State-of-the-Art Injection Molding Solutions at K 2022

It Can Be Done!

There's still a long way to go to save the world from the widely lamented flood of plastics, particularly in times of continued global growth in volume consumption and no substantial regional awareness of the problem. But this year, at least, the world's leading trade show K has succeeded in presenting practical solutions for greater resource efficiency on a broad front. A first foray through the trade show grounds.

K 2022 gave numerous practical examples showing visitors how recyclates can be reliably processed with digital aids. © Arburg

Of course, you can also see it this way: "What the energy crisis is unleashing is something like a sense of a new start," said Bengt Schmidt, managing director of the start-up **PlastiVation**, in an interview with ***Kunststoffe*** at K 2022. The organizers in Düsseldorf, Germany, may have headlined the world's leading trade show for the plastics industry with the focus topics of circular economy, climate protection and digitalization, but these themes were greatly overshadowed by the demand for highly energy-efficient solutions – even if all these topics ultimately pay into the same account (the keyword here is sustainability).

PlastiVation is quietly developing an all-electric injection molding machine series under the working title "Hurricane," which it claims will have the best performance on the market for a specific application in a few years, possibly by the next K. For this purpose, the company recently entered into a strategic partnership with a Swiss drive manufacturer to tackle the problem of the sluggish mass of large servo motors. PlastiVation has taken over the sales representation of **Tederic**. This company was present in Düsseldorf with three models of its Neo series, and was also the only Chinese injection molding machine manufacturer at K whose exhibits were connected to the umati internet platform.

According to the VDMA, 40 companies have taken part in an OPC-UA demonstration project. Each of the chosen machines was emblazoned with a QR code. Visitors to the trade show could scan it with a smartphone to access the umati platform, where they could see live data of the respective machine. In addition, a large dashboard was installed in the VDMA dome in the outdoor area, where visitors could actuate the data of the individual machines. Full digitalization.

Injection Molding with Solar Power

It doesn't get cheaper than this. That could be the title of a concept study, which **Wittmann Battenfeld** had drawn up together with its customer Wago and presented at the trade show on the Rhine. An eye-catcher for visitors to the booth was a solar panel, which was symbolically mounted on an all-electric injection molding machine and strikingly set the theme, namely operating an injection molding machine with direct current from renewable solar energy (**Fig. 1**). It all makes even more sense if you know that the servo motors installed in electrical machinery require direct current in any case. Technically, that means that the generally available alternating current (AC) must be converted into direct current (DC) by means of frequency converters. In the process, a (small) proportion of the energy is lost.

With solar cells on the company's own roof and the "green" electricity they generate, processors can not only save costs but also protect the environment. Wittmann

Fig. 1. Twin-track drives: the power electronics and drives of the machine are supplied with DC and the ancillary equipment with AC.

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Battenfeld and Wago have already applied for a patent for their solution to the question of how to use the direct current produced in this way directly and loss-free for operating injection molding systems. Another advantage of this concept is mentioned by Michael Wittmann, managing director of the Wittmann Group: "Apart from the fact that direct use of solar power keeps energy costs low, DC can also be readily stored in conventional batteries, and is thus an excellent solution for covering power peaks."

In the concept study, Wago produces terminal blocks of flame-resistant polyamide with a DC-operated machine (type: EcoPower 180/750+) and a 24-cavity mold. The parts are removed with a modified Wittmann DC-operated robot WX142, which is supplied directly via the DC intermediate circuit of the EcoPower, and likewise feeds the excess energy from a delay of the axes back into the intermediate circuit.

Besides the pure feeding and recuperation of DC on the injection molding machine, this development project also opens up the possibility of partial changeover, so that individual ohmic loads, such as temperature-control units, individual conveyors or mobile dryers, can alternatively be operated with alternating current. In the course of partial changeover, the DC intermediate circuit is still operated with DC current via the DC network. According to Wittmann, it is possible to equip the system with two feed lines, with the DC feed supplying the power electronics (drive technology) and the AC feed serving the ancillary equipment. For this purpose, the new B8X control system will in future be equipped with special components developed in-house in order to make the energy management within a work cell as efficient as possible and allow the use of renewable energies.

Two Screws Improve the Energy Balance

The theme of the public discussion, the circular economy, was the subject of a separate exhibition area in the outdoor area. In the Circular Economy Forum, the **VDMA** and 13 of its member companies demonstrated the high importance of technology in implementing the circular economy in the plastics industry. They ranged from the digital product passport, which facilitates homogeneous separation of the different plastic fractions, to the extraction and processing of recyclates. Another striking feature of the trade show was the high profile given to the processing of renewable raw materials in many places, and the abundance of biocompounds that now find their way onto and through injection molding machines as a matter of course.

