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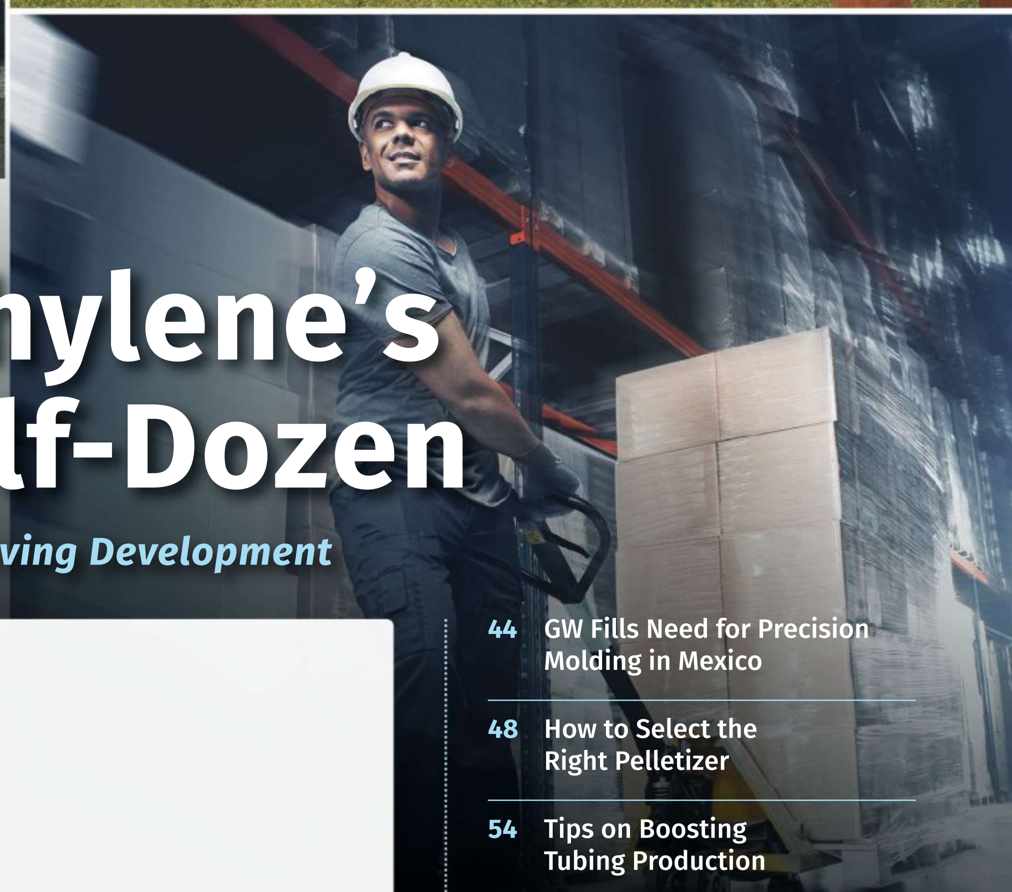

# Polyethylene's Hot Half-Dozen

***Key Market Areas Driving Development***


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Plastics Technology

## There's more on the web at *PTonline.com*

### BLOG: Costa Rica Cleans Coastlines with New Cement Aggregate

A new initiative in Costa Rica that's diverting plastics from shorelines and the ocean into cement for construction was highlighted in *Plastics Technology*'s blog by Senior Editor Heather Caliendo. Mixed, dirty plastics are collected, cleaned and pelletized to become an aggregate material added to cement without increasing that construction material's weight.
***short.ptonline.com/costarica***

### Molding 2019 Preview

In a little over one month, *Plastics Technology*'s injection molding conference and exhibit—Molding 2019—will take place in Indianapolis, March 19-21. With some speaker highlights from Molding 2018, catch a video preview of the tracks and sessions that will be part of this year's mecca of molding.
***youtu.be/PsNa1HW2b9k***


Stay up with our video reports by subscribing to our YouTube Channel: ***short.ptonline.com/yfZBD0uY***

### BLOG: Tiny Particles Make Big Contributions at Great Depths

The ability to act as an electrical insulator, endure harsh working conditions (like a mine), and provide colorability have helped graphene nanotubes find a niche in PVC-plastisol-based flexible

ventilation ducting in mineral extraction. Senior Editor Lilli Sherman reports on the development, following up on earlier reports about the unique additive's game-changing properties.
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# Call for Papers: Extrusion 2019

## Stage is set as conference devoted to all things extrusion heads for Chicago. Interested in speaking? Let us know by Feb. 22.

It's that time again.

*Plastics Technology* is bringing the world of extrusion to a new location in Chicago, Sept. 17-19 at The Extrusion 2019 Conference.

**Jim Callari**
*Editorial Director*

During this two-and-a-half-day event, business owners, plant managers, process engineers and manufacturing personnel will be brought up to speed on technology developments impacting all types of extrusion operations.

In 2015, *Plastics Technology* Magazine launched its first ever Extrusion Conference, an effort to bring the world of extrusion together in one place at one time. We organized a technical program with General Sessions of interest to all types of extrusion processors, and concurrent sessions that offer attendees a deep dive into the major types of extrusion: Film, Sheet, Pipe/Profile/Tubing, and Compounding.

Our first three conferences were held in Charlotte, N.C. Our efforts resonated with both exhibitors and attendees to the extent that we "outgrew" that location. Last year's conference was held in Cleveland and drew record numbers of attendees and exhibitors. In fact, the Extrusion Conference has grown every year since it was launched, and we are expecting the same in 2019.

This year's Extrusion 2019 Conference will be held at the Donald E. Stephens Convention Center in Rosemont, Ill., a short drive from Chicago's O'Hare Airport. We're hard at work putting the program together now, and when all is said and done, we'll have assembled a group of the finest technical minds in the industry to deliver presentations that you will be able to put in practice to improve operations at your plant. What's more, you'll have the opportunity to network with your peers and more than 70 suppliers in our exhibit area.

***When all is said and done, we'll have assembled a group of the finest technical minds in the industry delivering presentations that you will be able to put in practice to improve operations at your plant.***

To submit a title and abstract, please go to ***extrusionconference.com***. Then scroll down and click on "Interested in Speaking?" From there, click on "Apply Now" to begin the process. You will be brought to a page asking for a Title, Description (2-3 sentences), and Abstract. Please fill in those fields and indicate your Area of Focus from the dropdown menu.

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If you're involved in extrusion processing of any kind, this is the conference for you. The Extrusion 2019 Conference. Sept. 17-19. The Donald E. Stephens Convention Center in Rosemont, Ill. I hope to see you there.

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## Specialty Materials Being Developed To Enhance PE Recyclate

Another growth opportunity for polyethylene resins, in addition to those addressed in our cover story, "Hot Half-Dozen Applications Driving Development in PE" (p. 38), are specialty grades that enhance post-consumer recyclate (PCR), as shown by the following development activity:

ExxonMobil Chemical has been offering its "Rethink Recycle" program with Vistamaxx performance polymers, targeting high-value uses. Their use to compatibilize mixed PE and PP recycle has been shown to reduce need for costly materials separation and allows for higher PCR content, while enhancing end-product performance.

Photo: Starlinger

Nova Chemicals has formulated Novapol PF-0118-FI, a 1.0 MI butene copolymer LLDPE, the first in a new family, to be more forgiving and robust under the rigors of recycling. Either it can be recycled more often, or it can be used to enhance a higher percentage of lower-quality PCR. It is targeted for blending, trash bags, liners, general packaging, heavy-duty bags, stretch wrap and garment film. Collaborative work is underway on incorporating PCR into packaging and goods now made typically of 100% virgin.

Braskem's Wecycle platform involves different recycling technologies for polyolefins. The one used for LLDPE, LDPE and PP is undergoing lab trials; the technology for HDPE is in the validation stage with customers that are testing the recycled resin in low-volume thermoformed packaging. This technology reportedly allows creation of recycled HDPE with high quality and a high percentage of recyclate. It boasts stress-cracking resistance, tensile strength similar to virgin, and 70% higher mechanical properties than current recycled HDPEs.

### Ineos Styrolution to Build Texas ASA Plant

Ineos Styrolution GmbH has announced its decision to build a 200-million lb/yr ASA plant, with start-up scheduled for 2021 in Bayport, Texas. This follows previous investments in an 140-million-lb ABS/ASA plant in Altamira, Mexico. The company says the additional ASA capacity will allow for more flexible production of specialty grades to meet growing demand, and also will free up capacity to produce more ABS at the Mexican facility.

### Dri-Air Expansion Completed

The newly completed 6000-ft$^2$ addition at Dri-Air Industries in E. Windsor, Conn., will increase its manufacturing and warehousing capacity by about 50%. The added space will be used to boost stock inventory by 25%, reducing lead times, improving workflow, and allowing the firm to hire more employees and pull in outside processes, thereby gaining tighter quality control.

While inventory will be lifted across all product lines, larger dryers and hoppers—1000 lb and higher capacity—will be the primary focus for the added space. "This will allow us to stock larger hoppers and components for our fastest growing segment, our large dryer market," says Jason Sears, Dri-Air president.

## Two PET Resin Producers Buy Recyclers

Thailand's Indorama Ventures is one of two PET resin makers that are acquring PET recyclers. Indorama signed an agreement to buy a recycling facility from Custom Polymers PET, Athens, Ga. Indorama has been in the PET recycling business since 2011, with facilities that transform post-consumer PET bottles into flakes, rPET resins and polyester yarns in Europe, Mexico and Thailand. The Alabama facility has two production lines, one for rPET flake and another for food-grade rPET pellets, with a combined capacity of 68.3 million lb/yr. The company says this acquisition will enhance its ability to produce food-grade, 100% rPET pellets in the U.S. to meet increasing demand.

Second, DAK Americas LLC, an Alpek Polyester business, has signed an agreement with Perpetual Recycling Solutions, LLC to acquire the Perpetual PET recycling facility in Richmond, Ind. This operation has an approximate annual capacity of 100 million lb/yr of high-quality rPET flake. This facility will complement Alpek Polyester's current food-grade PET recycling capacity in Argentina and its fiber-grade recycling joint venture in Fayetteville, N.C.


## Chinaplas Looks Inside & Outside China for Further Growth

Chinaplas 2019, May 21-24 at the China Import & Export Fair Complex in Guangzhou, will be the 33rd occasion of this annual show. Organizer Adsale Exhbition Services Ltd. has been meeting with plastics-related trade associations in Southeast Asia as well as central and western China to promote the show's continued growth. Potential SE Asian partners include SME Corp. Malaysia, Thai Housewares Trade Assn., Thai Tool and Die Industry Assn., Thai Auto-Parts Manufacturers Assn., and the Electric Vehicle Assn. of Thailand.

In addition, the China Central and Western Regions Plastics Industry Alliances have joined with Chinaplas to help foster "communication and interaction among stakeholders in the plastics industry in the central and western regions," according to Adsale. China's eastern coast has long been the focus of the country's booming economic expansion, but inland regions are increasingly exhibiting the highest levels of business activity.

Adsale reports that in 2017, the export value of laptops from Chongqing in southwest China totaled $18.5 billion, making the city the world's biggest cluster for laptops, with HP recently establishing a manufacturing plant there. In automotive, the central Chinese city of Wuhan has become a hub, manufacturing 1.89 million passenger vehicles in 2017, while Henan province produced more than 250 million smartphones the same year, making it the largest production base for that product, according to Adsale. The year-on-year growth rate of plastics production in the 12 western provinces and regions was 8.44%.

## Westfall Technik Buys Another Molder, a Moldmaker & Mold Hotrunner Solutions

In little more than a year, Nevada-based holding company Westfall Technik has assembled a powerful collection of injection molding, moldmaking and prototyping operations, currently numbering an even dozen facilities coast to coast, with more than 1300 employees and over 260 injection machines. Those include three acquisitions in the last quarter of 2018: Amaray US, a packaging molder with 66 machines and 165 employees in two plants in Pittsfield, Mass., and Elizabethtown, Ky.; and Extreme Tool & Engineering, a medical moldmaker in Wakefield, Mich.

Broadening its capabilities, Westfall most recently purchased Mold Hotrunner Solutions (MHS) of Georgetown, Ont., a builder of valve-gate hot-runner systems. MHS also produces a unique micro-molding machine, the M3 (photo), the latest version of which was introduced at NPE2018 in Orlando, Fla.

## Self-Driving Shuttle Built on Giant 3D Printer

Local Motors in Phoenix, Ariz., creator of the world's first 3D-printed car, the Strati, was combined last year with the Launch Forth collaborative design community into LM Industries, based in San Francisco. LM Industries calls itself the world's first digital OEM, which can take concepts to deployed products in under one year. It brings products to market in an entirely new way, designing with its global community of experts and applying technology such as 3D printing to create and assemble products in small batches at agile microfactories. LM Industries creates transportation, accessibility and mobility products with customers such as Allianz Group, Airbus and the United States Marine Corps. Its efficiency allows products to be upgradeable like software—iterated regularly and fluidly to match rapidly changing consumer preferences.

One concept that continues to gain momentum is the company's small autonomous shuttle vehicle named Olli. Created in 2016 by Local Motors, Olli is a 3D-printed, self-driving "smart shuttle," offered as a sustainable transportation option for cities, hospitals, campuses and entertainment districts. LM Industries sees carbon fiber as a core component of the future of additive manufacturing and it's essential to the Olli, which is built from carbon-fiber reinforced thermoplastics.

Thermwood installed its Large Scale Additive Manufacturing (LSAM) system to produce Olli at Local Motors' facility in Knoxville, Tenn. With a build envelope of 10 x 40 ft, it's said to be the world's largest composite 3D printer. Thermwood says LSAM machines can be up to 100-ft long. They can print both horizontally and vertically and both print and trim on the same machine.

Since Olli is custom designed and 3D printed, different features can be added so that a new shuttle can be suited to fit a city or campuses. Local Motors can simply change the file and a print a batch of Ollis that fit a customer's needs. In early August, Olli was deployed at the State University of New York (SUNY) at Buffalo as part of a partnership with the school and New York State. The shuttle is being used on campus for mapping, autonomous education, and testing potential transportation options. LM Industries is inviting municipalities, campuses and designated districts to propose a short-term, local use for Olli. One location will be selected to receive a fleet of eight-person Olli shuttles to use for about three months. This is the second of the company's so-called "Fleet Challenges," more of which are planned.

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# Simultaneous Blowing/Filling Process 'Breaks Down Walls' in Supply Chain

## Amcor's LiquiForm technology supports new 'holistic' on-site processing service.

Superior bottle definition with LiquiForm is exemplified in this PET liquor bottle with embossed detailing.

By Matthew H. Naitove
*Executive Editor*

"You've heard of 'through-the-wall' bottle manufacturing? Now we're breaking down that wall between the brand owner and bottle producer." That's one way that Ashish Saxena describes Amcor 360, the new "transformational packaging service" from Amcor Rigid Plastics, based in Ann Arbor, Mich. Saxena is v.p. and general manager of Amcor 360 Packaging Solutions, which is placing machines and personnel in brand owners' and co-packers' facilities to deliver a package already filled with liquid product, not empty bottles to a filling line. The secret is a one-step process in which the contents actually form the container.

The LiquiForm process has been tested with a wide range of bottle shapes and sizes, in PET, HDPE and PP.

Amcor 360, "powered by LiquiForm," as Amcor puts it, is a service based on the patented LiquiForm process. Unveiled by Amcor in 2014, LiquiForm is a stretch-blowing process in which an injection molded preform is formed into a container not with compressed air but with the liquid contents of the bottle (see Sept. '14 Starting Up and April '15 feature for details). The first commercial application of LiquiForm was announced last February (see March '18 Starting Up) and Amcor 360 was introduced in October.

### BETTER BOTTLES, LOWER COST

Combining the bottle blowing and filling steps into one simultaneous step utilizes less equipment, less floorspace, and less energy. Saxena notes, "One co-packer tells me he has thousands of square feet dedicated to storing 'air'—empty bottles—which is incredibly costly. The ability to run from liquid to finished goods frees up space for manufacturing and eliminates incoming freight."

