State-of-the-Art Injection Molding Solutions at K 2022, Part 2

Inspiring Moments

While the first part of our review of the trade show mainly dealt with the omnipresent interaction between recyclate processing and assistance systems, on closer inspection we saw that the exhibitors also had some process engineering treats in store for the trade visitors. A small selection from our second tour of the trade show grounds.

The B-side of the door trim manufactured by foam injection molding shows the reinforcing ribs behind the natural fiber mat and the molded-on map pocket at the bottom. © Frimo

Aha experiences are absolutely a part of a successful trade show visit. Many know the inspiring moment when, in discussions with exhibitors, they gain a new insight that gives them an idea for their own business. The trade show review in the last edition revealed how increasing resource scarcity and regulatory requirements, but also the pressure from the consumer side, are pointing the way to the circular economy, and thereby opening up opportunities for new technologies. This article takes a look at some prominent methods.

With the multi-station concept, LWB Steinl presented an out-of-the-ordinary process for elastomer processing at its own booth. The innovation is that the injection molding cycle is separated into the individual processes of heating phase, demolding and secondary finishing, which are performed in parallel on separate stations next to the injection molding machine. Dominic Bauer, sales manager of LWB Automation, describes the advantage as follows: "By using interchangeable molds, which are sequentially transferred by an industrial robot to external heating and demolding stations immediately after injection, we are not misusing the injection molding machine as an oven, since the non-productive times can now be used for additional injection cycles."

Parallel instead of Sequential

As regards its main features, the concept is reminiscent of the "shuttle molding" for thermoplastic processing, presented by Zahoransky in 2009, in which mold inserts are also shuttled between the injection molding machine and cooling and demolding stations, on the fly. Besides the cycle time gain, the concept also offers advantages for falling or fluctuating release quantities, since individual exchangeable mold sets can be taken out of circulation and free capacities filled with the production of similar parts, according to Bauer.

At the LWB booth, a cell was constructed with an injection molding machine (LWB), four interchangeable molds, a six-axis robot (Fanuc) and the ancillary equipment – several robots and machines can be suitably combined in one factory. The process sequence contains some intricacies: if the robot removes the mold from the machine after injection of the elastomer (**Fig. 1**), the gripper does not need to use force. The gripper arm travels in two wedge-bars on the mold, one at each side; it is then pressed by the expansion force in its interior against the gripper after unlocking in the machine. The robot arm pivots the mold to the rack-like heating station, where it pushes it into one of the compartments. The heating station also acts like a press with a short stroke and a coordinated clamping force. Due to the pressing force, the mold is somewhat compressed and the gripper is thereby released again.

While the rubber parts – in this case two differently sized cylindrical parts of EPDM with undercuts – are being vulcanized in the heating station, a different mold is being transferred from the heating station to the demolding station. Since, after the parts have been baked, there is no longer any expansion force, removal is easily possible. An empty mold is subsequently pivoted in front of the injection molding machine and waits for the next cycle. To allow the transfer processes to take place efficiently, the robot arm has two end-of-arm tools, one of which can take over the part by rotating through 180° if the other is already loaded.

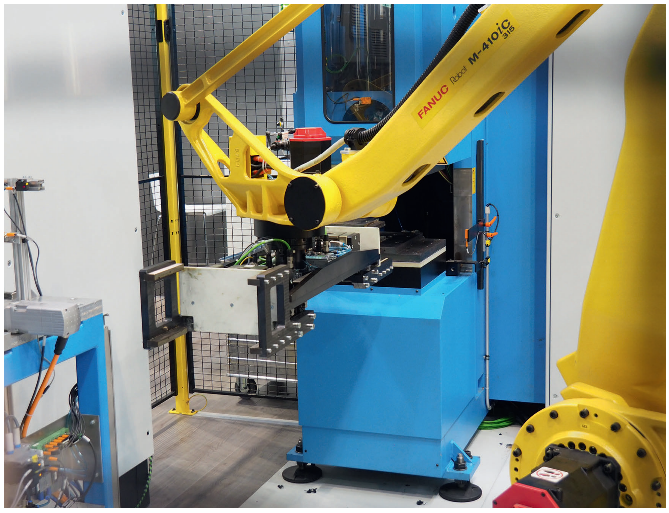

Fig. 1. The six-axis robot removes the mold from the vertical machine after injection and positions it in a heating station (not shown here) in order to run the non-productive secondary times in parallel.
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Eliminating Weld Seams from Fiber-Reinforced Parts

