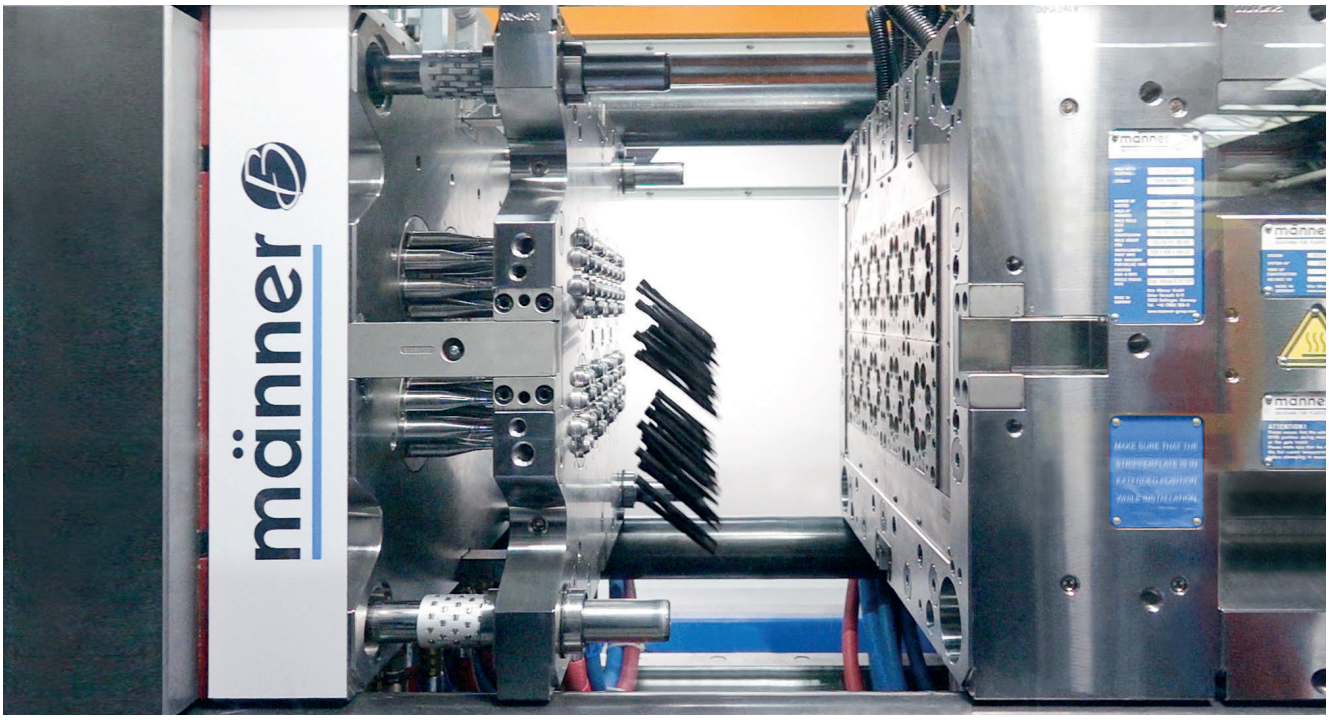
Maintenance During (Nearly) Uninterrupted Production

Pipette Tips: Männer Presents a Mold with Replaceable Clusters

They are both a precision product and a mass-produced item used daily in laboratories across the globe: pipette tips feature a challenging wall thickness/length ratio, an inner geometry that is key for analysis results, and a tip opening just a few tenths of a millimeter wide. They have been in extremely high demand during the coronavirus pandemic, which is why the mold construction and hot runner specialist Männer has developed a mold with an innovative cluster concept.



At the Männer test center in Bahlingen, Germany: an injection mold for manufacturing pipette tips, shown here in operation. Automation of the system is currently being set up © Männer

Pipette tips are used in laboratory diagnostics for collecting precisely defined amounts of liquid and transferring them to test receptacles. While their fill volume is determined by the height of the liquid level in the pipette, often marked at that spot, the analysis will be affected if there is too much or too little liquid. This means that the tip's geometry must be absolutely precise to ensure that the test results are reliable (**Fig. 1**).

The global capacity for the production of pipette tips is currently expanding in order to meet the enormous demand. This, however, requires complex production plants and investments totaling millions of dollars, which then have to be regained by an item that costs only a few cents each. The key to success includes molds with consistently high output rates.

