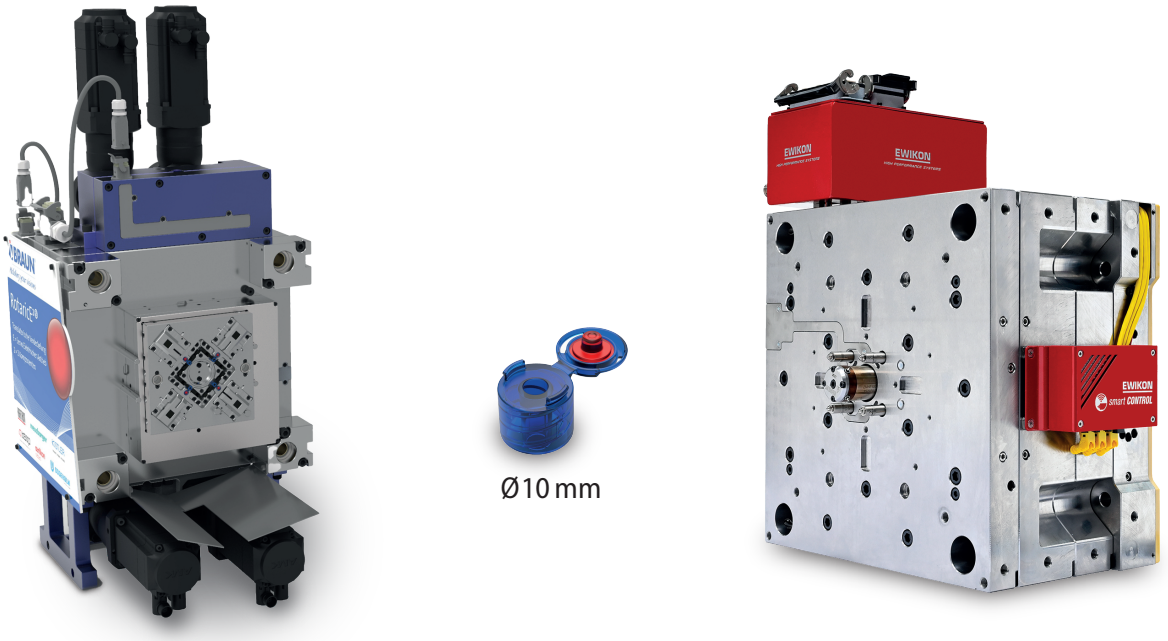
State-of-the-Art Injection Molding Solutions at K 2022, Part 3: Hot Runner Technology

Everything under Control

We have already taken a brief look at mold technology in the two previous parts (one of them in this issue) of our trade show review. In this edition, we look behind the cavity walls and along the data cable at what hot runner technology now offers in terms of mechanical, electronic and digital expertise.



The smart Control monitoring unit permits integrated monitoring of the injection molding production cell, including the mold, hot runner system and all ancillary components. The "Luer connector" application case was on show at K 2022. © Braunform / Ewikon; collage: Hanser

During injection molding, the hot runner must maintain precise and uniform temperature conditions during both the heating and cooling phases, since the quality of the injection molded part is directly related to the efficiency of the temperature control. Efficient control technology with comprehensive connectivity is therefore essential in principle. An illuminating tour of the trade show booths.

The Transparent Injection Molding Cell

The hot runner manufacturer Ewikon went well beyond its core competence in developing the smart Control assistance system. Managing Director Dr. Stefan Eimeke (**Fig. 1**) cannot stress that enough when talking to ***Kunststoffe***: "We are always quickly reduced to the hot runner system – no, smart Control is not just another separate data acquisition by means of an individual unit. On the contrary, we can monitor the entire injection molding cell, including the hot runner system and all ancillary components, independently of the machine manufacturers." Irrespective of whether we are dealing with the injection molding machine process parameters, such as injection time or holding pressure time, the signals from cavity pressure sensors, the flow rate of the temperature-control unit or the end position of the robot – the only prerequisite is that the equipment is OPC-UA capable.

