

# Eliminating micromolding cold runners

Westfall Technik's micromolding technology allows direct injection of materials into cavities, removing the need for cold runners and handling polymers in a gentler way.

By **Vijay Kudchadkar** and **Brian Matachun**



MHS' M3 series with Isokor technology addresses challenges of molding small, direct-gated plastic parts.



**Above:** Large and costly quantities of scrap are produced to manufacture micro-sized parts.

**A**s medical devices get smaller, manufacturers require innovative, more reliable ways to produce small and micro-sized plastic components. Conventional approaches are costly, inefficient, and often unable to deliver the required precision and speed. A new micro-injection molding technology called Isokor improves speed and precision by eliminating molding inefficiencies.

Most micromolders use cold runners to manufacture micro-sized parts, ejecting the cold runners with the parts after each molding cycle. Parts must then be detached from the cold runners, which are either scrapped or converted back into granules to feed back into molding machines. Though cumbersome, the process was the only means of making micro-sized plastic parts. Until now, companies procuring micro parts had no choice but to live with significant drawbacks and costs associated with using cold runners.

## Micromolding without cold runners

Harald Schmidt and a team of Westfall Technik engineers developed Isokor, an injection micromolding process that eliminates cold runners and is gentle to polymers until they reach the gates.

With Isokor, a low-shear screw gently melts the polymer. Material temperature gradually increases inside a specialized runner engineered to provide a high degree of temperature control and uniformity.

Material only reaches processing temperature when nearing valve gates. That reduces high-processing temperature and shear-heat exposure while minimizing melt residence time and maintaining resin integrity. Gates open and plungers inject material directly into cavities.

Isokor's micromolding technique increases allowable residence time of the melt. For example, the maximum allowable residence time for polyoxymethylene (POM) grows from 15 minutes using conventional molding processes to more than 55 minutes using Isokor, allowing the micromolder to directly inject into cavities without a cold runner system.

Eliminating cold runners significantly decreases cycle times and increases production speeds. Cooling time reduction results in a 50% to 75% reduction in cycle time. In addition, the micromolder does not have to wait for the cold runner to fill and pack during each cycle.

### The cost of scrap

The weight of a cold runner system can be 2x to 50x the weight of the part; an excessive amount of waste, especially when cold runners can't be recycled and resin is expensive. Even when regrind is permitted, it's not possible to reuse all of the cold runner scrap since the part volume is so small compared to the cold runner volume. The vast amount of cold runner material that can't be reused must be disposed of, sold, or ends up in landfills.

Cold runners require handling, which increases the number of steps in the process and production costs. Millions of parts have to be detached from millions of cold runners. Labor and energy are required to recycle cold runners and dispose of unused ones, so the scrap costs add up quickly. (See sidebar, above)

### Long cycle times

In injection molding, cooling time (for plates) is directly proportional to the square of the plastic's thickness. If the thickness of the cold runner is 3x more than the thickness of the part, required cooling time for the cold runner is 9x more than the part's cooling time. If the micro-sized part cools in 0.5 seconds, the

molder would be waiting an additional 4 seconds for the cold runner to cool down. If it takes 43 days to produce 1.5 million microparts on a 4-cavity cold runner tool, 17 days would be spent waiting for the cold runner to cool down.

Consider an application where the production goal is 16 million acetal parts per year. The part weight is 0.007g, the cold runner-to-part ratio is 25:1, and the cycle time is 12 seconds. The part would reach ejection temperature in 1 second and the cold runner would need an additional 6 seconds to reach the ejection temperature. Making 16 million parts require 278 days with an 8-cavity cold runner tool. Eliminating cold runners and using an 8-cavity valve gated tool, cycle time would reduce by 6 seconds and it would be possible to make the 16 million parts four months sooner. With a 32-cavity, valve-gated tool with Isokor technology, 16 million parts could be produced in less than 40 days.

### Annual cost of cold runner scrap 5 million PEEK micro parts



## Advantages

- Application: 5 million polyether ether ketone (PEEK) microparts/year
- Part weight: 0.0067g
- Material cost: \$198/kg
- Mold: Two-cavity cold runner
- Runner-to-part weight ratio: 27:5
- Per cycle: 2 useful parts; 55 parts worth of material scrapped
- Yearly waste: 921.25kg of resin, \$182,407.50 value
- Isokor production: Avoid 100% of above costs; 1 ton resin saved

With bioabsorbable materials, cold runner scrap costs climb quickly. Runner-to-part volume tends to be higher to reduce the shear stresses and shear rates. If part weight is 0.027g and runner-to-part weight ratio is 9.26:1, making 8 million parts wastes at least 2,000kg of resin. With a resin cost of \$3,760/kg, resin cost waste is nearly \$7.5 million.

### Short shots, voids

In cold runner conventional micromolding, material flows from the molding machine through long cold runner channels before reaching micro-sized cavities, during which cold walls of the mold cause the plastic melt to lose heat. Material contacting mold walls solidifies and forms a frozen layer, continuing to grow until the runner solidifies. The runner's core must be hot enough to fill the part and pack it sufficiently as quick core temperature drops may lead to short shots or voids.