In an own pavilion, **Engel** demonstrated how plastic waste can be processed as flakes on the injection molding machine directly after grinding. In a two-stage process, plasticizing and injection are subdivided into two mutually independent, coordinated process steps. In the first stage, the raw material, for example plastic flakes from a post-consumer or post-industrial collection, is melted. The unit also has the function of buffering raw material. This achieves a continuous processing operation. The melt is transferred to a second screw for injection into the cavity. Between the plasticizing and injection unit, a melt filter (Ettlinger) and a degassing unit are integrated into the process (**Fig. 2**) – this allows high-quality products to be produced even from contaminated plastic wastes.

A focus of the new process is on large-volume molded parts, which are already widely manufactured from recycled materials such as pallets or refuse containers. The advantage is that: "Direct processing of plastic flakes significantly improves the energy and CO_2 balance compared to processing of regrind," says Dr. Gerhard Dimmler, CTO of the Engel Group. The collected recyclable materials, after sorting and cleaning, are shredded, compounded, filtered and pelletized and transferred to injection molding as regrind. Pelletizing the regrind is an energy-intensive process; this step is completely eliminated by the two-stage process. However, this also changes the routine workflows in the supply chain.

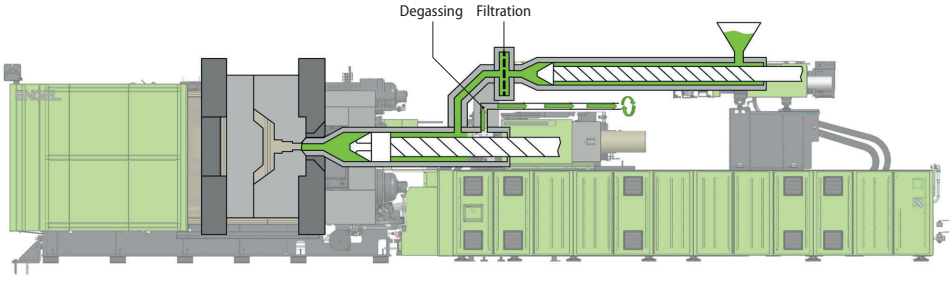

Fig. 2. Degassing: if residual moisture and volatile degradation materials were to pass through the melt filter without being removed before melt injection, this can lead to pores in the interior and defects on the part surface. Source: Engel; graphic: © Hanser

Reliable Processing of Fluctuating Material Qualities

In the **Arburg** pavilion, an Allrounder 370 A electrical machine manufactured a "Greenline" plug from Fischer, one of the market leaders in fastening systems. The exhibit was equipped with the so-called recyclate package and the machine manufacturer's new "aXw Control RecyclatePilot," which, by means of adaptive process control, keeps the shot »

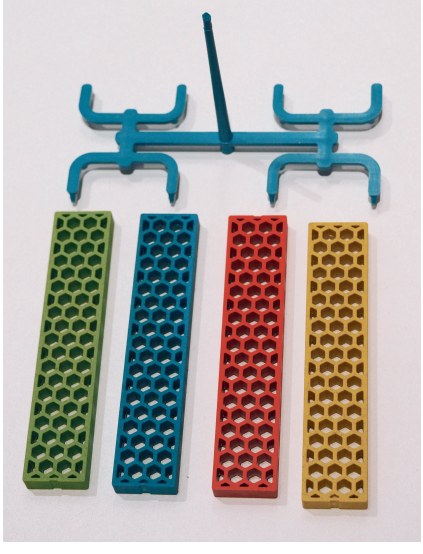

Fig. 3. The sprue from the 8-cavity mold (the picture shows products from different batches) is returned directly to the process.

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Fig. 4. The rABS for production of high-quality electronic boxes comes from post-consumer collections. © Engel

weight stable. In about 20 s cycle time, four plugs each were produced from a PA6.10, which contains 50 % renewable raw materials based on castor oil. The sprue was ejected directly into a grinder and the regrind was returned to the process as a post-industrial recyclate (PIR) and reused – a clear example, so to speak, of the circular economy on a small scale.