All data are recorded via this standardized interface. "If this is done by analogue means, you always need one cable per signal. With OPC UA, it is only a data interface, and we have integrated this interface into the second expansion stage of our unit," says Eimeke. The relevant data could be easily selected by mouse click or touch control. Eimeke continues, "The system thus provides transparency about the process status and energy consumption, and, by logging all parameters, provides a continuous process history together with the deviations that have occurred. Together with other additional features for process optimization and quality assurance, we offer our customers genuine added value."

With various functions, smart Control helps to optimize the part quality and energy consumption. For example, "virtual rheology": "The shearing is an extremely important quality parameter. If the shearing is too high, polymer chains may quickly become shortened and the polymers be damaged, or particular components may be demixed. Raw materials manufacturers specify limits for this, depending on the material. But since the shearing cannot be measured, no one knows whether the value in the

Fig. 1. Keeping shear under control: Dr. Stefan Eimeke, CEO of Ewikon. © Hanser/C. Doriat

running process lies within tolerance – smart Control shows this directly," explains Eimeke. "As far as I know, we are the only manufacturer to run a real live simulation, with which the shear rate of the melt flow in the hot runner and gate is computed."

Shearing Is Displayed in Each Cycle

Why does that matter? For this, we must know that a hot runner is always designed according to pressure loss, shearing and residence time – however they are in competition with one another and are kept in a certain balance by simulation at the beginning of the project with an assumed injection velocity. However, if the injection molding parameters are changed when the machine is set up, there is the risk of falling outside the limit shear values. "We calculate these values live from shot to shot, using the currently measured temperatures in the hot runner and the current volume flow rate of the injection molding machine, on one hand, and the stored viscosity data of the material and the geometry data of the hot runner on the other," says Eimeke. The graphical display of the rheology characteristics of the melt shows at a glance whether the cycle is moving within the standard.

An innovation that Ewikon presented for the first time at the trade show is the "energy Monitor." The idea behind this is that the user should know what effect it has on the energy consumption if he changes process parameters, such as temperatures or pressures, and finds the right balance between quality, cycle time and energy efficiency during set-up if possible. "The power consumptions of all the machines and equipment involved in the injection molding cell can be recorded, and the smart Control uses this to calculate characteristic values, such as the energy consumption per injection molded part or per volume of processed plastic. This allows the operator to see how much energy a particular setting saves per part," explains Eimeke.

As soon as the process is stable, all data can be saved as master process data at the touch of a button. They are used as a comparison and reference for mass production and can be monitored by means of a traffic light system. If defined threshold values are exceeded, freely selectable follow-up actions are triggered, for example an alarm or a warning message by e-mail to the process manager. In addition, the productivity of the entire system is shown on the display at any time, with the possibility of calling up detail information at each individual level.

The process data recorded for quality assurance are only stored in the smart-Control unit. Eimeke adds, "We don't work with a cloud, because no company wants to publish its injection molding parameters – that is its know-how. If, according to the data record, the parts are OK, you can download them and add them to the batch as a quality certificate."

And if something goes wrong while production is running, the system provides assistance. "We have integrated the knowledge database from the KUZ Leipzig. Cavities, weld seams and many more typical injection molding defects were grouped together over years, and displayed intuitively, together with influencing parameters and possible countermeasures." But the system can do even more than that: for example, it generates maintenance information, either because a particular number of cycles has been reached, or because detected process deviations indicate the imminent failure of a component.

During K, the system was to be seen operating live on an Arburg machine, which, with a 4+4-cavity mold from Braunform, manufactured 11 mm sized Luer connectors of PP with a TPE-septum (**Title figure**). Since the shot weight of the TPE component is only 0.05 g per nozzle, it was tricky to design this hot runner with four valve nozzles (type HPS III-S) and a gate diameter of 0.7 mm, not only from the point of view of the residence time. "Microparts are a megatrend; the requirements in this area are becoming ever greater," says Eimeke. "We have recorded the complete injection molding cell, including the cavity pressure and temperature, valve position of the shut-off nozzle, shearing in the gate, injection parameters of the machine and torque of the servo drives installed in the mold for the core-pull movement." On the exhibit, the browser-based user interface of the smart Control, which can be called up on any mobile device, could even be seen on the display of the machine control (Gestica).

