material quality, for example with the use of recycled or biopolymers, as well as general process fluctuations are other challenges. At the same time, pressure on unit costs is rising.

Processes are therefore being increasingly automated, cycle times shortened and numbers of cavities increased. However, increasing process complexity requires improved monitoring and control.

“With cycle rates becoming shorter and the injection-molded parts more complicated, the number of cavities increasing and batch-to-batch fluctuations increasing, there are ever more problems with part quality, for example because not all the cavities are filled simultaneously. Under these conditions, manual monitoring and control of the processes is no longer satisfactory,” says Erwin König, CEO of Priamus System Technologies GmbH in Salach, Germany, about current requirements. The company headquartered in Schaffhausen, Switzerland, specializes in systems for quality assurance, and open- and closed-loop control in injection molding processes.

With the example of the Reversecube inversely rotating cube mold from Foboha (**Title figure, Info box p.14**), König describes how complex processes are monitored and open- and closed-loop controlled today. “At the plastics processor Hermann Hauff, production by conventional manufacturing of multicomponent parts was operating almost flat out. With the new Reversecube, it was also a priority to ensure uniform filling in the 2 x 24 cavities, and therefore maintain high process stability, and a high product quality.” With Fillcontrol from Priamus, Hauff deploys sensor-based monitoring and process control.



The two halves of the Reversecube cube mold, in stacked arrangement, rotate in 90° steps. Bottom: injection and cooling component 1, analogous to the component 2 above, which is offset by 180° © Foboha

For this purpose, mold wall temperature and cavity pressure sensors register real process data within the mold. They detect the filling time differences in the cavities, monitor the viscosity and compression in order to optimize the processes adaptively.

Hot-Runner Balancing Evens out Differences in Filling Time

“In multicavity molds, filing all the cavities simultaneously is crucial for the part quality. With mold wall temperature sensors, we identify different volumetric filling degrees in the cavities and can automatically equalize them depending on the particular melt flow, until they are balanced out. Then the changeover point is suitable for all cavities, not only for some of them,” is how Erwin König explains the control principle (**Fig.1**). The temperature sensors at the end of the flow path recognize when the individual cavities are filled by a steep temperature rise.

“The differences in filling time are compensated by the automatic adjustment of the hot-runner nozzles. That is how we achieve uniform cavity filling. It is a continuous process, which also compensates for fluctuations in the process and between batches. Manual adjustment with, for example, 2 x 24 cavities would be very laborious, particularly for multicomponent applications. By automatic hot-runner balancing, we improve the filling time differences by a factor of around 10, depending on the application,” says König. »

An additional control switches to holding pressure at the correct time, depending on the viscosity of the melt. The patented changeover process is based on recognizing the melt front. In distinction to a rigid changeover via the screw volume or cavity pressure threshold, the automatic changeover also takes into account viscosity fluctuations. It is thereby changed over when the cavity is volumetrically filled (**Fig. 2**).

Control Loop Reduces Viscosity Fluctuations

Because fluctuations in the viscosity and melt flow affect the dimensional stability and part quality, the viscosity is monitored with cavity pressure and cavity temperature sensors. The pressure and temperature are used to determine the shearing stress and shearing rate, from which the viscosity is derived.

"In new molds, the processes are first set up manually and the shear stress and shear rate values determined are saved as reference values. If departures from these values appear in ongoing production, the system makes automatic corrections. The temperatures in the hot-runner manifold and in the injection unit as well as the injection profile are adjusted accordingly. We can thus reduce fluctuations by more than a half," is how Erwin König describes the viscosity regulation.

Compression Regulation Monitors the Melt Compression

The strength, dimensional accuracy and surface quality of an injection-molded part depend on how strongly the melt is compressed during injection molding. In the sampling of a component, the desired compression values are therefore saved as reference and the cavity pressure is continually monitored during production. If the measured compression deviates from the reference value due to process fluctuations, the holding pressure profile is adjusted until the optimum compression in the cavity is reached during the holding pressure phase.

"Only with sensors can we gain a genuine insight into the processes. Previously we had to apply trial and error until we had achieved satisfactory results. Now we reach stable processes with good results much faster because we can gain a good deal of process-relevant information from the measurement data." says Erwin König about the advantages of sensors.