With certain part geometries, the formation of weld seams in the injection molding process is unavoidable. In these regions, where two flow fronts meet during mold filling, the mechanical properties of the part are weakened. The reason for this is the incomplete welding between the flow fronts as well as the presence of undesirable inclusions and porous structures, particularly in the case of fiber-reinforced plastics. That is because, as a result of the rotational movement as the melt streams meet, the fibers cannot orient themselves and intermesh with one another in the flow direction.

A solution to this problem was presented by Smart Mold at the K show. The start-up is a spin-off of the University of Padua, in which Sirmax, an Italian manufacturer of compounds, has a 50 % share. At the Sirmax booth, Prof. Giovanni Lucchetta, founder of Smart Mold, explained the relationships between the novel and already patented GAPP technology (gas-assisted push pull). This is claimed to permit injection molding of geometries that require, for example, cores or multiple gates, without weld seams (**Fig. 2**).

The merging of two melt streams is usually made all the more difficult the greater the fiber content, since the fibers considerably reduce the mobility of the macromolecules and orient themselves usually perpendicular to the flow direction. According to Lucchetta, the strength of the weld with connections filled with 50% fibers is less than 20% of the value achieved by unreinforced plastics. Only by introducing a pressure gradient between the meeting flow fronts during the holding phase can the mutual penetration of the flow fronts be forced and the local morphology at the weld seam improved.

To achieve such a dynamic packaging phase, the GAPP technology is based on empirical knowledge. Miniaturized gas injectors, placed on both sides of the weld seam, and associated overflow cavities permit the melt in the cavity to be manipulated so that it overcomes the weld seam. One advantage is particularly emphasized by Lucchetta: "Because of the small size of the gas injectors, this technology is also suitable for existing molds without the need for expensive changes to the mold." The first applications were successful: the weld seams in the core layer of the parts made of a PP-GF35 were eliminated; tensile strength and stiffness in the former defect range increased by 240% and 21.5% respectively, achieving almost the characteristic values of the composite material.

Individual Product Selection at the Networked Manufacturing Cell

With several examples of automated, individualized and partly digitalized production, Boy has demonstrated how, in recent years, the company has grown from the production of small injection molding machines on the assembly line to a supplier of entire manufacturing systems. As evidence, an exhibit illustrated the increasing connectivity of the injection molding machines in a complex Industry 4.0 application. On a Boy 60 E VV vertical machine, sealable containers of polypropylene (PP) were manufactured. With an input field on a display, visitors were able to make a selection from several small gift articles, which were kept in storage boxes within the automation cell docked on the rear machine table (manufacturer: Gosewehr Robot Automation). A six-axis robot (Stäubli) installed in the automation cell then filled the newly injection molded boxes with the desired presents (**Fig. 3**).

At the beginning of a cycle, an IML film (in-mold labeling) is inserted into the mold and backmolded at the lid side of the vessel. After injection molding, a linear robot removes the gift box from the mold and transfers it to the six-axis robot. The box is rotated and is moved with the opening facing upwards in a defined manner. Before the six-axis robot removes the articles from the storage containers as chosen by the customer, the position and orientation of the articles are determined by means of a camera system with image evaluation and corrected by means of a vibrating plate if required. Once the selected articles have been placed in the gift box, the robot closes the lid and passes them to the visitor via a chute.

