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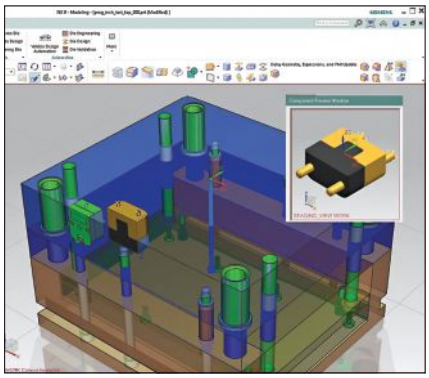

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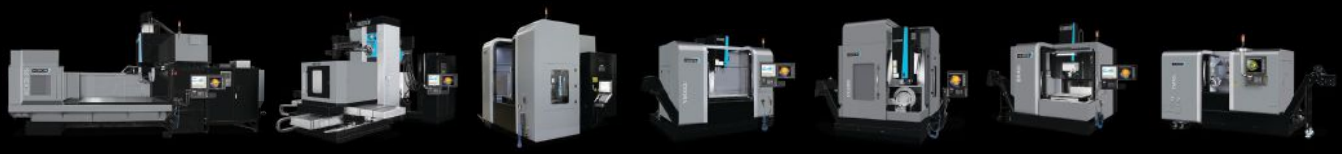

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Publisher
Ryan Delahanty ..... rdelahanty@gardnerweb.com

Editorial Director
Christina M. Fuges ..... cfuges@gardnerweb.com

Assistant Editor
Heather Wintle ..... hwintle@gardnerweb.com

Contributing Writer
Peggy Malnati ..... pmalnati@garpub.com

European Correspondent
Barbara Schulz ..... bschulz@gardnerweb.com

Art Director
Carla M. Turner ..... cturner@gardnerweb.com

Advertising Production Manager
Chris Larkins ..... clarkins@gardnerweb.com

GARDNER Business Media, Inc.

6915 Valley Avenue
Cincinnati OH 45244-3029
P 513-527-8800
Fax 513-527-8801
gardnerweb.com
moldmakingtechnology.com

Subscription Inquiries:
For questions or issues related to your subscription, please call 513-527-8800 or email subscribe@moldmakingtechnology.com

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February 2020 Volume 23 / Number 2

Features

Departments

ON THE COVER

This month's cover image demonstrates the innovative thinking that takes additive tooling beyond conformal cooling. The conformally cooled cylinder mounting plate was transformed to keep the cylinders from overheating and the switches from burning out, enabling designers to eliminate these problems and keep the mold running without downtime and constant repair. See related feature on **page 18**.

Images courtesy of (left to right) Midwest Mold Services Inc., The L.S. Starrett Co. and Husky Injection Molding Systems.

VIDEO ACCESS

5 TRICKS OF THE TRADE

Great Tips from This Issue

1. Cool New Tech
Produced in H-13 tool steel that's hardened and polished, new conformally cooled sprue bushing serves as drop-in replacements for standard B and U series cold sprue bushings.
PG. 22.

2. Go with the Flow
Optimizing cooling circuit geometry and determining if efficiency gains are truly worth the cost of changing to conformal cooling requires mold-flow simulation software.
PG. 26.

3. Ring It Up
To properly care for gage blocks, use wringability to evaluate the integrity of the gage block's surface condition.
PG. 30.

4. It's All in the Gate
The higher throughput of a valve gate may accomplish a faster fill time and avoid the need to wait for gates to freeze.
PG. 36.

5. Bad Vibrations
To reduce vibration, ensure cutter shank engagement in the tool holder is at least 2 1/2 x D, use short, balanced tool holders and minimize runout.
PG. 48.

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A Holy Mission: Introducing Kids to the Trades

Ever have that relative whose profession was a mystery growing up? Heck, my dad was an electrical engineer for a vacuum pump systems manufacturer who loved being out on the shop floor, and I didn't know that until I was an adult. Little did I know that a few years later, I'd be covering the trades in the manufacturing media and then unexpectedly bump into my father at a local tabletop trade show. Too funny.

Well, it happened to me again. This time more recently with my late Aunt Jo (or as most referred to her, Sister Raymond Mary Cline, a Sister of Mercy). In 1973, she began 35 years of service to Mercy Vocational High School where she taught business education and computer technology. In 1999, she made a move into the career services department as an assistant to the director of cooperative education.

This was a year into *MoldMaking Technology*'s life, and I **still** was not fully aware of what she was doing, how important it was and how closely tied it was to my career helping to educate mold manufacturing professionals and making connections to help fill the skills gap.

My aunt used her position there to focus on on-the-job learning for students, which often landed them full-time employment after graduation. She also launched a "shadow" program through which students would follow professionals, observe them working and ask questions. She constantly celebrated Manufacturing Day.

My aunt passed away a few years ago, but her legacy lives on at Mercy Tech. I share this story because I recently visited Mercy Tech and saw how much the program has grown. This experience has taught me to speak up more about the trades to family, friends and neighbors, so they better understand what I do for a living and the awesome career opportunities the moldmaking industry has to offer. It is part of my job to do so, and it starts at home!

I encourage you to shout from the rooftops about what you do!

When I think of my Aunt Jo now, I often wonder if we had talked more or shared more deeply about our jobs 20 years ago, we would have bonded over our passion for the trades, and perhaps come up with a way to work together to make a difference locally in filling the skills gap.

So, I encourage you to shout from the rooftops about what you do, so you don't miss an opportunity to open the door for someone to enter the trades. And while I'm at it, mark your calendars for Amerimold 2020, June 10-11 in Novi, Michigan, during which we'll have programming on the show floor focused on community and connection. Stay tuned for details. MMT

Christina Fuges

Christina M. Fuges
Editorial Director

Follow MMT on: Follow @MMT_ChristinaF

THIS MONTH ON moldmakingtechnology.com

EVENT: What is the Amerimold 2020 Sourcing Fair?

Amerimold's Sourcing Fair connects major OEMS who are looking to source new or increased mold-building and molding projects in North America with leading mold builders and molders attending Amerimold for free.
short.moldmakingtechnology.com/AME20SF

PODCAST: 3-in-1 Moldmaking Force Always Looking for Problems to Solve

MoldMaking Technology/ The Manufacturing Alliance Podcast sit down with two VPs to break down how three companies operate as one to provide creative solutions to complex manufacturing challenges.
short.moldmakingtechnology.com/3in1Pod

BLOG: In Automotive, is Additive Manufacturing an Answer for Die-Cast Tooling?

The largest high-pressure die-cast tool builder in North America is 3D printing die inserts and water jackets for major automakers. It's a tough sell, but one company is succeeding—and it's just getting started.
short.moldmakingtechnology.com/AutoAM

WEBINAR: Best Practices for Use of Reinforced 3D Printed Injection Mold Tools

Fortify's free webinar on February 20 will review best practices for designing, machining and running 3D printed injection mold tools to support prototype and low-volume production runs.
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2020 Editorial Advisory Board: **Davide Masato, Ph.D.**

By **Christina M. Fuges**

The next member of our new EAB is Davide Masato, Ph.D. Dr. Masato brings a young, academic and international perspective to the board. Born and educated in Italy, he now works as an assistant professor in plastics engineering at the University of Massachusetts Lowell (UMass Lowell). He has more than five years of academic experience in plastics processing technologies with a particular focus on injection mold design and manufacturing.

Dr. Masato has been working with several manufacturers developing solutions for micro- and nano-structured plastics surfaces, rapid heat cycle molding, vacuum venting, mold coatings, mold characterization and process monitoring. His current research interests focus on the design and characterization of innovative surface properties for injection molds, micro injection molding, mold design, process development and characterization, process simulation and model calibration. At UMass Lowell, he currently teaches mold engineering and computer-aided engineering classes.

Dr. Davide Masato, assistant professor in plastics engineering at the University of Massachusetts Lowell, joins *MMT*'s 2020-2023 Editorial Advisory Board.

Dr. Masato is also a member of the Society of Plastics Engineers, the Polymer Processing Society and the Italian Manufacturing Technology Association.

His areas of expertise include program management, mold design research, plastic part design, design for manufacturing, mold surface engineering, digital manufacturing, additive manufacturing, sustainable manufacturing, and microinjection molding, tooling and micromachining.

Dr. Masato has achieved several honors and awards, including Best Paper Award for SPE's Injection Molding Division at ANTEC 2018, Start Cup Veneto (Italia) Innovation Award in 2018, and a 2017 Honorable Mention Paper Award at the World Congress on Micro and Nano Manufacturing in Taiwan. Dr. Masato is also one of the co-founders of SmartMold srl., a start-up company based in Italy that designs and engineers mold surface treatments for injection molds.

Dr. Masato hopes his position on the board helps him to better promote new technologies in the field of mold design and engineering, better educate young plastics engineers in mold design, connect with industry people across North America to promote international collaborations, and remain updated on new mold technologies. During his EAB term, he will contribute insight on topics related to software, culture, equipment, mold materials/mold components and advanced technologies. MMT

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The EAB enhances the standing of the publication and strengthens its professional integrity through the active involvement of its members.

The Board represents all aspects of the mold manufacturing industry with a balance of moldmakers, molders, OEMs and academia, and various moldmaking segments and job functions. A member is selected based on his or her experience and knowledge of the moldmaking industry to serve a three-year term.

Charlie Daniels
Chief Financial Officer
Wepco Plastics Inc.
Middlefield, Connecticut
860-349-3407
charles@wepcoplastics.com
wepcoplastics.com

Dave DiCarlo
Sales & Program Manager
Michael Tool & Mold
Ontario, Canada
519-737-1269
ddicarlo@michaeltool.com
michaeltool.com

Brian Dippel
Operations Manager
X-Cell Tool & Mold Inc.
Fairview, Pennsylvania
814-474-9100
BDippel@xctam.com
xctam.com
**2019 Leadtime Leader Winner*

Mark Gauvain
Senior Director Business Development
JABIL Green Point Division
Waltham, Massachusetts
978-804-2279
mark_gauvain@jabil.com
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Robert Graup
Toolroom Manager
Intex Tooling
Ontario, Canada
416-799-7132
robert.graup@intextooling.ca
intextooling.ca

James Jergens
Operations Manager
Ernie Green Industries
Rochester, New York
585-295-8951 x 6226
jjergens@egindustries.com
egindustries.com

Kelly Kasner
Director of Business Development
Michiana Global Mold
Mishawaka, Indiana
574-259-6262
kkasner@mgmold.net
mgmold.com

Davide Masato
Assistant Professor
University of Massachusetts Lowell
Lowell, Massachusetts
978-934-2836
davide_masato@uml.edu
uml.edu

Camille Sackett
Director, Business Development and Engineering Support
Accede Mold & Die
Rochester, New York
585.254.6490
CamilleSackett@accedemold.com
accedemold.com

Rick Seaberg
Director of Engineering and Tooling
Matrix4 M4
Woodstock, Illinois
815-338-4500
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Don Smith
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A Conversation with ...
Quality Mold Inc.

Images courtesy of Quality Mold Inc.

Quality Mold Inc. in Chandler, Arizona, builds new molds and tooling for a variety of industries, but its primary focus is providing engineering changes and mold repair, including conventional TIG and Micro TIG welding and, most recently, laser welding, as shown here. The company built a solid reputation for reverse engineering and rebuilding molds sourced in China to make them production-ready, and prides itself on quick turnarounds and full-service capabilities.

You have a full-service mold shop. What exactly does that entail?

Steve Burke, plant manager: Quality Mold started out as a side business in Mike Hatfield's garage, providing welding and other repair services. He is a journeyman moldmaker and could also build molds, and as customers' requests grew, so did the company. He bought a Bridgeport and a grinder, and the company grew from there. Today, about 70 percent of our business is mold repair and revision work. We can do just about everything in house except heat treating and specialty coatings. We also build new molds and in fact we have three being built now. We have six CNC machining centers, including Mitsubishi TV-500 and TV-700 high-speed milling machines, Matsuura MC-600VF and MC-1000V milling machines; we have four EDM machines (wire and sinker) including two Mitsubishi EA12VM Advance sinker EDMs with a Mitsubishi MELFA RV-12SL robot, and we have several Mitsui surface grinders with Opti-dressers. We have our own welding department where we can TIG weld, micro TIG weld and, in the last four years, laser weld using our LaserStar 7700-3 Series Open Workspace Welding Workstation.

Quality Mold Inc.
400 E. Comstock Drive
Chandler, Arizona
480-892-5480
qualitymoldinc.com

- Full-service mold manufacturer founded in 1995 by Mike Hatfield, president.
- Specializes in designing, building and repairing/refurbishing single and multiple cavity molds ranging in size from 50 tons to 500 tons.
- Types of molds built include shuttle and insert molds, rubber injection molds, expandable and interchangeable tooling, multi-action molds, three-plate stripper molds, unscrewing molds, blow molds, metal injection molds, compression molds and more.
- Currently employs 14 team members.
- Industries served include medical, automotive and irrigation.

How did Quality Mold come to provide mostly mold repair and revision work?

Burke: The company's roots are in mold building, but we came to do more repair and revision work back when everything started going to China. We had to change our way of thinking, so would tell these customers that when their molds come in from overseas, give them to us. At that time most molds would come in with issues and we would work on them and get them to run correctly and get the dimensions in tolerance. It became our little niche business because a lot of shops would not touch a Chinese-built mold. We would say send them to us; we'll work on them. We became familiar with Chinese-built tooling. A lot of it was all handwork and they would cut things close and then go in with the disk grinder and grind away until they got it to where they wanted it and leave it at that. None of the surfaces would be correct to a solid model, so we would reverse engineer these molds and make sure they met specifications.

We also do a lot of mold refurbishments. Some of our bigger customers had older tooling built in the U.S.A. in the 1980s and 1990s, so they will send them to us, and we will put in new leader pins, bushings, locks, etc., and go over the molds and correct any issues like flash and make them some spare tooling as well. Their part designs haven't changed any, so they have molds with several million shots on them that they would like to keep in production. We do whatever is needed to keep those molds running.

Besides molds, we use our two Fanuc Alpha-1iAs and our Fanuc Alpha C400iB wire EDM machines to do a lot of work for several aerospace customers.