LiquiForm has proven ability to save costs in two other ways, as well. Forming the bottle with liquid instead of air reduces energy consumption by 40-60% and allows for faster forming times, potentially cutting overall cycles by 25-40%, according to Richard Sieradzki, v.p. and general manager of Amcor's LiquiForm Group, which licenses the technology. He notes that the time saved could be used for capping the filled container. In addition, forming containers with liquids enables more uniform material distribution, allowing for lightweighting. In the first two applications—one already commercial and one soon to be so—material savings were as much as 20%, Saxena says.

*Why pay for shipping and storing 'air'—empty bottles?*

Another key benefit is two to three times better definition of mold details. LiquiForm Group has established this with a test mold incorporating various textures and details. The process produces improved transfer of embossed mold details that mimick glass, as in the liquor bottle shown above.

The Liquiform process reportedly lends itself to a wide variety of liquid foods, beverages, and personal-care products. Sieradzki notes that the LiquiForm Group has tested the process

using liquids with viscosities from 1 cp to 10,000 cp and plans to experiment this year with viscosities up to 50,000 cp, in the range of ketchup and hair conditioners. The Group has used the process to make bottles from 200 ml to 1 gal capacity and plans to go both larger and smaller. It has made bottles as light as 8.5 g for still water and as heavy as around 100 g. Bottle shapes have ranged from simple rounds to complex shapes.

LiquiForm Group has used the process with PET and HDPE. Yoshino Kogyosho, Japan's largest bottle maker, has used the process with PP bottles. Sieradzki sees future potential for a Liquiform machine able to use all three materials.

*Still water will be a 'huge step forward' to higher volumes for the LiquiForm process.*

Amcor Rigid Plastics is one licensee of the LiquiForm technology; others include major bottle blowing, filling and capping machinery makers such as KHS, Krones and Sidel, as well as the Japanese processor Yoshino. Amcor developed the first commercial machine for the process, as well as the first commercial product, Nature's Promise liquid hand soap. A second, similar application is coming "very soon," Saxena says, and still another liquid soap project should reach fruition this year.

What's more, Amcor 360 is working on a still-water application to be released this year. This will be followed by flavored water and isotonic beverages. "This will be a huge step forward to significantly larger volumes for the LiquiForm process," Saxena says. Initial uses are medium-volume, he says, using a linear shuttle reheat stretch-blow machine. But beverage applications will be able to take advantage of high-output rotary machine platforms.

## COMPLETE PACKAGING SOLUTION

While the first LiquiForm hand-soap applications are being produced at existing Amcor facilities, beverage production will follow the new Amcor 360 model. Saxena describes this as a "holistic" packaging solution, in which Amcor 360 will provide the machine and operate it at the customer's location, supported by "best-in-class" preform and bottle design, a proven manufacturing "recipe" for the product, and a commitment to continuous improvement of the process.

This supply-chain simplification means that customers don't have to invest capital in equipment, don't have to worry about finding or training people to run it, don't need freight services or storage space for bottle inventory, and can improve their sustainability profile through energy and material savings in package manufacturing and logistics.

# Plentiful News in Hot Runners at Fakuma Show

## More compact hot runners, even for large parts; smarter controls; unusual nozzle designs; remote mold monitoring; and a new source of LSR cold-runners.

By Matthew H. Naitove
*Executive Editor*

The Fakuma exhibition in Friedrichshafen, Germany, is focused on injection molding—and that includes numerous displays of hot-runner nozzles and controls. Fakuma 2018 in October was no exception, with plenty of news in those categories for everything from micromolding to large automotive parts. Almost all suppliers had something new on hand, though several had already debuted their new entries at NPE2018 in Orlando. Without repeating what was previously reported, there was still a full slate of additional news at Fakuma, reviewed here.

### VALVE GATES DOMINATE NEWS

**Ewikon** expanded the range of tip inserts for its nozzles with a version that does not have a permanent valve-pin guide but does have pre-centering for the valve pin the gate area. This design is for when a fully open flow channel is required—e.g., for optical parts, very fast color changes, or reinforced and flame-retardant materials.

For materials sensitive to residence time, such as acetal homopolymer, Ewikon's valve gates now place the valve-pin seal in a cooled mold insert where it has no contact with the heated hot-runner components. This "cold" valve-pin seal is said to be leakproof and to prevent material degradation in the gap of the valve-pin seal. The thin layer of material that enters and fills the gap during startup acts as a sealing and lubricating film that minimizes wear between the valve pin and seal. This approach was applied first to the company's HPS III-MH valve gates, but has also been extended to HPS III-S standard nozzles.

*Even hot-runnner nozzles for larger auto parts are becoming thinner and shorter.*

In addition, Ewikon introduced its first cold-runner system for LSR, called Coolshot. It's an electrically driven valve-gate system in which linear stepper motors control each gate individually. Valve-pin positions can be adjusted in steps of 0.01 mm. A controller with 7-in. touchscreen is provided; remote control via tablet is available. A quick-clamping device allows the hot cavity plate to be easily separated from the cold nozzles in case of a lengthy process interruption, in order to prevent curing LSR in the cold runner.


**Haidlmair's novel FDU nozzle is now commercial. It produces a thin, slit gate that can inject more material faster and at lower pressure than a standard circular nozzle, and the thinner gate cools faster. Shutoff types are in development.**

Furthermore, Ewikon has joined the trend to web-based remote monitoring of molds. Its new Smart Control is accessible by mobile devices and PCs via browser. It monitors hot-runner nozzle and manifold temperatures, number of cycles run, system running time, and downtime. Hot-runner system pressure is optional. It's a compact box that can be supplied with new hot halves or retrofitted to existing molds. It transfers data via WLAN, Ethernet or USB and can send warning alerts via email or web.

**Gammaflux** showed for the first time a complete turnkey package consisting of its latest G24 hot-runner temperature controller (18 to 480 zones) integrated with sequential valve-gate control and hydraulic power unit in one device.

**Gunther** emphasized its recent focus on optimizing micromolding with hot runners, since a cold runner typically weighs more than the part or parts and is the limiting factor in cycle time. Gunther showed a 32-drop valve-gate system capable of molding 2 million nylon or acetal parts/week weighing 0.004 g and having a volume of 0.016 cc. The nozzles were Gunther's Blue Flow models with a 2.8-mm melt channel and 48-mm total length, all actuated together by an electric-driven plate.

### NOVEL DESIGNS

One of the more unusual hot-runner components to be seen at Fakuma was the FDU (Flat Die Unit) nozzle from **Haidlmair**, so named because of its resemblance to an extrusion flat die for sheet or film. After five years of testing and development, the

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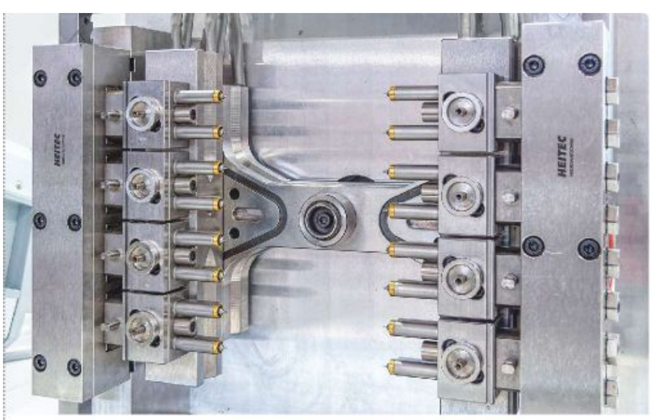
FDU is now commercially available in sizes from 120 to 280 mm wide for shot volumes of 200 to 2000 g per nozzle. It produces a "slit" gate that allows higher throughput at lower pressure than a conventional round nozzle of similar cross-section. A round nozzle with similar melt-delivery capacity would create a thicker gate that would take longer to cool. In molding parts such as boxes, crates, and appliance parts, FDU has allowed 12% to 25% faster cycles and up to 22% lower pressure. The nozzle is particularly suitable for polyolefins. Versions are available in steel or copper alloy, depending on the material processed. These are open-tip nozzles, but shutoff designs are now in testing. Also, the FDU is currently available only with a Haidlmair mold, but nozzles will be available separately in future.

***There's a new source of valve-gate cold-runner systems for LSR.***

Also new from Haidlmair is Haiflex, a system using compressed air for quick changing of vent, date, and handle inserts while the mold is in the press.

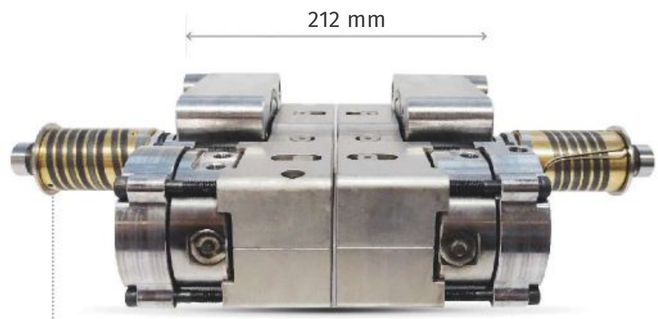
Haidlmair also promoted its new digital services, including FDM prototyping of plastic parts, laser 3D printing of metal core/cavity inserts for conformal cooling, and CT scanning of sample parts up to 1200 mm diam. height—large enough for molded pallets.




**Heitec has added valve gates to side-gating systems. All pins are synchronized by electric-driven cams.**

**Heitec** (represented here by Technoject) introduced what it calls "the next step in side gating"—by adding valve gates. SynchroValve electric-driven cam action actuates all valves together. The VDC Visio Drive Control comes with a small touchscreen.

New from **HRSflow** is a special low-height actuator for valve gates in stack molds (photo above right). The key to this Compact Stack Mold approach is the staggered arrangement of the cylinders to the side of the nozzle and the use of rocker levers to transmit the movement from the cylinder to the needle. The result is much lower stack-mold heights than when the cylinders and needles are aligned—132 mm for offset nozzles vs. 212 mm for in-line nozzles (HRSflow's Ga range for medium to large shots). Available for PP, ABS, and PC/ABS, this new technology is aimed mainly at large parts such as auto bumpers and bins or pallets.



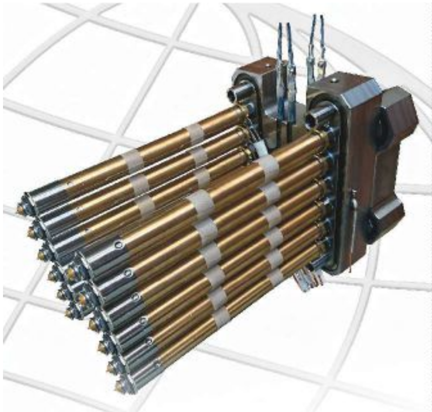

**HRSflow introduced the Compact Stack Mold system, which reduces mold height with offset instead of inline positioning of the valve-gate actuator cylinder and nozzle. It's aimed mainly at large parts.**

HRSflow also exhibited the first of three demonstration family molds for three very differently sized elements of a car door panel, designed to show off the capabilities of the company's Flexflow servo-driven valve-gate technology. Three identical molds are being built for HRSflow facilities in Italy, Michigan, and China. The tools are designed to mold three parts in PP or ABS: door liner (560 cc), map pocket (338 cc), and reinforcing bar (58 cc). Average wall thickness varies from 2.3 mm in the largest part to 3 mm in the smallest. Flexflow controls can ensure filling of all three parts simultaneously while preventing overpacking and flashing in the smaller parts. The tool is designed to run in a 1100-ton press. Two pressure sensors in each of the larger cavities, and one in the smallest cavity, provide data on the mold-filling process; and six contact sensors monitor mold deflection during filling.

## SLIMMER NOZZLES FOR LARGER PARTS

Slim is in at **Incoe**, which is broadening its line of Slim DF nozzles, now called Slim-Flo, for multicavity molds. These screw-in nozzles are based on the Direct-Flo series, but utilize the 25% slimmer SBH heater, which is replaceable and has a replaceable thermocouple as well as a second groove for a reserve thermocouple. These slimmer nozzles (both hot-tip and valve-gate) allow for closer cavity spacing while still long enough to reach deeply into the mold. The previously introduced DF 3 and DF 5 (the numbers indicate the flow-channel diameter in mm) for shots less than 110 g are now accompanied by the Slim-Flo DF 8 for shots of 30 to 675 g. Its OD has been reduced by 24% to 19.8 mm and the minimum nozzle spacing has been cut by 15% to 27.5 mm. It's available in lengths up to 240 mm.

Incoe says automotive molders have been asking for slimmer nozzles to minimize mold work. As a result, the company has been outfitting its standard DF nozzles with Multipower heaters that



New, larger sizes of Incoe's Slim-Flo screw-in nozzles show how slimmed-down nozzles that allow tighter gate pitches are desired even for molding larger parts.

integrate all cables inside the nozzle. This feature is available for the DF 8 and 12 (140 to 2000 g shots). Also in development is a slimmer DF 18 version (420 to 3500 g shots) with internal cables. Similar "slimmed" DF 22 and 25 nozzles (500 to 9000 g shots) will come later.

Brand-new from Incoe this spring will be commercialization of its more compact HEM hydraulic cylinder for valve-gate nozzles in DF 18, 22, and 25 sizes. (DF 5, 8, 12 with HEM actuator are already available.) For the larger DF valve gates, minimum nozzle pitch is reduced to 51 mm and minimum distance between cylinder and inlet bushing is 55 mm.

**Milacron** again promoted a novel solution for gating in the center of round parts with center holes. The Mold-Masters Core Ring valve gate, which was shown in developmental form as a conceptual model at Fakuma 2017 (see Dec. '17 Close-Up for illustration), has a stationary pin to form the center hole in the part (such as a gear) and a reciprocating sleeve that moves up and down to open and close the gate. Melt is thus distributed uniformly around 360° for balanced filling without knit lines and uniform shrinkage, and no visible gate (Milacron has referred to this as the "No-Gate" nozzle).

Also new is the Mold-Masters ThinPak series of hot-runner systems for thin-wall packaging. New nozzles, gate seals and manifold designs are engineered to withstand pressures up to 2800 bar (40,600 psi), 40% higher than standard Mold-Masters manifold designs. The robust gate seals are serviceable from the parting line. The gate has a beefed-up design using high-strength materials and a larger contact area. The valve-disk bushing reportedly controls any weepage and directs it to easily cleaned areas—a feature said to extend service intervals by up to three times. Further, Milacron says the new nozzle and manifold seal provide greater reliability, even on cold startup, allowing for a wider processing window.

One of two new developments from **PSG**, part of Meusburger Group, is the SmartFill Shot 4557 series, a larger size of screw-in valve-gate nozzle (hydraulic or pneumatic) with flow channel up to 22 mm diam., vs, 18 mm for the next-largest 4547 size. Nozzle lengths are 100 to 680 mm. These units have the thermocouple spring-loaded against the nozzle body.

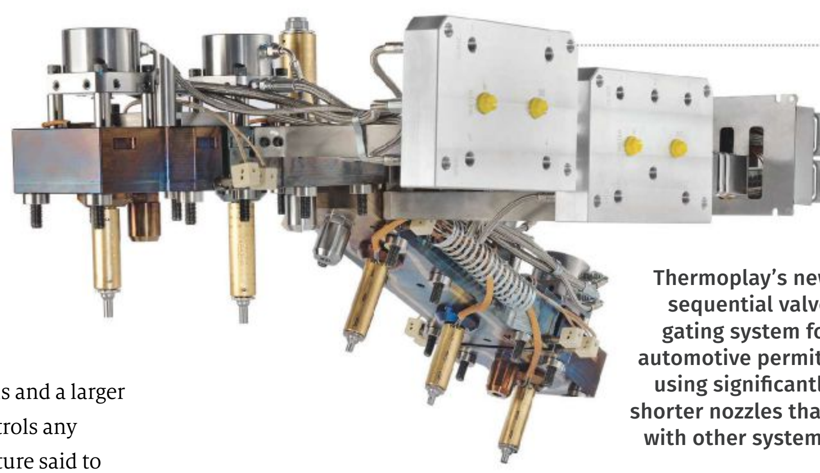
A new version of PSG's profiTemp+ hot-runner temperature controller handles up to 192 zones, vs. a maximum of 120 zones for a single device before now. Also new is a hydraulic valve-gate sequence controller, which provides two different opening speeds for up to 12 zones independently.