Without online monitoring, quality control would be limited to sampling and problems due to process fluctuations would often remain unrecognized. With sensor-based monitoring, 100 % quality control of all parts throughout the entire production process can be implemented for the first time. Process deviations are immediately recognized by the measurement and corrected by the system. As a result, rejects are significantly reduced. If unacceptable parts are nevertheless produced, they are automatically sorted out. The 100 % parts control also allows end-to-end documentation of the injection molding process and traceability of each individual part.

Sensor Technology Reduces Process Costs and Increases Parts Quality

"Technically speaking, injection molding processes can now run completely autonomously without corrections by users. In practice, the automation leads to the machine operator simultaneously supervising more machines than used to be the case. Less downtime means higher productivity. Cycle times can be further shortened because processes are optimized by measurement of pressure and temperature," is how Erwin König describes the improvements.

"Smaller, more effective, more robust and more practical," the CEO also says about the advances in sensor technology. As an example, he names the compact sensors from Priamus, which are also used in this application. A typical cavity temperature sensor has a diameter of only 1 mm, which is no longer a problem in the design. It is no longer directly connected to the cable but to a coupling via a spacer. This results in a compact and easy-to-handle solution. For cleaning and maintenance work, the

Reversecube

The mold system developed by Foboha [1] can manufacture two and more parts from different materials or colors and assemble them simultaneously with the injection cycle. The system uses mold areas separated into two stacked cube halves, for operations occurring simultaneously. The molding compounds for two individual parts are simultaneously injected into the cavities of the closing planes via hot-runner needle valve systems. The cube halves rotate through 90° with respect to one another. After each rotation, the next injection operation takes place. With the rotation, the individual components manufactured simultaneously are free for removal at the side opposite the operator. For this, a six-axis robot is integrated in the system. Simultaneously with the injection cycle, it removes the parts from the lower cube and places them in the second part, which is still located in the cavities of the upper cube half. The cube concept with the counter-rotating halves allows the manufacturing and assembly of two (and more) components in a very confined space in a shorter cycle.

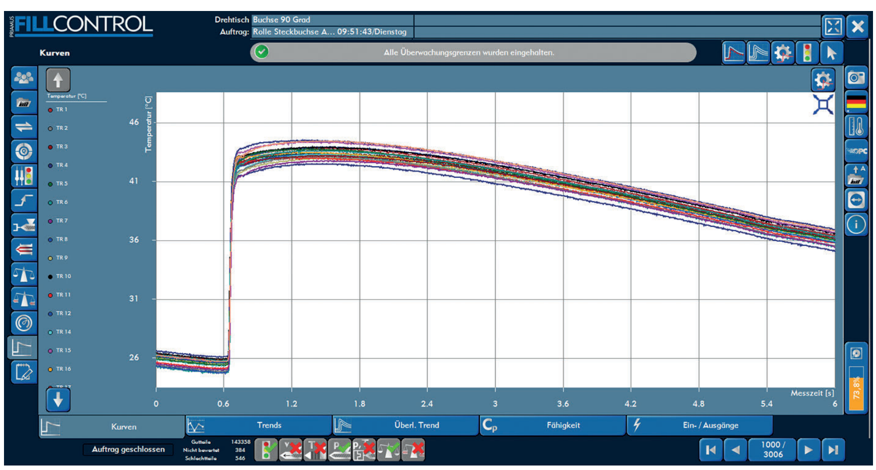


Fig. 1. Different volumetric degrees of filling in the cavities can be identified with cavity temperature sensors. This balancing is evened out until all the cavities are filled simultaneously © Priamus