At the main booth, Arburg also showed, with several exhibits, how recyclates of different origin (PIR/PCR) can be reliably processed (**Title figure**). Here, fluctuating material qualities can be managed with the appropriate machine technology and digital assistance functions of the Gestica control system. The recyclate package comprises both hardware and software: "On the one hand, a modified cylinder module ensures uninterrupted feed of even poorly flowing materials, and a wear-resistant screw with a special geometry ensures homogeneous material treatment. On the other hand, the aXw Control ScrewPilot compensates for faults in the filling profile, and the aXw Control PressurePilot lays the basis for a bionically optimized pressure control," explains Guido Frohnhaus, CTO of Arburg.

Processing of Alternative Materials

At the Circular Economy Forum, **Wittmann Battenfeld** presented an application in which a compound of wood flour and PIR polypropylene from Fasal Wood is processed into toy building blocks. The injection molding machine is embedded in a manufacturing cell (type: Insider), in which the entire ancillary equipment, including handling robots, is integrated. The system presented at K is equipped with a robot, a conveyor belt and a type S-Max 3 screenless granulator from Wittmann. Here, too, the sprues of the injection molded parts are conveyed directly into the grinder after demolding, ground, and returned to the process (**Fig. 3**). The finished parts are conveyed on the belt to a tubular bagging machine and packaged. The bags are made of a Bornewables (Borealis) brand material, obtained entirely from waste and waste streams.

To ensure the quality of the parts, a software package is used. Thus, the new HiQ Melt Premium software computes the melt flow index directly in the control system and compares it with a reference value. Otherwise, the user does not know whether the flow behavior of the melt (usually quoted by the material manufacturer as the MFI or MFR in a particular bandwidth) changes during production. As a result, the viscosity fluctuations are immediately displayed to the tool setter and documented during metering of the material. The already established HiQ Flow software compensates for the viscosity change in the same shot. The machine setter's workload is thus reduced and the process stability increased. The package is completed with the HiQ Metering software for active closing of the non-return valve.

Broader Applications for Recyclates

To promote the development of a circular economy, it is necessary to make recycled plastic wastes usable for a wider range of applications. Visible parts with high-quality surfaces have so far posed a particular challenge. To obtain them as finished injection molded parts without secondary finishing, a high proportion of virgin material is usually required, if any recyclate can be added at all. Together with partners, including Moldetipo (moldmaking), Incoe (hot-runner system) and Standex Engraving Mold-Tech (mold engraving), **Engel** and the technology company **Roctool** demonstrated that there is also another way.

On an e-mac 465/160 injection molding machine, electronic boxes with a high-gloss surface were produced from rABS, sourced from post-consumer collections. On the top side, the boxes are provided with special patterns by laser engraving in the cavity; on the side surfaces, there are fixtures for mounting fans and connections (**Fig. 4**). The slim design with a wall thickness of 1.2 mm additionally saves material – conventional injection molding would require a greater wall thickness.

The key to the high surface quality of the recycled part is the mold temperature control from Roctool, which is based on induction technology and permits outstandingly accurate reproduction. The trade show exhibit utilizes the new energy-efficient, compact and air-cooled Roctool generators. Here, too, the full potential is only exploited in interaction with assistance systems; in this case, including iQ weight control from Engel, which recognizes fluctuations in the raw material and automatically adapts the injection profile, changeover point and holding pressure to current conditions in the same cycle.

Precision in a Confined Space

Moldmaking in general had a big presence at K. One of the workhorses at the Arburg booth, a three-component cube mold from **Foboha** with two rotating mold inserts each (at each cube side), is reported on in this edition of ***Kunststoffe international*** on p. 49. This "Citi" technology ("cube with integrated turning inserts") has since been patented.

Fig. 5. Luer connectors with molded-on septum on the lid. This is closed while still in the mold by means of a sophisticated mechanism. © Arburg