Hot Runner System for Micro Injection Molding

Günther Heisskanaltechnik, too, has gone with the trend toward micro injection molding. At K, the hot runner specialist presented for the first time a low-profile mini valve system equipped with BlueFlow low-energy heaters. Günther initiated the development project »

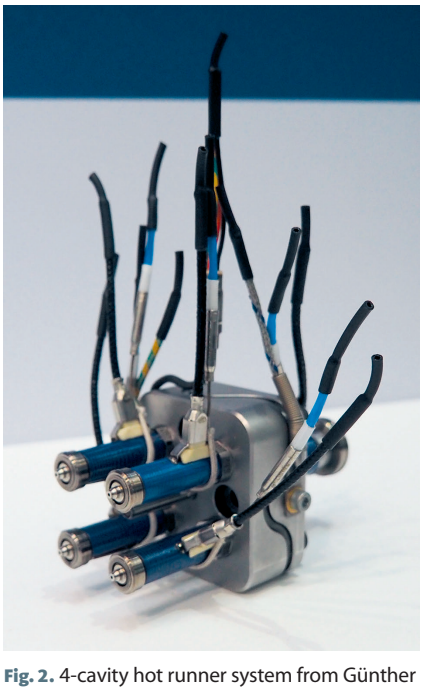


Fig. 2. 4-cavity hot runner system from Günther for microparts. The installation height, incl. valve system, is 129 mm. © Hanser/C. Doriat

Fig. 3. Dr. Stefan Sommer, new managing director at Günther, with the mini hot runner system and the two new control units, blueMaster pro (left) and blueMaster compact. The latter without its own display, but with (temporarily) docked-on smartphone.

© Hanser/C. Doriat

together with its partners Christmann Kunststofftechnik and IES, which eventually resulted in an exhibit with a Babyplast injection molding machine. The compact 4-cavity hot runner system has a nozzle spacing of 26 x 26 mm (**Fig. 2**). The gate point has a diameter of 1 mm. According to Marc Tesche, CEO of Christmann Kunststofftechnik, the balanced manifold with the externally pressed-in heater ensures optimum heat transfer to the manifold block and therefore a homogeneous temperature distribution.

The patented BlueFlow heaters, which are manufactured by thick-film printing, are only about 20 µm thick and are claimed to save up to 50 % electricity compared to conventional heaters from competitors. "Such a space-saving and energy-efficient hot runner design in this form is only possible with this technology," said Dr. Stefan Sommer (**Fig. 3**), still an authorized signatory until the end of 2022 and shortly afterwards appointed managing director of Günther, in a conversation at the trade show. The thick-film heating elements for hot runner nozzles are more intricate than conventional heaters and have a smaller diameter. Thus, the BlueFlow technology permits a more individual hot runner design, allowing a smaller mold.

"In the future, it will be possible to use molds for micro injection molding on such small performance-adapted injection molding machines as the Babyplast. Production will become more flexible in general, but also much more energy efficient, which of course is in the interests of all injection molding processors who want sustainability and energy savings," said Sommer. A new patent-pending lifting mechanism, which is installed in the mounting plate, rounds off the Mini system. With this system, on the small machine (type: 6/12 PT; clamping force: 60 kN), a small part is produced, which is installed in the sensor of a Hall probe, which measures the strength of magnetic fields. The part is usually made of PEEK; a PA6-GF15 was only used at the trade show because of its better availability.

The Smart Hot Runner System as Goal

Sommer is strategically planning to deepen the electronic and digital expertise within the company. The takeover of Esys GmbH in 2020 laid the foundation for this. The aim of the Günther Group is to make predictive maintenance of the machines and digital monitoring and control of processes a reality. "We are pursuing the vision that a smart hot runner system will become so intelligent that, with data autonomously calculated and analyzed live by means of sensors, the maintenance intervals of the hot runner system will be included in production planning and spare parts ordered in good time. If we avoid unforeseen maintenance and repair intervals, the downtimes will be considerably reduced," predicts Sommer.