**Thermoplay** of Italy has several new products. One is a new series of valve-gate nozzles for fast cycles. They feature enlarged melt channels for fast injection and improved thermal exchange between pin and cavity plate for faster cooling of the gate area while leaving an attractive gate vestige. A new, patented system is said to minimize leakage between pin and pin guide. This new design is available for FN (24 and 32 mm diam.) and DN (22- and 30-mm) nozzles.

***New low-height valve-gate actuators allow for thinner stack molds.***

In addition, Thermoplay has a new hot-runner system for molding large parts for automotive, appliances and pallets. These prewired sequential valve-gating systems use a new system of joints that distributes thermal expansion of the manifold and allows use of significantly shorter threaded nozzles than would otherwise be used. Another important aspect cited by the company is savings provided by reduced thickness of the nozzle plate in this system.

Thermoplay also brought out a new temperature controller (TH-M6 EVO HP) with up to 240 zones, 15-in. touchscreen display, USB port, and optional WLAN remote connection for online technical assistance and remote adjustment of settings and testing of electrical connections.



Thermoplay's new sequential valve-gating system for automotive permits using significantly shorter nozzles than with other systems.

There's also a new, compact and low-cost TH-M6 model with just three zones. It has the same features as six- and 12-zone models in this series, including a wide touchscreen display.

Also new is a sequential controller for up to 16 valve gates (hydraulic or pneumatic). It has a hand-held pendant with 6.5-in. touchscreen.

Plastics Technology

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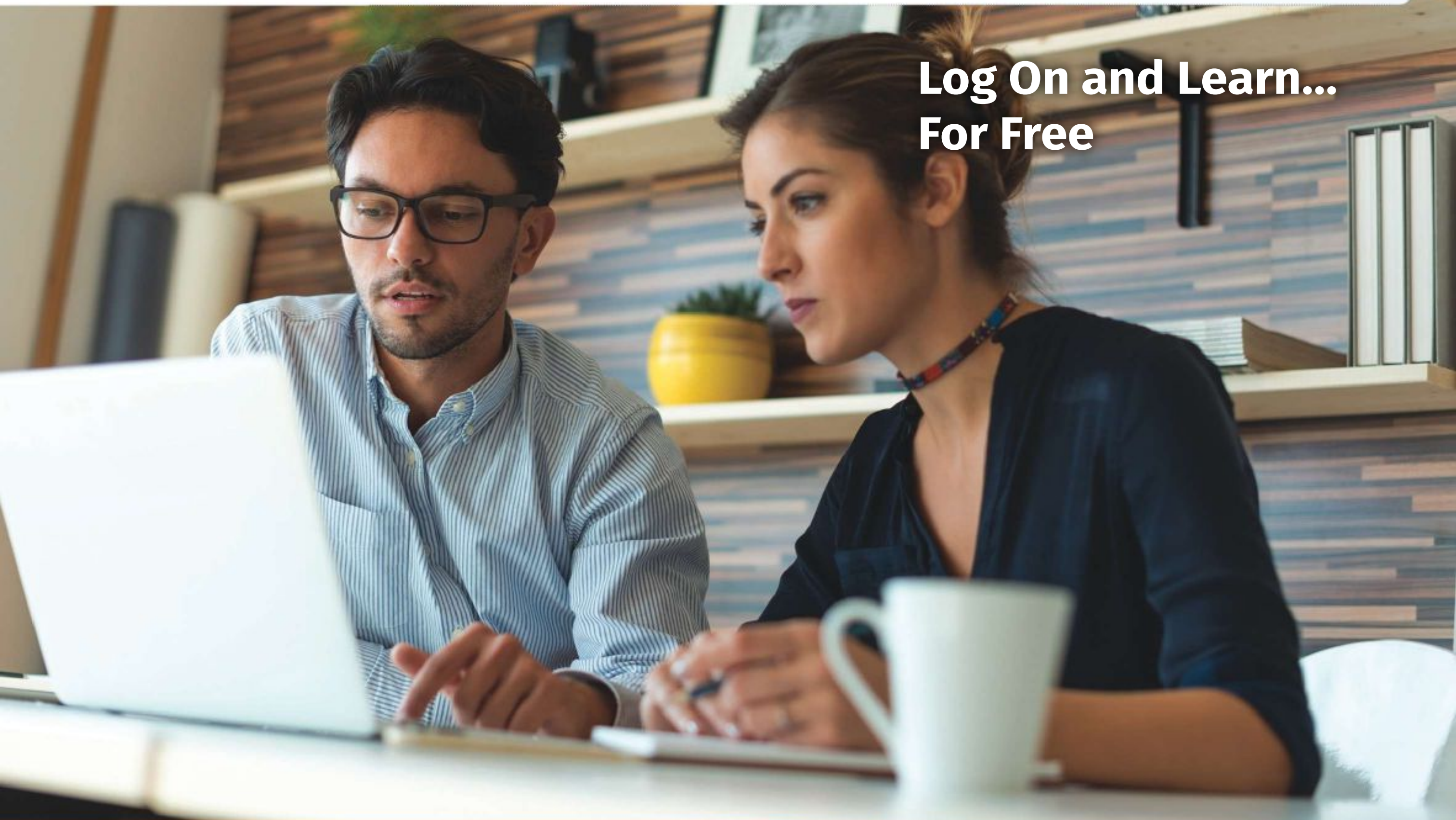

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# MATERIALS

## PART 2 Heat Deflection Temperature vs. Dynamic Mechanical Analysis

Here's a real-world example of a part failure demonstrating why DMA curves have more value than single-point data generated by HDT.

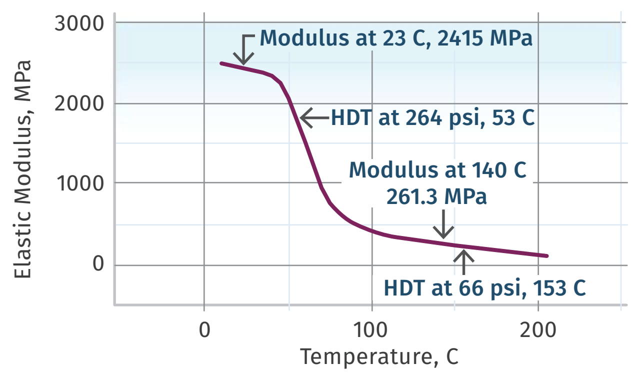
By Mike Sepe

Several years ago, I was working with a client on a part being molded from an unfilled PBT polyester. The part was exhibiting excessive deformation at the operating temperature of 140 C (284 F). The engineers I was working with were baffled by the failures. They had a data sheet that showed that the material had a heat-deflection temperature (HDT) of 153 C (309 F). Consequently, in their minds, this was a guarantee of success at 140 C. This reflects a lack of understanding regarding the meaning of HDT. What is actually being measured?

This question was addressed, at least in part, 40 years ago in a paper written by Michael Takemori and presented at the Society of Plastics Engineers' ANTEC. He showed that the HDT was a measurement of the temperature at which the modulus of a material declined to a particular value due to an increase in temperature. The exact modulus value will depend upon the geometry of the specimen. However, a number of different calculations using these varied geometries show that the HDT at 66 psi (0.455 MPa) is associated with a modulus between 27 and 35 ksi (190-240 MPa), which is the modulus at room temperature of an LDPE with a density in the range of 0.916-0.919 g/cm$^3$. The HDT at 264 psi, a stress four times higher, will be associated with a modulus four times higher, or in the vicinity of 108-140 ksi (750-960 MPa), the modulus of an HDPE on the lower end of the density spectrum (0.946-0.948 g/cm$^3$).

Here is a quote from the introduction to Takemori's paper. "Since this measured HDT corresponds to a single point on the deflection-temperature curve, a great deal of potentially useful information is discarded when one merely reports the heat-distortion temperature." Takemori provided some examples of these curves he referred to in order to illustrate the position of the HDT value on the curve. It is this discarded information that gets so many designers and engineers in trouble when they rely on a value that expresses a single point on a very useful curve, a curve that is provided by dynamic mechanical analysis (DMA).

### Modulus vs. Temperature Behavior of an Unfilled PBT Polyester




**The DMA curve provides several obvious advantages over the HDT numbers. First, it provides a complete and quantitative picture of the effect that temperature has on the load-bearing properties of a material. Second, it gives designers the ability to observe the effect of changing temperature on modulus. Third, because the heating rate of the DMA test can be controlled to be identical to that of the HDT test, the amount of time required to generate these complete curves is essentially the same as the time needed to determine the HDT.**

The HDT on the data sheet for the unfilled PBT in question had been measured at 66 psi. When we located a more complete data sheet, it showed an HDT at 264 psi of 53 C (129 F), a full 100° C lower than the value my client was counting on as a reliable indicator of behavior under load. They were stunned by this drastic reduction in the measured HDT value. What could possibly explain such a large change? Worse yet, a close inspection of the fine print on the data sheet showed that the test specimens used to generate the test results were 6.4 mm (0.252 in.) thick.

The part that was failing had a nominal wall thickness of 2.5 mm (0.100 in). There was one more important difference between the application environment and the HDT test. The application temperature of 140 C was often maintained for 8 to 10 hr while

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the part was under load. Consequently, some provisions were needed to account for creep. The HDT test involves heating the test specimen at a constant rate of 2° C/min until the required deflection is achieved. Once that point is reached, the test stops. It is true that because the HDT test utilizes a constant load, creep is a component of the test. But the test duration in this case is barely over 1 hr. And the effects attributable to creep are conflated with those related to the rising temperature in a way that is very unclear unless additional data is available about the temperature-dependent behavior of the material.

The accompanying graph shows the curve provided by DMA for the PBT that was failing in my client's application. This shows the full property spectrum for the material as a function of temperature. The first revelation for the prospective user of this material is the rapid change in modulus that occurs between 45 C and 100 C. Over this relatively narrow temperature range the modulus of the material decreases by over 80%. By the time the temperature reaches that of the application environment of interest, the material retains only 11% of the stiffness it possesses at room temperature.

**Since the measured HDT corresponds to a single point on the deflection-temperature curve, a great deal of potentially useful information is discarded when one merely reports the heat-distortion temperature.**

This readily explained the failures my client was experiencing. This rapid change in modulus is associated with a very important phenomenon that all polymers exhibit, called the glass transition. This transition is a relaxation that involves the amorphous portion of the material. Once the material has passed through this transition, only the crystals contribute to the load-bearing capability of the material. In most unfilled semi-crystalline materials, an associated decline in modulus of 80-90% is typical. And in most of these polymers, the HDT measured at 66 psi is located on this lower plateau. Temperatures in this region are relatively high, giving the impression that the material is structurally capable at these elevated temperatures.

The glass transition, and the rapid and significant decline in modulus that it produces, is also behind the large difference between the HDT values at 66 psi and 264 psi. The higher modulus associated with the HDT measured at 264 psi takes us into the glass-transition region, where each incremental change in temperature produces a much larger change in modulus than that which occurs when we are operating above or below the glass transition. Many unfilled semi-crystalline polymers, including PBT, the various nylon polymers, PPA, PPS, and PEEK will exhibit these large temperature differences between the two HDT values simply because the associated modulus value for the lower stress level typically occurs on the lower plateau where only the crystal structure governs performance, while the modulus for the higher stress level frequently appears somewhere in the glass-transition region where the modulus is in rapid decline.

The DMA curve provides several obvious advantages over the HDT numbers. First, it provides a complete and quantitative picture of the effect that temperature has on the load-bearing properties of a material. Anyone serious about designing a product and selecting an appropriate material should be able to understand the benefit of having a complete modulus-temperature curve instead of relying on what amounts to one or two points on this curve. Finite-element analysis (FEA), a tool for predicting performance at operating conditions, relies at minimum on an accurate input value for modulus. In most cases, the value that is used is the one on the data sheet, which is measured at 23 C. With the DMA curve, the exact modulus at the application temperature can be used.

Second, the ability to observe the effect of changing temperature on modulus allows the design engineer to identify temperature regions where the material may be susceptible to more significant levels of creep or stress relaxation. One of the principles of viscoelastic behavior is that increasing temperature and increasing time have the same effect on load-bearing properties. In a formal treatment of viscoelasticity, this principle often gets lost in the complexity of the math. But it can be understood more simply by observing the changing slope of the modulus curve in the graph. Above and below the glass transition, each temperature increase of 5° C reduces the modulus by about 1700-3500 psi (12-24 MPa). This equates to a condition where an applied stress will result in a relatively small amount of time-dependent movement. Within the steepest portion of the glass-transition region (50-75 C), this same 5° C change produces modulus reductions of 30,000-45,000 psi (210-310 MPa). A part produced in this material and placed under load in this temperature range will deform substantially in relatively short period of time.

Third, because the heating rate of the DMA test can be controlled to be identical to that of the HDT test (2° C/min), the amount of time required to generate these complete curves is essentially the same as the time needed to determine the HDT.

The question then is, why are we content with using HDT values, when the technology for generating these complete curves has been around for over 30 years? And why are so many practitioners in the field of polymers either unaware of this option or insistent upon defending the use of obsolete techniques to characterize elevated-temperature performance? This is a question we will take up in our next installment.

ABOUT THE AUTHOR Mike Sepe is an independent, global materials and processing consultant whose company, Michael P. Sepe, LLC, is based in Sedona, Ariz. He has more than 40 years of experience in the plastics industry and assists clients with material selection, designing for manufacturability, process optimization, troubleshooting, and failure analysis. Contact: *(928) 203-0408 • mike@thematerialanalyst.com*.

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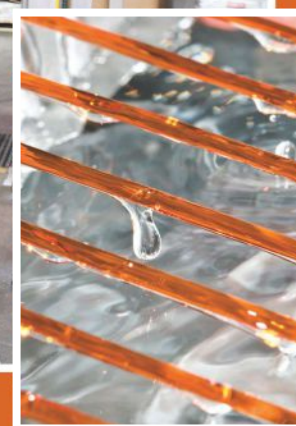
Jim Drew, Plant Manager, OptiColor, Inc.

*Jim Drew, Plant Manager (left) and ENTEK's Linda Campbell at OptiColor, Inc.'s, Huntington Beach, CA Facility*



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# INJECTION MOLDING

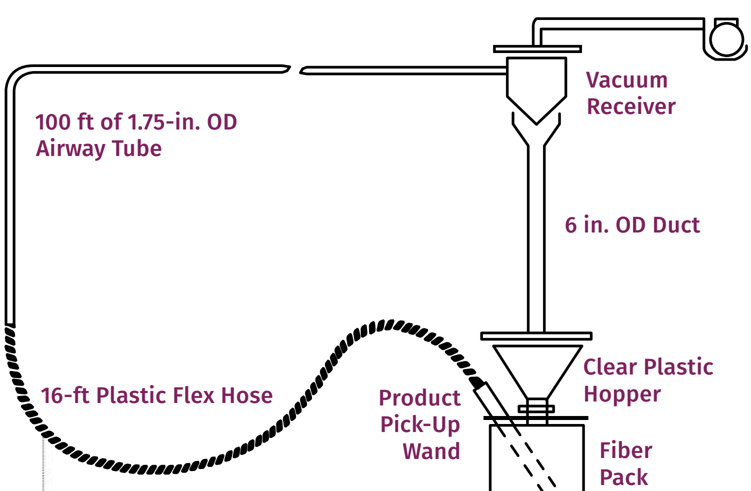
## What's With All the Static?

Static buildup on polymers can cause a variety of problems, some rather unpleasant. Yet there's an inexpensive way to eliminate it, and we have data as proof.

By John Bozzelli

If you have worked with plastic pellets for any length of time, you probably have had a significant physical experience with static electricity. Most of us have had a rude awakening and gotten zapped when we accidentally put our hand somewhere near a conveyor, pellets, or parts. If you have not had this experience, ask around, but be careful, as someone might just want to provide you a first-hand experience.

Conveying pellets—and sometimes parts—into dryers, machines, hoppers, conveying lines, or wherever, generates static electricity. If you provide the grounding link, it is a moment you'll remember. Static charge can be thousands of volts; enough to provide a spark, ignite a powder explosion, knock you down, and foul up your processing. How?




Airway loop designed to develop static on pellets.