The injection molding machine, three-axis handling unit, six-axis robot and the digital input unit and the camera system necessary for part identification during filling of the boxes are connected to one another via control technology. Alfred Schiffer, Managing Partner at Boy, adds: "With this application, we want to make clear that our injection mold- »

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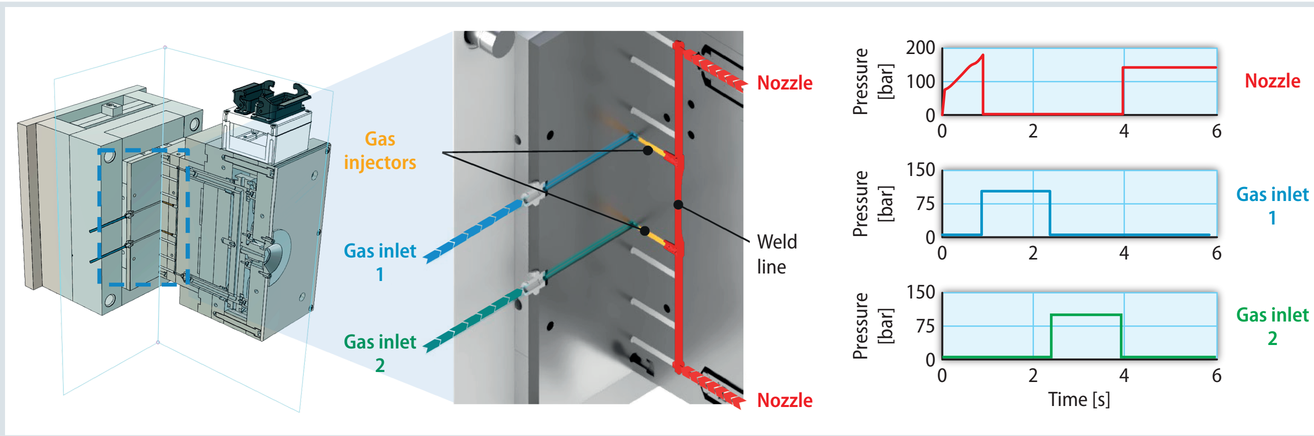

Fig. 2. GAPP technology eliminates weld seams and considerably improves the mechanical part properties. During the compression phase, nitrogen gas is used to move the melt fronts through the interface of the connecting line. Source: Sirmax; graphic: © Hanser

ing machines not only produce precise, diverse and durable plastic parts, but can also be completely integrated into automated production lines and complex manufacturing workflows."

Some of the give-aways were produced next door, with other systems running at the booth. For example, a ruby-red egg cup of an SMMA copolymer (styrene methyl methacrylate, type: NAS 30; manufacturer: Ineos Styrolution) was produced on a Boy XS E. The new model was presented to the trade visitors for the first time at K. Unlike its predecessor, Boy XS, it has an energy-saving servo motor pump drive. Or a wine pourer with decanting function – the 2-component part of transparent NAS 30 and a black TPE was manufactured on a Boy 100 E hybrid with electromechanical injection unit, which was equipped with an additional injection unit (type: 2C S).

No less complicated was a manufacturing cell in which a Boy 35 E VV universal bit holder was overmolded with a glass fiber-reinforced polyamide to form a handy handle. The LR 5 linear handling developed by Boy itself removes the handle from the mold and places it in a cooling station. Then the robot transfers a temporarily cooled T-handle to an automatic placement machine, which inserts four tool bits into the hexagonal openings of the handle. Here, too, visitors were able to choose from the offered bits individually at an input terminal.

Fig 3. The newly molded blue box, which is visible in the background, is equipped by the robot with small gifts, which the trade show visitor previously individually selected on a display. © Dr. Boy

High-Quality Surface without Additional Energy Input

In view of its advantages, thermoplastic foam injection molding (TFIM), despite the easy-to-use additional equipment, is still far too rarely used. This much is known: apart from the fact that the process reduces material consumption compared to non-foamed injection molding, it also reduces the energy and clamping force demand, since the blowing agent dissolved in the melt increases its flowability. In addition, the non-localized foam pressure permits thicker ribs to be molded. These effects can be used for reducing the wall thickness, which in turn shortens the cooling and therefore the cycle time.

