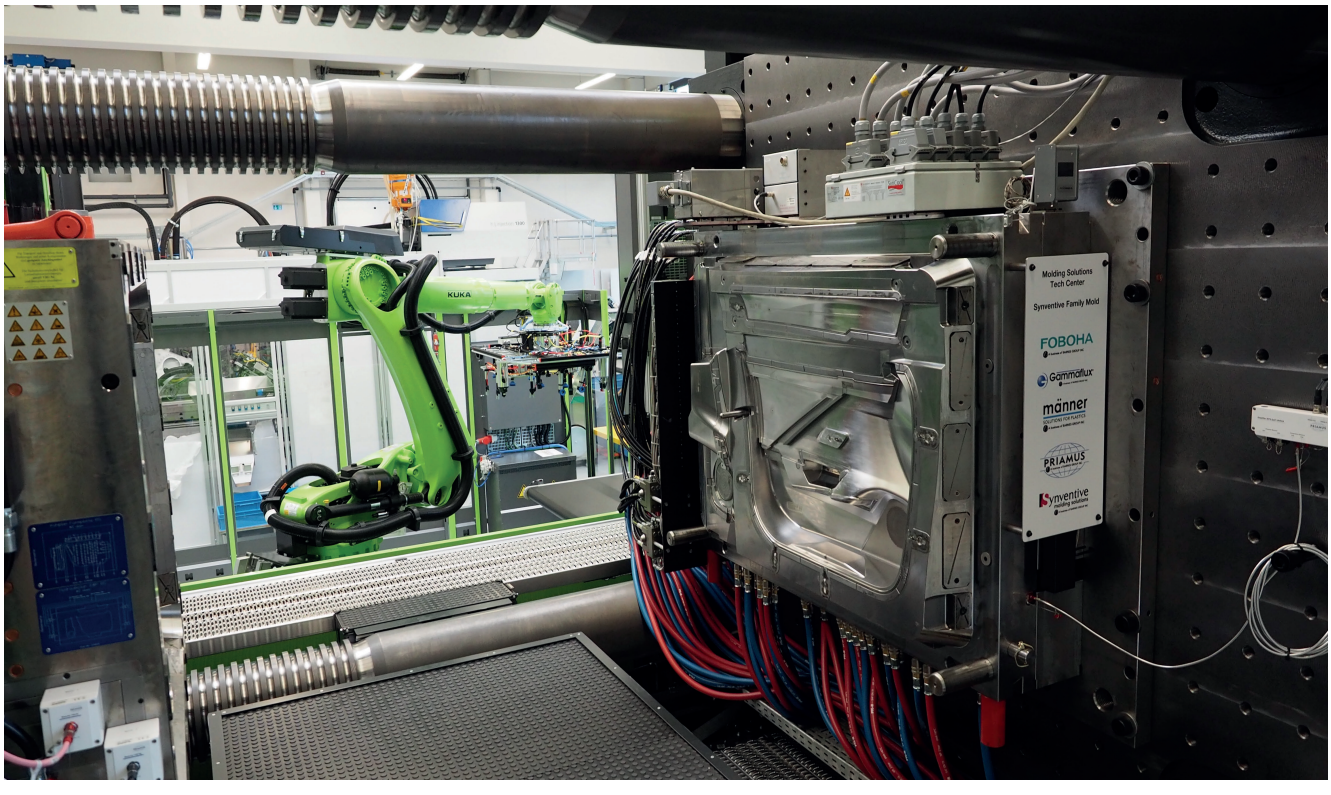
Single-Shot Injection Molding of Heterogeneous Components

Leading-Edge Process Control

Family molds belong to the state-of-the-art in injection molding – at least when wall thicknesses and volumes of individual components vary considerably. Using a trial mold soon ready for series production, Synventive demonstrates that – though demanding – optimal process control can be achieved using the right technology. The filling of each mold cavity is controlled individually and in real time. The ***Kunststoffe*** editorial team were among the first guests at the new Tech Center.



View into the mold space of the Engel Duo 2700 at the Tech Center. In the background, a 6-axis robot with 180 kg load-bearing capacity which removes the components. © Schröder/Hanser

Synventive Molding Solutions GmbH partnered with its affiliated company Foboha in expanding the Tech Center at the Haslach, Germany, location. Part of the overall package is an Engel Duo 2700/17060 injection molding machine including 6-axis handling, a materials dryer, mold turner and family mold equipped with a hot runner from Synventive's full range of active-Gate hot runner control systems. This is truly an eyecatcher and the tool is now available to interested customers. The ***Kunststoffe*** editorial team had the chance to visit the plant as one of the first guests.