When flowing, some resins can develop a charge of static electricity, which will naturally look for a way to dissipate or go to ground. This static charge can (and does) foul processes by causing irregular feeding or separation of blends. Do you ever run a masterbatch of resin granules blended with a solid colorant? Next time you are walking through your shop take a close look at pellets in various hoppers. Often the colorant actually separates itself from the natural resin. The granules separate due the different charge between the natural and colored granules. It can be due to vibration, pellet-size difference, or static charge. Granules may cling to the sides of the hopper, conveying tube, or discharge wand.

Ground wires are often attached to conveying equipment to prevent static buildup. The charge difference literally causes pellets to repel one another or migrate to the sidewalls of a container. Low humidity and dry pellets often exacerbate static buildup. With higher humidity or moisture, the water, which is polar, dissipates the charge. Just like in your home, you can build static electricity by walking on a rug when the humidity is low. Humidifiers add water to the air and minimize the static buildup.

Do not jump to conclusions here; I am not suggesting you add moisture to the granules. But wouldn't it be nice if there were a surface coating or additive that would minimize or eliminate this static charge and not influence processing, physical properties, or part performance?

As it happens, there is just such a product. It has been tested with a number of resins and shown to eliminate static and not influence physical properties or part performance. Not only does it work well, but the amount needed is very small—only 100 ppm (0.010%). For 1000 lb of pellets, all you need is only 0.1 lb or 46 g. What is this magical fairy dust? It's polyethylene glycol 400 molecular weight. As for cost, sit down for this: Amazon sells a gallon for about $100, and for significantly less in bulk.

Too good to be true? As an advocate of Scientific Molding, I believe that if you do not know the answer to that question, you must develop an experiment to provide data that tells you what you need to know and not guess at it. Therefore, I consulted Robert Pierce, a former colleague of mine in technical service for Dow Plastics in the late 1980s to early 1990s.

Bob made up sample blends of high-gloss ABS and transparent ABS with several different color concentrates. The samples were dried in a desiccant dryer for 3 hr at 180 F. Each sample was then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loaded into an airway loop and conveyed continuously around the loop. At the end of the airway loop, the material dropped from a vacuum receiver through a clear plastic surge hopper and then into a fiber pack. A vacuum wand in the fiber pack would again pick up the material and send it back through the airway loop (see diagram).

After a few minutes of operation, Bob noticed that a significant static charge developed. A large quantity of color and some resin would build up on the clear plastic surge hopper. At this point, he slowly added a measured amount (100 ppm) of polyethylene glycol 400 MW to the blend. In each case, there was an immediate elimination of the static and the granules stopped clinging to the surge hopper. Continued running of the equipment showed no recurrence of the static buildup on resin or color pellets.

Samples of the resin with color were molded into ASTM test specimens and tested for physical properties. The table presents data compiled by Bob Pierce that was typical of all samples. The data speaks for itself: There is no significant difference between the ABS with or without this surface additive.

Bottom line: Polyethylene glycol 400 (do not use a lower molecular weight) eliminates static on plastic granules without diminishing physical properties or part performance. Cost is minimal; it is highly effective and is readily available.

### Physical Properties of ABS With & Without Polyethylene Glycol Surface Additive*

| Physical Test | Without E-400 | With E-400 |
|---|---|---|
| Izod Impact, ft-lb/in. @ 72 F | 4.1 | 4.0 |
| Izod Impact, ft-lb/in. @ 0 F | 1.4 | 1.5 |
| Tensile Yield, psi | 5858 | 5937 |
| Tensile Break, psi | 4869 | 4785 |
| Elongation, % | 76 | 77.2 |
| Modulus, $10^5$ psi | 3.33 | 3.53 |
| Instrumented Impact @ 72 F | 470 | 440 |
| Instrumented Impact @ 0 F | 130 | 120 |
| Gardner Impact | 94.7 | 96.2 |
| DTUL, F Annealed | 225 | 225 |
| DTUL, F Unannealed | 170 | 173 |

*SABIC Magnum ABS 9010: with a 25:1 letdown ratio using 60% $TiO_2$ color concentrate and polyethylene glycol 400 MW.

**ABOUT THE AUTHOR:** John Bozzelli is the founder of Injection Molding Solutions (Scientific Molding) in Midland, Mich., a provider of training and consulting services to injection molders, including LIMS, and other specialties. Contact *john@scientificmolding.com*; *scientificmolding.com*.

TOOLING

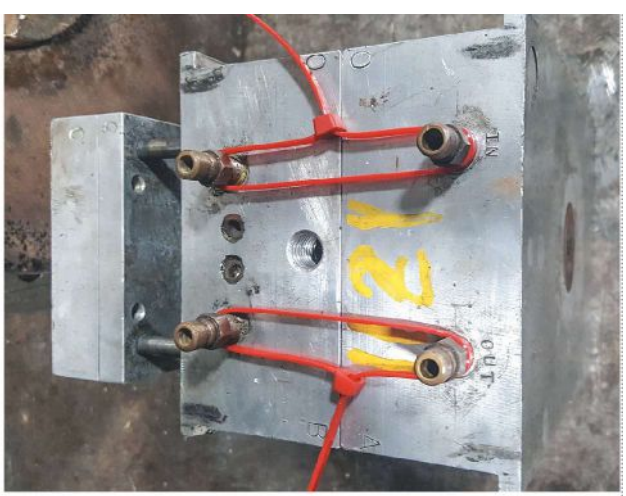
# What You Should Know About Injection Mold Safety Straps

## Every mold should have one in order to be safe and OSHA compliant.

While the function of a safety strap is to prevent a mold from accidentally coming apart during transportation and handling, its purpose is to protect people—*not* the mold or the machine.

By Jim Fattori

The most common cause of mold halves separating is when a setup person uses only one eyebolt to lift a mold that doesn't have a safety strap or a lifting bar. It doesn't matter whether the eyebolt is in the ejection half or the injection half. When the hoist lifts the mold up, it is going to tilt in one direction or the other because an eyebolt hole is rarely at the mold's exact center of gravity. Various factors, such as the clearance and lubrication between the leader pins and their bushings, and the angle and direction that the mold tilts, will determine whether half the mold will disengage and fall to the ground.




Wire ties can act as a safety strap on small MUD inserts.

Another way a mold can come apart is when one side slaps up against a platen during setup. The conservation of energy and momentum can send the other side of the mold sailing towards the opposing platen, like the steel balls on the ends of a Newton's Cradle pendulum "clicker." I'm sure many of you know some less common ways a mold can come apart, such as a racking system that's difficult to maneuver, a mold cart with a wobbly wheel, an inferior wooden skid, or an inexperienced forklift operator and a tight turn.

Every mold should have a safety strap—especially small molds, such as MUD inserts. When personnel are handling a large mold, they do so with extreme caution, because they know if something goes wrong, it's probably going to be, at the very least, *loud*. Small molds and MUD inserts are much less intimidating. They are often considered relatively harmless. This misconception is one reason people can get hurt.

***The purpose of a safety strap is to protect people.***

Let's say you have a small MUD insert for a 08/09 UF 321 frame, with a $1\frac{7}{8}$-in. laminated A-plate. The injection half of this particular MUD insert weighs about 32 lb. If it ever disengages from the ejection half, say from a height of 34 in.—the standard height of several mold carts—it will hit the ground in 0.4 sec. That's less time than it takes to yell, "Look Out!" and it is definitely less time than it takes to comprehend the situation and move safely out of the way. Due to gravitational acceleration, this 32-lb block of steel will hit the ground with a force of over 90 ft-lb. That's more than enough to send a person to the hospital, and OSHA will probably want to know why.

The majority of the molds I have seen have their safety straps painted red. Despite this being the predominant color in our industry, it is not the correct color to use. OSHA has very specific color standards and they specify red for Dangerous situations, "where an immediate hazard presents a threat of death or serious injury to employees." The color yellow, which stands for Caution, is more appropriate. It's used, according to OSHA, for "minor hazard situations where a non-immediate or potential hazard or unsafe practice presents a lesser threat of employee injury. However, Employers are allowed to comply with the most current consensus standards applicable to their operations, rather than with the OSHA standard, when the employer's action provides equal or greater employee protection."

In other words, red is acceptable. However, since employees must be trained in the meaning of the various OSHA colors used throughout the workplace, these colors should be used consistently. Even though the purpose and use of a safety strap is not "out of the ordinary, unexpected, or not readily apparent," it is still important to train all relevant employees on the proper use of safety straps, the special precautions they should take, and the potentially hazardous conditions associated with any misuse or abuse.

Safety straps should be located on the operator side of the mold. If they are located on any other side, there's a good chance the setup man will not see them and attempt to open the mold while they are still engaged. Keep in mind that what the mold designer thinks is the operator side, and what the actual orientation of the mold is out on the production floor, may be two different things. In a case such as this, it is a good idea to put a placard on the operator side of the mold, saying something to the effect of, "Remove Safety Strap."

**Single Shear Strength of ASTM A574 Alloy Steel Bolts**

| UNRC Bolt Diam., in. | Single Shear Strength, tons |
|---|---|
| ¼ | 2.8 |
| 5/16 | 4.4 |
| ⅜ | 6.3 |
| 7/16 | 8.6 |
| ½ | 11.2 |
| ⅝ | 17.5 |
| ¾ | 23.9 |
| 1 | 42.4 |

How many of you have mold safety straps scattered around your shop, or perhaps an assortment stacked in a lost-and-found box? One way to control the number of straps that have lost their homes is to paint, stamp or engrave the corresponding mold number on the strap's outer face. Ideally, you should use a mold-strap design that does not require removing it from the mold at all—but there are not many commercially available choices. Whatever strap design you choose, if it's face mounted on the side of the mold, you will most likely get dents in your tiebars. If a mold barely fits between the tiebars, you must remove the strap in order to hang it in the machine. That defeats the purpose of the strap and can be a definite safety concern. For these reasons, safety straps should be installed in a pocket—flush mounted with the operator side of the mold.

On occasion, a mold may have multiple safety straps—one or more on either side. You see this from time to time on large molds, or molds that have spring-loaded plates, which cause the mold to be partially open when sitting on the bench. Some companies' mold-design guidelines specify installing straps on opposing sides of the mold. As long as you use an appropriately sized strap and mounting bolts, there is no need to use more than one, regardless of how large the mold is, or whether it has spring-loaded plates. In fact, multiple safety straps can be detrimental during the setup procedure, especially when they are out of sight. Once again, there is an exception to every rule. If the mold has multiple parting lines, such as three-plate, stripper plate, or molds with a floating core plate, either a long safety strap, or multiple short straps are required—but all of them mounted on the operator side.

There are many different types of mold safety straps readily available from molding-supply companies. Some are made from plastic, typically recycled glass-filled nylon. Others are made of steel. In my opinion, the existing plastic mold straps are too weak and have some inherent design flaws. They are supposed to be strong enough to keep the mold halves together, but weak enough to break if someone opens the mold in the press without removing them first. That sounds all well and good, but these nylon straps have multiple, glass-oriented knit lines in critical locations. There's also a strong likelihood that these exposed plastic straps will get damaged over time in a production environment. They are available in two different lengths but are not available in different amounts of holding power. The basic premise of a plastic safety strap makes a lot of sense; it's the design and engineering of those currently available that I have a problem with. Since there is an exception to every rule, plastic wire ties, wrapped around water fittings on both the injection and ejection halves of a small MUD insert, work very well at protecting personnel.

The metallic types of safety straps come in a wide variety of designs and construction. Some are cast iron, while others are machined carbon steel. Some look like dog bones. Others rotate or swivel. One unique design automatically unlocks when the mold is mounted in the machine, and locks back up when the mold is removed. Some of these straps incorporate shoulder bolts in their design, but most use standard alloy-steel SHCS (socket-head cap screws). Screws are used primarily in applications where they are in tension—fastening one object to another. In a safety-strap application, they are subjected to shear, which is perpendicular to the fastener's axis. The shear strength of a bolt is considerably less than its tensile strength.

*Safety straps should be OSHA yellow.*

If someone attempts to open a mold with a safety strap still engaged, every strap I have ever seen will break before any other damage occurs—and that's a good thing. It protects the machine and the mold, without being a safety risk to personnel. One mold-component supplier has the disclaimer, "To ensure adequate protection, use mold straps of sufficient size and quantity." But how does the mold designer know what size and quantity are sufficient?

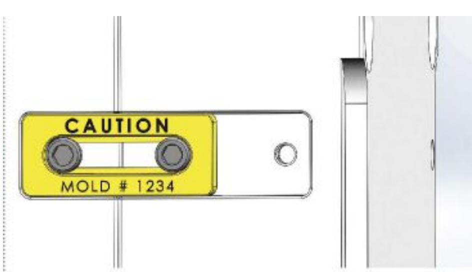
Ideally, a safety strap should be strong enough to prevent the mold from opening under various unforeseen circumstances, but always less than the holding power of the mold clamps and the machine's mold-opening force. The mold-opening force varies widely, depending on the type and size of the molding machine.

It can range from about 5 tons to over 100 tons. It is typically about 10% of the clamp tonnage, no matter whether it's a hydraulic or electric machine.

Some safety straps have strength ratings of 2000, 3000 or 5000 lb. That is a static-load rating. Dynamic loads are the bigger concern. Unfortunately, there is no way to accurately measure or predict how much dynamic load a mold will be subjected to under every circumstance. Assuming the strap is stronger than its mounting bolts, I would select the bolt size based on the mold-opening force of the machine—with a large safety factor. For example, for a 100-ton machine with a 10-ton mold opening force, I might use 5/16-in. ASTM A574 alloy-steel bolts (not SAE grade 8 bolts). From the accompanying table, a 5/16-in. bolt has a single shear-strength rating of 4.4 tons. In this example, that is slightly less than half the mold-opening force, and yet a very significant amount of holding force in the event of an accident.

In summation, a good safety strap and mold design will have the following features:

- One strap per parting line.
- Located on the operator side.
- Made of carbon steel.
- Appropriately sized ASTM A574 alloy-steel bolts.
- Painted, powder coated, or otherwise decorated glossy OSHA yellow.
- CAUTION stamped or engraved in large, opaque black letters.
- Flush-mounted in a pocket.




A well-designed mold and safety strap.

- Never needs to be removed from the mold.
- Contains the corresponding mold number.

The safety strap shown above is one that I have developed over the years. It has all of the desirable features listed. To disengage the strap: remove one screw; slide it over; reinstall the screw. To re-engage it: remove one screw; slide it over; reinstall the screw.

Despite all I have said here, the best safety strap also functions as a lifting bar. I discussed these bars in my May 2017 column, "Locating Rings, Platen Damage and the Center of Gravity." These lifting bars have a large bolt fastened to each half of the mold to prevent separation, and an eyebolt hole at the mold's center of gravity to keep it level when lifting. Even though the need to remove these large, robust lifting straps prior to opening the mold is glaringly obvious, they should still be painted OSHA yellow. If the setup man happens to forget to remove the lifting bar with its large bolts, there is a chance the mold clamps can rip right off the platen. PT

# Hot Half-Dozen Applications Driving Developments in PE

## Sustainability, consumer convenience, and evolving e-commerce packaging are driving new advances in polyethylene.

At the K 2016 show, Italian machine builder Macchi ran this 5-layer line to make all-PE film for easily recyclable stand-up pouches—an important trend in today's sustainability-conscious market. The film was an undisclosed formulation from Dow Chemical.

**By Lilli Manolis Sherman**
*Senior Editor*

By far the lowest-cost global producer, the North American polyethylene resin industry has been booming for the last few years, with a new supply of commodity grades brought on stream and more to come—often through collaborations that complement or enhance each partner's technologies. At the same time, specialty, higher-performance grades have been developed to meet major market trends, which include sustainability, consumer convenience, and evolving e-commerce packaging needs.

Key sources from three leading PE suppliers weighed in on these trends and discussed the half-dozen growth applications and the new materials launched in the last few years to meet their needs. These sources included Olivier Lorge, global PE market development manager at ExxonMobil Chemical; Chris Foy, leader of PE R&D, and Alan Schrob, market group leader, of Nova Chemicals; and Louis Orozco, technical service & technology manager at Braskem.

Sustainability loomed large in their market analyses, embracing topics such as ocean plastics, reuse and recycling, lightweight solutions like single-piece closures, and newer all-PE structures for high-tech packaging.