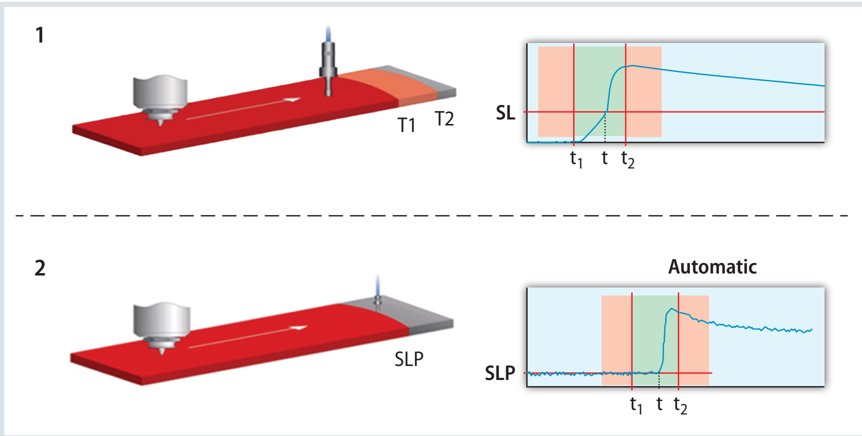


Fig. 2. Changeover via fixed values, such as screw path or cavity pressure threshold causes different degrees of filling in the event of viscosity fluctuations (1). The automatic changeover via the flow-front position balances out viscosity fluctuations (2). SL – switch level (limit value for manual configuration); SLP – switch level point (limit value accurately detected by the program/chip)

Source: Priamus; graphic: © Hanser

mold no longer has to be dismantled and the cable no longer removed.

Compact sensors are both available as temperature sensors but also as pressure sensors. For strongly abrasive molding compounds, specially wear resistant sensors are available, which normally have an improved lifetime of at least a factor of 10. At Priamus, the pressure sensors are exclusively equipped with a patented sensor and sensitivity identification (type: Priased), which greatly simplifies the handling and avoids setting errors and confusions – especially if several sensors are installed in the mold. ■

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Company Profile

Foboha and Priamus, like Männer, Synventive, Thermoplay and Gammaflux, are companies within the “Molding Solutions” strategic business unit of the Barnes Group Inc. This unit’s goal is the development and sale of high-tech injection molding solutions:

- www.barnesgroupinc.de/bgi-businesses/industrial-segment/molding-solutions.aspx

Service

References & Digital Version

- You can find the list of references and a PDF file of the article at *www.kunststoffe-international.com/archive*

German Version

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New Design Possibilities in Moldmaking

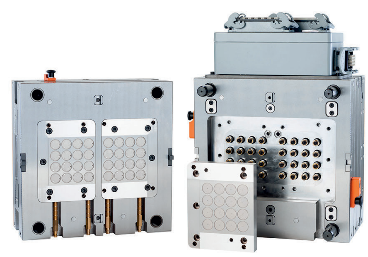
Additively Manufactured Hot Runner System

For the further development of the Streamrunner and also for customer demonstration purposes, **Hasco** hot runner has developed an innovative 32 cavity injection mold tool. The mold, that will produce shopping trolley tokens, will be trialed in the in-house injection molding technical center of the company.

The special feature of the mold is the 32-cavity Hasco Streamrunner. According to the company, the additively manufactured hot runner manifold offers moldmakers and injection molders unprecedented freedom in design and opens the door to new design possibilities in moldmaking. The 100 % leak-free manifold offers particularly gentle passage of the melt and makes for considerably lower shear in the material, resulting in better quality moldings. The flow-optimized design speeds up color changes and material too. Through the use of the additive manufacturing process, very compact designs can be produced with a nozzle pitch down to 18 mm and minimum manifold height of 26 mm.

With the new test mold, the hot runner specialists at Hasco have additional possibilities to obtain further knowledge in the application of additively manufactured hot runner manifolds, especially in the high-cavity segment. The first series of tests have confirmed all the advantages in the balancing of the Streamrunner. A filling study showed from the very beginning a very uniform opening behavior of all 32 nozzles and synchronous filling of the individual cavities. In the coming months, further trials will be carried out with a wide variety of different thermoplastics. Furthermore, special tests are also planned in the field of color change as well as individual maximum load tests.

In addition to the Streamrunner, numerous standard quality mold components are used in the token mold. Heat sensors additionally integrated in the system show a highly uniform temperature profile and confirm the previously carried out thermal simulations. The new tool locks Z730/… secure the mold from unintended opening, whereby the smaller variation of the lock secures the ejector plate. The cycle counter A57300/… integrated from left counts every shot. The overall molding tool is coordinated precisely through corresponding pressure plates. DLC-coated components ensure accurate and low-wear guiding and centering.



The special feature of the mold is the 32-cavity Streamrunner © Hasco

To the product presentation:
www.kunststoffe-international.com/a/article-329818