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BY DAVID GEHMAN

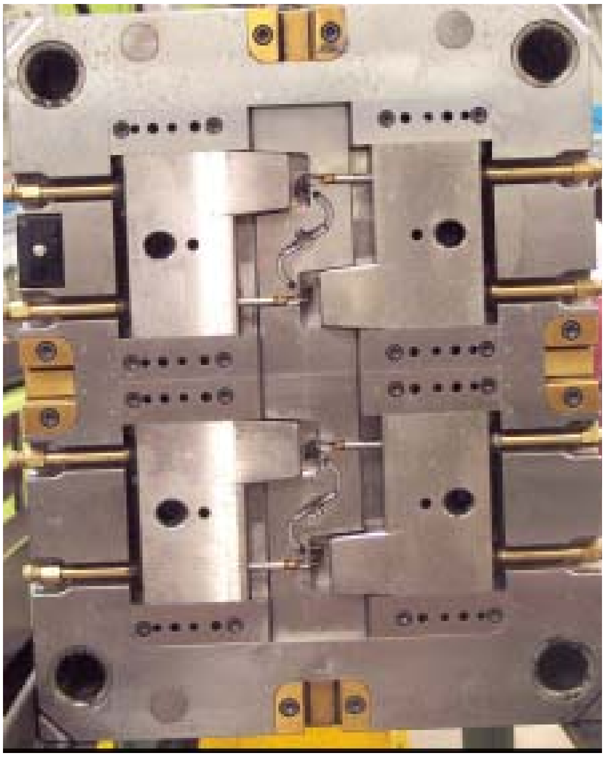
CUTTING INTO MIM

Metal injection molding is growing—and so is the need for tooling.

Back in the early 1980s, someone looked at thermoplastics injection technology and saw a way to apply its benefits to metal parts. The result was the development of metal injection molding.

With MIM, a mold is mounted on a thermoplastics injection machine and a metal powder carried in a thermoplastic binder is injected into the mold—via conventional injection methods—to form a part.

This is a simple explanation for a moderately complex process (see sidebar, page 44), but MIM has proven itself in the production of small, high-volume parts. The process is designed to eliminate metalcutting—more accurately, to avoid multiple setups on small parts.



Kinetics

Tooling for MIM is similar to that for thermoplastics injection molding, but with some differences.

Why should a person who makes a living by cutting metal consider it? Simple: it requires tooling. So, if you're good at making dies and molds, and if you like having long-term relationships with customers, you might consider joining the MIM supply chain.

MIM has increased noticeably in the last couple of years. Metal powder processing has made its way into classrooms. Additionally, word of mouth has driven MIM adoption in medical parts and firearms manufacturing and other areas where small, highly complex parts would otherwise require many costly manufacturing setups.

"We've never seen such an uptick in activity as in the last half year," said Paul Hauck, director of design engineering and marketing for Kinetics Inc., Wilsonville, Ore., a MIM parts manufacturer since 1982. "Maybe we as an industry have finally educated enough people."

While the MIM market remains fairly small—the Metal Powder Industries Federation indicates that annual sales of MIM products represent around $200 million in value worldwide—anything moving upward in manufacturing is worth a closer look.

Plastics Tooling + A Little More

MIM toolmaking, like many toolmaking considerations, presents two sides—the technical and the business.

On the technical side, the concepts of MIM tooling are identical to tooling for thermoplastics injection molding. The innards of both types are identical. Geometrically complex or feature-rich parts are likely to have undercuts, through-holes, ribs and bosses. Because of these geometric features, many MIM tools require slides, complex cores or other items both moving and stationary that characterize high-end thermoplastics tooling. And, similar to all thermoplastics tooling, MIM tooling requires mold bases, cavities, ejector pins, cooling channels, sprues and, potentially, hot-runner components.

In practice, however, some important differences exist between tooling for MIM and thermoplastics injection molding.

"Anything you can do with plastics-mold tooling you can do with MIM tooling," said Greg Brasel, vice president of manufacturing for Earth City, Mo.-based Megamet Solid Metals Inc., which has been producing MIM parts since 1991. “You use standard techniques, materials, coatings, inserts and components. But you do have to make sure there is no flash or vestiges on the molded parts.”