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This detailed eagle part was molded from an injection mold built by Quality Mold Inc. for an inventor who had a good idea. It is called a gun leaner, and attaches to a shotgun barrel. The wings protect the gun if it leans against a tree or other object. The wings can also act like a hook so if a hunter is climbing into a tree stand he can hang his shotgun on a tree limb. Quality Mold is approached, on average, once a month by inventors of new products and provides not only sage advice to these creative folks but access to resources for financing their projects if they need it.

Speaking of tolerances and specifications, Quality Mold offers a mold warranty. How does that work?

Burke: For any mold we build, if it has any issues like the workmanship, the function or the tool design, we will take care of it. The warranty covers cavities, cores, parting-line surfaces, and ejection. For example, if the runner's not dropping like it should be, there's an issue. Maybe it's a three-plate mold and the puller pins aren't holding the runner; we'll get the mold back and we will do what it takes to fix it. We will increase that undercut and make any kind of design adjustments free of charge. When we're done with the mold, they should have a full functioning mold they can put into the press and run.

It's about relationship building. If I am in the middle of a mold repair I quoted, on any mold, and I find something else that isn't right, I'll alert the customer and either go and take care of it at no charge, depending on what it is, or we will work with the customer to get it resolved. A lot of our customers have been with me for over 15 years. I'm knowledgeable about what they need to get done and I'm familiar with their molds. We are a busy shop, but if a loyal customer needs something done quickly, I'll do whatever it takes to get that job done for them asap.

We also have an inspection room with a coordinate measuring machine (CMM) and optical comparator, both from L.S.

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Finally, we have a 3D Systems Konica Cubepro Trio 3D printer, which we purchased about three years ago to provide prototype parts for customers who wish to determine the fit and function of parts they design before we build the mold.

Quality Mold offers financing. What is that all about?

Burke: That's something that our office manager set up. The financing is not through us but it's through a company that will provide financing for inventors that have new products, but they don't have a lot of money and they're not aware of what it takes to have a mold built. They may have an idea for a little part, but they have no idea that a M.U.D unit could cost around $10,000. It is not unusual for me to get inquiries along these lines once a month, so we have this service for them. There is a link on our website where they can apply to get the funding that they need to build the mold. I also try to educate them about molds and molding. Most people think we work with plastic; they have no clue what a mold is. Sometimes I have to tell these inventors that they are jumping ahead too fast and that they need to meet with a part designer to ensure their product is moldable. If it is then I tell them to get a 3D model or at least a 2D sketch of the part and then we can provide a more realistic quote for the mold. I also advise them about locating an injection molding company and probably someone in marketing so they can properly market their product. There are a couple of local companies that I'll refer them to for the part design and the marketing aspect of it. But nine times out of ten they have no clue what a mold costs, and when I give them a ballpark estimate their eyes get big. If they say they might have to go to China because of the pricing, I warn them to be careful where they go because some places will build one mold for them and a second mold for themselves to run and sell the product there. MMT

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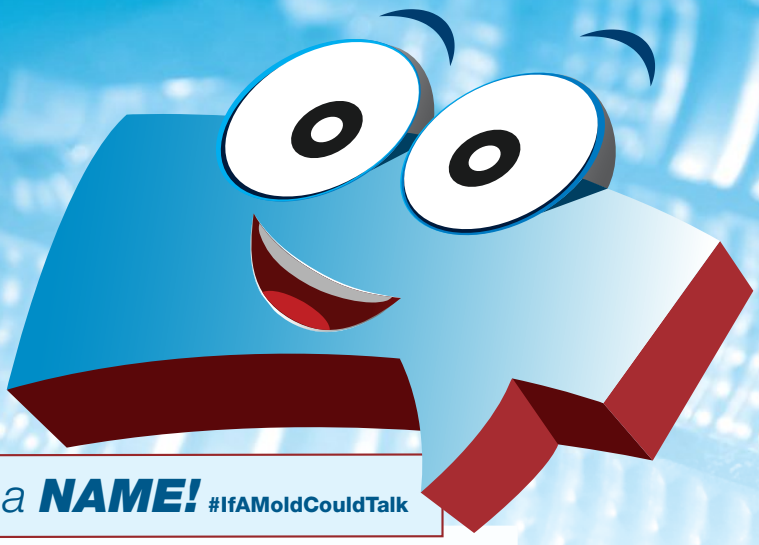

MMT

Give me a **NAME!** #IfAMoldCouldTalk

This is your chance to name our new friend and make your mark on the MoldMaking community! Tweet or submit your ideas today! #IfAMoldCouldTalk

The moldmaking industry comes to life when conversations turn toward the challenges of a mold build, the absurdity of customer requests, the outrageous employee mistakes, or the unrealistic expectations of next-generation moldmaking professionals.

Yet, one of the many things the men and women of this industry do well is laugh at themselves. They are the hardest working people I know, but they can always find humor and joy in the daily frustrations of their work. Hence, *MMT*'s ever-popular "Top 10 Reasons to Be a Moldmaker" t-shirts.

Well, recently I found another way for mold manufacturers to unleash their sharp wit and wisdom gleaned from years of experience: Introducing the **"Life of a Mold"** campaign!

Consider the life of a mold, what it goes through, from design, to first shot, to maintenance and repair.

It's basically MMT's version of a meme! We can't wait to find out what you think we should call our new industry mascot! Submit your ideas on **moldmakingtechnology.com/zones/amerimold** or Tweet using the hashtag **#IfAMoldCouldTalk**. We need your ideas by **Feb. 10**, so act fast!

—Christina Fuges

Then consider what a mold would say as it passes through quoting, designing, machining, inspection, molding, polishing, assembly, cleaning, welding, etc.

It's basically MMT's version of a meme! But before we ask you to share your mold rantings given a scenario, let's first give this character, this industry mascot, a name.

We'd love to hear your ideas for what we can call our new buddy! Head on over to our website moldmakingtechnology.com/zones/amerimold to submit your idea. We need your ideas by Feb. 10, so act fast!

We'll announce the winning name on our social media channels and in next month's issue of *MoldMaking Technology Magazine*. Make sure to follow us on Twitter at @MMTMag to stay up to date with our new friend's adventures, and to play along with us as we learn what our little friend's voice sounds like. If you want to tweet your ideas, use the hashtag #IfAMoldCouldTalk so we can all follow along.

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By Jason Murphy

Additive Tooling Simplifies the Mold Build Process

Three ways that additive tooling is moving past conformal cooling to bring speed and efficiency to the overall tooling process.

As tooling complexity increases, it is necessary to explore ways to simplify your mold-building process, and that is where additive manufacturing can help. Conformal cooling remains the most common application for additive manufacturing in mold building and molding because it helps eliminate hot spots in molds that can lead to longer cycle times and part defects. However, maybe it's time you consider other ways to apply additive manufacturing in your mold building process.

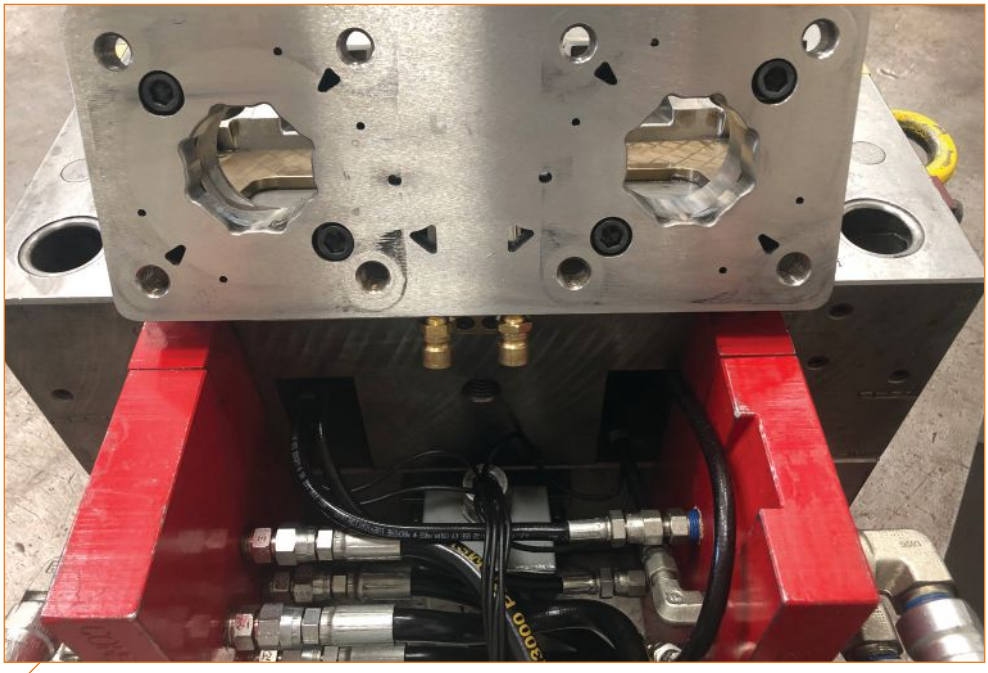
Following are three alternate applications for additive tooling. Additive tooling can be made out of metal, specifically tool steel, and is used to produce high-volume class 101 molds; it can be a sub-insert that goes into a larger mold or mold base; and someday it will involve the production of complete mold plate cavities that form plastic parts.

Gating

Gating into cavities is often one of the most compromised areas of a mold design. Gating is typically in an area for noncosmetic surfaces or around moving actions, as opposed to using fill and flow analysis to determine the optimal gate location. Hot runner systems offer direct part gating and gate location flexibility to conserve raw material costs, but there are still challenges with determining the appropriate gate style and best location to drop a hot runner into a cold runner.

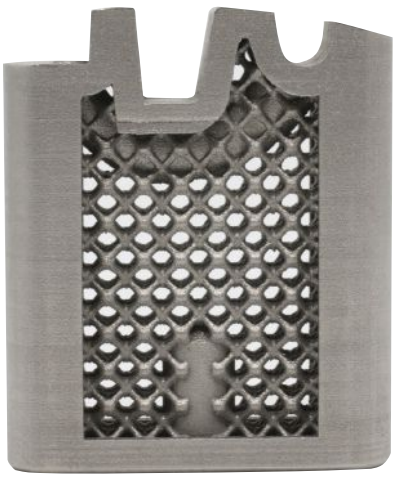
For example, a self-degating option can reduce overall part cost. So, use a subgate or cashew gate to achieve automatic degating and eliminate secondary trimming or manual degating. A cashew gate is a very popular gating method because it enables gating into the underside of a part and away from the cosmetic or functional surface, then cleanly breaks and pulls out upon ejection. However, cashew gating does require a split insert to achieve the gating detail or an off-the-shelf solution, both of which pose challenges because they do not provide enough steel in the required areas within the cavity.

An alternative is an additively manufactured cashew gate that enables a flexible design to create the proper geometry for smooth extraction that avoids sticking, particulate build-up



Images courtesy of Next Chapter Manufacturing.

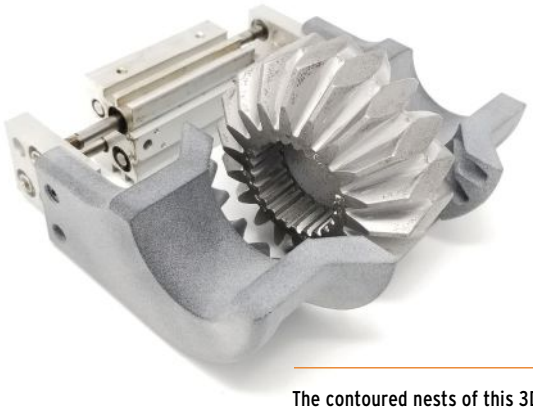
This laser sintered 420 SS cooling plate mounted to a mold is one example of how mold builders can use additive manufacturing beyond conformal cooling.



This one-piece laser-sintered cashew gate insert has added strength and helps avoid flash, wear or breakage.

This 3D-printed end of arm tool with an integrated vacuum circuit features one-piece frame design.

Images courtesy of ForeRunner 3D Printing.



The contoured nests of this 3D-printed end of arm tooling enable accurate part alignment as they come off the mold.

and breakage that causes blockage of the injection point. A 3D-printed cashew gate's one-piece design adds strength and eliminates flash, wear or breakage, which is common with the traditional two-piece design. The internal cashew gate detail is polished using ultrasonic finishing to achieve the smooth surface required for ejection.

Using an additively manufactured cashew gate also provides the design freedom to put gate inserts in areas where steel conditions are not favorable.

Cylinders

Heat buildup in molds is not only a cooling time drain, but it can be detrimental to critical components, electronics and sensors. It can also lead to downtime and mold crashes resulting in costly repairs and missed shipments. High-temperature molds with hydraulic cylinders are a good example where heat can build up, causing the position switches to fail in production.

For example, consider a molder that was running a mold over 300°F; an aluminum cylinder body will act like a heat sink and draw that heat away, build up and cause the switches to fail. This results in significant downtime and frequent mold crashes, impacting customer delivery and mold repair costs.

One solution is to use the existing mounting plate as a reference and build an additional mounting plate with a cooling circuit, which serves as a barrier to the heat transfer and eliminates switch failure. However, multiple mount-

This laser-sintered 420 SS cooling plate with integrated circuits between mounting holes covers the entire mounting surface with even temperature control.

ing screws and cylinder bores do not permit conventionally drilled water circuits because the cooling would have to squeeze between the holes in the plate.

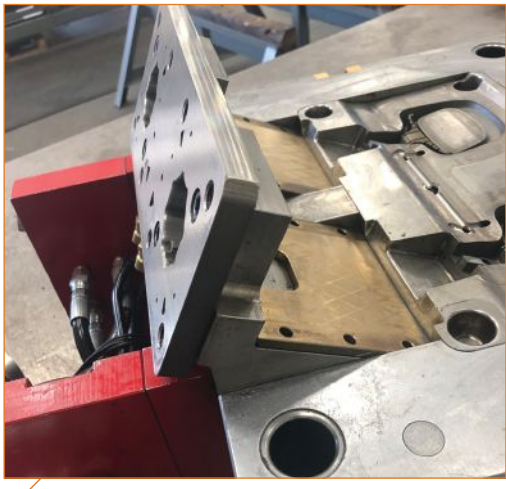
An alternative option we used with a customer is a laser sintered 420 SS cooling plate that allowed the 67-inch-long cooling circuit to cover an entire 5 by 11 inches plate without disrupting the fixed features. We achieved this by routing the cooling circuit between the existing mounting holes to cover the entire mounting surface with even temperature control.