Says Nova's Schrob, "As an industry, we have a responsibility to educate consumers on the value of plastics in their lives and to be a part of the solution, from reducing unnecessary packaging and food waste to ensuring everyone treats end-of-life plastic products as the valuable carbon resource they are—*and* has the opportunity to recycle them, which will ultimately stop them from ending up as trash in our natural environment." These company sources see supply-chain collaboration as essential to innovation and sustainable solutions.

Many applications need to be re-engineered for recycling and to keep plastics and the goods they protect entirely out of the waste stream. Nova's Foy and Schrob offer these examples:

- **Reducing food waste through improved plastic packaging:** Improving moisture and oxygen barrier performance, and package integrity (toughness and seal) in PE-based flexible film structures helps extend shelf life—and thus reduces food waste.

- **Expanding the uses of post-consumer recycled (PCR) content:** Across the industry there is R&D on technology for creating "clean" recycled PE streams and finding ways to incorporate them into finished products with performance comparable to virgin resin.
- **Moving from multi-material to mono-material, recyclable flexible films:** Many brand owners are working with suppliers and converters to redesign food packaging to eliminate materials such as foil and nylon to meet consumer demand for sustainability and the recyclability timelines that the plastics industry has set through the American Chemistry Council. Where multilayer blown and cast films, along with lamination, have been dominant for many applications, oriented PE in films like machine-direction or biaxially oriented PE are being explored to deliver stiffer and tougher all-PE films.
- **Rigid to flexible conversion:** Replacing traditional packaging materials with flexible plastics packaging can reduce packaging volume by 75-97%. While there is a growing anti-plastics movement centered on reduction and elimination of some single-use plastics, studies show that not only does plastic generally have a lower total lifecycle carbon impact, it also is more cost-effective. Industry sources advocate changing the economics for end-of-life plastics and building out waste-collection and recycling infrastructure in the world's rapidly developing regions, most notably in Southeast Asia, to stop the flow of plastics and other materials into waterways and oceans.
- **Conversion of two-piece (PP + PE liner) to one-piece (all-PE) closures:** The trend from two-piece to one-piece closures in carbonated soft-drink and hot-fill applications is big in North America, as a mono-material composition makes closures easier to recycle. That means one part must provide all the required properties, and the interaction between the closure design, the resin and the way it's molded are all critical to producing closures that will perform consistently.
- **Material substitution in industrial storage containers:** Polyethylene drums, intermediate bulk containers and storage tanks offer significant benefits over metal in many applications: they're non-corrosive, lighter, more affordable, non-reactive to acids and chemicals, and less susceptible to temperature extremes. These blow molded or rotomolded industrial containers are also sustainable and less energy intensive to produce, and they can be endlessly reused or recycled.

Consumer convenience is also a driver that is evident in on-the-go foods, pre-portioning, reclosable packaging, and the retail shift to e-commerce. While optimization of packaging for this segment is in the early stages, Foy and Schrob expect brand owners to opt for more cost-effective single-serve packaging based on flexible plastics, while delivering recyclability and adequate protection of food.

For example, squeeze pouches require a fitment and closure for dispensing, so R&D is being focused on ensuring that the entirety of these new packages is recyclable while providing seal integrity, shelf-life and other required performance attributes.

Another aspect of consumer convenience, when it comes to Baby Boomers and the older Silent Generation is easy product identification through colors, graphics or larger print; and ease of use, such as easy-open and recloseable packaging, and spill-preventing design.

E-commerce has been driven partly by convenience. Packaging for any product that may be sold online is being rethought through the lens of the e-commerce supply chain, say Nova's Foy and Schrob. And, as Amazon, Walmart, and other big e-tailers also pursue sustainability targets—Amazon's "frustration-free packaging" is a significant example—they're looking for ways to eliminate secondary cardboard boxes and ship products only in their own container—yet another reason to develop tougher packages that arrive at the consumer's door intact. Says Nova's Schrob, "We see the e-commerce trend moving toward elimination of secondary packaging."

Meanwhile, online food purchases have different requirements from other e-commerce purchases. Today the largest segments of online food purchases are click-and-collect, which has a supply chain similar to traditional in-store grocery shopping; and meal kits, which face a unique set of challenges. We may see returnable meal-kit shipping containers in the form of flexible, PE-based corrugated boxes or flexible cans.


**Flexible stand-up pouches are a big deal because of the conversion from aluminum and glass, which results in 70% lower emissions than aluminum, takes up much less space, and are very damage resistant and safer to transport. (Photo: Nova Chemicals)**

## WHERE'S THE R&D ACTION?

Most of the current R&D underway appears to involve PEs produced with metallocene or other single-site catalysts. ExxonMobil's Lorge identified two types of current R&D activity globally. At Baytown, Texas, the focus is on catalyst and process research—namely, novel catalysts that can produce new polymers that provide exceptional performance and processability.

The company's Exceed, Enable and new Exceed XP families of metallocene hexene LLDPE film resins are part of this R&D thrust, as are new additions to its portfolio of Vistamaxx propylene-ethylene specialty elastomers for use in broad applications from very soft fabric and films to very hard TPOs. At its Belgium and China facilities, the emphasis is on application development. Says Lorge, "We are working with our customers to develop innovative solutions, laminate films, and all-PE packaging for products ranging from food to liquid household cleaners, using our Exceed XP."

Noting that sustainability has been one of Braskem's pillars, Orozco says, "We believe society itself has become more critical regarding how sustainable the products they buy are. This factor, combined with shifts in how and where we buy, such as e-commerce, has made us rethink previous applications that now have a bigger impact in the new market." As examples, Orozco cites two metallocene catalyzed hexene families—Flexus and Proxess, within Braskem's LLDPE film-resin portfolio. Flexus provides better properties in the film but sometimes is difficult to process in older machines. Proxess is much easier to process in old machines, particularly for LDPE substitution. All these products allow weight reduction vs. current packaging as well as enhancements in the products' presentation, explains Orozco.

**Replacing traditional packaging material with flexible plastic packaging can reduce packaging volume by 75-97%.**

Nova's Foy and Schrob see growing demand for higher-value PE made from metallocene or other single-site catalysts due to the performance requirements for today's packaging applications. They say this is why we are seeing expansions in octene PE capacity, including Nova's second Advanced Sclairtech plant. According to Foy, Nova's bimodal technology allows for flexibility in PE structure and tailoring of end-use performance, leading to highly differentiated resins for things like improving seals or barrier in demanding film applications; producing closures that satisfy the physical demands of the application while not imparting any taste or odor; and best-in-class, high-performance resins for the rotomolding.

Says Foy, "With all of the new PE products and end-use applications we see in development, having multiple design parameters for PE is key. Multi-modal products, in combination with higher-alpha-olefins and, potentially, additive optimization, are keys to how we design resins today and will be even more important in the future."

### FOOD-PACKAGING DRIVERS

Food packaging reigns as one of the hottest areas of development, with all-PE structures for stand-up pouches and freezer films in the lead. All sources see flexible stand-up pouches as a big deal because of the conversion from aluminum cans and glass jars. The pouches result in 70% lower emissions than aluminum, take up much less space, and are very damage resistant and safer to transport. The new PE pouches also boast convenience, good shelf appeal and excellent printability.

The first-ever all-PE stand-up pouch reportedly was commercialized in 2016 by film processor Accredo Packaging of Sugar Land, Tex., in collaboration with Dow Chemical, making pouches for dishwasher pods from brand owner Seventh Generation.

Lorge says ExxonMobil researchers are working on replacing oriented nylon 6 and PET; he cites the example of a customer that replaced a nylon 6 layer with an Exceed XP resin and a very thin EVOH layer, making the flexible food pouch easy to recycle.

Lorge also gives an example of flexible freezer film for chicken—an all-PE, non-barrier, three-layer structure of Enable LLDPE and HDPE, with Exceed XP in the sealant layer—that reduced bag failures in transport. ExxonMobil has also launched new Exceed XP 8784, which boasts improved processability, extreme film toughness and goodsealing properties for high-performance coextruded films for laminated sacks, freezer films, barrier packaging and sachets.

Nova's new Surpass HPs667-AB is a bimodal HDPE said to provide excellent oxygen barrier and stiffness in extrusion laminations and/or cast film. (This resin's blown-film equivalent is HPs167-AB.) The material can help in replacement of multi-material films, adds stiffness to aid in rigid-to-flexible conversions, and can be used in injection molding applications where high barrier is required. The material was used in a novel milk jug by Tetra Pak in 2016, said to be the world's first aseptic carton bottle for ambient white milk.

Surpass VPsK914, a new octene LLDPE sealant resin, is said to allow for faster foolproof sealing in most demanding food and food e-commerce applications. It reportedly produces a strong film without adding plastomers and cost to the film formulation. It reportedly offers toughness comparable to a typical PE sealant plastomer blend, suiting it for products such as granola and bone-in chicken.

Braskem's new addition to its Proxess family, touted for excellent processability, flexibility, and blending with other resins, is Proxess 1509XP, a 0.9 MI LLDPE with stable coefficient of friction due to a special additive package tailored for lamination. It can replace LDPE or other metallocene LLDPEs due to its superior processability for coextrusion of general-use, high-performance and technical films for automatic packaging and lamination.

## HEAVY-DUTY SACKS

As just one example of progress in this field, there's been a major improvement in sacks for 25 kg/55.2 lb of plastic resins, which today are 105 microns thick—downgauged more than 50% since 1998. Lorge says these are three-layer film constructions with Exceed XP ►

ExxonMobil's Vistamaxx PBE is used to formulate thinner, stronger, stretch-hood films.

in the skin and a blend of Exceed XP and HDPE in the core, which provides very good sealing and excellent stiffness.

Nova's Surpass VPsK914 ultra-durable sealant resin also plays a big role in heavy-duty bags for sharp and heavy contents, and is said to enable up to 20% increase in line speeds vs. a typical octene LLDPE.

Surpass SPsK919 is described as a stiffer, tougher and clearer multi-modal octene LLDPE, with exceptional creep performance optimized for heavy-duty bags and e-commerce packaging.

## PALLET STRETCH FILM & HOODS

Power pre-stretch (PPS) cast-film technology pioneered by ExxonMobil for securing loads/pallets of various goods in transportation is growing fast in the U.S. and Europe, says Lorge. "We have been working with cast stretch-film producers and machine manufacturers to improve these film structures. The Vistamaxx 6000 family of specialty olefinic TPEs, specifically targeted for PPS films, is combined with Exceed XP 3812 LLDPE to provide the extra strength and elongation needed."

Nova's Schrob notes that traditional basic stretch film is a very large and mature market for which Nova offers several products—both blown and cast resins. New Novapol PF-Y-818 is a butene LLDPE said to be tougher and clearer than traditional butene LLDPE, and it can process up to 20% faster on many blown film lines. Applications include stretch film, retail bags, trash bags and industrial liners.

Braskem offers puncture- and impact-resistant Flexus metallocene LLDPE resins and has a partnership with Austria's SML Maschinengesellschaft mbH to develop new stretch-film solutions. At the K 2016 show in Germany, the two firms featured a 13-layer, 12-micron stretch film with outstanding properties. Two Flexus resins for stretch films are 3600, a 4.5 MI grade, and 7200 XP with 3.5 MI. Flexus Cling, a 4.3 MI grade, is designed for the cling layer.

The alternative pallet stretch-hood blown film technology is growing fast for both palletized goods and appliances, according to Lorge. Typically three-layer film structures, where both Exceed XP and Vistamaxx resins play a part, offer better protection against rain and other contaminants and boast toughness, high tear resistance and excellent puncture resistance, as well as high snapback and elastic recovery—and they cost less than paperboard.

## SHRINK FILM

Used for food packaging, including water and carbonated beverages, shrink wrap has come a long way, according to ExxonMobil's Lorge. "For wrapping six 1.5L bottles, we went from 100-micron LDPE shrink films 20 years ago, to monolayer films in 2010 with Enable metallocene branched LLDPE, to today's three-layer, 50-micron, all-PE solution with Exceed XP in the skin and Enable 4002 in the core. ExxonMobil is also working with customers to replace thick, foggy films with clear, glossy films for better shelf appeal and printability.

Braskem's new Proxess 2609, a 0.6 MI LLDPE, is designed for shrink film, ice bags, industrial sacks, and mortar packaging.

The trend from two-piece to one-piece closures in carbonated soft drinks and hot-fill applications is in earnest now in North America as the mono-material compositions make closures easier to recycle. (Photo: Nova Chemicals)

## CAPS & CLOSURES

For this rigid packaging market, Foy and Schrob point to Nova's development of HDPE grades that leverage the company's Advanced Sclairtech single-site catalyst technology. Surpass CCs757 sHDPE resin was designed for water closures, where line speed, organoleptics, consistency and physical performance are essential. A single railcar of these resins can make up to 100 million closures, so the functionality of that resin is critical, as it translates into consistent performance of each closure throughout the supply chain. Meanwhile, Surpass CCs154 sHDPE resin for carbonated soft drinks is tailored for carbonation pressure and ESCR.

Nova's Sclair 2807CC sHDPE is designed for multiple uses, including one-piece closures for non-carbonated beverages, personal-care, industrial, and standard-weight hot-fill beverage applications. Its excellent balance of processability, stiffness, ESCR and organoleptic properties enables resin consolidation for closure manufacturers.

## ROTATIONAL MOLDING

Nova has developed Surpass RMs245-U/UG sHDPE resin specifically for large tanks and custom rotomolded goods. This "all-around performer," say Foy and Schrob, has an industry-leading combination of stiffness, toughness, and ESCR. It also has a best-in-class 1600-psi hydrostatic design basis (HDB) cell classification, which translates into improved sidewall stiffness in large storage tanks. Higher stiffness enables downgauging tank wall thickness by 10-20%, or making walls with the same thickness that have an additional safety margin. It also boasts outstanding melt flow and processing characteristics. PT

By Tony Deligio
*Senior Editor*

# Filling a Precision Molding Niche in Mexico

**Originally opened and dedicated by Mexican President Vicente Fox in 2006, GW Plastics has expanded the business and capabilities of its facility in Querétaro, adapting and evolving along with that country's thriving injection molding market.**

**GW Plastics Querétaro's tool room is capable of maintenance and some engineering changes, eliminating the need to ship tools back to the U.S.**

In its corporate "Mission and Values" statement, custom injection molder and moldmaker GW Plastics says of its clientele, "Customers are the only reason for our existence and must be treated as such." It was that spirit of service that brought GW to the central Mexican city of Querétaro in 2006—its first foray outside the U.S.—to better serve customers that had ventured south; and it is that same dedication that pushes the company to continuously improve that operation, which is now entering its 13th year.

"We try to cultivate long-term business relationships with our customer base," explains Justino Barrientos, sales manager for GW Plastics Querétaro. "We don't want to have a one-year relationship; we want to be there for many years and to keep growing that base."

Featuring 26 highly standardized injection molding machines from Sumitomo Demag and Engel, ranging in clamp force from 60 to 660 tons, the approximately 52,000-ft² operation has seen numerous changes over the last dozen



years, with more in the works. When *Plastics Technology* visited in the fall of 2018, blueprints of the facility sat on plant manager Eric Olvera's desk. The company was considering plans to boost capacity by 30% via an expansion and reconfiguration of its current space, which, without any new construction could house up to 31 injection machines, according to Olvera.

Olvera's office on the second floor affords him a bird's-eye view of GW's operations in two ways—the first being a window overlooking the manufacturing operation, which in addition to molding includes mold machining and assembly; the second via a screen featuring live process feedback from the RJG sensors outfitted on every production tool running at the facility. Olvera's own historical view of GW Plastics Querétaro extends back to its origins. When the facility opened in 2006 with six injection presses, he was the materials manager, working his way through the ranks in the intervening years to become the plant manager today.

Over that period, he's seen numerous changes to GW and the Mexican market, with growth as an underlying constant. During that time, sales have nearly quadrupled as the company enjoyed sustained annual growth of 10% to 15% in Mexico. Globally, GW has operations in Vermont (two plants, including headquarters in Bethel), Texas, Arizona, Ireland and China, with the majority of its business in medical applications, followed by automotive. The Querétaro operation focuses largely on automotive, but medical business is growing, too. In Mexico, medical interest is expanding enough that plans are underway for a proposed expansion/reconfiguration including cleanroom and liquid silicone rubber (LSR) molding.

In Querétaro, GW Plastics has grown beyong molding to include assembly operations, including ultrasonic welding.