Any flash or prominent witness lines where the mold separates translate into unwanted metal on the finished part. Most likely, it will have to be machined off, but the whole idea is to keep MIM parts away from machines that remove metal.

On top of this, the leakage that causes flash is a tooling time bomb. While MIM feedstock is no more abrasive than glass- or mineral-filled thermoplastics molding compounds, like those materials, it will wear the tooling. Because MIM pressures are higher than conventional thermoplastics processing, leaks cause relatively more feedstock to escape. Fugitive feedstock will rapidly cut deeper and deeper into the tooling.

Because of the need to prevent leakage, MIM mold shut-off, or kiss-off, must be as tight as possible. This includes all areas where metal meets metal as the mold closes, including parting lines, molded ribs and features created by slides or other moving elements in the mold. Thus, all pins, slides and moving components of the cavity or core must seal tightly.

A second contrast is that MIM ejector pins tend to be proportionately larger than on thermoplastics tooling. This is to minimize distortion or breakage of the relatively tender part prior to sintering.

Finally, vents must be smaller than for thermoplastics molds to prevent creation of tiny, sharp protrusions on the molded part. Vents for thermoplastics range from 0.002" to 0.004"; vents for MIM tooling are a magnitude smaller, 0.0002" to 0.0004".

Megamet

Standard thermoplastics injection machines are used for MIM.

The overriding need for good sealing of molded parts means that making tooling for MIM can be a challenge. “I’d put it this way,” Brasel said, “if you don’t know GD&T [geometric dimensioning and tolerancing], you’d be happier doing something else.”

Another aspect that makes MIM toolmaking a challenge is that MIM parts shrink 20 percent or more as they change from the green to sintered state. Therefore, tooling can go through several intermediate stages prior to final sign-off.

“For tough geometries, you sometimes have to make the tooling undersize and whittle metal away after test shots show you finished sizes,” explained Brasel.

Exact shrinkage depends on the type(s) of metal powder used, the type of binder and the part geometry. As with many filled thermoplastics, there can also be variances between shrinkage along the direction of injection flow and shrinkage transverse to it.

Long-Term Opportunities

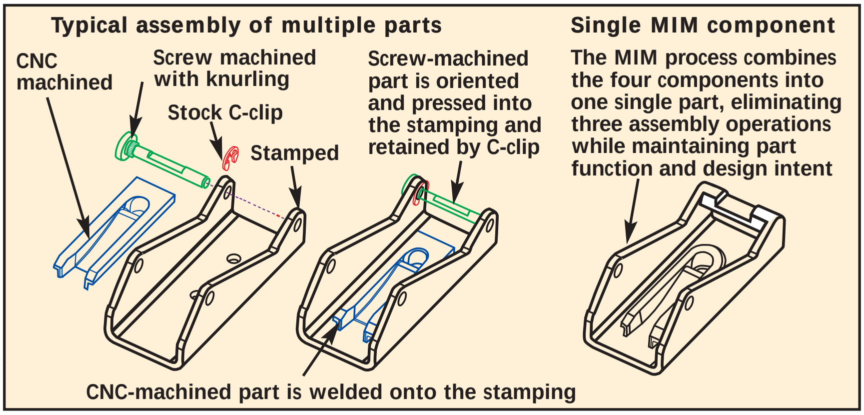
The fact that MIM tooling can be iterative and that it almost always will require maintenance offers toolmakers an opportunity to strike long-term arrangements with MIM part manufacturers.

Mike Harris, sales engineer for Mueller Machine and Tool Co. LLC, St. Louis, said: “When you’re approaching MIM projects, you want to be part of a team. Ideally, you want to be included at the beginning and during the designing of the part as well. You have to pay close attention to how much a client knows about MIM, shrink factors and MIM tooling.” Mueller supplies tooling to Megamet and produces dies for casting, stamping, drawing and trimming, as well as special machinery and fixturing.