Keep in mind that some areas the cooling circuit profile will change because there is not enough steel through which the profile can safely fit. Using additive manufacturing, you can make the profile narrower in one direction and wider in the opposite direction to maintain the volume of flow. The result is a mold running at +300°F degrees while keeping the cylinders cool and eliminating issues with the limit switches.

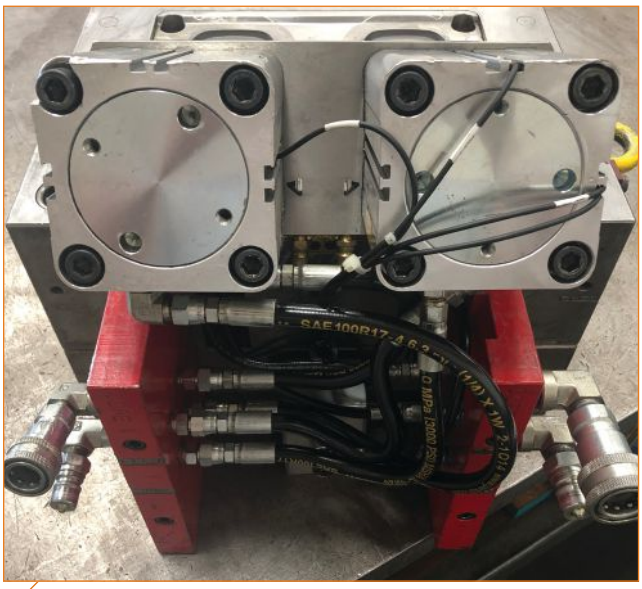
This customer has reported no issues or downtime since installing the sintered cooling plate. You can apply this same method to cool a specific area of a mold that is experiencing friction and galling, resulting in less wear and extended component life.

End of Arm Tooling (EOAT)

As many mold builders continue to offer gauges, end of arm tooling and



With a laser-sintered 420 SS cooling plate mounted to a mold, the mold can run at +300°F degrees while keeping the cylinders cool and eliminating issues with the limit switches.



Using additive manufacturing, you can make the profile of this cooling plate with hydraulic cylinders mounted to the side of a mold narrower in one direction and wider in the opposite direction to maintain the volume of flow.

design the 3D contour of the part shape into the EOAT, so that the molded part upon ejection mates perfectly with robot picking up the part. This design yields an efficient part handoff to any secondary automation or packaging, reducing scrap.

Another EOAT design uses a multi-material additive manufacturing approach that incorporates a flexible TPE-like material to produce a rigid frame structure with soft flexible features that act as a seal. This seal is important for vacuum picking applications where conventional cups are not viable or when a specific profile is required to match the part contour.

As you can see, a little creative thinking can yield robust, efficient EOAT options that guarantee uptime and eliminate scrap. Plus, with additively produced EOAT, if a crash occurs, you can just print another one. MMT

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Jason Murphy, President and CEO

secondary automation, they need to consider additive manufacturing. Frequently, EOAT is an afterthought and is fabricated out of an industrial erector set of 80/20, hoses, fittings, grippers and a mix of other parts. This method is an inefficient mix of components that increases weight and size, slowing down the robot due to the payload or exposing wires and hoses, which causes mold crashes.

An efficient solution is a monocoque design that incorporates an additively manufactured, one-piece frame, which has critical part-positioning locators and handling features and integrates pneumatic circuits with the structural frame of the EOAT. Integrated wire channels also provide a clean method of routing wires to keep them protected during production. The result is EOAT that is up to 60% lighter, yielding faster, more accurate part picking and reduced cycle time of the overall process.

Accurately aligning parts as they come off the mold demands complex locating features. One option is to

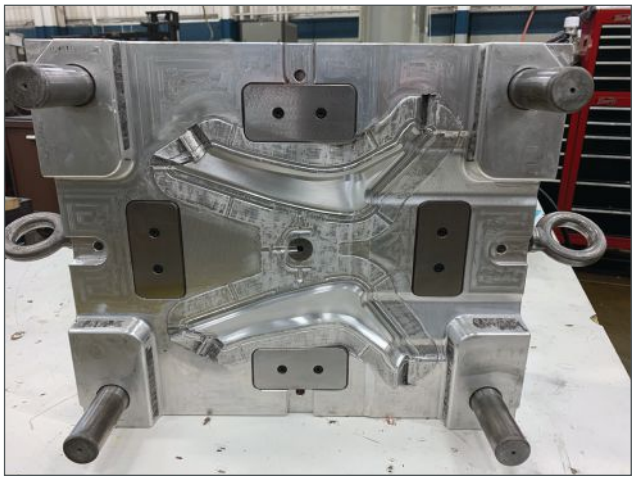
By Peggy Malnati

Conformally Cooled Sprue Bushing Solves Sprue Cooling Problem, Eases Cost Pressures on Molder

Use of a new conformally cooled sprue bushing helped solve a molder's problem with a big sprue that was hard to cool and preventing faster ejection times.

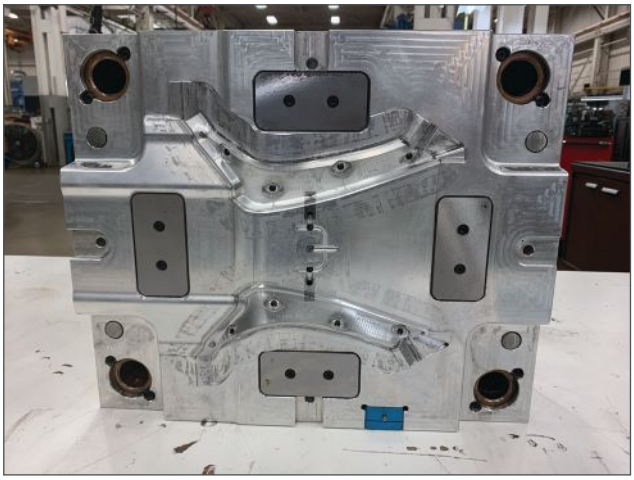
Midwest Mold Services Inc. (Roseville, Michigan) builds prototype and production tools with both aluminum and steel alloys for injection and compression molders. The shop recently produced a 1+1 injection tool for an automotive molder, which was tasked with producing a low-volume spoiler seal in a thermoplastic vulcanizate (TPV). As is nearly universally the case in automotive, the molder was under tight pressure from its OEM customer to reduce cost. Although the tool worked well, the molder asked if the Midwest team could suggest ways to reduce cycle times to help ease cost pressures. The molder already had tried different TPVs to see if a material change could help. The challenge was that a single large cold sprue fed a cold runner, which in turn fed two cashew gates to produce two seals per shot. While not especially large, the 9 by 3-inch/23 x 8.0 cm seals were contoured parts with geometry and featured four insert-molded polyamide 6/6 (PA 6/6, also called nylon) fasteners per cavity. The 0.31-inch/7.94-mm diameter sprue was 4x thicker than the seal, whose nominal wall was 0.0-inch/2.0 mm. Hence, cooling the sprue became the rate-limiting step, making it difficult to shorten molding cycles and eject parts faster without causing stringing from the still-cooling sprue.

"Typically, for a part like this, we'd have used valve gates instead of cashew gates and gated directly into the part to improve cycle times," explains Doug Carmer, Midwest Mold sales director. "The problem was that the entire cavity side of the part was a Class A surface, which meant that, to



Images courtesy of Midwest Mold Services Inc.

Cavity (A) side of a TPV spoiler seal tool (left) and A surface of part (right).



Core (B) side of a TPV spoiler seal tool showing placement location for the four PA 6/6 fasteners (left) and B-side of part showing fasteners attached (right).

produce an aesthetically acceptable surface cost-effectively, we could only use cold-runner gating options." Carmer and Gary Driscoll, Midwest VP—operations sat down and started looking through part catalogues to see what options they could offer their customer. "We didn't think we'd get what we wanted with performance metals, as we'd only had marginal success with them previously," adds Carmer. "We also saw water jacket-wrapped sprues, but we didn't want to have to tear up the tool, which wasn't particularly large, and our experience with any kind of O-rings, as you'd have in the water-jacket option, is that eventually they always leak."

At last Carmer and Driscoll discovered what was then a new technology—a conformally cooled (cold) sprue bushing in a part catalogue. The product was said to be ideal for situations where cooling a large sprue mass that fed a small part was slowing down ejection. They asked if their customer wanted to try it and got the go-ahead.

Conformal Cooling: Putting Water Where it's Needed

Whether it's applied to molds or sprue bushings, what makes conformal cooling so effective versus traditional cooling methods is that it permits cooling channels to be placed exactly where they're needed and where CAE results specify. Typically, channels follow the shape or profile of whatever needs to be cooled and can be positioned far closer to hot spots than is possible with conventional baffles and bubblers (in the case of molds) or gun-drilled channels (in the case of sprue bushings). This, in turn, makes it easier and faster to pull heat out of both molten plastic and metal tooling. Since the hold step in injection molding can account for as much as 80% of the total cycle time, according to injection molding training consultancy RJG Inc. (Traverse City, Michigan), by shortening the hold segment, molders can eject solid parts faster and achieve shorter overall cycle times, helping to improve throughput and press utilization rates.

In the case of the conformally cooled sprue bushing, a complex spiral channel winds around the interior of the structure, just outside the central channel where molten plastic flows. This puts cooling water much closer to the molten sprue than water-jacketed sprue bushings can manage, and the channel's design also covers more of the area of the sprue. Because the cooling channel's geometry is too complex to gun drill, which is limited to straight lines and right angles, the entire sprue bushing must be additively manufactured using a process called direct metal laser sintering (DMLS).

When Big Sprues Limit Cycle-Time Options

The conformally cooled sprue bushing was designed and is sold by PCS Co. (Fraser, Michigan), a manufacturer and distributor of mold components, mold bases, hot runner products, and molding supplies for the plastic injection and die-casting industries. The sprue bushing's patented spiral cooling channel was produced via additive manufacturing by

MIDWEST MOLD SERVICES INC.

CHALLENGE: TPV part was molding slower than desired owing to large sprue that was hard to cool quickly.

SOLUTION: Replace a conventional cold sprue bushing with a conformally cooled cold sprue bushing by PCS Co.

RESULTS: Cycle time was reduced, easing cost pressures on molder.

Images courtesy of PCS Co.

Conformally cooled sprue bushing showing superimposed spiral cooling channel that wraps around sprue to pull heat out (right) and photos of whole and halved conformally-cooled sprue bushings, which are produced in H-13 tool steel (left).

Service Doesn't End with Mold Delivery

Midwest Mold Services Inc. (Roseville, Michigan) builds prototype and production tools with both aluminum and steel alloys for injection and compression molders. It produces rotary molds, two-shot and multi-shot molds, insert molds, hot and cold transfer molds, structural injection molds, low-pressure and gas-counter pressure/gas-assist molds, and molds for complex parts. The company also is a prototype and low-volume plastic part manufacturer—with production runs of 50 to 10,000 shots or up to 100,000 parts annually. Additionally, Midwest supports customers by offering design, assembly, packaging and logistics/shipping services.

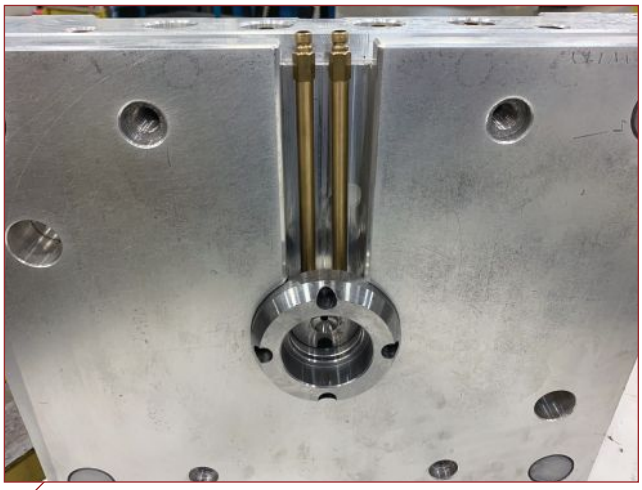
The Detroit-area company was founded in 1994 as a service business supporting tier one/tier two custom automotive molders with day-to-day mold repair and maintenance needs. Company owners quickly realized that opportunity existed to leverage their expertise to become a full-service mold supplier that today employs 40 people. Although the automotive market remains vital, the company has expanded into industries ranging from recreational vehicles, motorcycles, agricultural equipment, lawn and garden, and military/aerospace to medical/dental, telecommunications/electronics, and consumer goods.

Midwest is equipped with high-speed/multi-axis CNC mills, wire EDMs, and equipment for grinding and part surfacing, all operated by skilled, certified machinists. Additionally, the company offers 3D printing capabilities for rapid prototyping of both parts and small injection molds. The company uses SolidWorks CAD, which can translate files from AutoCAD, CATIA, Softech, Unigraphics, KeyCreator, ProE, SDRC Ideas, ACIS, Cimatron, Step, Parasolids, SolidEdge, SolidWorks, IGES/VDA-FS, Delcam DGK, Rhino and many more. Not only is Midwest Mold ISO 9001:2015 certified and able to hold EDM and grinding tolerances to ±0.0005 inch/0.01 mm, but the company also is a member of Michigan's Coast to Coast Tool & Die Collaborative (MCCTD), which comprises 13 companies that joined forces in 2008 to grow their own operations and support other members in a globally competitive market.

PCS's partner/supplier. PCS says it was the first company to offer conformally cooled sprue bushings, which work with any thermoplastic molded via cold runners. Produced in H-13 tool steel that's hardened and polished, these products are intended to be drop-in replacements for standard B and U series cold sprue bushings and are available from PCS in 10 of industry's most popular sizes, although the company says that custom sizes are available. PCS also offers conformally cooled gate inserts for molds using hot runners.

"We've had good success introducing this technology to the marketplace due to the considerable savings that are seen when the sprue is limiting cycle time," notes Kelly Beauchamp, PCS key account manager. "On average, we've seen 30 percent cycle-time savings, although savings can be as low as 15 percent and as high as 80 percent depending on the application."