## EVOLVING AND ADAPTING

Olvera says GW's customers' demands, as well as the company's capabilities, have evolved over time. "When we first started, the parts were simpler than those we're doing now," Olvera says. "Today we're producing more complex parts with tighter tolerances." Back in those early days, the operation focused strictly on molding, but now it has moved into assembly and highly customized secondary operations, including specialized leak testing for safety-critical automotive fuel-system components. Beyond insert molding and overmolding, secondary operations include ultrasonic welding and pad printing. Automation is applied on every machine. On the tooling side, the plant now runs more high-cavitation molds, ranging up to 64 cavities; and its in-house tool room has made it more self-sufficient for maintenance, repairs and some engineering changes. "It has been many years since we had to send a tool back to the U.S.," explains Barrientos.

In addition to its process-monitoring technology, GW Plastics is a staunch proponent of RJG's training offerings, with two certified Master Molders on its staff and the application of Scientific Molding principles throughout. On higher-cavitation tools, cavity separation is applied to segregate parts as they're molded, with 100% inspection required on many jobs, given their safety-critical role in a car's fuel, steering or brake systems.

Running on the floor when *Plastics Technology* visited was a system used to hold car windows in place, comprised of a metal stamping that must be preheated before overmolding. On another insert molding job, two Cognex cameras were in place to check for the presence and proper alignment of inserts; while an adjacent machine ran a gas-tank enclosure, where a terminal was inserted and overmolded. Post-molding operations for this job include testing for conductivity as well as leaks. The same RJG screen as in Olvera's office sat on the machine.

Running many safety-critcal parts for the automotive and medical sectors means that GW Plastics Querétaro must undertake inspection of its production.

GW Plastics Querétaro's climate-controlled inspection operation includes two coordinate measuring machines.

"All the machines and all the tools are connected to a computer, and every second we monitor what's happening on the production floor," Olvera says. "The process is monitored through the different sensors that we have installed on the machines, so at the end it will result in process stability, which translates to good product." GW Querétaro's quality performance recorded a reject rate of 1 ppm in 2018, or better than Six Sigma standards.

The newest machine on the floor is an Engel duo 500, while above the plant floor the latest addition is an overhead crane. A fully enclosed and climate-controlled inspection room houses two coordinate measuring machines (CMMs). "We have a zero-defect philosophy," Olvera says. "That is something we believe in highly." Querétaro is certified to ISO 9001, ISO 13485 and IATF 16949. "The entire production facility operates in a climate-controlled environment following Good Manufacturing and 5S Practices, which further contributes to process stability and strong quality results," Olvera notes.

Giving employees ample training and a path for career growth has helped GW Plastics Querétaro maintain low turnover rates in a region where they're typically quite high.

### FINDING & KEEPING TALENT

As its capabilities and its customers' demands have increased, so has its competition, which Barrientos describes as "fierce." One area where GW Plastics Querétaro finds itself battling other precision molders in Mexico is for workers. Including hourly and salaried staff, the facility has 129 employees, all of whom it must fight to keep.

"We believe in local people, and we have created extensive training programs, competitive wages, employee profit sharing, and benefit packages to make sure our workers feel comfortable and happy here," Olvera says, "because we try to keep our people, work together with them. It has been hard in the last three years in the Querétaro area to maintain our people." The company has risen to the challenge, however, holding to a single-digit turnover rate since 2017, according to Olvera.

In addition to special events, like a spring festival and Christmas holiday celebration that bring together employees and their families, the company has held onto workers by showing them a path to advance within the business, while recognizing them along the way. "Myself as an example," Olvera says, "I started as a materials manager. Very much at first, we're looking at what is the potential talent that we have inside. That helps when people feel they have a future with the company; that they can grow together."

"That becomes motivation for the other employees," Barrientos says. "They say, 'OK, I can actually get to be a manager here if I work hard and get results.' People are our most important asset. We must treat each other with respect and trust."

"It is the people that are making the parts; it is the people that are touching the parts," Olvera adds. "It's important that they feel committed and happy to be working here. That is the basis of our business—we are people serving people at the end of the day."

Barrientos concludes, "GW's culture is rooted deeply in trust, respect, and integrity in all that we do. It starts at the top with Brenan Riehl, our CEO, who believes passionately in the power of 'servant leadership,' the philosophy of which runs throughout the organization, creating an environment of collaboration and teamwork."

# Follow These Guidelines to Select the Right Pelletizing System

Which pelletizing system is right for your application? Is the one you're using today necessarily the right choice for tomorrow? Here's is an analysis that can help you decide among the three major options.

By Merritt Christian, Nordson Corp.

Companies planning to invest in pelletizing equipment can select the right system by making a thorough inventory of their operational and application needs, in addition to the basic consideration of cost. Three major types of pelletizing systems are available, each with a distinctly different range of strengths and weaknesses. With the growth of the plastics industry and the continual emergence of new requirements in the marketplace, even a company that has long used a particular system may need to consider an alternative when the time comes to add capacity.

Pelletizers are essential components in resin manufacture, compounding, masterbatch production, and recycling. A high-volume system that is appropriate for a polymerization plant will be very different from one that suits the needs of a toll compounder. One that can produce micropellets for use in masterbatch may not be the best choice for processing post-consumer regrind. What follows is an evaluation of each type.

**TABLE 1** Pellet Properties

| | Pelletizing Technology | | |
|---|---|---|---|
| **Property** | **Strand** | **Water Ring** | **Underwater** |
| **Shape** | Cylindrical | Round but flat | Spherical |
| **Size distribution** | Inconsistent | Improved vs. strand | Most consistent |
| **Bulk density** | X | X + 5-10% | X + 5-10% |
| **Clogging in hopper or at feed throat** | Highest tendency | Mid-range tendency | Lowest tendency (spheres act like ball bearings) |
| **Dusting** | High, due to cut in solid phase | Less, due to cut in melt phase | Less, due to cut in melt phase and to flowability of spheres |

## UNDERWATER PELLETIZERS

The underwater pelletizer (UWP) is a die-face pelletizer. This means that molten polymer is cut into pellets as it exits the die holes, which are arranged in a circular pattern in a round die. The crucial difference from the water-ring pelletizer (also a die-face pelletizer) is that the cutting chamber is completely filled with process water, so that the polymer drops are immersed in water as they exit the die holes. Because of forces that minimize surface tension, each drop takes on a spherical shape, which is unique to UWPs.

The process water transports the spherical pellets from the cutting chamber to an agglomerate catcher (which removes clumps of plastic) and then to a centrifugal dryer. The pellets enter the dryer at the bottom of the unit, and a rotating shaft with lifting vanes de-waters the pellets, which exit the dryer at the top. A similar type of dryer is used with the water-ring pelletizer.

As with other pelletizing systems, the cooling water in the UWP is supplied by a process-water unit, which tempers the water—that is, mixes hot and cold

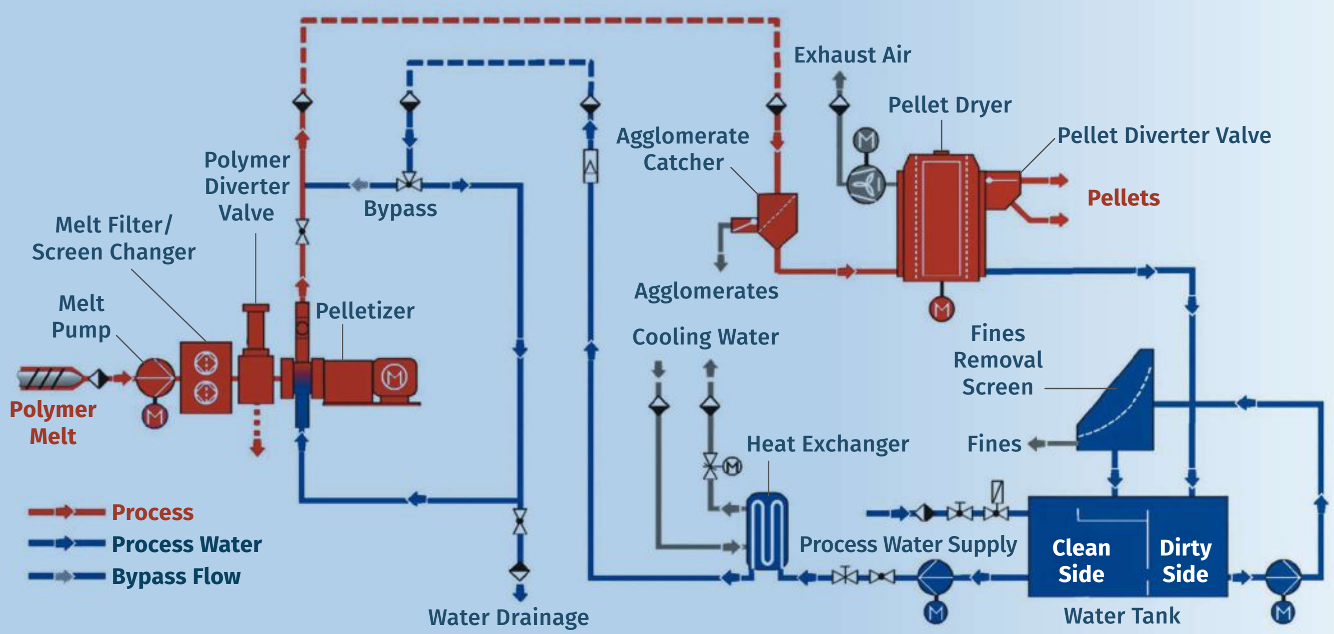



FIG 1 Flow diagram of typical underwater pelletizer.

water to ensure a constant temperature—and filters out dust and fines. Water temperature must be carefully controlled and adjusted according to the properties of the polymer being pelletized. Failure to do so can lead to malformed pellets or process disruptions.

In UWPs, all cooling water is transported to and from the cutting chamber by means of pipes, making unnecessary water troughs or water slides found in other pelletizing systems. As a result, the centrifugal pellet dryer and water-treatment equipment can be installed at some distance from the pelletizer—in another room, for example, or on another floor.

Another feature made possible by water piping is the water bypass system, which allows water to continue circulating to maintain the required temperature while diverting flow from the cutting chamber. This enables the operator to disconnect the pelletizer from the cutting chamber in order to perform tasks such as changing the cutter head.

The bypass system works in coordination with a polymer diverter valve for stopping and starting polymer flow into the die holes. Before starting up the pelletizer, the valve is switched to the "production" position for flushing the die plate. Next, with the valve in "divert" position, polymer can be cleaned out of the cutting chamber. Finally, the pelletizer is re-coupled to the cutting chamber; the water bypass switches to send water into the cutting chamber; the diverter valve is switched to production position; and pelletizing begins. The whole process is automated, takes place in seconds, and is initiated by means of an on/off button in the PLC controller.

Several options are available for controlling the pressure of the cutting blades against the die plate. Among these are a manual system, in which the operator uses a hand wheel, and PLC-controlled hydraulic systems. Other options include spring-loaded and pneumatically actuated systems.

*The UWP is the most complex pelletizing system and entails the greatest investment cost. In turn, it offers advantages over other pelletizing systems.*

Process-water systems are available with varying degrees of capability. An entry-level system that is completely skid-mounted has a capacity of up to 4400 lb/hr and can be provided with an optional belt filter for continuous automated filtration of fines down to 150 µ. More elaborate systems provide automated self-cleaning, filter down to 70 µ, and have capacities as great as 77,000 lb/hr.

As the foregoing features suggest, the UWP is the most complex pelletizing system and entails the greatest investment cost. In turn, it offers advantages over other pelletizing systems in these areas:

- **Automation.** The UWP has the greatest scope for automation, with PLC control governing many of its features. Functions such as blade sharpening and in-line die-plate grinding can be pre-programed, minimizing downtime.

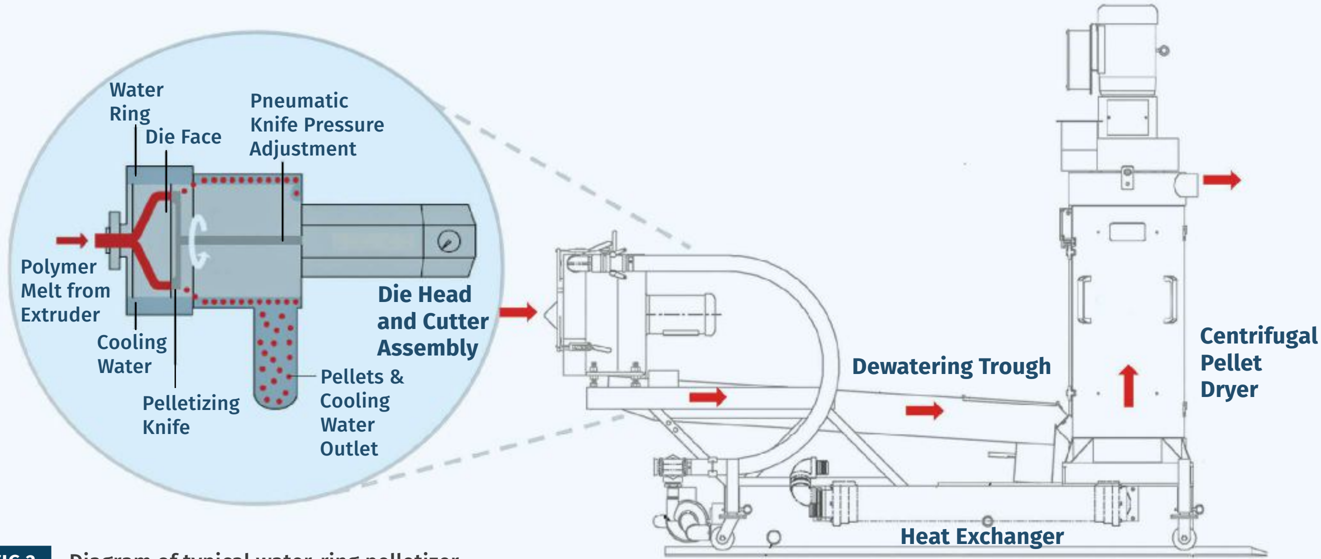



FIG 2 Diagram of typical water-ring pelletizer.

- **Throughput.** UWPs can be designed for throughput capacities up to 70,000/hr, vs. 44,000 lb/hr for strand pelletizers, and 11,000 lb/hr for water-ring pelletizers.
- **Versatility.** The UWP can process virtually any polymer and can be used for the full range of applications, including compounding, hot melts, masterbatches, polymerization, recycling, and reclaim. Strand pelletizers can be used for all of these applications except for hot melts. Water-ring pelletizers, owing to their lower throughput capacity and limitation to high-melt-strength materials, are chiefly recommended for recycling and reclaim.

**Strand Pellets**
- Cylindrical, flat 90° edges
- Flat ends can stick together, bridge.

**Water-Ring Pellets**
- Rounded but flat (like an aspirin).

**Underwater Pellets**
- Spherical
- Highest bulk density, best flow characteristics for materials handling.

**FIG 3** Pelletizer type influences pellet geometry.

- **Blade life.** Extended through control over cutter pressure.
- **Range of pellet diameters.** Wide, and includes micropellets, which are used in production of masterbatches and expandable polystyrene, as well as in rotomolding.
- **Pellet consistency and geometry.** In addition to being more uniform in size, pellets made in UWPs have a spherical shape that enhances flow into hoppers and feed throats and increases bulk density.
- **Dust and fines.** Low as a result of polymer being cut in molten form.
- **Integration with upstream equipment.** The operator can use a single interface on the pelletizing system to access the extruder, feeding equipment, screen changer, and melt pump.
- **Footprint.** Small in comparison with strand pelletizers.

Along with cost and complexity, the UWP system has another disadvantage: the potential for die "freeze-off" when running certain products. This occurs when a process variation upstream of the pelletizer causes reduced or uneven polymer flow at the die plate, so that the polymer solidifies in the die holes. Freeze-off can cause distortions or non-uniformities in the pellets produced. A consistent and high level of melt pressure at the die plate is essential for preventing freeze-off.

## WATER-RING PELLETIZERS

In water ring pelletizers (WRPs), as in UWPs, molten polymer flows into multiple holes arranged in a circular pattern in a die plate and is cut into pellets as it emerges from the die face. The cutting is accomplished by a series of rotating knives that are also arranged in a circular pattern. The die face is made of hardened metal, so that wear takes place mainly in the knives. Pressure is hydraulically applied to the cutting assembly to ensure proper contact with the die face.