To fix these problems either the injection velocity and/or the cold runner size must be increased. Increasing injection velocity significantly increases shear rates and stresses in material, so this solution can't be used for shear-sensitive materials. Often the only option is increasing the cold runner 50% to 90%, creating production problems by increasing costs of cold runner scrap and cycle times.

## micromolding

### Inconsistent part weights

The weight of a plastic part depends on cavity volume, material properties, melt temperature, and pressure during the molding cycle. For a robust process, the melt temperature delivered to each cavity, during each cycle, must be consistent. Melt temperature variation depends on the screw design, screw revolutions per minute (rpm), material viscosity, cycle time, back pressure, and barrel temperature profile. When the melt flows from the machine to the cavities, cold runners increase melt temperature variation. So, when molding with cold runners, it's difficult to deliver consistent melt temperature to each cavity during a cycle. This usually results in unacceptable parts and increases scrap rates. Due to melt temperature variation, shot-to-shot part weight consistency and dimensional stability also reduces.

Degating cold runners from parts may not be precise, and it's possible to leave gate vestiges on some parts. And, small gate marks on micro-sized parts become significant – inconsistent degating and large gate vestiges can create surface defects and microfractures, increasing scrap rates.

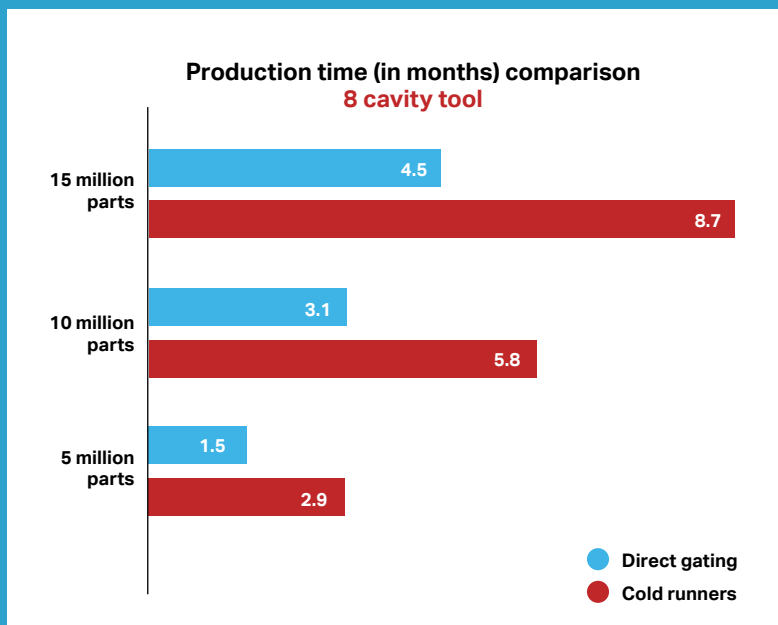
### Conventional hot runners

Micromolders have explored using conventional molding machines and hot runner technology. Conventional molding with hot-runners subjects the melt to high processing temperatures in the machine barrel and the hot runner channels.

However, residence time for conventional hot runners is too high for many sensitive materials such as acetals and polysulfones.

High cavitation is necessary for high-volume applications. However, with conventional hot runners, higher cavitation leads to longer residence times due to increased hot runner volume.

For a 50mg part, an optimized 32-cavity hot runner would have a minimum volume of 40cm<sup>3</sup>, which results in a large runner to part volume ratio. For sensitive materials, it's important to remove the material from the hot runner system as quickly as possible as small increase in cycle time or any stoppage in production can degrade material. These challenges made traditional hot runner processes not feasible for micromolding.



## Isokor vs. direct gating

- Higher quality direct gated parts, eliminates wasted cold runner material, secondary processes
- Cleaner gate vestiges
- Faster cycle times for 0.001g to 0.400g parts
- Extremely high production outputs
- Increased allowable melt residence times
- High cavitation in lower tonnage; smaller footprint, machine
- Cleanroom suitable
- Energy savings

### Improved part quality

In conventional molding, material experiences high shear stresses and shear rates before reaching cavities. And, before entering cavities, material temperature is also lower than recommended processing temperature. With Isokor, material is treated gently until injected into cavities at recommended processing temperature, allowing for better injection process control. Cavities are filled and pressurized in milliseconds, improving shot-to-shot consistency and cavity replication, improving quality performance issues such as short shorts, sink marks, and voids.

Clamp tonnage is directly proportional to the projected area and melt injection pressure. In cold runner micromolding, cold runner projected area dictates the size of the molding machine. Increasing tool cavities results in increased cold runner projected area. As molding machines

get bigger, micromolders lose the ability to control micropart filling. With Isokor, clamp tonnage is dictated by the projected area of the micro-sized parts only, making it easier to scale production and maintain control throughout the molding process. **tmd**

### Westfall Technik

<https://www.westfall-technik.com>

*About the authors: Vijay Kudchadkar is a territory sales manager for Westfall Technik and can be reached at [vijay.kudchadkar@westfall-technik.com](mailto:vijay.kudchadkar@westfall-technik.com). Brian Matachun is the senior director of Healthcare Sales at Westfall Technik and can be reached at [brian.matachun@westfall-technik.com](mailto:brian.matachun@westfall-technik.com). Both Matachun and Kudchadkar are degreed plastics engineers. Kudchadkar has 9 patents in injection molding and Matachun has more than a decade of experience in complex micromolding.*