The doctor of physics announced the new blueMaster series of temperature control units as a new platform for digital progress, which were also presented at the K show for the first time. "The blueMaster compact allows remote monitoring of quality parameters during injection molding by means of a simple user interface on the smartphone or tablet. With intuitive menu guidance, even inexperienced users are able to set up a hot runner system. The blueMaster pro is intended for all future technologies. It regulates the machines in a network, which it connects to a higher level in order to control the network in turn by means of data exchange with the other level. In future, one machine in the network will control the other machines," says Sommer, explaining the transformation in quality.

Control Technology with "Easy to Use" App

The four new blueMaster-pro variants are suitable for six to 24 control loops. The OPC-UA-capable traditional table-top controllers have a large range of functions and can be controlled either via the built-in 7-inch display or via a tablet browser if customers want to do without the display. Control via the control station is also possible. The network is connected via Ethernet or WLAN. An assistance tool not only supports the setting up of new molds, but also allows group management of multi-cavity systems and multicomponent applications. In addition to the clear graphical display of temperatures (curve recorder), a hot runner diagnosis function is also integrated on the user interface.

The blueMaster compact control units are designed for smaller applications or for use in service or laboratory applications. According to Sommer, they feature adaptive optimization of the control, i.e. they adapt their control behavior to the connected load without user intervention – adjustment of PID parameters is no longer necessary, the control remains stable even at extremely small loads. Four modes of operation (open-loop, closed-loop control, master operation, monitoring) are available per zone. "The newly developed control algorithm is even more precise and the automatic adaptation of the control parameters ensures good control quality without overshooting," explains Sommer. The units are optionally available with three or six control circuits and have integrated many of the features of a large control system.

In keeping with the new compact controller, which does not require a

Fig. 4. With CEO Torsten Glittenberg, Witosa is further expanding its portfolio of additively manufactured hot runner nozzles in different variants. © Hanser/C. Doriat

display (**Fig. 3**), Günther has developed an app that is easy to use even for users without injection molding training. The user-oriented introduction with assistance functions makes operation so simple that a guide manual is practically obsolete. The up-to-date menu guidance with graphical temperature displays is easy for users to interpret. "It gives them all the important parameters at a glance," stresses Sommer. "In addition, all the measurement data can be quickly and reliably uploaded to a cloud and used for documentation or a more detailed evaluation."

The app can be installed on all conventional smartphones or tablets, allowing position-independent operation of the control units. Communication takes place via Bluetooth, so that multiple controllers can also be operated. The integrated wireless charging module also simplifies handling during operation.

Valve Nozzles from the 3D Printer

Witosa rolled out a completely different digital approach as a business model in the previous year. With the presentation of the first additively manufactured one-part hot runner nozzles (type: Monolith), whose design is adapted for each application case with in-house developed algorithms, the company entered new territory in fall of 2021. "Sales of 3D-printed nozzles have risen rapidly since the introduction, and we have therefore rigorously expanded the field of additive manufacturing in R&D," CEO Torsten Glittenberg told ***Kunststoffe***. At K 2022, the hot runner manufacturer has now presented other products manufactured by the SLM (selective laser melting) process.

These are the so-called "energy blockers," the first additively manufactured pressure pieces in the world, which, according to Glittenberg, reduce the energy consumption of the hot runner manifold by up to 52 % compared to commercially available manifold systems with titanium or ceramic pressure pieces. "With these parts with perfectly formed internal three-dimensional structures, they make a considerable contribution to the energy revolution and to maintaining the position of the injection molding companies in the German-speaking region (Germany, Austria, Switzerland)," says Glittenberg. "We are talking about real savings potentials that can be leveraged with low investment. This has been confirmed by several applications measured under actual production conditions."

On the other hand, Witosa has expanded the product portfolio of 3D-printed hot runner nozzles. At the trade show booth, the trade visitors were able to see the first additively manufactured valve nozzles with the characteristic outer honeycomb structure in various sizes (**Fig. 4**). As with the open version of the Monolith nozzle, the base body is manufactured by SLM and, thanks to AI, has a kind of printed-in smart insulation and thermal conduction system. Thanks to the thermally balanced design of the Monolith needle-valve nozzle, the needle guide could be placed closer than ever to the gating point," explains Glittenberg. This maximizes the lifetime of the gate opening and ensures an unprecedented precision on entry into the valve diameter. The valve guide itself is designed as a single, separate part of powder-metallurgical steel, and can thus be detached from the otherwise monolithic nozzle and exchanged.