Stand-Alone Mold Clusters with Eight Cavities Each

Männer has developed a mold concept (**Fig. 2**) specifically for the production of pipette tips, which not only meets strict technical requirements but also focuses on high availability. To almost entirely avoid downtimes in an operation that runs 24/7, the mold contains multiple clusters with eight cavities each that can be removed and replaced (**Fig. 3**). Each cluster contains a nozzle head and its own electric supply for the individual heated nozzle tips, allowing mold maintenance to occur right on the machine if production irregularities arise. A cluster simply needs to be replaced with a prestocked one, and production can continue.

Fig. 1. Polypropylene pipette tips. The wall thickness is 0.3 mm, the diameter of the suction opening is 0.35 mm © Männer

The mold concept considers the compatibility with existing pipette tip systems on the market to ensure that it can be integrated into existing production plants. Männer's hot runner expertise offers key benefits such as exceptional balancing exhibited during the start-up behavior and the so-called short-shot test. In three cycles, all cavities are filled to a level of 85 % each, and the weights of the molded parts are then compared to each other. The smaller the deviation from nest to nest, the better the hot runner is balanced. This also means that the parts' geometry is very precise, and overfilling and underfilling can be avoided – a significant factor for customers.

Precise Molding Geometry as the Basis for Accurate Diagnostic Results

Another key to the dimensional accuracy of the pipette tips is the centering of the cavity's core. In the event of a wall thickness of approximately 0.25 to 0.3 mm, there is not much space on any side. If the core were not centered, it would diminish the inner geometry and, consequently, the fill volume. In the worst-case scenario, this could lead to inaccurate diagnostic results. The key to staying within narrow tolerance ranges is to evenly fill the cavities. Because the connection is on the side, there is a possibility that the thin core could slightly avoid the melt stream (e.g., when the injection takes place very quickly), and it would no longer be completely centered. The temperature control and the hot runner technology from Männer – which individually regulates the nozzle tips – ensures optimal balancing, the controlled filling of the cavity, and better control of the wobble.

The precise temperature control in the entire hot runner is also the solution to counteracting a common phenomenon in open systems: so-called "drooling" (i.e., the melt that keeps flowing into the cavity when the mold opens). Thanks to optimally designed flow cross-sections and geometries, combined with Männer's outstanding temperature control, drooling and degenerated plastic in the hot runner are things of the past.

The extremely thin tip of the core has received additional attention. When the suction opening of the pipette is limited to a width of 0.35 mm to prevent aerosols from entering, the corresponding delicate core tip has to dip into a bushing of approx. 0.36 mm at a high speed, as mass-produced items require rapid cycle times (in this case, 5 s, not counting the removal). In order to avoid damaging the tip despite the small touching diameter, Männer has developed its own technical solution for the design of the opposite bushing.

Digital Mold Memory

In laboratories, pipettes are used with hand-held devices and fully automated pipetting systems. Using conductive pipette tips (**Fig. 4**), the latter requires that the fill level can be detected. In addition, they only have to minimally dip into the liquid, which reduces the threat of contamination – especially in the case of small volumes. For these applications, the types of materials used consist of conventional polypropylene as well as added conductive carbon blacks. The challenge is to optimally design the hot runner so that these additives do not lead to clumping – especially at bends and ends of the flow path. If the material remains there for too long, it will become thermally damaged, diminish the parts' quality of the production, and make it erratic. However, in the case of this mold from Männer, no carbon black deposits can be detected.

For monitoring the mold, moldMind II – the "digital cockpit for injection molding" – is used. Developed by Männer, the mold memory stores information in real-time and saves relevant process data throughout the entire lifetime of the mold. The system records performance maintenance, cycle numbers and times, temperature profiles, internal pressure, and critical events, as well as defines maintenance intervals.

Defined Quality Standards for a High Degree of Process Reliability

The medical technology market is an international business – this has never been more apparent than during the »