What probably often stand in the way of a wider application are the well-known, process-dependent surface defects, such as silver streaks. They can only be avoided with a certain extra effort, for example by means of dynamic (variotherm) alternating temperature control. Engel and the automotive supplier Faurecia have now presented an innovation at the trade show: the "MicroJect Advanced" process jointly developed by Faurecia Interiors and Eschmann Textures International makes it possible to generate foamed visible parts with a high-quality Class-A surface without additional energy input.

To demonstrate the potential of this

technology, large-area sample parts with a challenging surface structure were produced on an Engel duo 1000 injection molding machine with a MuCell unit from Trexel. The mold for a car door module announced in advance of the trade show was not ready for use at short notice, but the parts produced at Faurecia were exhibited. Here, the conventional foam streaks, weld seams, tiger stripes and gloss differences can only be seen on the reverse side of the part; the visible side is impressive with very fine, different textures and design surfaces, which are produced directly in the injection mold (**Fig. 4**).

Fig. 4. Plastic, color and reproduction in a ceramic-coated mold produce a partial textile appearance (right). Various textures can be combined in one part (top), only the reverse side (left) shows the surface defects of foaming. © Hanser/C. Doriat

Dr. Alexander Roch, Injection Team Leader at Faurecia, explains how it all works: "The cavity is coated with a technical ceramic, which acts as a short-term barrier during injection. In this manner, the melt on the cavity wall remains in the plastic state until a sufficiently high cavity pressure has built up to smooth the surface." You could call this a sort of passive variotherm process. "In a ceramic coating, a laser can introduce much more intricate and complex textures than into a steel surface. The process thus offers completely new design possibilities for the surfaces of plastic parts", continues Roch.

For plastics processors who produce parts in parallel on several production cells by physical foam injection molding, Engel also presented a new plant technology. While each injection molding machine used to require its own gas supply, Engel now offers centralized units (type: e-foam XL multi) for supplying several machines with highly compressed nitrogen. Only the metering and control technology remains decentralized on the individual machines. With this concept, Engel reduces the investment costs for foam injection molding, and therefore the unit costs per part.

Weight Reduction thanks to Alternative Materials and Know-How

The last exhibit, too, is a variant of physical foaming, also presented on a large machine, in this case a MacroPower 1100/12800 from Wittmann Battenfeld, which is equipped with an energy-saving, speed-controlled servo motor and a constant pump. In the manufacture of a door interior trim (**Title figure**) with a one-cavity mold from Frimo, they have a double "lightweight design effect." First, the door trim only consists of a lightweight natural fiber mat, onto which a map pocket and a thin support structure are molded. Second, the material used (type: Borcycle EE1300SY, Borealis), a 15 % mineral-reinforced PP containing 30 % PCR (post-consumer recyclate), is foamed by the use of the patented Cellmould process.

"A manufacturing process like this actually runs on a vertical press. For the first time, we are processing a natural fiber mat as a supporting structure with a horizontal standard injection molding machine and trimming in the mold", says Rainer Janotta, head of Business Development BU Form & Trim at Frimo. In this application, a Wittmann Robot WX152 picks up the cut-to-size natural fiber mats from a buffer stack and hangs them in an IR heating station. The heated mats are introduced into the stationary half of the injection mold with a combination gripper, the other part of which is designed for part removal, and then formed, punched and back-molded after the mold is closed. Finally, the robot lifts the finished part and offcut material from the mat out of the mold, while the preheated natural fiber mat on the gripper waits for the next cycle. The part passes to the deposition position, the offcut material falls into a waste bin.

"The lower part of the door trim comes out of the machine with a high-gloss finish, the upper part with the fiber mat is pressed laminated by the OEM", explains Janotta. "The mat consists of 25 % flax and kenaf and 50 % virgin PP. The lower density already results in part of the weight saving. In addition, the fine-celled foam structure in the map pocket and ribs additionally reduces the overall weight by 11 %." By the way, as sustainability is essential, the part is 100 % recyclable. This was demonstrated in a study by Volvo for a similar part. ■

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