"This can be a good solution for molders who need to reduce cycle times to stay competitive in their markets," adds John Harding, PCS sales manager. "Accordingly, it's priced higher than conventional cold and hot sprue bushings because, on the one hand, additive manufacturing is a slower and more costly production process than conventional machining and because, being a unique product, there is some barrier to entry, including the cost of purchasing the additive manufacturing printer. On the other hand, payback can be really swift, with some molders seeing an ROI in a matter of weeks or even days depending on the application. With cooling accounting for 70-80% of the injection molding cycle, if you can impact the cooling process, you can greatly improve cycle time. Of course, the key is finding the correct application where cooling a big sprue that feeds a small part is slowing down the ability to eject faster."



Cavity side of mold showing how water lines were plumbed into conformally cooled sprue bushing.

Easy Install; Perfect Solution

"We were really surprised at how easy it was to install PCS's conformally cooled sprue bushing," Carmer continues. "We didn't connect it to existing water circuits. All we had to do was put a couple of pipes into the clamp plate to feed the water, and our customer added another set of jumpers in their water setup to cool the sprue even faster. And since it has no O-rings, it doesn't leak. It worked perfectly and reduced our customer's cycle time. For bigger jobs where you're using robotic handling, it also would keep your equipment from getting gummed up. We'll definitely recommend it to anybody having a similar problem." MMT

CONTRIBUTOR

Peggy Malnati is a Detroit-based contributing writer for *MoldMaking Technology* focused on application stories and shop profiles. She has provided writing and communications services for the global plastics and composites industries since 1984. pmalnati@garpub.com.

FOR MORE INFORMATION

Midwest Mold Services Inc. / 586-888-8800 / midwestmold.com
Doug Carmer, Sales Director
PCS Co. / 800-521-0546 / pcs-company.com
Dave Cataldi, President

By Matt Danford

Simulation Shows Additive's Moldmaking Merits

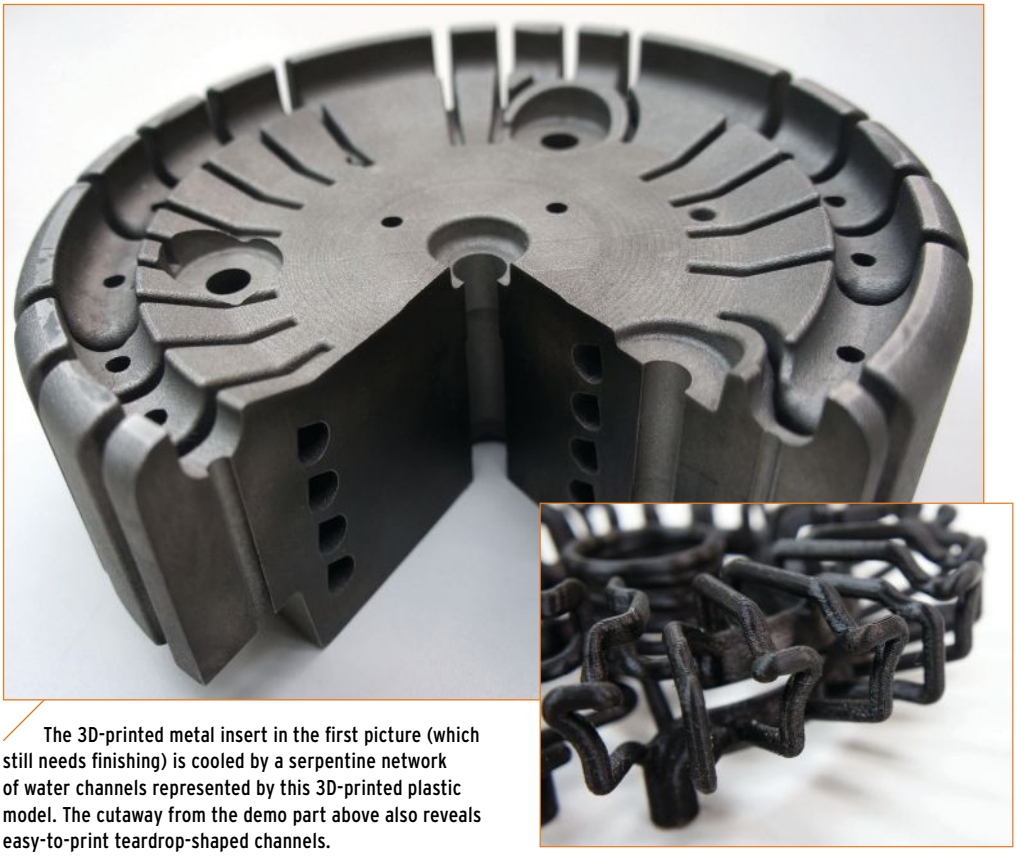
Virtual prove-outs prove the worth of stirring things up, both within the cooling channels of individual molds and in the plastics industry at large.

During the past two years, B & J Specialty has gotten used to leaving customers a little nervous after meetings.

This is no concern for the Northern Indiana plastic injection mold manufacturer. So says Jarod Rauch, a design engineer who has played a leading role in the company's drive to push metal 3D printing as an alternative to CNC machining. Education is the antidote to fear, he continues, and B & J is more than capable of proving the merits of new methods. In any case, shocked looks and skeptical headshakes are becoming less common as broader attitudes shift. "We're seeing more large companies wanting to go this way without a manufacturer like us having to sell it," he says.

Additive manufacturing is attractive in plastics-part molding because it facilitates conformal cooling. This is the practice of printing mold inserts with waterlines that conform to the contours of the cavity walls. By funneling water at a constant distance from the edges of the pool of molten plastic, these serpentine channels cool parts more evenly and quickly than traditional straight bores. 3D-printed inserts are particularly useful for parts with thin structures, tight corners and other hot-spot geometry that would be difficult or impossible to mold without warpage, sink marks or other defects.

Results reported by B & J indicate that conformal cooling can speed injection molding cycles by 35 to 50%. Whatever customers' concerns about shifting processes and materials, such gains have been increasingly impossible to ignore since the shop's 2017 investment in a powder-bed fusion machine. "I'd say that in the next 5 years, almost all of the molds we



The 3D-printed metal insert in the first picture (which still needs finishing) is cooled by a serpentine network of water channels represented by this 3D-printed plastic model. The cutaway from the demo part above also reveals easy-to-print teardrop-shaped channels.

Large plastic injection molds like this are often divided into inserts. Only problem areas warrant 3D-printed inserts, because the process remains more expensive than CNC machining.

build will have 3D-printed inserts with conformal cooling passages," Rauch says.

However, he emphasizes that not all conformally cooled molds are created equal. About a year after purchasing the new additive machine, B & J took another step with the addition of mold-flow simulation software. Without capability to model how water flows through the channels, optimizing cooling circuit geometry would be more difficult. So would determining whether efficiency gains are truly worth the costs of change. Simulation has also become a key tool for educating new customers, some of which make it a veritable litmus test for awarding work.

If this mold manufacturer's experience with conformal cooling is any indication, CNC machining businesses pursuing other additive opportunities may also find themselves thinking more holistically.

Rauch says he never envisioned himself diving into computational fluid dynamics (CFD) when he started working at B & J 22 years ago. And if this mold manufacturer's experience with conformal cooling is any indication, CNC machining businesses pursuing other additive opportunities may also find themselves thinking more holistically. That goes for not just the unfamiliar aspects of 3D printing, but also the broader context in which the process is performed.

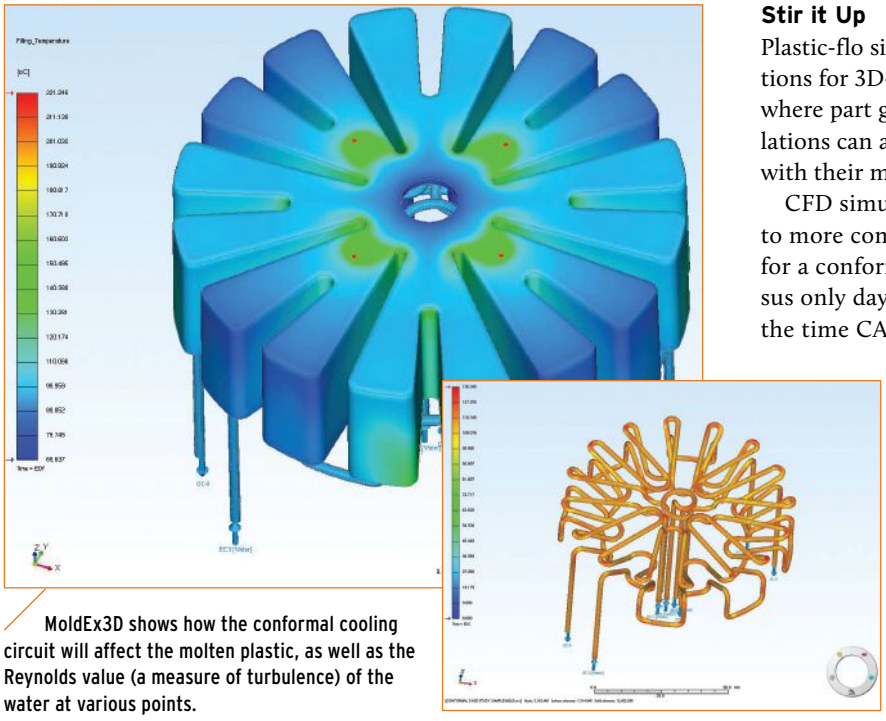
Thinking Ahead

The average passerby would likely marvel at the advanced manufacturing technology within B & J's 27,000-square-foot facility, which stands out amid the cornfields of Noble County. Beginning in a garage in the 1970s, the company's growth can be attributed at least in part to its willingness and even commitment to expanding beyond core expertise in the pursuit of new opportunity. The existence of B & J Medical, a separate, 54,000-square-foot facility dedicated entirely to machining medical parts, is evidence enough of that.

So is the company's more recent investment in additive manufacturing. In this case, however, the process was entirely new, for the shop as well as for OEMs and molders accustomed to traditional CNC-machined inserts. Leveraging the new metal printer, a DMP PRO X 300 from 3D Systems, would require the newly educated to become educators themselves.

Without simulation software or success stories to tout, the shop agreed to print replacements for worn, conventionally machined inserts at cost for a long-term, trusted customer, just to prove a point. As expected, conformal cooling improved injection molding speed by 30% while also improving part quality. Now, virtually all molds produced for this customer contain 3D-printed inserts.

However, virtually all of this customer's molds contain CNC-machined inserts, too. Among other factors, design time, material costs, and time on the printer itself push the shop's additive rate higher than the one it charges for CNC machining, Rauch says. Even with the right geometry, justifying a move away from machined inserts often requires careful attention to optimizing the cooling circuit, and simulation is essential to do the best work. "A good designer can come up with something that will perform well right out of the gate, but we want to offer that 'wow' factor," Rauch says. "If you don't have simulation, you're designing in the dark."



Images courtesy of B & J Specialty.

MoldEx3D shows how the conformal cooling circuit will affect the molten plastic, as well as the Reynolds value (a measure of turbulence) of the water at various points.

Stir it Up

Plastic-flo simulations help identify potential locations for 3D-printed inserts by revealing in advance where part geometry cools slowest. Plastic flow simulations can also be used to compare 3D-printed inserts with their machined counterparts.

CFD simulation tools are more important. Due to more complex internal designs, the design phase for a conformally cooled mold can last weeks, versus only days for machined inserts, Rauch says. By the time CAD files are imported into 3D Systems' Cimatron software for design of the conformal cooling circuit, the pressure to start production can be intense. These simulations help speed the process by showing how the way water flows through the circuit will affect mold cooling.

Most importantly, CFD analysis is critical for ensuring the channel geometry facilitates turbulent flow. Turbulent flow is the primary factor separating one conformally cooled mold from another, Rauch says. Essentially, the goal is to achieve the same cooling effect as stirring hot coffee before taking a sip. The level of turbulence within the conformal cooling channels is measured according to the Reynold's number, which is provided by MoldEx3D's CFD simulation tools.

At higher Reynold's numbers, he explains, the flow is turbulent. That is, the water churns as it barrels through the snaking channels, creating a mixing action that prevents the outer portion of the stream from heating too quickly. At lower Reynold's numbers, the flow is laminar: that is, straight and smooth, like water exiting a faucet. The faster the transition from laminar to turbulent flow as the water moves into the insert, the faster and more uniformly the molten plastic cools.

Various channel geometry tweaks can help accomplish this. "Adding features such as helixes and twisted elliptical passages all help in achieving high velocity and turbulent flow," he explains. "It's just like a garden hose. If it's laying out straight, the water coming out the other end will most likely

have laminar flow. But if you coil and pinch the hose, the flow will transition into being turbulent.

"Having a good understanding of fluid dynamics is vital when designing optimal conformal passages," he continues. "For example, if you are driving 80 miles per hour down the interstate, you won't be able to take a sharp right turn without slowing way down. But if you take an off-ramp, you can better maintain speed. This is similar to how directional changes need to happen in conformal cooling."

> The goal is to achieve the same cooling effect as stirring hot coffee before taking a sip.

Simulation also helps ensure that changes in geometry at one point in the circuit are properly balanced elsewhere. Large numbers of tunnels with differing profiles and diameters can result pressure drops or spikes, he explains. This can result in hot spots during molding that lead to part defects.

Proving it Out

Success with conformal cooling has required not only getting an additive manufacturing education, but also becoming additive manufacturing educators when customers balk.

This is largely because the benefits of conformal cooling also depend on the customer's behavior, Rauch says. For example, differing internal geometry might leave a conformally cooled insert less robust than a machined one. Oftentimes, cooling channels lie only a few millimeters beneath the molding surface. This makes delicate handling during cleaning or other care particularly important.

Another potential problem, buildup within the twisting internal passageways, can be remedied by flushing the inserts with an acid solution. This issue also can be prevented by conducting regular flow-rate tests as part of routine maintenance. Water quality is critical for the same reason, so the company recommends closed-loop filtration systems.

All of this is solely up to the customer. However, simulation software has proven to be a critical educational aid nonetheless, Rauch says.