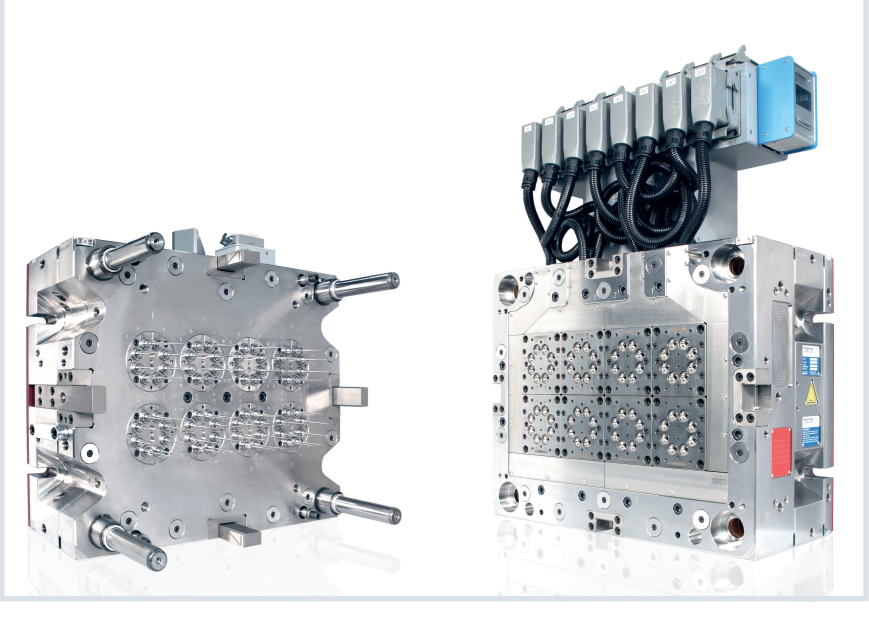


Fig. 2. 64-cavity single-face mold for pipette tips. The mold concept also takes into account the compatibility with available pipette tip systems on the market to ensure that it can be integrated into existing production plants © Männer

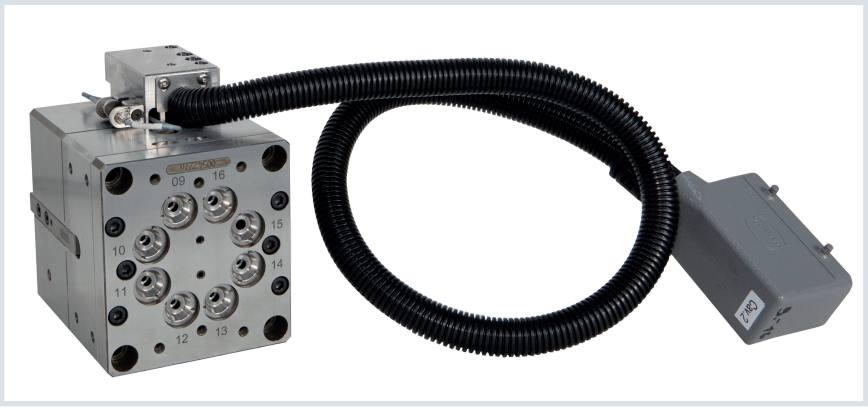


Fig. 3. Replaceable mold insert: cluster for eight pipette tips with own electrical supply for the individually heated nozzle tips © Männer

current coronavirus pandemic. Partnerships and the ability to supply products globally are crucial. Männer, a specialist for valve gate nozzles and a business within the Barnes Molding Solutions strategic business unit, was able to integrate its partners' expertise (**see Info box**) in the fields of open systems, sensor systems, and control technology.

In order to expand its presence in the diagnostics sector, Männer is currently investing in additional production machines with a focus on the production of cores, including those with extremely small diameters. Thanks to partnerships with injection molding machine makers, automation specialists, and manufacturers of peripheral devices, Männer has access to a complete production plant on-site (**Title figure**) to optimize the removal and automation of the pipette tip molds and perform the corresponding mold qualifications.

Because of the global composition of Molding Solutions' network, Männer has the ability to build molds in a Barnes facility in China, ship them to Europe for qualification, and ultimately add them to machines in the USA to produce plastic parts. The goal of the Group is to provide its customers, most of whom are also operating globally, with the best process safety possible by using defined quality standards.

Qualification via Camera Eye

High-performance machinery and expert process engineers are available at four Molding Solutions' qualification locations in China, Germany, and the USA to create the best possible conditions for the entire production. Upon request, production cells complete with office space can be installed in closed areas in order to protect sensitive new developments. After the mold has earned the "SAT-Ready" qualification and received complete documentation and optimal process parameters, it can be moved. During this current period of travel restrictions, customers can watch the qualification process online via Männer's high-resolution cameras. The goal of this integrated and global approach is to supply not only molds but also high-performance production systems that customers can use successfully in demanding markets. ■

Fig. 4. Pipette tips made of conductive polypropylene for fully automated pipetting systems so that the filling level is detected © Männer

The Author

Dr. Sabine Kob is a freelance journalist specializing in plastics technology.

Contact

Barnes Molding Solutions is a strategic business unit within the Barnes Group, which includes renowned brands from the injection molding environment (tooling, hot runner, temperature control and process control) with the companies Männer, Synventive, Thermoplay, Priamus, Gammaflux and Foboha. The group has own production facilities in Europe, China, and the USA Its parent company, Barnes Group Inc. (USA), is a provider of highly engineered products and industrial solutions.

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