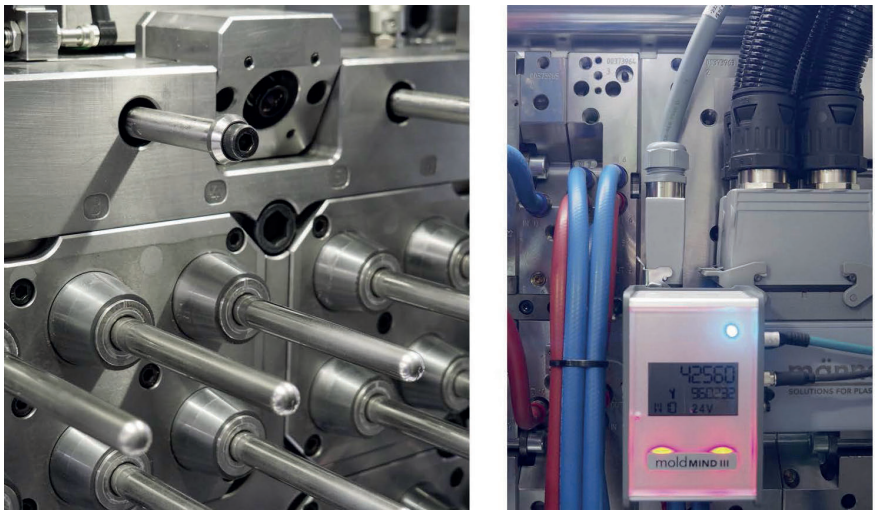

Fig. 6. Camera eye in the parting line (left, top) and digital mold cockpit (right). © Hanser/C. Doriat

How functional integration can be used to save time and costs was demonstrated by Arburg and its tool-making partner **Braunform** with the example of Luer connectors, which are used as closure caps in the pharmaceutical industry. Here, the component bodies, lids and septum are integrated in one part. The two-component injection molded parts (**Fig. 5**) were manufactured by an Allrounder More 1600 machine, with caps and unscrewing directly in the 4+4-cavity mold. The innovative solution saves a second mold and an additional assembly line.

Injection molding requires sensitivity and precision: the part weight of the PP component is 0.28 g, the soft TPE component, which is molded on as a septum, weighs as little as 0.05 g. The PP was produced from a renewable or chemically recycled feedstock (ISCC mass balance). Both components are guided in a fully balanced hot runner manifold (Ewikon). For the PP, direct side gating with multiple nozzles was chosen; the TPE was injection molded via four slender valve nozzles with a pneumatic lifting plate for the valve drive. This is exactly the challenge: "The sidegate arrangement defines the space, which makes the rotational movement difficult for the capping mechanism," explains Reinhard Steger, Business Development Braunform. The mold maker's solution is to turn the rotary movement with a servoelectric rotary drive into a translational movement, thus allowing a compact radial arrangement of the mold cavities with slides or masking devices by means of a sprue, or preferably a sidegate, system.

In the application of this RotaricE^2 technology, a central role is played by four servoelectric axes of the Arburg-affiliate AMKmotion, which are monitored via the Gestica machine control. They control the internal mold sequences for core back (release of the cavity for the second component), lifting the cap by means of a pin in the mold, capping the closures and unscrewing the Luer thread. This compact design makes it possible to use a large number of cavities in a confined space. According to Steger, mass-production molds with up to 64+64-cavity design are possible.

Via the "aXw Control CycleAssist" assistance function, the Gestica control unit knows the programmed cycle sequence. It graphically compares the current times of each cycle step with previously defined reference values. Unproductive time periods can be displayed with a mouse click and the cycle times thereby shortened. This allows high productivity to be programmed.

Anyone Who's Anyone

Mold makers who act on an equal footing with their customers have usually already taken the road to "big data" themselves. Thus, the "Moldlife Sense" computer system integrated into a 32-cavity mold of **Hack Formenbau** permits monitoring throughout the complete life cycle. The mold also ran at the **Arburg** booth and, on a hybrid Allrounder 630 H machine in a "packaging" and cleanroom version, produced transparent blood tubes from unbreakable PET.

Arburg together with its cooperation partner Hack, has implemented the new solution for communication between the mold and machine. A true-and-tested sensor system allows changes to be identified and localized during the mold movement and graphically displayed in "Moldlife Sense." Two cameras take pictures or videos of mold separation and part output (**Fig. 6**). In addition, there are four position sensors and four knock sensors for the column guides. In this way, even slight deviations from, e.g., slide and ejector movements can be registered, process changes identified at an early stage and damage to the mold reliably avoided. The data are transmitted directly to the machine control system via an OPC-UA interface. This shows corresponding faults and performance-dependent maintenance intervals. In addition, users can call up the dashboard from Hack directly in the Gestica control and via the network using an integrated browser.

The so-called "moldMind," designated by the mold and hot-runner specialist **Männer** as the digital cockpit of the injection mold, takes a similar direction, capturing the relevant process data and events of a mold in real time and recording them throughout the entire lifecycle (**Fig. 6**). The intelligent monitoring system identifies faults at an early stage and thus minimizes downtimes. The data can be called up directly on the device or via the Connectia Cloud, provided by the parent company Barnes. **Haidlmair** also offers a suitable solution, with real-time monitoring and documentation of production by Mould Monitoring from its subsidiary Digital Moulds. »

Info

Continuation Follows

In the coming editions, we will report on further highlights from the world of injection molding, which provided material for discussion at K 2022.