Interestingly, Kinetics prefers to work out all tooling dimensions prior to sending 3-D solid models to its tooling suppliers. “Otherwise, we’d consume an inordinate amount of time on the moldmaker’s part with every prospective project,” Hauck explained. “We’d rather have shops focus completely on each final project’s tooling.”

But then, Kinetics has 34 years of experience making MIM parts. Manufacturers with less in-house knowledge are more likely to want to bring toolmakers into the picture sooner rather than later.

If early partnering is useful, collaborative arrangements during product runs can be equally valuable. “When



Kinetics

With MIM, a part that otherwise would need multiple metalcutting operations performed on it can be made in a single molding.

Megamet

MIM parts can exhibit geometries almost impossible to machine.

you make hundreds of thousands, or millions, of parts, tooling condition is golden," said Brasel. "Toolmakers could help themselves by becoming more proactive about ongoing maintenance. You can't just make the tool, ship it and forget it."

For high-volume, long-run MIM tooling, shops might consider formal maintenance agreements, both for scheduled checks and for emergency repairs, such as replacing an ejector pin that has begun leaking with an oversized one.

"Anything that allows longer tooling life and gives us a dependable and predictable link to ongoing maintenance would be a plus," Brasel said.

A more overarching business consideration is that of macroeconomic cycles. Those industries that favor MIM, including aerospace, military, medical and telecommunications, have business cycles that differ from general manufacturing cycles. In other words, with the right mix, one can stay busy more or less independent of the overall manufacturing scene.

A final point is that like all long-run, mass-production methods, MIM is time- and price-sensitive. As such, both MIM toolmaking and manufacturing have begun to move offshore. But for a while the potential need for rapid iteration prior to first run, combined with the definite need for responsive, on-going maintenance, should help persuade MIM parts manufacturers to have their tooling done locally.

The upshot is that MIM toolmaking might be for you if you:

- welcome metalcutting challenges;
- can be creative about long-term business arrangements;
- adopt time- and labor-saving technologies; and
- can add enough value to compete with offshore suppliers.

If you already do die and mold work, moving a step further might not be difficult. And if you don't, the incremental—and growing—market offered by MIM might entice you to take the MIM toolmaking challenge. △

What is MIM?

Metal injection molding of parts has been around for 35 years. Generally, MIM parts weigh less than 250 g and are, at most, the size of a folding cell phone. However, larger components are becoming more common.

If 20,000 to several million parts are needed, and the parts have complex geometries—20 to 30 measurable dimensions that would call for three or more machining setups—MIM is a viable option. Some of the parts it has been used for include computer hard drives and other peripherals, hand tools, firearms, fluid injectors and sprayers, medical products and cutting tools.

MIM requires three steps:

- injection under heat and pressure of a mix of powdered metal and thermoplastics or other binder into a mold cavity, analogous to thermoplastics injection molding;
- removal of the binder by heat or solvent, leaving just metal powder; and
- sintering of the metal powder at a temperature below the melting point of the metal, but high enough to cause the almost-microscopic powder to coalesce virtually into solid metal (the resulting density is greater than 96 percent that of solid metal).

MIM can be done with carbide, other metals and metal alloys, including precious metals. The metal feedstock particle size is far smaller than metal particles used in other powder metallurgy and might better be described as metal "flour." It is as fine as metallic paint pigment (less than 20µm).

Attributes of MIM parts include:

- net shape with good dimensional tolerancing;
- great freedom of shape, including molded-in blind- or cross-holes, small radii, thin sections and other complex geometry; and
- mechanical properties nearly equivalent to metal processed with conventional cutting, welding, forging and stamping.

Depending on the application, sintered parts might be hardened (including case-hardened), polished and finished. Machining might be required to add features, remove molded-in supports for sintering, touch up the part or achieve a final dimension.

Ongoing and future developments for MIM include environmentally friendly binders, continued refinement of metal powders, process simplification and cost reduction, and design tools (including mold analysis) that accommodate the shrink factors in the process.

—D. Gehman

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About the Author

David Gehman has been writing about manufacturing and software for more than 20 years as both a journalist and a marketing communications specialist.