28-pin micro-plug. The individual pins are barely visible to the naked eye

Extremely Economical Micro Parts

Precision and Micro Injection Molding. Until now, micro parts have been injection molded on standard machines. However, these machines are huge and expend a huge amount of energy on producing the molding compound – 99 % of which ends up as sprues. A new machine series offers a high-precision, cost-effective way of processing thermally homogeneous plastic compound in a dosage suitable for micro injection molding, thereby serving the precise needs of the market.

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What characteristics must injection molding machines possess to produce miniature or micro plastic parts? What is the optimal process for the production of such parts? These are fundamental questions, but more important still is: which machine offers the greatest benefit to molders?

There are many suppliers of injection molding machines whose products differ mainly in the machine concept and the design of the injection process. For high efficiency and also the best-possible quality for precision and micro parts, the production machine must be selected on the basis of the parts requirements and not vice versa. The machine concept, together with the selected drive technology, determines the productivity and energy consumption. The injection process, which is where the main technical differences between the various approaches are found, determines the quality, availability and, consequently, the productivity.

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What Clamping Force and which Shot Volume Are Needed?

Which requirements does a micro part impose on the injection molding machine? A 28-pin micro-plug made from POM weighing 3 mg **(Title photo)** shall serve to illustrate the requisite clamping force and shot volume. The projected area of the part, including gate, is 0.75 cm^2, and so a clamping force of 15 kN would be quite sufficient. Assuming that the least possible regulatable locking force of an injection molding machine is 10 % of its maximum force, each machine in excess of 150 kN would be technically unsuitable and waste energy.

For a mold with two cavities, each having a molded-part volume of 2.5 mm^3, the shot volume for both parts is just 0.005 cm^3 and is thus at the edge of what is feasible. Given such small quantities, the smallest-possible shot volume of an injection unit, with allowance made for the maximum dwell time of the respective polymer, is crucial. The smallest standard injection units fitted with a 14-mm screw have a minimum shot volume of 0.5 cm^3 under optimal conditions. This means that as much as 99 % of the plastic is wasted on the sprue. And it means that 99% of the material must be purchased, transported, stored, dried, melted, injected and cooled, only to be reground or discarded as waste – an incredible waste of resources. The associated energy expenditure drives up production →

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Fig. 1. MicroPower machines are available in two sizes; the 150 kN clamping force version is shown here (photos: Wittmann Battenfeld)

costs unnecessarily. At the same time, the oversized sprue extends the total cycle time, because it needs a long cooling time because of the large wall thickness. If the volume or wall thickness of the sprue were in a reasonable ratio to the product, the cycle time could be halved and thus production doubled for the same number of cavities.

The Injection Process Determines the Quality

The Micropower series (**Fig. 1**, manufacturer: Wittmann Battenfeld GmbH) has the very solution to this problem. Consisting of two models with clamping forces of 50 and 150 kN, this all-electric series covers the entire applications spectrum of small, precision and micro-injection molded parts. Two injection units with injection volumes of 1 and 3 cm^3 are available, with the minimum shot volume being less than 0.05 cm^3.

The injection module **(Fig. 2)** is of particular interest from a technical point of view, as it combines a diagonally arranged screw with an injection piston. The injection unit, which is a reengineered version of the Microsystem 50 model introduced in 1998, has a shot volume of 0.05 to 3 cm^3. It allows the injection of small, precision parts weighing a few grams to micro parts weighing only a few milligrams.

The unit processes all injectable materials on the first-in-first-out principle, and its universal screw geometry can accommodate all standard granules. A 14-mm screw plasticizes the polymer without stressing it and with the least-possible degradation. The exact quantity of shot is metered via the axial stroke of the screw. The back pressure for metering is regulated precisely by a servo motor. As soon as it has received the exact amount of thermally homogeneous melt, the injection piston accelerates the polymer to injection speed. Due to the smaller piston diameter compared to a screw injection unit, the injection speed can be set and controlled much more sensitively. The appropriate injection pressure is built up directly in the sprue only once the polymer has reached the cold cavity. This approach is therefore conducive to an extremely small melt cushion and very short flow paths. In addition, a cold material plug does not even arise in the first place, as there is no polymer between the cold mold and the injection unit. The MicroPower and its Microsystem predecessor are thus the world's only injection systems injecting thermally homogenous melt – this ensures that the micro parts are of unrivaled quality.

It is also possible to minimize the size of the sprues relative to standard technology to one-twentieth and thus to slash cycle times. In practice, savings are made of up to 90 % on polymer, 50 % on cycle time and 60 % on energy, compared to standard injection molding machines. One example is gears made from PEEK and weighing 27 mg **(Fig. 3)**. Simply by minimizing the sprue from 1.2 g to 190 mg, the manufacturer managed to save EUR 135,000 on material costs per year.