WRPs produce pellets that are rounded but flat, similar to aspirin tablets. As the polymer exits the die holes and is cut by the rotating knives, the resulting pellets are thrown outward into a ring of water that is fed tangentially into the cutting chamber. The water cools the pellets and transports them to a water trough for further cooling and transportation to a centrifugal dryer that operates in the manner already described. Water is returned to a tempering and filtration system and recycled into the pelletizing process.

The WRP is the most compact of the three major pelletizing processes and provides a degree of automation. One operator can easily control the system, using a pushbutton control to stop and start the system and adjusting the cutter rpm to control pellet size.

TABLE 2 **Production Factors**

| Production Factor | Pelletizing Technology | | |
|---|---|---|---|
| | **Strand (Dry-Cut)** | **Water Ring** | **Underwater** |
| **Capital investment** | Lowest | Mid-range | Highest, especially for throughputs less than 1 ton/hr |
| **Maximum throughput, lb/hr** | ~14,300 | ~11,000 | ~77,200 |
| **Pressure at die** | Lowest | Mid-range | Highest |
| **Shear stress due to pressure requirement** | Lowest | Mid-range | Highest |
| **Means of varying cooling** | Cooling length and residence time | Adjusting trough slope, optional cooling water control | Adjusting water flow rate, temperature, and pipe length |
| **Emissions** | Open system | Partially open system | Closed system |
| **Labor** | Greatest, quality is operator dependent but simple process | Available fully automated or open to operator intervention | Fully automated, fast startup process, constant quality |
| **Space** | Large footprint, only in-line installation is possible | Mid-range footprint | Compact, water system can be remote from pelletizer |
| **Integration with upstream process** | More or less independent | More or less independent or fully automated. | Highly automated, should be linked with upstream process |

The system costs less than UWPs. It is significantly less sensitive to process variations such as melt temperature and pressure and does not present problems of die freeze-off.

Because pellets are cut from the molten polymer before it encounters cooling water, the WRP is limited chiefly to processing high-melt-strength materials such as polyolefins and polystyrene. The process is particularly unsuited for high-heat or sticky materials. There are also capacity limitations in comparison with UWPs.

## STRAND PELLETIZERS

In strand pelletizing, polymer is cut into pellets after it has cooled and solidified. By its nature, this system is operated in-line with extrusion. Molten polymer is metered into a strand die that is much like a sheet die except that the material exits the die through multiple holes, each forming a strand of polymer. The strands enter a water bath or trough, where they are cooled, then are dried by a de-watering unit or air knife, and finally are fed into a strand pelletizer, where they are cut into cylindrical pellets. A disadvantage of this pellet shape is that the flat ends of the cylinders can stick together and cause bridging.

After cutting, the pellets fall into a classifier, which removes oversized pellets or agglomerates and conveys the rest of the pellets downstream.

TABLE 3 **Product Versatility**

| Polymer Characteristics | Pelletizing Technology | | |
|---|---|---|---|
| | **Strand** | **Water Ring** | **Underwater** |
| **High glass content (30 to 50%)** | Difficult; brittle strands, inconsistent cut, increased fines | Not suitable | Wear-resistant option needed for die and pellet dryer |
| **Shear-sensitive** | Low pressure at die minimizes loss in viscosity | Low pressure at die minimizes loss in viscosity | High-pressure at die could cause shear thinning; care needed |
| **High color content (masterbatch)** | Greatest cleaning effort; contaminants carried downstream | Easier product/color change; medium cleaning effort | High cleaning effort; more components to clean |
| **Very low particle size (micropellets)** | Possible, but difficult to handle | Not possible | Standard process, but high pressure (melt pump) required |
| **Low Viscosity** | Cannot handle due to low melt strength | Not possible | Possible down to <1000 mPas (hot melt adhesives) |

In addition to being the lowest in cost, strand pelletizing can be used with a wide range of polymers, is simpler to use than other pelletizing systems, provides easier access to component surfaces for cleaning and color changes, and facilitates polymer change-overs through rapid replacement of cutting components. Thus it is particularly appropriate for toll compounders and other companies that make short runs with frequent job changes.

The strand pelletizer has little scope for automation and is more labor-intensive than other pelletizing systems. Consider, for example, the work involved in stringing up to 75 strands over and under guide rolls with each new job startup. Strand pelletizers also are limited as to pellet size, with the small pellets required in some applications being difficult to obtain without strand breakage. Two other weaknesses derive from cutting pellets from solidified strands: There is a greater potential for cutter wear and for generation of dust and fines than with other pelletizing systems. Strand pelletizers also are more readily affected by process variations, which can cause dropped strands and other difficulties. And finally, the need for a water bath means strand pelletizers have a larger footprint on the factory floor.

Some of these weaknesses of this "dry-cut" process can be mitigated with an alternative "wet-cut" strand pelletizer called a water-slide system. Instead of a water bath, the strands enter a water slide, in which spray nozzles cool the strands and provide a cascading water flow that moves the strands toward the pelletizer. Instead of using an air knife, this system reroutes process water away from the strands just before pelletizing and then lets it rejoin the pellet stream just afterward to form a pellet/water slurry, which further cools the polymer. The slurry enters a centrifugal pellet dryer at the bottom of the unit, and a rotating shaft with lifting vanes de-waters the pellets, which exit the dryer at the top.

*Pelletizers also vary widely in the types of polymers that they are able to process effectively.*

In the water-slide system, because pellets are cut from strands that are still wet and softer than those in the water-bath system, there is less cutter wear. The water-slide system also provides more scope for automation through greater control over process-water conditions. In addition, there is a capability for "self-stranding," in that dropped strands are replaced as strands are fed into the water slide, reducing need for operator intervention. On the other hand, the drying process generates additional dust and fines, requiring a more sophisticated filtration technique in the process-water system. This is also the case with centrifugal pellet dryers used with water-ring and underwater pelletizers.

## FACTORS AFFECTING PELLETIZER CHOICE

This discussion of the capabilities and requirements of the major types of pelletizer systems makes it apparent that for every application, the range of pelletizers varies from those that are ideally suited to those that are totally inappropriate. The differences among the types of systems are summarized in three accompanying tables.

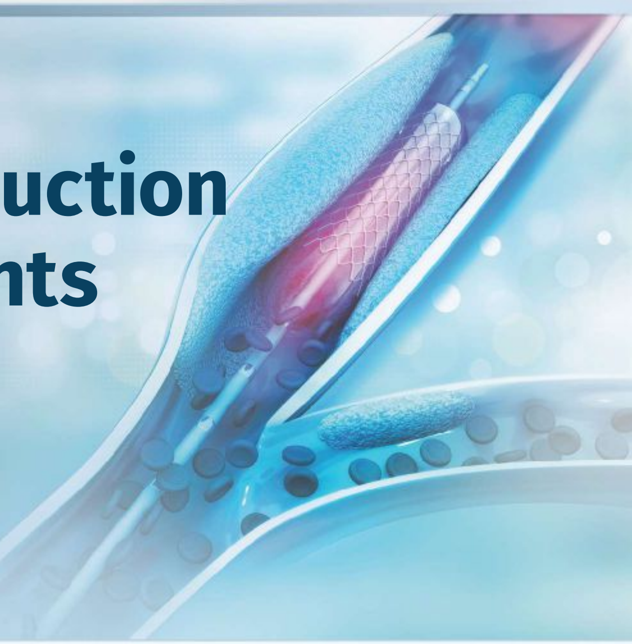
As shown in Table 1, the pellets produced in the available systems differ widely in shape, consistency, flow properties, and generation of dust and fines. These properties substantially affect pellet performance in material-handling systems downstream of the pelletizing process.

The comparison of production factors in Table 2 shows even wider differences among the available pelletizing systems. The chief differences involve capital investment, throughput capability, scope for automation, and flexibility of deployment. They determine whether a system is right for a high-volume polymerization plant, a custom compounder, or an in-house compounder with a limited budget and a low tolerance for system complexity.

Pelletizers also vary widely in the types of polymers that they are able to process effectively, as shown in Table 3. Only one system, the underwater pelletizer, is capable of handling virtually any type of polymer.

The marketplace has room for all of the systems discussed. There exists a vast potential for pelletizing systems, driven by strong global growth in consumption of plastic products, a flourishing recycling industry, and a gathering trend toward localized production of resins, compounds and additives. To meet this demand, suppliers of pelletizing systems can be counted on to develop improved and innovative equipment. PT

**ABOUT THE AUTHOR: Merritt H. Christian** is pelletizing market-development manager for Nordson Corp.'s Polymer Processing Systems business. He is responsible for sales in North and South America of Nordson's BKG brand of underwater and water-ring pelletizers.He joined Nordson in 2016 after four years at SK Chemicals America, where he was in charge of business development for Advance Polymer Solutions. He has also worked for Amoco, Owens Corning, PolyOne, DSM, and Sukano Polymers. Contact: *merritt.christian@nordson.com*; *nordsonpolymerprocessing.com*.



# How to Improve Production of Catheters and Stents

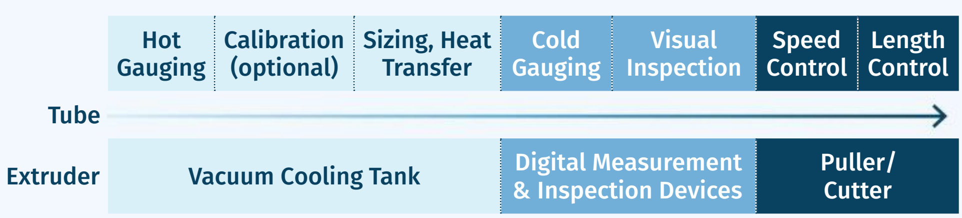
## Advances in downstream extrusion equipment have boosted production control.

By Chris Weinrich
*Conair*

The increasingly sophisticated uses of medical tubing demand that processors exercise ever-greater control over key process factors such as quality, precision, repeatability, traceability and cleanliness. Often, they must do so while producing increasingly complex tubing configurations, including micro-bore tubing sizes (less than 0.060-in. diam.) for heart and brain catheters; multi-lumen structures for diagnostic, interventional, and therapeutic uses; and complex bump profiles—all while meeting tight tolerances for tube structure and material properties.

Repeatable extrusion isn't an art. It's a science that starts well upstream with the fundamentals of material selection, blending and plastication. At the point of extrusion, die temperature, material pressure and, in many cases, air-assist pressure play critical roles in forming the tube profile. But finishing the molten tube into medical-grade product is the domain of a growing range of downstream tools.

**FIG 1** Typical Steps in Medical Tube Extrusion




Typical steps in medical tubing extrusion.

Years of development efforts by extrusion equipment makers have resulted in a steady stream of improvements that make production of catheters and stents more repeatable, controllable, and automated than ever before, while reducing the need for off-line, manual quality-assurance, cutting and finishing work.

Starting from the extruder, medical tube production typically follows a six- or seven- step process that encompasses several different types of equipment, including the vacuum cooling tank, several gauging and measurement devices, a puller and a cutter, as in Fig. 1.

### STARTING AT THE END

Because precise regulation of the speed of medical tube extrusion is crucial to a quality product, let's begin by considering the puller or, in many cases, the puller/cutter, which is typically the last piece of downstream extrusion process equipment. Pullers today (Fig. 2) are computer-controlled and servo-driven, so they can pull extruded tube through the process at extremely precise rates and adjust speeds in very small increments. By maintaining highly consistent line speeds, today's pullers help to maintain very precise control over tube wall thickness. Or, by varying line speed, pullers can make real-time changes in tube dimensions, from changes in wall thickness to more complex features.

Improved process controls enable the puller to coordinate line-speed changes with changes in air-assist pressure at the extrusion die. This makes it possible—with the help of pre-programmed recipes—to automate tube OD and wall-thickness changes and to repeatably produce "bumps," "bubbles" or tapers in medical tubing.

And because the puller's servo drives track position and speed so accurately, measuring and cutting finished lengths of medical tubing—even with complex taper-bump-bubble shapes—is relatively easy. Continuous positioning and quality data is collected from in-line sensors and gauges, then used by the puller's computerized control to manage cutting operations. Should sensors detect an unexpected variation in tube quality, its position can be marked and the defective section automatically cut out and discarded. Traveling-table cutters make it possible to measure/cut tube lengths continuously at line speed.

FIG 2 Pullers today are computer-controlled and servo-driven. They can pull extruded tube through the process at extremely precise rates and adjust speeds in very small increments.

## BACK TO THE BEGINNING

Now, with speed and length control out of the way, let's return to the beginning of the extrusion process, to the point where the tube is leaving the extruder and passing through air on its way to the vacuum/cooling tank.

Controlling the sizing of small-diameter, single- or multi-lumen medical tubing has required machine builders to scale down previous vacuum-sizing/cooling equipment, reduce water turbulence, and provide finer, more precise quantification and control of vacuum level, water temperature, and water flow (Fig 3).

Within these tanks, extruded tube typically undergoes several different operations:

**Hot gauging:** The first of several sensors in downstream extrusion controls is an ultrasonic gauge. Positioned underwater in the first 12 to 18 in. of the vacuum-cooling/sizing tank, this gauge measures tube OD and wall thickness before the tube has had a chance to cool. Hence the name—"hot gauge."

*Repeatable extrusion isn't an art. It's a science that starts well upstream.*

Reading wall thickness at four points around the circumference of the tube, the gauge measures the uniformity of the tubing wall and allows for on-the-fly control of this important variable (Fig. 4). This is a substantial improvement over other control techniques that provide no feedback until farther downstream in the process. Use of a hot gauge at the head of the extrusion line enables puller speed to be adjusted immediately to increase or decrease the wall thickness of the tube. The puller, in turn, has been tuned to make smaller incremental adjustments so that, together with the faster gauge readings, it can produce extremely tight wall-thickness control.

**Sizing:** Drawing a vacuum within these cooling/sizing tanks serves multiple purposes. By drawing vacuum to reduce the pressure of the air and water within the tank, the tank creates a pressure differential that allows air within the extruded tubing to expand outward, which is essential for sizing. Sizing may be aided by a calibration tool, or not, depending on the application.

For simple, single-lumen tube designs made of non-sticky polymers like PEEK, polycarbonate, or HDPE, a "contact sizing" process is often used. This involves passing the tube through a calibration tool. The differential pressure between the vacuum tank and the air inside the still-warm tube—at atmospheric pressure—causes it to expand outward until it is limited by the calibration tool.

More and more tube designs, including multi-lumen tubes, are sized using a "non-contact" process, which is the preferred way to size tubes made of popular, but sticky medical tube materials, such as urethane (TPU), that will not pass smoothly through a calibration die. This method injects an air-assist—a bit of positive air pressure—through the back of the die and into the tube. As seen in Fig. 5, the differential pressure—this time caused by pressure in the tube rather than vacuum outside—helps the tube to expand and hold even complex profiles.

No matter how the tube is sized, drawing vacuum in the cooling tank also can be a significant aid to the cooling process. The negative pressure of the vacuum prevents cooling water from leaking out the opening where the extruded tube first enters the tank. Preventing this leakage, or drool, by keeping the tank/water interface vertical, like a wall, is essential to continuous, even cooling around the

FIG 3 Controlling the size of small-diameter, single- or multi-lumen medical tubing has required machine builders to scale down the size of previous vacuum-sizing machinery to provide greater process control.

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extruded tube profile. If a leak is allowed to occur, it cools one portion of the tube wall first, leaving hotter material in the other portion to "draw down," causing a thinning (and often a bulge) in that section of the tube wall, as shown in Fig. 6. Thus, even a minor leak of cooling water can cause major tube ovality problems.


**FIG 4** Extruded tubing passes through an immersed ultrasonic gauge, which reads its wall thickness and displays real-time output on a screen. (Photos: Zumbach Electronics)

**Heat Transfer:** The other major job of the vacuum/cooling tank, of course, is to transfer heat away from the hot tube, enabling it to cool properly. The rate of heat transfer must be carefully regulated to ensure that the polymer retains the most desirable molecular structure and mechanical properties. Steady, gradual cooling is conducive to tubing that requires a crystalline structure. If tubing materials are cooled too quickly, their molecules will take on an amorphous structure, resulting in less-than-optimal performance. For example, tubing made with nylon that is cooled gradually develops a more crystalline structure and exhibits better elongation and burst strength than a similar tube that is cooled rapidly.