Kai Irlenborn (**Fig. 1**), Sales & Marketing Director Europe of Synventive, is planning live tours so, as Covid restrictions permit, customers can experience the solution live at the expanded Molding Solutions Tech Center of Foboha Germany GmbH, which, like Synventive, is also a member of the Barnes Group. Six companies are part of the

Fig. 1. Kai Irlenborn of Synventive was closely involved in setting up the system. © Hanser/Schröder

Barnes Molding Solutions group (**see Box**). The joint use of the Tech Center is only one example of collaboration among the companies. Even more partners in the group are involved in the project – more on that follows below. The trial and development mold was constructed by Müller Modell- und Formenbau GmbH and manufactures an assembly consisting of three individual polypropylene parts:

- a door coating including loudspeaker mesh screen with a part weight of 1500 g and a wall thickness of 2.5 mm,
- a map pocket weighing 350 g with a wall thickness of 2.3 mm, and
- a door armrest with a part weight of 200 g and a wall thickness of 2.1 mm.

The total shot weight is 2060 g. The assembly of the family mold can be seen in **Figure 2**.

Complete Freedom Regarding Filling Direction

The tool's injection or distribution concept is designed to enable direct gating of components with or without a cold runner. Customers are also free to choose what filling direction they prefer: either from right to left – or outward from the middle. "With this tool we want to demonstrate the versatility of the technology. That is why there are many variants possible for manufacturing. Switching colors is also possible," emphasizes Irlenborn. "For the largest component, seven injection points are available – partly with direct gating or using cold runners. At the moment we are filling outward from the middle using three injection points. But filling from left to right using four injection points is also possible. Customers decide what filling concept they want to use."

The injection operation for all components within the family mold can start or end simultaneously in order to avoid warpage or surface defects. That is why pressure-regulated melt valves in the hot runner system check the required injection volume per component, much as with individual injection molding machines.

The Core: A Melt-Pressure Controlled System that Responds in Real Time

A key role in intelligent injection molding is played by the Dynamic Feed technology, which allows individual melt pressure control for specific nozzles or distribution areas. This technology addresses the difficulty of achieving consistently uniform filling behavior for each component by using central injection molding parameters in family and standard molds with several different mold cavities. Challenges include varying wall thicknesses or flow path ratios, which require different melt pressures or different melt volumes and can lead to local overfilling of individual cavities when the end of a given flow path is reached too early. At the same time the mold is exposed to asymmetric loads due to the varying surface designs, reducing mold service life. »

Barnes Molding Solutions

The following companies are part of the Barnes global platform:

- Foboha Germany GmbH: Moldmaking with a focus on "anything posing a technical challenge." This includes multi-cavity, multi-component and thin-wall technology and Reverse-cube molds.
- Gammaflux Controls GmbH: Temperature and sequential valve gate control systems for the plastics industry.
- Otto Männer GmbH: Development and manufacture of high-precision molds and valve gate hot runner systems.
- Priamus System Technologies: Intelligent process monitoring and process control systems for injection molding. Sensors, digital amplifiers and software systems are also part of the Priamus product portfolio.
- Synventive Molding Solutions GmbH: Hot runner systems and temperature control systems for injection molds primarily for the automotive sector.
- Thermoplay: Hot runner systems in standard and customized designs.

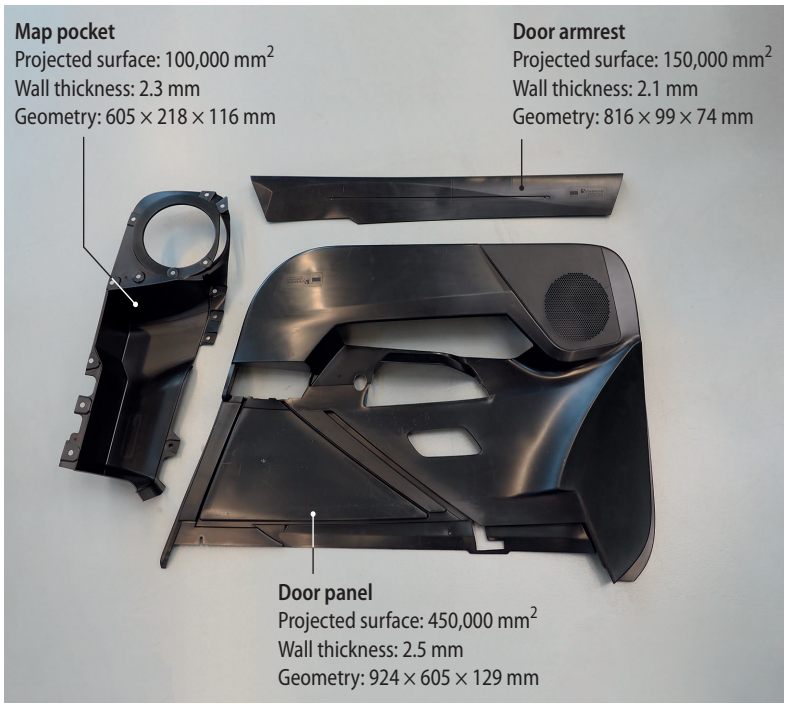


Fig. 2. The trial and development mold manufactures an assembly for the door panel. © Hanser/Schröder