For customers in the medical, pharmaceutical and packaging sectors in particular, Witosa could offer another innovation: the Monolith hot runner nozzle as a floating version. In this case, the original 3D-printed die is complemented by a die head also manufactured by SLM. This, like the nozzle itself, contains a specially designed thermal conduction system and thus insulates the nozzle with respect to the injection mold. The energy losses resulting from thermal contact with the holding plate or mold plate by the previously commercially available nozzles are thus passé.

Since Witosa now also has a large number of screw-on melt-chamber variants in its program for the Monolith series, the company can immediately model the entire range of applications. But that is not yet the end. According to Glittenberg, "We want to successively expand the newly created portfolio »

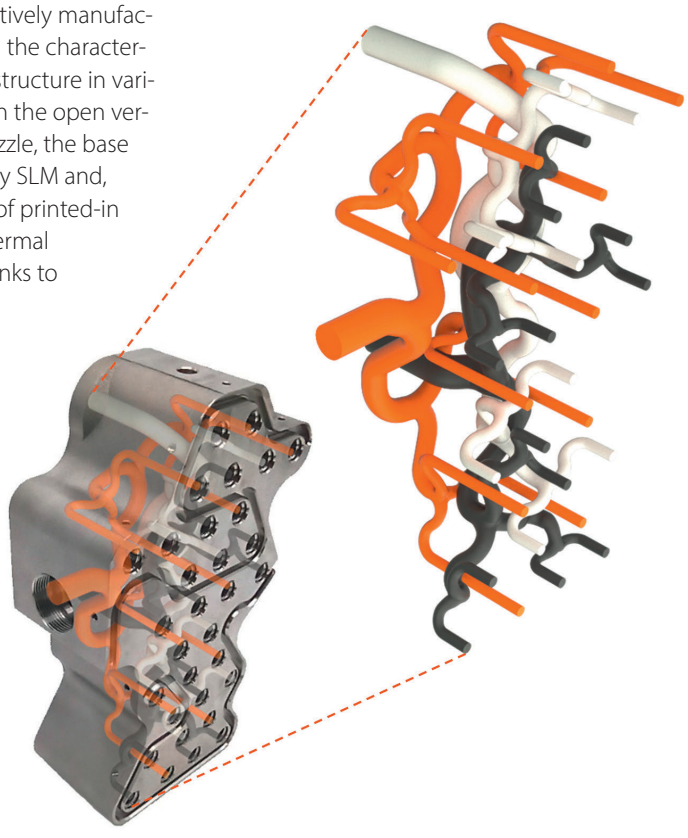


Fig. 5. The 3D-printed Streamrunner hot runner manifold opens up new design options for multicomponent injection molding. © Hasco

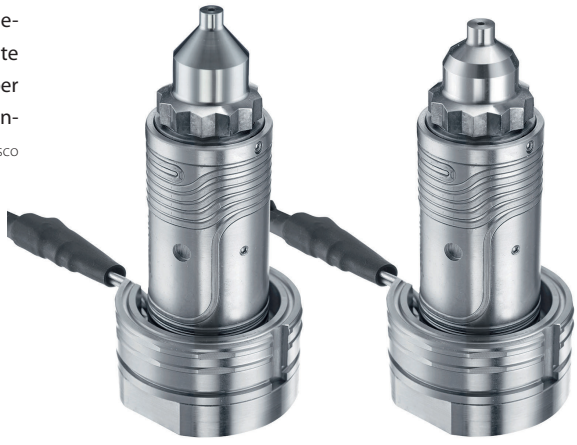


Fig. 6. The interchangeable Vario Shot Xgate valve prechamber simplifies mold maintenance. © Hasco

in the future. We have therefore invested in new SLM systems and greatly expanded our printing capacities because of the expected continued growth in demand."