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A PDF file of the article can be found at
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German Version

Read the German version of the article in our magazine ***Kunststoffe*** or at
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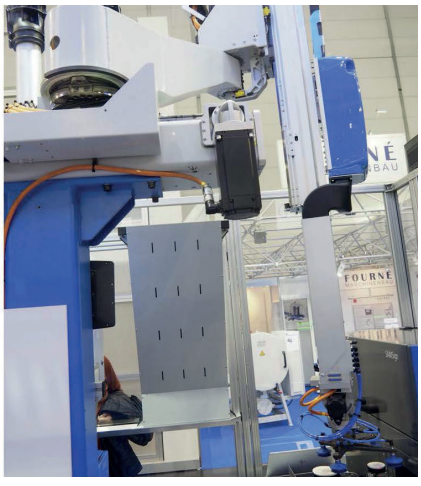

Fig. 7. The constancy of the part weight is graphically displayed on a monitor (left). A new combination of Scara and linear robots is used for part handling (right). © Hanser/C. Doriat

Documented Process Accuracy

The **Sumitomo (SHI) Demag** booth also presented a special type of monitoring, in a manufacturing cell that had been designed by the moldmaker and LSR specialist **Elmet**. An injection mold with a Smartshot E all-electric valve-gate cold-runner system produced four different LSR lids for beverage and food cans per cycle. The precision of the injection process is documented by a load cell from Mettler Toledo, which weighs each individual cap with an accuracy of 0.01 g, stores the result in a database, graphically displays it on a monitor and thus makes deviations in the injection molding process visible (**Fig. 7**). The finished Smartcaps are also laser marked as traceable parts at the end.

Precise and reliable metering into the 4-cavity injection mold is provided by the Smartmix Top 7000 Pro dosing system. Elmet itself developed both the systems that it uses. According to the manufacturer, the newly developed system is the most compact liquid silicone dosing system for 200 liter container units on the market. Compared to its predecessor, it contains a new pump system, which only holds about a third of the liquid silicone in the system and is therefore much easier to clean. In addition, the optimized follower plate geometry also helps to reduce the amount of residual material. The new system utilizes up to 99.6 % of the material; drum changing takes place fully automatically.

"The combination of high-precision metering, all-electric injection molding machine and electrical valve-gate cold runner permits an unrivalled accuracy in the reproduction of the part weight. The process accuracy visualized via the part weight shows visitors the precision with which a liquid silicone mold can produce using our equipment," said Harald Wallner, CEO of Elmet.

The second attraction at this booth was a robot developed by Sumitomo (SHI) Demag itself. The innovation (type: SAM-S) stands for six-axis hybrid robot kinematics, consisting of a combination of a Scara and a linear robot (**Fig. 7**). The series – currently planned with two sizes (12 and 25 kg load capacity) – is suitable for applications for which a linear robot is too inflexible and an industrial robot too complex for the operating personnel. The basic robot has five servo axes and can optionally be extended with a sixth axis.

Fig. 8. Three recyclates of different viscosities, plus three kinds of additives, are processed in one heating step by the DCIM process. © Hanser/C. Doriat

Blending, Compounding or Reinforcing Polymers

And that takes us back to the interplay between energy efficiency and sustainability. With the DCIM (direct compounding injection molding) process from **KraussMaffei**, in which a single-screw extruder is mounted in piggyback arrangement on a standard hydraulic injection molding machine (usually the GX series), the processor not only assumes material responsibility or gains a competitive advantage in the most favorable case by creating his own formulations.

"Since the entire material compounding and processing take place in one heating step and the compounded melt passes into the plasticizing unit of the injection molding machine without cooling or interim storage as pellets, the user also reduces his energy costs and carbon footprint," summarizes Michael Ruf, CEO of KraussMaffei. In addition, polymer degradation is reduced.

Technical parts that are suitable for direct compounding usually have cycle times of 20 s and more. In these cases, the additional material compounding takes place without affecting the cycle time. Like the injection molding unit, the extruder also operates in discontinuous operation. It stops automatically when the shot volume for the next cycle has been reached. DCIM should be particularly attractive for processing recycled material, bioplastics and natural fibers.

In the trade show application, three recyclates of different viscosities, plus masterbatch, stabilizer additive and iron mica as filler, were processed into a five-part polyolefin folding box (**Fig. 8**). To homogenize all the ingredients, the DCIM screw, with 30 L/D, has an unusually large length/diameter ratio. It just remains for the trade show applications to take shape in the real life. ■

Dr. Clemens Doriat, editor