Dynamic Feed makes it possible to set a separate injection profile for each hot runner nozzle or distributor segment to ensure the mold cavities are filled individually. In the family demo tool, the melt valves are located in a transducer block between the bridge manifold and the submanifold.

The injection and holding pressure profile is influenced by changing the flow cross-section. A pressure sensor downstream of the melt valve measures the melt pressure in the flow channel and transmits the measurement data to a controller. This results in a real-time melt pressure control system that ensures the mold cavities are filled individually.

A Crucial Difference: What Happens Is Regulated, Not Controlled

What is special about the Synventive system? Irlenborn emphasizes, "We are proud to be able to offer our customers a closed-loop process." In contrast to an open-loop control with no control unit for reaching the setpoint value, a closed-loop control constantly compares the setpoint value with the actual value (input and output value). A closed-loop control ensures that the specified individual target melt pressure is attained and remains constant in the process. For the family tool, this means that a closed-loop control monitors each individual injection profile in real time to ensure uniform component results.

Improving the Component Surface Using Software

The third generation of the field-tested Synflow control software is also used in the demo tool. A large number of setting parameters allows Synflow to monitor and control the pin opening motion of individual hot runner nozzles, enabling optimized molded part results to be achieved, especially in sequential injection molding and family molds (**Fig. 3**). The precise hydraulic control of the opening speed for each pin and pin opening position enables flexible use of the system.

Advantages in process management of family molds include individual control of the filling balance and the holding pressure, resulting in optimal filling of each component – even with demanding dimensional, shrinkage and warpage requirements – as well as clamp force reduction. Synflow helps avoid common error patterns such

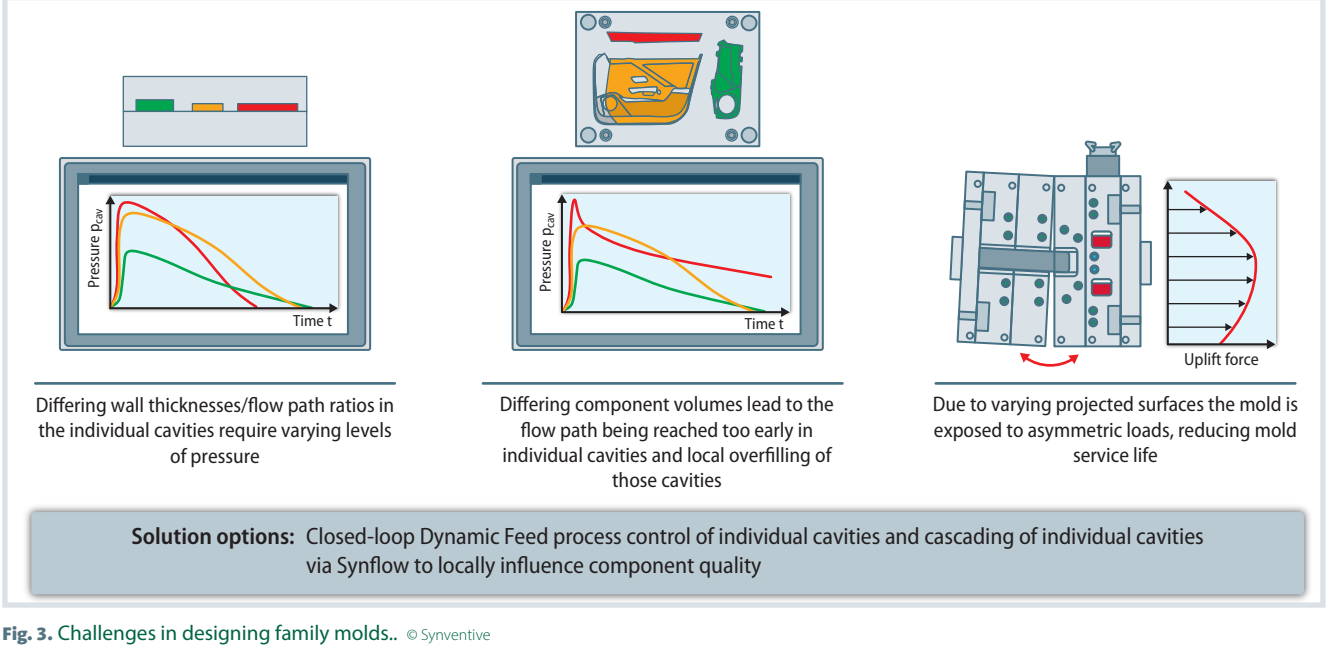


Fig. 3. Challenges in designing family molds.. © Synventive

as flow front disturbance marks, marks opposite direct gating, sink marks after the painting process or reduced adhesion of coatings.