Multicomponent Injection Molding Reaches New Heights

Hasco, too, immersed itself in the world of additive manufacturing some time ago. With the so-called Streamrunner, the Lüdenscheid/Germany-based company also entered a new era in hot runner technology. This is a 3D-printed hot runner manifold, which enjoys high degrees of freedom in design depending on the manufacturing principle. "With this technology, the flow channels can be designed rheologically so as to completely avoid sharp edges and regions of poor flow. This material-safe melt guidance leads to significantly lower shear loading in the plastic and subsequently improves the quality of the injection molded parts," explains Florian Larisch, Executive Vice President Hot runner Division. Thanks to the flow-optimized design, color exchange can also be carried out faster, since the melt splitting and material deflection can take place via generous radii.

The free three-dimensional design of the melt channels also opens up completely new possibilities for multicomponent injection molding. Various plastic components or pigments can be distributed in a very confined space and the channels intertwined together (**Fig. 5**). This allows product designers to overcome previous restrictions on the design of plastic parts and make use of new design options.

Since the additively manufactured manifold does not require separate deflection elements, the nozzle spacings can be made very narrow. According to Larisch, cavity spacings of 18 mm are possible, depending on the nozzle size used. The height can also be 20 to 30 mm lower than with conventional manifold blocks. A cost advantage is that the compact design is satisfied with lower mold sizes and therefore also smaller injection molding machines. "In addition, the low mass of the manifold block reduces the energy demand," says Larisch, pointing out an additional cost saving. On request, the Streamrunner is also available as a fully wired installation system or as a completely assembled hot half with precisely matched control technology.

Interchangeable Valve Melt-Chamber

In addition, Hasco is expanding its nozzle program with the new Vario Shot Xgate interchangeable valve melt-chamber (**Fig. 6**). "For some years, the powerful, highly efficient Vario Shot nozzle series has enjoyed increasing popularity. With over 1000 nozzle variants, we permit countless challenging applications – from gating on a submanifold to a high-end needle-valve solution. The particularly wear-resistant Xgate now simplifies maintenance of the injection molds and also significantly reduces maintenance costs," says Larisch. The lifetime of the gates is significantly lengthened and thereby ensures high part quality over millions of injection cycles.

The easy-to-change melt chamber, with its compact and easy-to-manage sealing seat, offers precise valve guidance with precentering, and is highly resistant to abrasive and chemically aggressive materials. The two new variants of the Vario Shot Xgate are individually tailored to the particular application case as a solution for either amorphous or semicrystalline polymers. Larisch continues, "In this way, the gate area and the contact surfaces can be variably designed for the required temperature management."

3D Data within a Few Minutes

With the example of the new hot runner configurator from Barnes Molding Solutions, two manufacturers showed how 3D data from 1, 2, 4 or 8-cavity hot runner systems can be generated within a few minutes. The intuitively designed

Fig. 7. Valve nozzle MCN-EP, here with 22 mm diameter and heating band. © Männer

configurator, according to the company, permits designs for part weights from 0.1 g to 300 g, for the time being only for the top selling nozzles of Männer and Synventive. The configurator is still in preparation for the nozzles of the third hot runner manufacturer in the group, Thermoplay. In the guided selection menu, users can access a material database, which currently comprises about 12,000 plastics.

Männer is also expanding two product lines with further valve nozzles. Like the tried-and-tested MCN 8 and MCN 6.5 models, the new MCN 5 valve nozzle from the Slimline series is particularly suitable for confined installation conditions in multi-cavity molds, in particular for direct gating close to the core or interior gating. And the packaging series for high-speed molds is complemented by the MCN-EP with small diameter and permanently centered closure valve (**Fig. 7**). The patent-pending design of the nozzle tip is claimed to facilitate high-precision gates and allow correction of the tip protrusion without secondary finishing.

But Männer not only has its nozzle series in mind, but also the optimization of the manifold. Thus, Dr. Stefan Kruppa, Vice President for R&D Molding Solutions, announced a 3D-printed manifold with the aid of artificial intelligence, but without going into detail. In any case, the design of the melt guide is intended to provide optimum balancing for a non-symmetric multi-cavity hot runner. The system has also been registered for a patent.

The sister company Thermoplay has expanded its TFS series of side-gating nozzles with two nozzles for larger part volumes. The second group of innovations is targeting special applications. They include, for example, nozzles for a 45° gate for manufacturing conical parts or multi-tip nozzles for small and micro parts, which are connected to multiple gating points. In the 3D printing process, Thermoplay provides an option for faster delivery times and presented the new multi-tip nozzle with an additively manufactured carrier ring.