For one, it proves beyond a doubt that fundamental fears about mold performance are largely unfounded. A material like H13 tool steel lasts just as long whether it is forged or solidified from a bed of powder. Sintered metal also can be heat-treated just as easily, and it is just as smooth after finish-machining or EDM operations. When inserts do wear, they can be welded for repair, just like their forged counterparts.

For another, seeing results play out on screen can sway those who already convinced by the merits of conformal cooling but are still concerned about changing maintenance procedures. "The best tools we have for convincing them are our own case studies, and our mold flow simulations and CFD analytical tools," Rauch says. "This allows me to show things in black and white, so they can see first-hand what will be in store if they decide to change." MMT

CONTRIBUTOR

Matt Danford is a Senior Editor for *Modern Machine Shop* magazine covering topics related to data-driven manufacturing, shop management, cutting tools and moldmaking. MDanford@MMSOnline.com.

FOR MORE INFORMATION

3D Systems / 803-326-3900 / 3dsystems.com
B & J Specialty / 260-761-5011 / bjspecialty.com

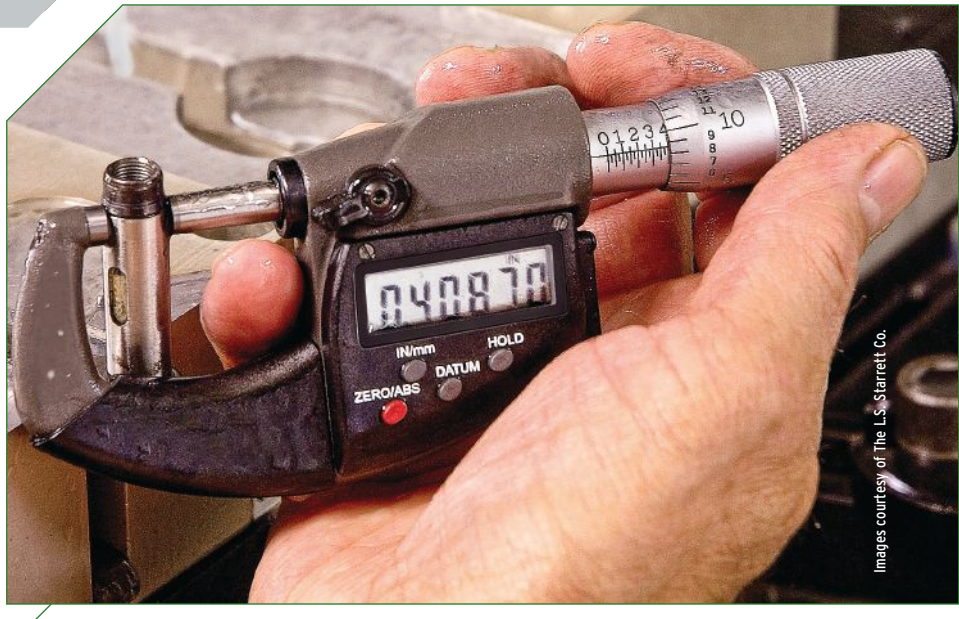
By Scott Robinson

Best Practices for Improving Measurement Accuracy and Reliability

Mold builders who check gage readings and accuracies with gage blocks and ensure a reliable reference with granite surface plates will maintain primary standards that ultimately lead to reliable gaging and better-quality molds.

Mold builders who produce the highest quality molds should use the best quality control practices, as the quality of a mold is only as good as the accuracy and reliability of measurements.

A mold builder can avoid difficult gaging situations by enforcing strict quality control processes, which ensure gages are properly calibrated to international standards of measurement and employ proper care and maintenance procedures to maintain accuracy. This approach to measurement and inspection will ultimately lead to consistent, reliable gaging results and improve mold quality.



Images courtesy of The L.S. Starrett Co.

The electronic micrometer provides an IP67 level of protection against coolant, water, chips, dirt, dust and other contaminants in hostile shop environments.

Defining Measurement

The British *yard* and *meter*, as defined by the Weights and Measures Act of 1878, are the two units of measurement most common in the United States. These practical measurements are defined as the international inch in terms of light waves.

The meter is the basis of all measuring systems with the international inch defined as 25.4 mm exactly. Over the years, the meter has been defined in different ways. Currently, the meter equals the distance light travels in a vacuum during 30.663318 cycles of a Cesium atom. Of course, this cannot be used for regular measurement, so the physical relationship is translated by the National Institute of Standards and Technology (NIST) using lasers and atomic clocks and transferred to today's most basic and accurate precision standard: gage blocks. Gage blocks are the standards that bring this technology to the shop floor where different sizes of blocks may be combined to give any required dimension.

Assessing Gage Blocks

Precision gage blocks are the primary standard for dimensional quality control in the manufacture of interchangeable parts. These blocks are used for calibrating precision measuring tools and for setting numerous comparative type gages used in incoming, production and final inspection areas. Gage blocks provide the most economical, accurate method of setting dial test indicators and other gages used in con-

junction with surface plates for inspecting workpieces with exacting tolerances.

Essentially, gage blocks consist of hard, stable material with a flat, parallel gaging surface on each end. The measuring surfaces are ground and lapped to an overall dimension with a tolerance of plus or minus a few millionths of an inch. Gage blocks may be stacked or "wrung" together to form accurate standards of any practical length, limited by assembly and handling of the wrung together blocks.

Gage blocks come in several grades or degrees of accuracy. Grade 0 is the most popular grade, as it is usually suitable for most applications and offers the best combination of accuracy and cost. Higher accuracy grades of blocks, such as Grade 00 are primarily used as masters to check other gage blocks and for applications that require extreme accuracy. Grade B (±50 microinches) blocks are relatively inexpensive but are limited to workshop use, where exacting accuracy is not required.

Gage blocks are available in various materials, such as chromium carbide,* which is long-wearing, dimensionally stable and extremely corrosion resistant. Gage blocks of this material will maintain their accuracy many times longer than steel blocks and are available in ASME B89 Grades 00 and 0.

Another material option is ceramic, yielding long-wear and corrosion resistance. Ceramic gage blocks fill in the gap between steel and chromium carbide and are available in Grades 00 and 0. These blocks have favorable mechanical and thermal properties that compare the closest to steel of any alternative gage block material.

Steel is the most economical gage block material available, and steel's thermal and mechanical properties are adequate in typical workshop environments. The main disadvantage of steel is its susceptibility to corrosion.

Various styles of gage blocks are available, including rectangular, square and heavy-duty. Certain accessories can extend the use of gage blocks such as height gages, snap gages, scribers and dividers.

Ensuring Even Work Surfaces

Every linear measurement depends on an accurate reference surface from which the user takes final dimensions. Precision granite surface plates provide the best reference plane for work inspection and layout before machining. They are also ideal bases for making height measurements and gaging surfaces, parallelism, etc. A high degree of flatness, stability, overall quality and workmanship also make them an appropriate choice for mounting sophisticated mechanical, electronic and optical gaging systems.

The percentage of quartz in the stone is the most important element for the performance and life of a granite surface plate. Quartz is more than twice as resistant to wear as the other minerals in granite. It provides bearing points that are of a hard, highly polished, smooth character that protects the accuracy and finish of both the surface plate and the tools and instruments used on it.

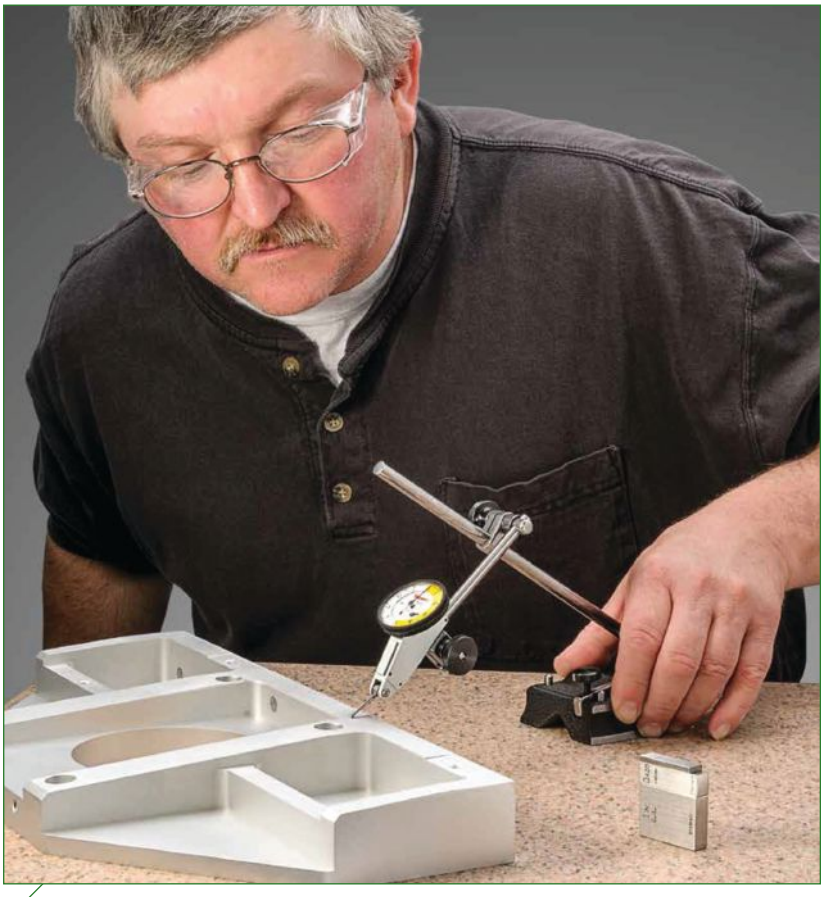
Electronic and mechanical depth micrometers measure parts with depth features like internal notches in 1 to 0.0001-inch increments accuracy and 50 millionths (0.00005-inch) resolution.

Use surface plates without work clamping ledges for sustained accuracy and reliability. Ledges are for work clamping purposes only. If you use excessive torque when applying clamps to ledges, it can adversely affect measurements taken near the plate edges. If clamping is important, install T-slots and threaded metal inserts on the surface.

Some applications may warrant customized, special plates. For example, you might need a custom-made plate for inspecting oversized workpieces, such as a complex mold. Or a special plate or modification to a standard plate might be required for workholding attachments such as threaded inserts, studs, adaptor holes, T-slots and dovetails, etc.

Granite surface plates come in three grades of accuracy:

- AA: Laboratory grade for precision operations in constant temperature gaging rooms and metrology departments.
- A: Inspection grade for general work in quality control.
- B: Toolroom grade for production checking work throughout the shop.



Gage blocks provide the most economical, accurate method of setting dial test indicators and other gages used in conjunction with surface plates for inspecting workpieces with exacting tolerances.

All surface plates must pass a critical final inspection to prove that their surfaces are within the specified tolerance. The final inspection is typically done with an autocollimator in a controlled atmosphere. This instrument is checked and certified against standards traceable to NIST.

Taking Good Care

To properly care for *gage blocks*, use wringability to evaluate the integrity of the gage block's surface condition. Wringability is the ability of two surfaces to adhere tightly to each other in the absence of external means, which is an important property of gage blocks. Blocks that don't wring may give erratic and unreliable results and should be replaced.

To prepare gage blocks for wringing, free blocks from nicks and burrs because imperfections on one block may damage the surface of another block. Check blocks for defects with a gage block stone before wringing. Use a stone with serrated grooves because it gives a better "feel" for nicks and burrs that catch the edges of the serrations.

If stoning is required, this process will remove a small amount of raised material, improving the repeatability of readings and providing block sizes that appear to be truer to their original tolerances. Ultimately, blocks that are free of defects will wring together better.

To wring gage blocks, clean all surfaces. Use an oiled wring pad to wipe the surfaces of the blocks. Next, use a dry pad to remove as much oil as possible. The blocks should then slide together without any feel or bumps or scratching and should adhere to each other strongly after being rotated into place.

If you suspect a problem with a block, use a formal wringability test that does not require a laboratory to perform. Wringability is an important gage block property but is, fortunately, a quality that can be controlled and monitored readily by the user of the blocks. With proper use and care, quality gage blocks will provide long, reliable, accurate service.

The *granite surface plate* is a precision piece of equipment that requires proper installation and maintenance. Before use, furnish the plate with a reliable support system. Typically, this is a hard rubber pad attached to the bottom of the plate forming a non-distortable three-point support system. The pads are installed during manufacturing, and the plate rests on them throughout lapping, inspection and shipping. They are a critical factor in surface plate accuracy, so do not remove them.

Furnish plates up to and including 6 feet wide by 12 feet long with a non-distortable three-point support system. When mounting the plate on a stand, be sure only the pads are resting on the stand. Never support the plate by the ledges or under its four corners, as this will completely void guarantee of accuracy.

Support larger plates on multiple support points (six or more points) with granite pedestals and leveling wedges. Plate size determines the number of support points and proper positioning. Plate thickness and overall working height determine the height of the granite pedestals. Use nylon slings when lifting the granite, and if a forklift is required to move the granite surface plate, place protective padding between the metal forks and the granite.

Once set up, plates do not require extensive care and maintenance. Keeping the surface clean and free from buildup of dust, dirt, grease, grime and other foreign particles will maintain accurate tool readings and extend plate life. Environment and usage determine cleaning frequency. However, as a rule, clean a plate daily if you use it every day. If you do not use the plate for an extended period of time, use a surface plate cover.

Take care when using granite surface plates. Do not treat them as workbenches or lunch tables, do not drop wrenches or hammers on plates that will chip and nick the surface, and do not spill coffee or drinks or drop food on the granite as they can cause permanent stains.

When you are ready to measure a workpiece, set it down gently on the plate, as a sudden jolt or blow to the plate with a heavy metal object will chip or nick the surface. Also, when inspecting workpieces, especially small parts, use different areas of the surface plate because using the same spot over and over, year after year, will wear that area of the plate.

Check surface plates regularly for wear using a repeat reading gage with a manual indicator. Generally, long before a surface plate has worn beyond specifications for overall flatness, it will show worn or wavy spots, which will produce measurement errors. The reading gage will readily detect these error-causing areas.

Precision gage blocks are the primary standards vital to dimensional quality control in the manufacture of parts.

Set the gage on the plate and zero it at any point on the table. Move the gage over the plate, and if there are hand movements in the indicator more than 0.000025-inch for a AA plate, 0.000050-inch for an A plate or 0.000100-inch for a B grade plate, then the plate may have some high and low spots and be out of tolerance. Specifically, the tolerance must repeat from side to side within the specified tolerance range to be an accurate plate.