Making Processes Transparent

"For the Barnes family, supporting customers in process optimization is one of the key skills needed in the future," Irlenborn emphasizes. "Data-driven insight for all software solutions is the process data actually generated in the mold and hot runner." Consequently, the cavities of the family mold were equipped with Priamus temperature and pressure sensors that measure values directly. Additional temperature and pressure sensors monitor the mold, the hot runner manifold and the valve gate nozzles.

Data from the Priamus pressure and temperature sensors (**Fig. 4**) deliver their impulses to the company's own Fillcontrol software solution. The special feature of these temperature sensors is their ability to detect the flow front. This means filling of the components is visualized in real time, and the time required to set up the cascade molding process is reduced. If the actual values deviate from the previously specified setpoint values, the quality of components is evaluated by the monitoring functions and defective parts automatically rejected. Fillcontrol compensates for varying flow behavior of the melt during mold filling by automatically optimizing the pin opening times.

In the family tool presented here, the following systems work hand in hand: Synventive Dynamic Feed regulates the volume flow to the cavities by means of melt valves in the hot runner. The opening of the cascade molding valve pin is controlled by the Priamus Fillcontrol software. Synventive Synflow, in turn, determines the motion profile, i.e., the pin opening speeds. The signals are converted by a G24 hot runner temperature controller from Gammaflux, also a member of the Barnes family.

Last but not least, the entire tool is monitored by the Molding Solutions "moldMind" solution. The "digital cockpit for injection molds" captures relevant process data in real time and stores it as a tamper-proof record during the entire life cycle of the family tool.

The device can also be used as a central storage location for comprehensive tool data, important documents and reports, such as all maintenance logs. For remote access, the data can be stored in a customer-owned cloud or, starting in the fall of 2022, in a moldMind cloud of its own.

A Wide Field of Application

The trial and development tool offers a whole range of possible applications, including:

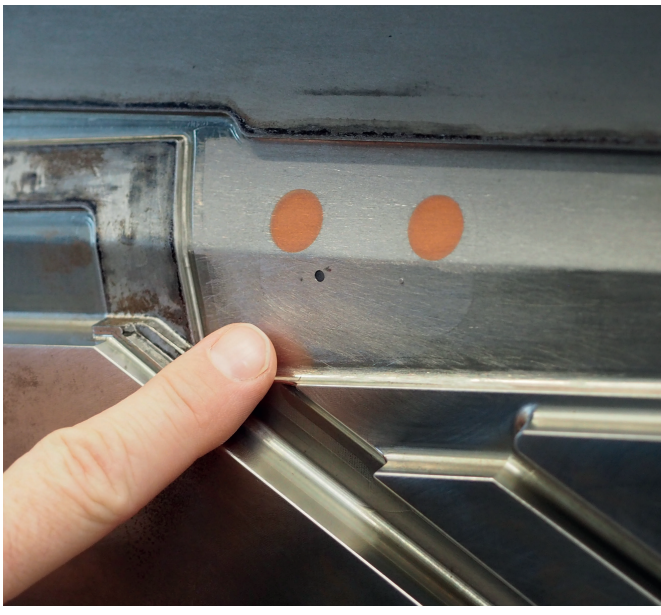


Fig. 4. Making a clear difference: one of 19 sensors installed in the mold. © Hanser/Schröder

- processing of long glass fibers,
- suitability for film insert molding,
- suitability for injection compression molding, and is
- capable of foam injection molding (MuCell).

Precisely because it offers so many possibilities, it is important to demonstrate them. As Irlenborn says: "We can demonstrate the added value of these technologies to our customers here on site. This is the only way we can make the benefits obvious. For example, we can reduce the clamping force by up to 50 % – simply through pressure control. And it is also possible to regulate the holding pressure individually. We believe that in this way we can reduce cycle times by 10 % to 15 %. Family molds deliver cost savings by reducing investment in molds and machines and eliminating cost-intensive fine-tuning of the degree of gloss and color for an assembly because the molding is done in a single shot. We are convinced that family molds, with the right closed-loop process control, can work in a stable, cost-effective and flexible process." ■

Susanne Schröder, editor

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