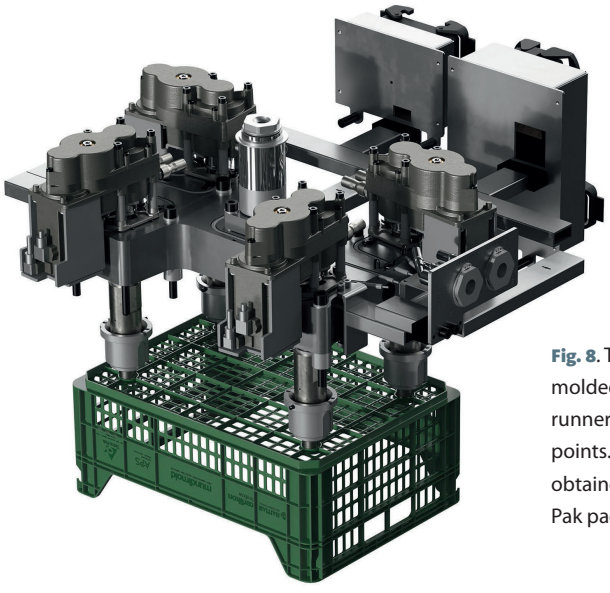


Fig. 8. The fruit crate is injection molded with an all-electric hot runner system with four gating points. The PE compound used is obtained from the recycling of Tetra Pak packaging. © Oerlikon HRSflow

Optimized Hot Runner Systems for PCR Compounds

To demonstrate its commitment to the circular economy, Oerlikon HRSflow has developed special hot runner solutions for PCR compounds. Their applications were shown as examples of a practical product. For the production of a fruit crate (**Fig. 8**), Mundimold processes an optimized PE compound from the Spanish supplier APS, which is obtained from the recycling of Tetra-Pak cardboard packaging. In the production of this challenging part, which was presented at the trade show at the Haitian booth on a servohydraulic injection molding machine of the Jupiter series with twin-platen technology and 4500 kN clamping force, a servo-controlled Flexflow needle-valve hot runner system with four gating points contributes to the repeatability of the process. According to Vice President Sales Stephan Berz, the new TTC cooling bush from Oerlikon HRSflow, which prevents blocking of the needles even with short cycle times, ensures high gate quality. The low energy consumption of the Flexflow system is also intended to support energy-efficient production.

At the Billion booth, a connection for a garden irrigation system was manufactured with a sophisticated 2-component mold (**Fig. 9**), which is equipped with two different hot runner systems with one nozzle in each case. In the first phase, a face-to-face torpedo system is used for injection of an ASA styrene copolymer, and in the second phase a screw-in cylindrical valve system for injection of an SEBS elastomer. During this second phase, the part can be customized by means of special markings in the mold. The special features include the automatic exchange of the mold version, which permits the production of three different product variants – in this case with different connection diameters – without the dismounting of the mold or interruption of production workflows. ■

Dr. Clemens Doriat, editor

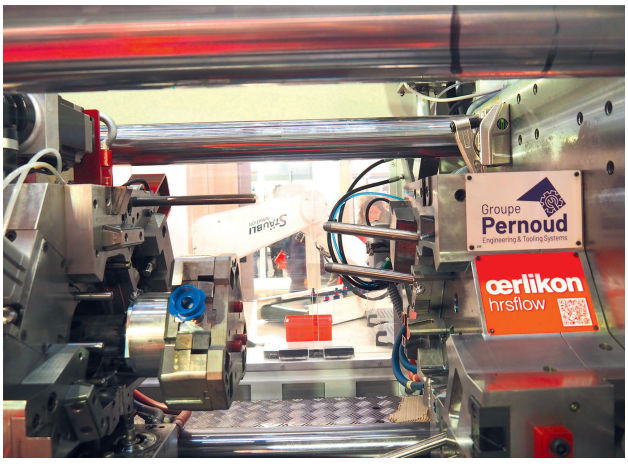


Fig. 9. Two-component mold from Groupe Pernoud with two different hot runner systems from Oerlikon HRSflow, which permits automatic exchange between three product variants without dismounting the mold.

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