An effective inspection program includes regular checks with an autocollimator, laser or electronic levels providing actual calibration of overall flatness traceable to NIST. If tolerance variations are excessive, transfer the plate to work involving less accuracy or resurface the plate to restore it to its original accuracy level. Outside facilities or manufacturers are available to assist with the resurfacing process.

Mold builders who check gage readings and accuracies with gage blocks and ensure a reliable reference with granite surface plates will maintain primary standards that ultimately lead to reliable gaging and better-quality molds. MMT

*Note: chromium carbide gage blocks are exclusively Starrett-Webber croblox®

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By Glenn Marx

The Fundamentals of Hot Runners

What exactly does a hot runner do? If you've been in the injection molding industry for any length of time, you might think the answer is obvious, but it is not.

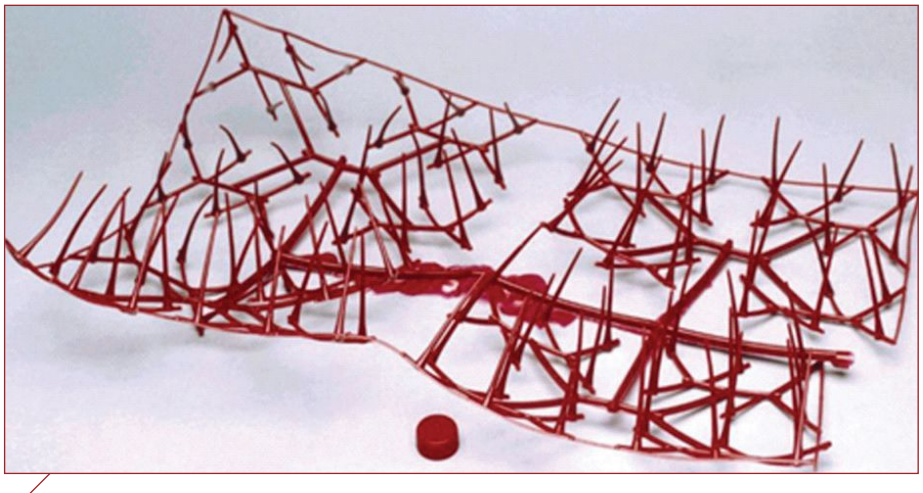
Very intelligent and experienced people in the plastics industry frequently ask for hot runner basics because although they know that a hot runner is a critical component in the injection molding process, some don't understand what it does or how it works.

Remember those plastic model kits you put together as a kid? The excess plastic that held those tiny components for the model in place is called a cold runner, and it is essentially scrapped plastic. Cold runners created during industrial production are very much like those models but on a much larger scale. When you consider the cost of resin, cold runners can be an expensive prospect because of the unwanted scrap plastic they produce.

The concept that hot runners eliminate wasted plastic is a pretty basic fact, but hot runners have additional advantages to the injection molding process. For those who want to know a little bit more about hot runners, here is a breakdown.

Faster Cycle Times

As higher volumes of plastic are injected into a mold, it takes longer to cool. Because a hot runner eliminates the volume that would have been cold runner plastic, faster injection molding machine (IMM) cycle times are typically achieved.



Images courtesy of Husky Injection Molding Systems.

Cold runner scrap from a three-plate mold.

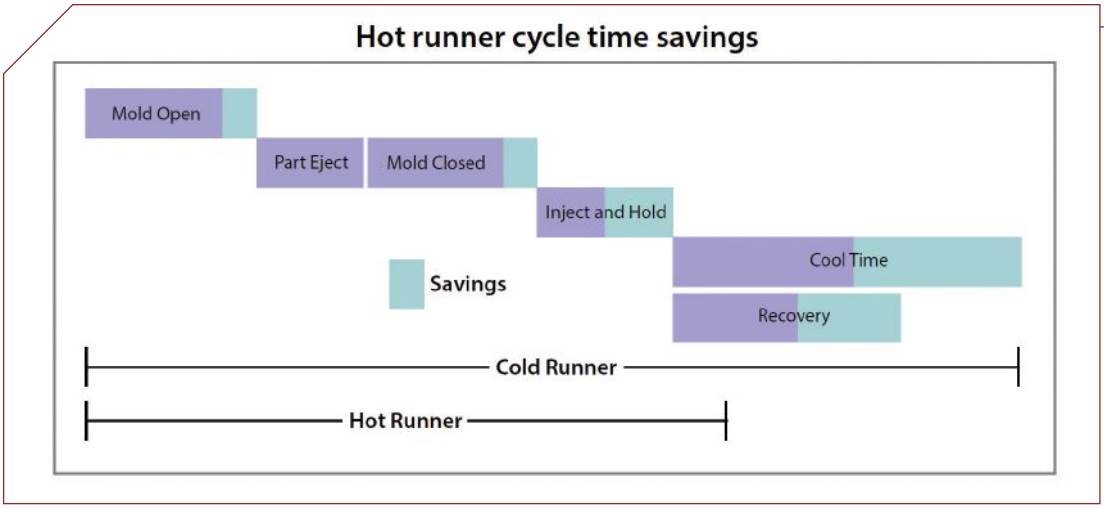
Let's review the injection molding cycle: The cycle begins as the mold opens, and when the mold is completely open, the parts are ejected. After the parts have cleared the molding area, the mold closes. Once the mold closes, molten plastic travels from the injection unit, into the mold. Then the part begins to cool. Once the mold starts to open again, the cycle is complete.

Hot runner systems can reduce the time of each function within the cycle except the actual part removal time (ejection). A hot runner system eliminates the cold runner (that solidifies), so there's no need to clear it away from the mold, which also causes the mold open and mold closed strokes to travel less distance, requiring less time for mold movement. Since there is no need to fill a cold runner channel, resin volume and IMM screw movement are reduced, lessening recovery and inject time. Finally, because less heated plastic is introduced into the mold, it takes less time to cool the molten plastic.

Reduced Labor

Consider the plastic model kit again. Before you can begin assembling any part of the kit, you must first separate the useful pieces from the useless cold runner. In a leisure environment, this is necessary but not prohibitive. In an industrial setting where thousands or even millions of parts are being molded, the time required to separate good parts from scrap runners comes at a very high cost.

With a hot runner system, the part separation from the runner is automatic. When the mold opens, finished parts are immediately carried down the conveyor into a box or a final package. There is no need for human intervention or downstream equipment to cut the part from the runner. By eliminating the cold runner, you reduce manufacturing time and costs while increasing productivity.



Gates

When plastic is injected into a mold, there is a tiny feature at the perimeter of the cavity called the gate. This gate identifies the connection point between the mold and the cold runner or hot runner. The gate serves a few different purposes.

The gate facilitates the flow of resin into the cavity by funneling it into a smaller opening. This causes the velocity of flow to increase, which reheats the resin at the appropriate time upon entering the cavity. This helps the resin plasticize and fill all the minute details in the cavity.

After a cavity is filled with injected plastic, the gate thermally cools more quickly than other cavity details because it is so small. The cooled gate is like a plug that keeps the cavity under pressure by stopping the back-flow of material.

With a hot runner, the gate can be either thermally cooled, or mechanically closed-off with a valve stem (with a pin). In either situation, the still-molten plastic in the hot runner separates at the gate, from the resin that is still cooling in a freshly molded part. The two main classifications of gates are thermal gates (hot tip) and valve gates.

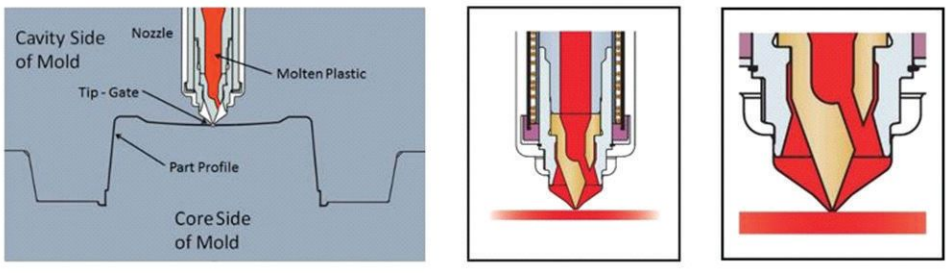
A *thermal gate* is formed by a funnel-shaped hole and often, a sharply pointed tip that is aligned with the gate hole. Many people call this type of gate a *hot tip* or a *pinpoint* gate. The hot tip relies entirely on the thermal properties of the metal in the gate area to cool the gate geometry. The goal is for the gate to break clean at the weakest point in the gate geometry when the mold opens.

Hot tips are simple. They require less expertise to handle and are easier to maintain. A hot tip may sufficiently meet the goals of your molding project. The tiny gate thermally cools to a plug, shutting off plastic flow. On the next cycle, injection pressure must blow out that plug, or slug, from the gates. Because thermal cooling properties are not extremely precise, the blow-out happens with irregularity.

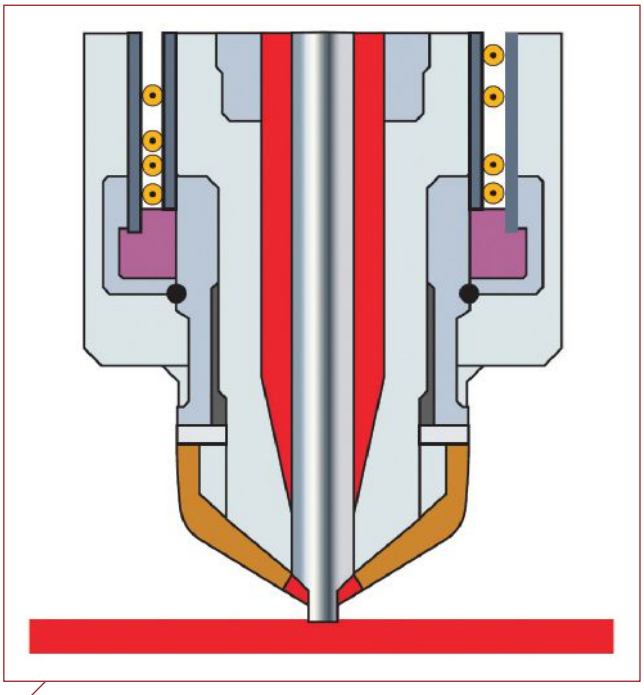
On multicavity molds, the blow-out is sporadic, like the timing of popcorn popping. Depending on the cavitation and parts being molded, the haphazard firing may be an issue. On multi-cavity molds, the split-second difference can cause an imbalance between parts. This inherent aspect of a hot tip can be reduced, by varying degrees, with a valve-gated system.

Although hot tips are generally inexpensive upfront, they are limited to applications where product quality and gate quality are not critical, such as thinwall containers and closures.

While thermal gates shut off plastic flow by freezing (cooling), *valve gates* use a movable pin (the tip of a valve stem) to control the plastic flow. A valve gate has a funnel-shaped hole too, but it involves a movable pin. The tip of the pin, also called a valve stem, opens or closes in the gate, allowing plastic to flow, or causing it to stop. The valve stem is closely timed with the IMM signal to inject plastic. The



Thermal gate nozzle and tip configuration.



Valve gate nozzle and tip configuration.

pin opens just before injection and closes when plastic stops flowing into the part cavity.

Given the same nozzle size, a higher throughput of plastic resin is typically more achievable with valve gate tips, which enable a molder to use a hot runner with a highly engineered, high viscosity resin that may not be possible with thermal gates. The higher throughput of a valve gate may also accomplish a faster fill time. In addition to this, valve gates do not need to wait for gates to freeze. Their actuation mechanisms quickly shut off the in-flow and back-flow of plastic. All these factors can help provide faster cycle times and wider processing windows with valvegates.

Common choices of valve pin actuation are *pneumatic*, *hydraulic* and *servo-driven mechanisms*. With these systems, molders can closely control valve gate stem movement. In multiple drop systems, they might fire valve pins simultaneously, or independently, depending on the part or parts being molded.

A multiple-drop mold may benefit from independent valve-pin-movement timing. In this case, the solution could be to actuate stems with split-second-apart timing, using a sequential valve gate controller. In a different scenario, parts may require extremely exact synchronization of stem movement. This can be accomplished with valve pins attached to a plate that actuates all pins with the exact same timing. This feature ultimately provides better part balance between multiple identical cavities.

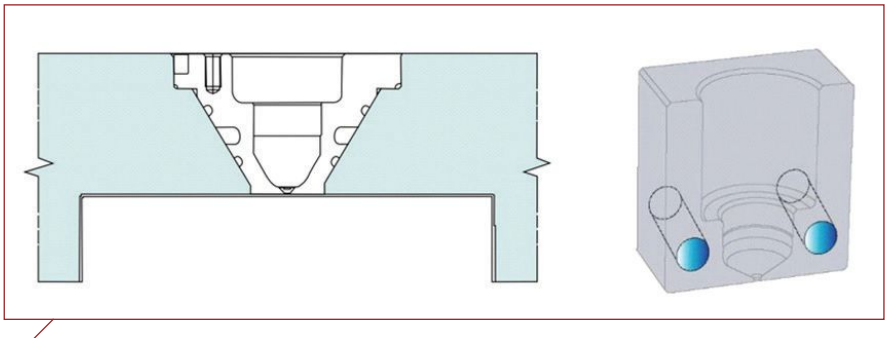
Many complex molding scenarios are possible by timing valve-stem actuation, for both synchronized and independent movement systems. Valve gates that are actuated via servo control can also provide variable linear speeds and different actions of the stems. These profiled movements can contribute optimized longevity of component wear, as well as lower vestige, for more cycles and better-looking gate cosmetics.

Both thermal gates and valve gates have their advantages, depending on the application. Entry-cost alone may not be the best reason to decide on a specific solution. There are purpose-driven reasons for choosing either a hot tip or a valve-gated hot runner system. Resin type, mold cavitation, part tolerance, cycle time, processing window and other factors can have end-profit impacts on hot runner choice.