Upgrading to a Manufacturing Cell with Docked Function Modules

Since the unit reliably produces a thermally homogeneous melt, this unique injection process ensures a larger processing window, greater dimensional stability and lower parts warpage combined with less polymer degradation. The result is high-quality parts and stable production combined with a low reject rate. The range of applications is by no means limited to micro-parts. Thanks to the two clamping force ranges and the maximum injection volume, larger parts such as plugs, lenses, gaskets and coils can be produced economically, too **(Fig. 4)**.

As the base machine, the MicroPower is an assuming yet high-precision and rapid all-electric injection molding unit. The parts can fall freely through the delivery chute or be removed by a handling device. The generous space around the clamping unit itself offers sufficient space for larger molds.

As an additional benefit for customers, the machine is designed to integrate possible downstream production steps through simple docking of functional modules. Examples include fully automatic quality control with an image processing station or the packaging of parts individually or in bulk. Even sophisticated applications such as insert molding and combinations of different materials can be realized inexpensively and easily as a result.

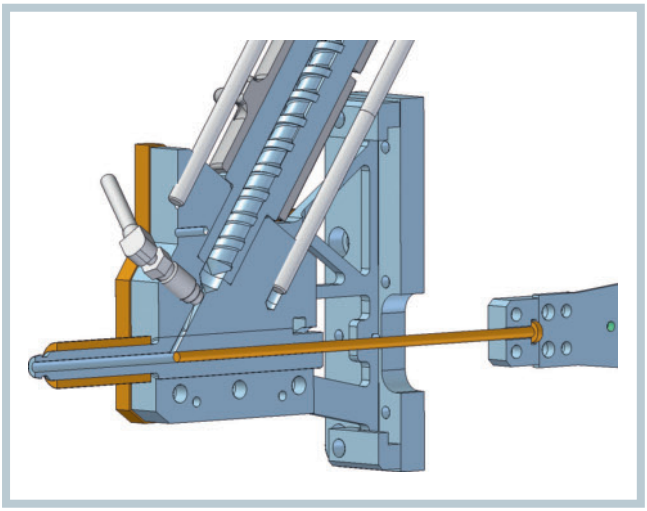

Fig. 2. The optimized two-stage injection system couples a 14-mm screw with the injection piston via a transfer bore

Fig. 3. Gears made of PEEK for medical technology. Due to the fact that the sprue could be reduced to less than 0.2 g, the manufacturer saved more than EUR 135,000 per year on material costs when producing these articles

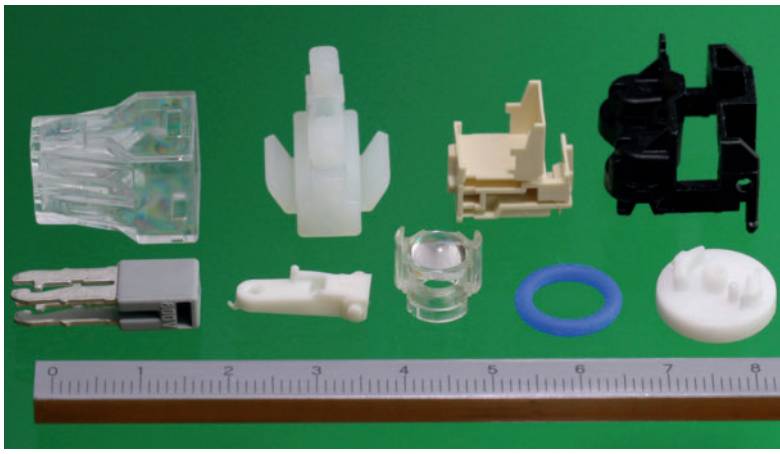

Fig. 4. Small components for the electronics industry, too, can be produced with the MicroPower

Peripherals Trimmed to Micro Dimensions

Consistent with its own philosophy of being a one-stop supplier of economic system solutions, Wittmann Battenfeld has adapted the entire peripheral equipment to the production of small and micro parts, starting with material dryers for smaller volumes and throughput rates, to material conveyors, through to temperature control systems boasting modified performance data. For the field of automation – a Wittmann domain – the company has developed a flexible vertical robot for small parts. The Scara W8VS2 robot, driven by three servo motors, offers highly dynamic, accurate removal of MicroPower-molded parts for further processing **(Fig. 5)**. It has been designed especially for such demanding tasks as insert molding and overmolding.

The powerful and intuitive Unilog B6 controller simplifies the handling of the injection molding machine and all integrated peripherals. It is now available across all model series from Wittmann Battenfeld, from the smallest MicroPower model to the largest of the MacroPower series.

Fig. 5. Standard modules, such as robots, camera, stacking units and special automation solutions, can personalize the workspace. The neat machine internals offer an ideal basis for cleanroom applications

Conclusion

The fact that the basic version of the MicroPower can be expanded to molders' needs by simply adding various functional modules and using peripherals adapted to the small amounts of material, offers enormous flexibility. The main benefit of the micro-machine, however, lies in the unique parts quality and its economic operation. By dint of shorter cycle times, lower material and energy consumption, it can achieve cost savings of between 30 and 50 % when compared to standard machines. Given such a savings rate, the capital investment quickly pays for itself. ■

THE AUTHOR

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