Gate Cooling

Whether you are working with thermal or valve gates, the area around the hot runner gate must be cooled by water to stabilize molding functions over long periods of production time. Cooling lines are placed in strategic locations in the cavity of the mold, right next to where the hot runner nozzle enters close to the gate. This cooling helps a part separate at the gate, from the still-molten plastic in the runner, when the mold opens. Otherwise, when separation happens, there can be stringing at the gate, particularly with thermal gates.

Two main styles of cooling hot runners are *circumferential cooling* and *line cooling*.



Gate cooling configurations.

Circumferential cooling is fed by a water line, but it provides 360 degrees of cooling around the nozzle and tip clearance holes. This style is inserted so the water lines can be machined around the whole insert. Line cooling is merely drilled near the nozzle clearance hole and the gate. This is a simple but often effective measure against stringing and overheating. Both cooling styles can also reduce cosmetic concerns in gate function.

Gate Cosmetics

Detaching the cooled plastic part from a molten runner usually creates a small, unwanted blemish on the final part. This mark is called vestige, and it happens even when nozzles and gates are sufficiently cooled, as described above.

The advantage of a hot runner system is the ability to manage the vestige left by the gate. The level of importance in regulating vestige is directly proportional to the cosmetic, decorative or polished nature of the part. Many of the factors that cause vestige cannot be controlled, but there are some estimated expectations.

For example, parts from sprue tip nozzles will have a high, sprue-style vestige. In most applications, the high vestige left by a taper sprue tip is often not acceptable for final parts. However, these can sometimes be useful when gating from a hot runner system into a cold runner. Gating into a cold runner rather than directly into the part can still sometimes provide resin savings to the molder.

The height and characteristics of hot-tip gate vestige vary widely depending upon gate style, water cooling, resin and other factors. Often, a hot-tip gate can enter the cavity at a location with a raised dimple. This molds a concave dimple on the part, which can be desirable for keeping the vestige below the surface of the molded part. Some short stringing still often happens, even in the best applications. If part cosmetics are critical, hot-tip systems are often an undesirable compromise in vestige quality, compared to a valve-gated system.

Therefore, with parts that require more discriminating cosmetics, or parts that require a very small vestige, a valve-gated system is typically the best choice. The stem and gate in a valve-gated system can be manufactured very precisely so that there is a minimal amount of vestige. Valve-gated systems typically provide the best gate vestige.

Keep in mind that the part volume, resin type and the intended use of the part will cause various features to be required of the hot runner system. The viscosity of the resin will direct the throughput requirements of the inlets (sprue) and outlets (nozzles/tips) of the system. This is typically measured in grams per second. So, details are important in guiding a hot runner application engineer to recommend the appropriate hot runner system. MMT

FOR MORE INFORMATION

Husky Injection Molding Systems
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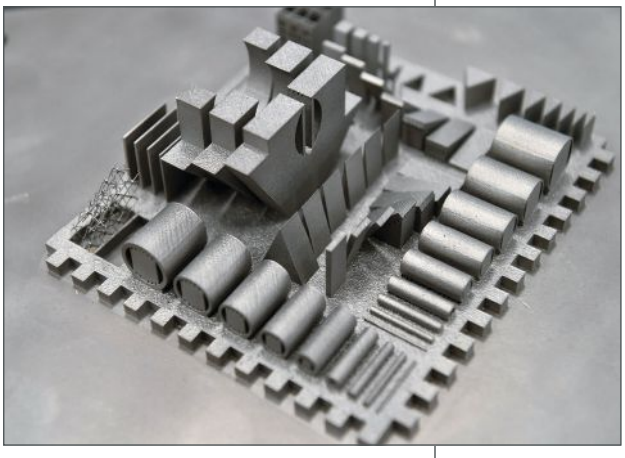
Building Confidence in AM for Tooling

By Christina M. Fuges



This part is an example of a build voestalpine uses to develop the processing parameters for a given AM tooling powder.

The start of any good product is the raw material, and that's what voestalpine is all about. Known in moldmaking circles for its Bohler and Uddeholm brands with their tool steel product lines, voestalpine has also invested in the additive arena with its AM tooling powder development, and why not? The company knows the tooling marketplace and can provide its material in wire, billet, block or round bar form. By providing custom-designed materials for additive manufacturing (AM), the company wants to bring new potential for specific tooling applications with productivity benefits that exceed those of generic "me too" powders. However, using the right material for the application is just one part of successful additive manufacturing.

The key to additive manufacturing is determining the most appropriate path of production for a particular part. Then once you design the part and determine the method of manufacturing, material selection is the next step. The three elements of a quality additively produced part are powder, parameters and the system. Let's focus on the powder.

Sami Arsan, P. Eng., PMP, CAM-F, voestalpine's vice president advanced and additive manufacturing technologies in North America, says that the five material aspects to consider for AM powder for tooling are: chemical composition, particle size distribution, particle shape, particle flowability and particle density.

Changing any of these five powder aspects will impact the quality of the part you are building with AM, and each one varies across the available AM technologies. As a result, voestalpine has invested in a lot of R&D to study AM powder material and to ensure its materials meet industry standards and customer requirements. In addition to the powder quality, humidity and oxygen content must be controlled during any handling processes, from mill to point-of-use.

AM needs to be a more integrative, holistic approach with the right powder to postprocessing partner.

short.moldmakingtechnology.com/AMTooling

PODCAST: Bringing in Curious Next-Generation Mold Builders

By Christina M. Fuges

Camille Sackett discusses instilling a culture of independence, empowerment and freedom, and attracting curious next-generation mold builders.

Camille Sackett grew up in Westchester County, New York, with three generations working at the Tarrytown General Motors plant. Touring the GM plant as a child, Camille developed fondness and respect for manufacturing. After working for Eastman Kodak as an engineering intern, she started with family-owned Accede Mold & Tool in 1993. Camille has served as a drafting/presentation engineer, senior mold design engineer, second-shift engineering manager, quality management system (ISO) manager, in "before-the-order" engineering and quoting, and most recently, as director of business development and engineering support. Today, she is proud to be a part of Accede's senior leadership team.

"With three children—a daughter in high school, a son in middle school and a son in elementary school—I am vocal in promoting U.S. moldmaking and the plastics industry," Camille says. Among other things, she runs school district technology-based clubs, shares industry promotional videos, and continually touts the excitement and opportunity within manufacturing, specifically moldmaking.

Camille has plenty to share about this family-owned company that fosters a culture that allows the team to take risks and to take on hard, complex projects, developing long-lasting relationships, instilling a culture of independence, empowerment and freedom, and attracting curious next-generation mold builders.

short.moldmakingtechnology.com/AMTPod

VIDEO: How to Really Use a 3D Printer

By Heather Wintle

HP's latest 3D printer, the HP Jet Fusion 500/300 Series, is designed to overcome existing color 3D printing challenges and open up innovation for small- to medium-sized product development teams and design businesses, universities and research institutions. Learn about how color 3D applications are enabled with a 3D printing system that allows the production of functional parts in full color, with voxel control, in a fraction of the time. At Amerimold 2019, Barbara Arnold-Feret presented this technology to conference attendees.

Barbara Arnold-Feret: 3D printing for HP is an exciting new area for us. We believe that this is the future of manufacturing. 3D printing represents integration, disruption, as well as the ability to make more profit. This impacts production by allowing you to get parts faster, integrate them into your manufacturing floor and do things that you couldn't do before. As part of that portfolio of products that we offer, we're showcasing the 580 machine.

The 580 machine is really oriented toward doing parts at around 100 pieces per week and below, for those that are you wanting to do two prototypes with jigs, fixtures, accessories, etc. and into the product mix. The 580 in our portfolio is an all-inclusive solution. That means that you print, you clean, you do everything within this footprint of the machine. If you open up the lid, you can actually see the printing area. You have a carriage that dispenses ink, as well as has a heat source. Multi Jet Fusion uses a heat source and actually fuses the material into a part. It's not binder jetting. It's not laser ring. It's not doing fused deposition modeling. It actually is a completely unique process called Multi Jet Fusion.

So when you look at this machine, what does that mean for you on a manufacturing floor? That means that you get the color, you get the durability, you get the ability with the accuracy and the reproducibility in an affordable solution. HP offers you a lot of ways to get this machine and integrate it into your manufacturing. Is it going to replace injection molding? No. But should you integrate it into your factory to give you another option on those jobs that you know, on the things that you can do now easily, on things that are having a short run, and you have to store the tools forever.

Watch the video or read the transcript to find out more.

short.moldmakingtechnology.com/HPAMEDemo

Barbara Arnold-Feret demonstrates the HP Jet Fusion 500/300 Series at Amerimold 2019.

Simplicity and Consistency Are Key to Molds in Motion

By Christina M. Fuges

Richard Oles, President and CEO of ALBA Enterprises in Torrance, California, used webcam video, animation and PowerPoint slides to engage webinar attendees and immerse them in a family of technology options for mold movement. For example, hydraulic cylinder solutions engineered specifically for the plastic and die cast industries, mechanical couplers and plate actuation systems.

Rich took a technical approach to the conversation, examining some challenging motions in tooling and some possible solutions. Other topics included how to monitor the motion in your mold or die such as induction, mechanical and magnetic switches and how to diagnose these switches when wired in series. Lastly, he looked at some failures when connecting a machine to a mold to move the ejector plate.

The main takeaways from this webinar include understanding what's possible with cylinders, couplers and latch locks, how technology suppliers are still inventing new ways to use these mold components to improve molds in motion, and the importance of innovation in these everyday products to save time with consistency.

Listen and watch this free archived webinar to see mold motion in a different light and discover possible solutions to common preventable problems.

short.moldmakingtechnology.com/AlbaWeb

ALBA's free webinar reviews solutions for the majority of mold and die movements, revealing how simple concepts can have a big impact on the bottom line in both dollars and time.

Conformal Cooling: Not Just Faster Parts but Better Parts

By Christina M. Fuges

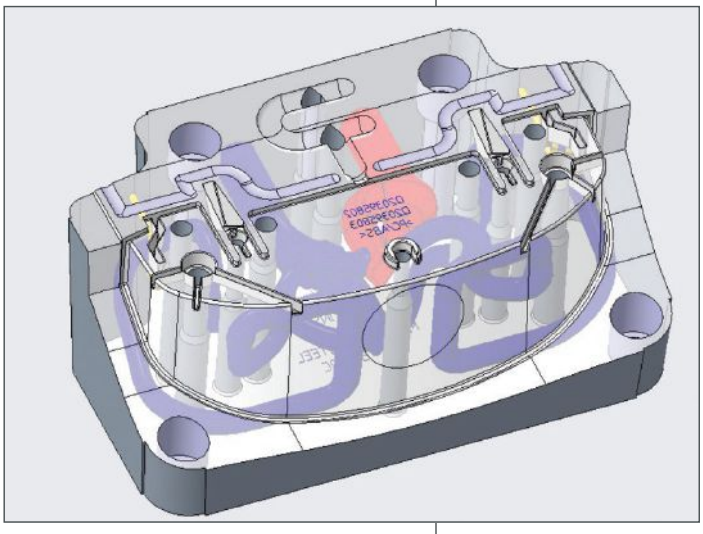


Image courtesy of EVCO Plastics.

Core block with conformal cooling channels.

EVCO Plastics (DeForest, Wisconsin) has been offering direct metal laser sintering (DMLS) conformal-cooled inserts for five years. Like many shops today, they outsource this work, but not to local job shops with metal printers that are not tailored to the injection molding industry. Evco uses mold builders who have expertise in DMLS.

When Evco contracts out the building of a conformal cool insert, the shop is making them a blank. It's not a finished piece. For example, if it's a core, Evco will design the mold and conformal-cooled insert with the help of the outside vendor. Then once they get the blank back, they finish machine for accuracy. "It's important to realize that it is not a finished piece coming out of the machine, although they are pretty accurate," Evco Plastics Design Manager/Tooling Engineer Mark McDonald says.

The key to selling this technology to customers, according to McDonald, is getting beyond the theoretical and proving out a conformal cooled-insert against a traditionally manufactured insert. For example, a long-time customer of Evco ordered a rebuild of a one-cavity mold they ran for years and requested conformal cooling. To prove out the benefits of conformal cooling, Evco built the inserts (core, cavity, slides) to put into this new mold where the customer was having cooling problems, and then tested the cycle times. This revealed the savings conformal cooling offered. It gave them the data they were looking for to prove conformal cooling improves cycle time. This particular tool's cycle time went from 32 seconds down to 17 seconds due to better cooling.

McDonald stresses that the advantages of conformal cooling go beyond cycle time; it also improves part quality, CPK values, part flatness, and sink. The key to staying up on all of the latest technology involved with conformal cooling is building a network of capable shops and establishing a solid supply chain, according to McDonald. MMT

short.moldmakingtechnology.com/EvcoDMLS

Index Contraction Nearly Stops

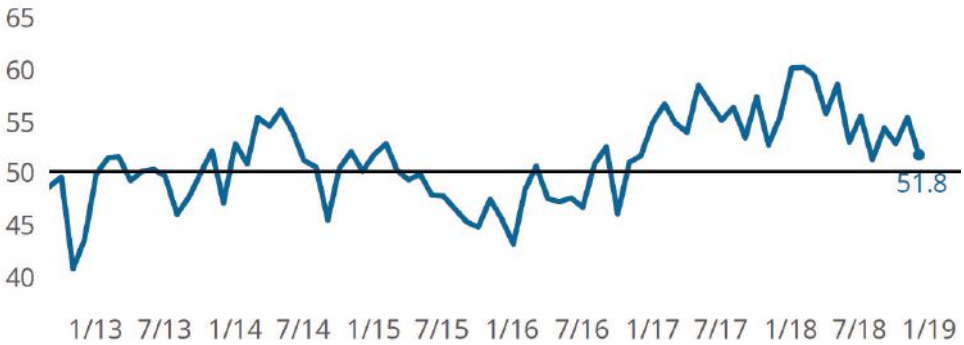
December 2019 - 49.8

The Gardner Business Index (GBI): Moldmaking was nearly unchanged in December after reporting its sharpest contraction in almost 4 years in November. Index readings above 50 indicate expanding activity, while values below 50 indicate contracting activity. The further away from 50, the greater the magnitude of change in business activity. December's improved reading came as a result of expansionary readings for new orders, production and backlog. The Index was pulled lower by employment, exports and supplier deliveries; only supplier deliveries moved lower. Monthly new orders and production readings oscillated above and below the 50 line, which divides expanding from contracting business activity. The lack of a trend here and an accelerating contraction in backlogs and exports placed further pressure on the Index. However, the backlog activity reading expanded for the first time since April due to expanding total new orders and a slowing contracting in export activity. Excluding supplier deliveries, all components registered higher activity in December than during November. MMT

ABOUT THE AUTHOR

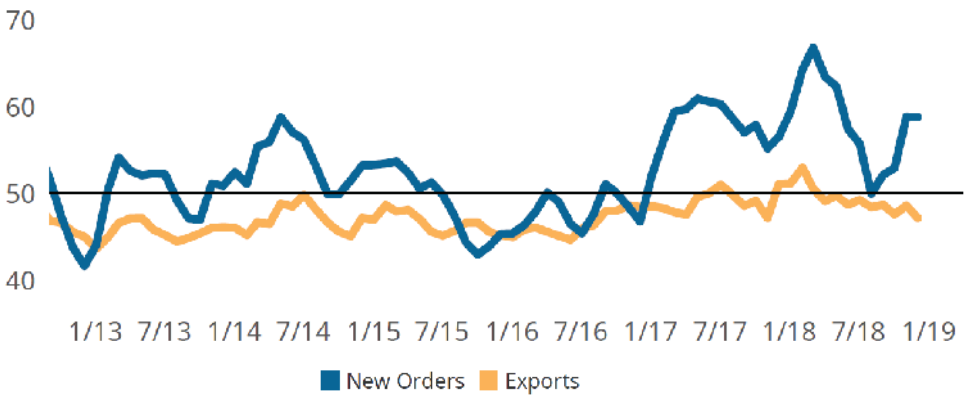
Michael Guckes is the chief economist for Gardner Intelligence, a division of Gardner Business Media (Cincinnati, Ohio, United States). He has performed economic analysis, modeling and forecasting work for nearly 20 years among a range of industries. He is available at mguckes@gardnerweb.com

Gardner Business Index (GBI): Moldmaking



The Moldmaking Index closed out 2019 slightly below a reading of 50. Five of the six components of the Index experienced improved readings during December. Three of the six components reported expanding activity.

New Orders and Exports (3-Month Moving Average)



Slowing and contracting new orders and exports in 2018 and 2019 facilitated a simultaneous contraction in backlog activity. December's backlog reading was the first expansionary backlog reading since April and the first to drive the Index higher since February of 2018.

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Stay ahead of the curve with Gardner Intelligence. Visit GBI's blog at gardnerintelligence.com.

Collaborative Robots Set Standards for Ease of Use, Reliability and Safety

FANUC introduces the CRX-10*i*A and CRX-10*i*A/L (long arm version) collaborative robots that set new standards in terms of ease of use, reliability and safety. The company offers the widest range of collaborative robots that can handle products from 4-35 kg. The new 10 kg payload CRX-10*i*A and CRX-10*i*A/L provide a reach of 1249 mm and 1418 mm respectively. Like the entire family of collaborative robots, the CRX-10*i*A and CRX-10*i*A/L are designed with FANUC's world-renowned technology, proven reliability and sensitive contact detection that enables them to work safely alongside people in a variety of industrial and manufacturing jobs.

The CRX-10*i*A and CRX-10*i*A/L collaborative robots offer customers unique advantages including safety rated contact stop detection like all FANUC collaborative robots; easy installation; programming ease; and reliability.

Customers can set up the collaborative robots straight out of the box, even without prior experience using a robot. The ergonomic design includes a lightweight and compact arm that fits in virtually any floor space configuration.

The collaborative robots also feature a compact R-30*i*B Plus Mini Controller and easily connects with third-party grippers. They offer lead-through teach programming and a new tablet interface with icons for touch control, no programming knowledge required. The CRX-10*i*A/L arm's swing motion makes it easy to access/grab parts located behind the robot. The collaborative robots supports FANUC's intelligent features such as integrated *i*RVision and *i*RPickTool software.

The new CRX-10*i*A and CRX-10*i*A/L collaborative robots will be available in Q2 2020.

FANUC America / 888-326-8287 / fanucamerica.com / Booth 4201 at PLASTEC West

Linear Needle Guide Unit Ideal for Maximum Precision

The **Hasco** linear needle guide unit Z073/ is used when maximum precision is required in the flat guiding of plates in injection molding units and die-casting molds. A tight-fitting tolerance between the square centering guide and the circulating needle rolling elements in the guide retainer permits reliable and highly precise centering.

This virtually free of play system ensures highly precise, flat guidance of components and is designed specifically for stripper plates. Circulating needles enable an unlimited stroke. The guides are exceedingly low-wear on account of the rolling friction and the large contact surface of the needles with service temperatures of up to 200°C. The resulting long service life can be extended still further by using the high-performance lubricating spray Z261/.

In addition to the complete sub-assembly Z073/, the square centering guide Z0731/ and linear needle guide unit Z0732/ can be supplied separately.

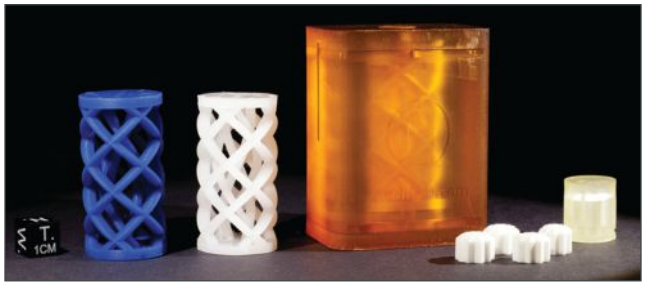
HASCO America, Inc. / 877-427-2662 / hasco.com / Booth 4030 at PLASTEC West

Freeform Injection Molding Creates Mold Cavities with High-Performance Materials

AddiFab has been working on freeform injection molding (FIM), a unique blend of AM and injection molding, and now the company is ready to step into the spotlight. The FIM technology is deceptively simple, yet extremely versatile. According to the company, the proprietary platform is used to create injection mold cavities, which are tough enough to process reinforced PEEK and other high-performance materials. They are also dissolvable, which enables injection-molding components that are too complex for conventional tooling.

AddiFab has been doing extensive testing on specific grades of Tefabloc, one of Mitsubishi Chemical's high-performance TPE materials. The Tefabloc material parameters were easy to dial in, meaning it was quickly able to overmold, as well as demonstrate the geometric complexity that is possible with FIM. After successful results, the company will test KyronMax, a group of reinforced polymers which are among the most competitive materials in the Mitsubishi Chemical portfolio, for metal replacement in structural applications, along with FIM for outstanding material properties that can be achieved on an additive platform while using current feedstocks.

AddiFab ApS / 452-680-3210 / addifab.com / Booth IL02 at PLASTEC West



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VISI CAD Library Offers Complete Catalog

Progressive Components and Tooling Software Technology, LLC (TST) announce the complete Progressive catalog is available within the VISI CAD libraries and available to download via the companies' websites. The VISI CAD library offers over 7,000 products from Progressive Components that are exclusively distributed in North America. In addition, several new features were added to VISI CAD, including the option to add standard componentry using built in VISI functions, automatic updates to the assembly manager and the BOM with ordering information for purchasing, and the ability to insert rapid tooling inserts and accessories.

Progressive Components / 800-269-6653 / procomps.com / Booth 3945 at PLASTEC West

Data Management Software Collects, Processes Data from Multiple Machine Tools

Marposs announces its data management software, C-THRU4.0, designed to collect and process data from multiple machine tools equipped with Artis machine monitoring systems via a central hub. This information can be accessed remotely, via an iPad, computer or laptop as well as offering the ability to integrate with MES and higher level ERP systems. The data collected can be used to analyze tool life, machine capability and cost comparisons, as well as alarm tracing and counts, profit and loss accounting, profitability analysis and more, all leading to enhanced productivity and profitability.

The software works by feeding real-time information from the machine tools to a cloud platform network, which can then be accessed and used in either a centralized or decentralized manner. This interconnectivity helps to optimize production flow from preventative maintenance, process stabilization and quality assurance to resource planning. Production costs and quality are always transparent and traceable through the statistical recording and evaluation of performance indicators.

To initiate C-THRU4.0, data collected from the monitoring processes is coordinated with the customer's cost and resource information to provide a dashboard that meets the customer's needs. Any changes coming in from the customer side can be fed back to the machining center. This interconnectivity and data flow supports the move toward the Industrial Internet of Things (iIoT) and Industry 4.0.

Marposs Corporation / 888-627-7677 / marposs.com / Booth 1337 at PLASTEC West

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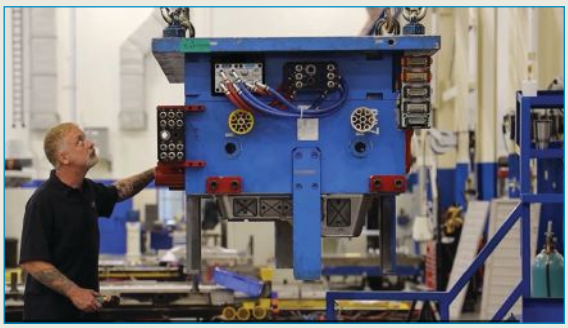

YouTube Videos

Scott Phipps, owner of mold repair and engineering services provider United Tool and Mold, shares the company's philosophy that lead its team to success.
youtube.com/c/moldmakingtechnology

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Look at how happy you made our new friend by reading all about our hashtag #IfAMoldCouldTalk campaign! If you have an idea for our little buddy's name, don't forget to head over to moldmaking technology.com and submit your idea.
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@MMTMag Hot Tweets

@AMBA_molders strongly supports the reinstatement of tariffs and applauds the Trump administration for heeding the calls of the more than 150 American mold builders who filed comments supporting the tariffs.
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Conversations

2030 is the tipping point year for baby boomers turning 65 and retiring, and to attract a younger generation to mold building, shops should start thinking out of the box.
Linkedin.com/company.moldmakingtechnology

Photo Share

"I AM A RHINOCEROS! I CAN'T WAIT TO GET UP IN THE MORNING AND START CHARGING!" Love that United Tool and Mold attitude!
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CUTTING TOOLS

Tips for **Mitigating Chatter and Vibration**

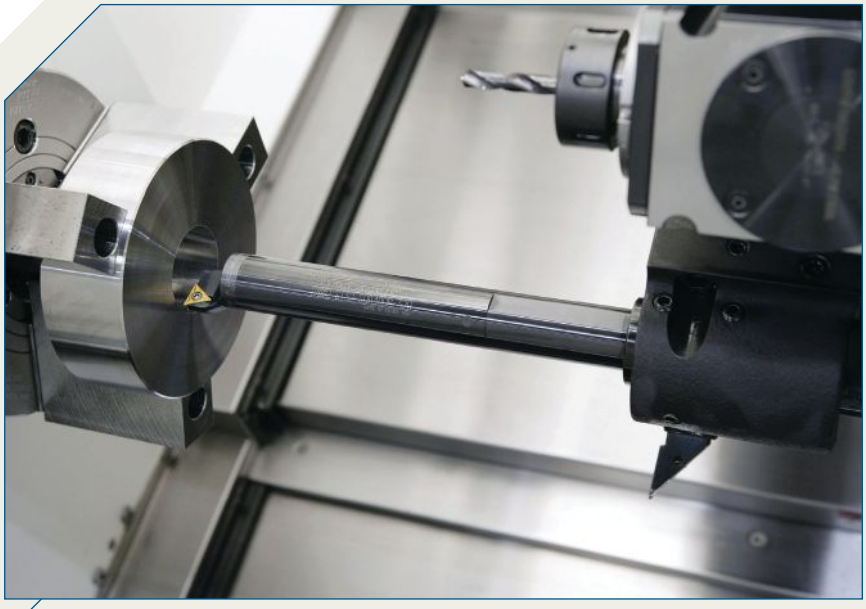

Image courtesy of BIG KAISER Precision Tooling.

There are several ways to eliminate vibration and chatter when machining, including by identifying tool deflection and better programming. Another solution is to employ damping technologies like the product pictured here, which is designed to dampen vibrations and reduce chatter in deep-hole finish boring and extended-reach face milling applications.

By Jack Burley

Vibration can be a common problem faced by shops. A resonance frequency issue, vibration happens as a tool is trying to move out of its designed path or center. As it does, the tool starts to deflect, which causes chatter. This can have an adverse impact on machining: tool life is negatively affected, spindle bearings take up vibration which affects their life, lost productivity from slowing the process down, and out-of-tolerance workpieces.

There are a few ways to combat vibration. One is to identify tool deflection as the root cause of the problem. This can take several forms, from cantilever deflection to holding being done with a pulling element. Since deflection is based on the amount of force, the higher the force, the greater the deflection.

Better programming reduces such forces, leading to a smoothly run operation. Better tool selection, sharper cutting edges, reducing length and applying five-axis technologies all can be beneficial in the anti-vibration fight. But keep in mind that three important forces play a role on tools—radial, axial and tangential.

There are a few ways to combat vibration.

As for starting points, programmers should consider the length to diameter ratio. Anything 4:1 and less, the manufacturer's recommendation is good to go. But for a ratio lower than 5:1, some changes are in order. Look at the insert radius and change to a sharper cutting edge. At a ratio of 6:1, chatter is very likely, and adjustments are necessary if over 7:1.

For small end mills, adjustment for chatter is still recommended. A few steps can be taken to reduce engagement. Reduce the number of flutes, use both a variable flute and helix end mill, which should break up the chattering. Reducing the depth of the cut can also help—focus on the axial and radial forces.

The biggest problem is when there is chatter in the shank. Cutter shank engagement in the tool holder should be at least 2 ½ x D. Using both the shortest tool holder possible and balanced tool holders, as well as minimizing runout are good options to reduce vibration.

Vibration reduction techniques extend into programming solutions. Among those is utilizing trochoidal milling programs, installing CAM software that maintains constant chip thickness, employing circular interpolation in corners with a smaller tool, and finding the tool assembly's "sweet spot"—all leading to finding the machine's natural frequency.

Ultimately, damping technologies offer the greatest possibility of eliminating vibration. Although not a new concept, damping can automatically identify the source of vibration and help with the frequency. MMT

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Jack Burley, Vice President of Sales and Engineering

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