*A planetary cutter can be used with brittle, shatter-prone tubing materials.*

There are two basic ways to slow heat transfer and promote more even cooling: One is to increase the distance from the extrusion die to the cooling tank. This gives the tubing more time in air, which has a low rate of heat transfer. But this may not be practical. The second option is to increase the cooling-water temperature, since warmer water will extract heat from the polymer at a slower rate.

Ultimately, if you're serious about making tube extrusion a repeatable and scientific process, you should develop and utilize specific cooling-water temperatures for each material and each line speed. The latest vacuum-cooling tanks enable precise control over water temperatures (to ±1° F) and flow rates so that optimal rates of heat transfer are maintained. Such precise temperature control ensures consistency in material properties, sizing and quality.

Downstream from the cooling tank, the now-cooled tubing passes through two more inspection steps:

**Cold Gauging:** First is a laser gauge, which measures the final OD and wall thickness/ovality of the tubing. If your process is working properly, this "cold gauging" step should be relatively simple, essentially confirming that upstream process controls are responding as expected to control tube quality.

**Visual inspection:** A bit farther downstream, medical tubing lines typically add an additional monitoring tool, an automated vision system that can inspect finished tubing for non-programmed variations or flaws in the tubing, such as gels and surface imperfections. Flawed sections are digitally "marked" so that the cutter can cut out and remove them.

**Cutting:** Depending on the material being extruded and cut-quality standards, a number of highly precise cutter designs can be used on catheters and stents. For example, state-of-the-art puller/cutter technology can maintain cut-to-length tolerances of ±0.015 in. or better on even small microbore tubing (down to 0.008 in.) when used with specialized input devices. It uses a fly-knife cutter, which chops through the tubing with a high-speed rotating blade.

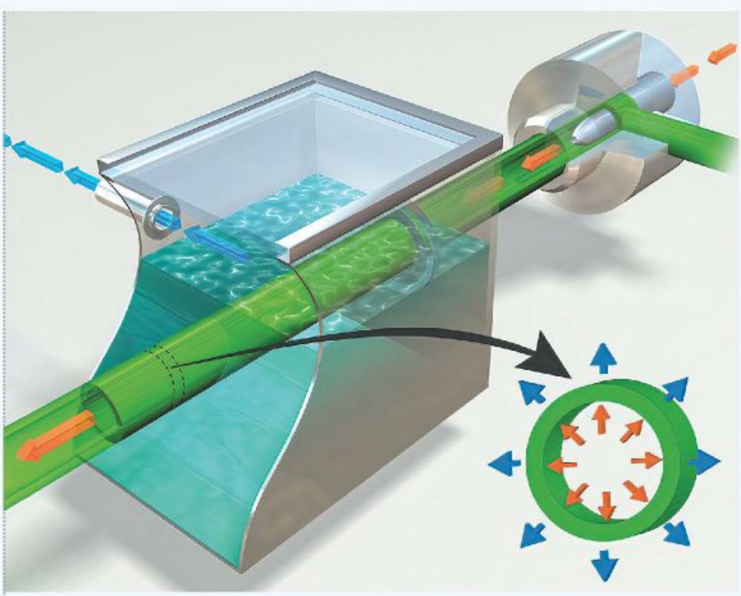


**FIG 5** Shown here is non-contact tube sizing in a vacuum tank. Hot tubing (green) passes through the extruder crosshead (top right), where it receives a burst of positive air pressure (orange). The combination of positive air pressure inside the tube and low external pressure in the vacuum-tank water sizes the tube.

For more challenging applications, where a fly-knife cutter might deform or fracture the tubing, a planetary cutter can be used with brittle, shatter-prone tubing materials. Planetary cutters utilize a spinning blade that rotates around the tube, slicing rather than chopping though it. This gentle, lathe-like action cuts without causing tube deformation or generating particulates.

Combining the inputs of in-line gauges and vision systems with servo pullers and software-based control systems makes new levels of extrusion automation possible. Processors can create specialized programs (or "recipes") for repeatable, automated production of value-added tubing features. For instance, taper or bubble tubing requires repeated adjustment of OD during extrusion so that one end of each cut-to-length section is larger in diameter than the other. Today's software and control features make production of these complex features simpler and far more repeatable. And, together with particle-free cutting methods like planetary cutting, they also make it possible to automate precision cutting and finishing operations that until recently had to be done manually, off-line. PT

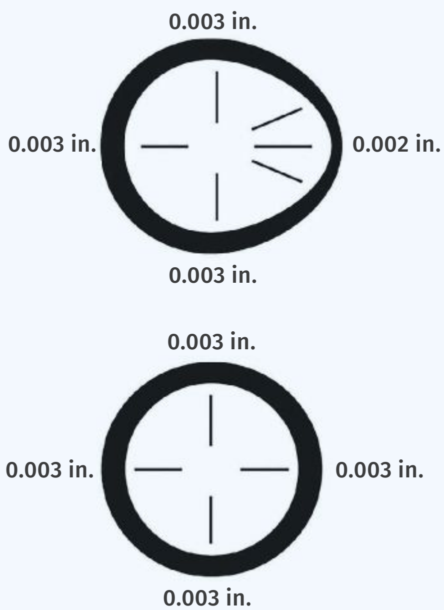



**FIG 6** Problems with tube ovality (left) may result from several issues, such as a misaligned die or leakage of cooling water.

**ABOUT THE AUTHOR: Chris Weinrich** is director, packaging & medical, for the Conair Group, Cranberry Township, Pa. He joined Conair in 2012 and assumed his current role in 2017. He was previously general manager for Conair's downstream extrusion business. Prior to joining Conair, Weinrich worked at Xaloy Inc. for eight years, where he was global product and sales manager. Before that, he worked in the Extrusion Division of Milacron for 15 years, holding several positions in technical service, engineering and product management. Contact: *cweinrich@conairgroup.com*; *conairgroup.com*.

# Keeping Up With Technology

**PRODUCT FOCUS** **Auxiliary Equipment**

MATERIAL HANDLING

## Plant Supervisory Computer for Conveying, Drying, Blending, Cooling


Mowis 3 is the latest version of Moretto's plant supervisory computer for all phases of materials conveying, loading, drying, blending and storage, as well as process cooling. This server-based, multi-user platform manages from two up to 1100 client devices. It is self-configurable and offers integrated wireless connection, as well as Ethernet connection for web-based remote monitoring and assistance. Utilizing the OPC UA communications protocol for Industry 4.0, it interfaces with management systems (ERP, SAP, etc.). There is no annual fee.

MATERIAL HANDLING

## Conveying & Drying News at Fakuma

At the recent Fakuma 2018 show in Germany, Piovan of Italy (parent of Universal Dynamics here) introduced three new products. One was a line of Pureflow filterless receivers—the first for the company—in sizes from 2 to 200 liters.


For conveying multiple materials to multiple processing machines, the latest version of Easylink+ fully automatic coupling station has an updated controller. It can convey up to 60 materials to as many as 60 locations. Integration with Winfactory 4.0 is said to ensure complete product traceability.

There are also new hoppers for the company's Modula dryers. They have an embossed diamond pattern (photo), which won't show dents as easily as smooth-sided steel hoppers.

MATERIAL HANDLING

## Plug & Play Screw Conveyor

New Low Profile Flexible Screw Conveyor from Flexicon Corp. rolls below mezzanines and other low-headroom areas, receives material from overhead equipment, and discharges the material into process equipment and vessels throughout the plant.

Ready to plug-in and run, the self-contained unit features a "push-type" drive system positioned at the lower intake end of the conveyor, versus a standard "pull-type" drive positioned at the upper discharge end, reducing overall height by approximately 2 ft.

A special screw within the straight conveyor tube is engineered to move a range of difficult-to-convey bulk materials that tend to cake, pack, smear or plug, as well as fragile products prone to breakage, with no separation of blends.

At 9 $ft^3$, the integral bin accommodates the contents of approximately one-third of a bulk bag or several typical 50-lb bags, depending on bulk density. Except for the polymer tube, all material contact surfaces are of stainless steel.

HEATING/COOLING

## TCUs Ready for Industry 4.0

At the recent Fakuma 2018 show in Germany, Single introduced the Smart Line series of temperature-control units, described as "Industry 4.0 ready." These TCUs incorporate an extensive array of fieldbus interfaces—20-mA TTY, RS232, RS485, Euromap 66, Profibus, and OPC UA—in order to send data to a web portal accessible from anywhere. The TCU with 7-in. touchscreen is linked via a local network and to a Smart Hub, a mini server the size of one's hand. TCU data collected by the Smart Hub is transmitted to the Single Data Portal through an encrypted connection. The Smart Hub provides a website (Single Net) that can be accessed by PCs and mobile devices, as well as by Single service teams to provide diagnostic support. In this system, the "cloud" for offline data storage is located at the user's plant within the Smart Hub.


The portal can send email alerts in case a process drifts out of limits and also suggests potential solutions. (For example, a "Flow below limits" message might be accompanied by a suggestion to check for a clogged filter.) Also available is a spare-parts list. More advanced options include rule-based predictive maintenance and energy monitoring and optimization.

The Single Net site includes a dashboard that shows all connected Smart Line units and key data such as set and actual temperatures, flow rate, and pressure. Any individual unit can be selected for more detailed examination, including a graphical overview of historical data for a selectable time period (up to four weeks). More than 100 parameters are logged every 5 sec. The unit can also be operated via remote control from the website.

In addition, Single introduced the Water Compact WK3 series of portable TCUs with energy-saving variable-speed pumps. They can provide water at 90 C to 180 C. They have insulated tanks, pipes, heaters, and heat exchangers—all designed to minimize heat inside the cabinet, leading to longer life of the electronics. This insulation, plus the variable-frequency pump drive (VFD), are said to save up to 70% in energy use and allow for up to 30% savings in cycle times. Units are available with heating capacity from 3 to 9 kW. They have a 3.5-in. touchscreen.



HEATING/COOLING

## Variotherm & Economy TCUs Debut at Fakuma

Frigel of Italy bought Green Box Srl, an Italian competitor in industrial cooling systems, early last year. One result of that acquisition is Frigel's first entry into "active" variotherm hot/cold mold-temperature-control systems, shown at the recent Fakuma 2018 show in Germany. "Active" systems alternate between circulating hot water at up to 180 C and cold water. (Frigel already supplies "passive" variotherm systems, which suspend cooling during mold filling, allowing the incoming melt to heat the mold, and then turn on cooling flow.) Frigel's new Thermogel THC units have heating capacity up to 54 kW and cooling capacity up to 180 kW. They have a 7-in. touchscreen control interface.

Thermogel THC is built by Frigel Intelligent Cooling Systems India Ltd. (FICS), a joint venture of Frigel and Matsui Technologies India Ltd. Also being built by FICS is a new small, low-priced TCU, Thermogel TDK. It heats pressurized water up to 160 C, and it's small enough to fit under an injection machine.

INJECTION MOLDING

# Faster Robots & Cobots

Two new robot developments from Sepro were shown at October's Fakuma 2018 fair in Germany. Both involve increased speed for standard or collaborative automation.

The new Sepro S5-25 Speed three-axis Cartesian robot has a vertical (Z-axis) stroke speed that is 50% faster than the standard S5-25, allowing for robot in/out times under 1 sec and overall molding cycles under 4 sec. This speed is made possible by a more powerful, higher-torque servomotor, plus upgraded electronics and pneumatic valves and a lighter vertical telescoping arm.

This model was developed for Sumitomo (SHI) Demag, which offers it as the "Speed 7." It is aimed at presses of 120 to 450 tons for simple packaging applications like flower pots, thin-wall food containers and tubs. It has a payload capacity (including tooling) of 7 kg, horizontal stroke of 1500 to 6000 mm, demolding stroke of 700 mm, and vertical stroke of 1200 mm. A smaller S5-15 Speed model was introduced two years ago, and a larger S5-35 Speed unit will be introduced at the K 2019 show this October. (Also coming in October is the new Visual 4 control for Sepro robots.)


The other new development from Sepro at Fakuma was the Seprobot, a "collaborative robot solution" designed to meet the requirements of most injection molding applications where limited human-robot collaboration is required, without sacrificing any of the speed or load-carrying ability of conventional three-, five- or six-axis robots. Typical collaborative robots, or cobots, are more limited in those respects. The company says the Seprobot is aimed at the 40% of injection molding applications in which human interaction with the robot is required only occasionally for removing finished parts or moving supplies or components into the robot's operating zone.


Sepro's solution for such cases is a physical enclosure with safe access for operators through openings protected by laser sensors, light curtains or other safety devices. (The photo at right shoes a Yaskawa six-axis robot with a laser scanner.) Most of the time, the robot operates at full speed, slowing down or stopping only when sensors detect humans entering the guarded space, and returning to full speed automatically when they depart.

EXTRUSION

## Small, Energy-Saving Extruders from New Source

R&D firm Omachron Plastics Inc., Pontypool, Ont., has launched its first commercial extrusion equipment, including a modular extruder line based on new screw, barrel and feed designs. They combine low-shear, high-mix, low-pressure melt handling with high-precision, closed-loop computer control driven by high-accuracy temperature- and pressure-measurement subsystems. The result is a compact machine that reportedly uses up to 95% less energy/lb of material processed and can typically achieve a dimensionally stable product within 20 min of being turned on, thereby minimizing the expense of startup and product changeover. A typical 5-hp system with the unique auto-start sequence can be purged between colors with 10 to 20 lb of material, and startup also typically requires 10-20 lb of material to make dimensionally stable product.

The Omachron extruders are small and the subsystem components are light enough to enable all maintenance to be carried out by one or two people in minutes, not hours, without the need for a crane or other lifting equipment. Omachron has also developed compact, low-cost, low-pressure downstream equipment with low power consumption, including dies for thin film, sheet, profiles, tubing, pipe, corrugated pipe and other products. The company says its proprietary plasticating system and associated downstream equipment produce geometrically accurate parts with little or no internal stress, yielding excellent mechanical, physical, optical and chemical properties.

Current product offerings include desktop systems (1-in. and 1.25-in. screw diam.) with 1 to 20 hp that provide outputs from 10 to 600 lb/hr. All these systems can operate from single- or three-phase power, enabling their use in rural areas where three-phase power is not available. A new, compact system to provide 2400 lb/hr is planned for later this year. The firm's first injection molding machines are due next year.

# Prices Flat or Lower for Commodity Resins

## Low feedstock prices, higher supplier inventories, and slowed demand are key drivers.

By Lilli Manolis Sherman
Senior Editor

Prices of PE, PP, PS and PET dropped in December—with PP and PS in starring roles--and were expected to be flat generally through January and into this month. Driving the trend were continued lower feedstock prices globally, starting with crude oil, and globally higher supplier inventories with lackluster seasonal demand.

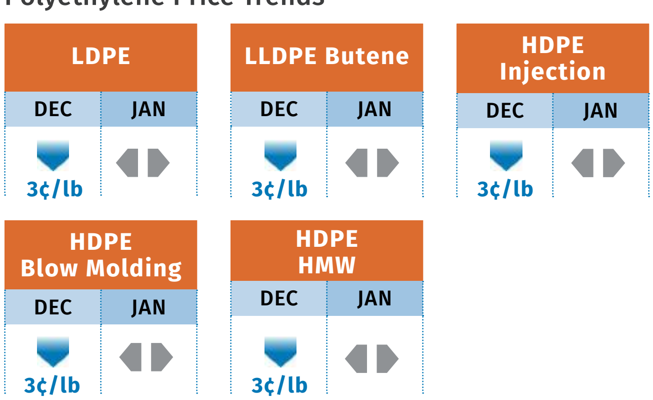
Those are the views of purchasing consultants from Resin Technology, Inc. (RTi), Fort Worth, Texas; senior editors from Houston-based PetroChemWire (*PCW*); and CEO Michael Greenberg of The Plastics Exchange in Chicago.

### POLYETHYLENE PRICES DROP

Polyethylene prices dropped 3¢/lb in December, following a similar slump in November. Marching into 2019, PE suppliers issued increases of 3-6¢/lb for Jan. 1 and additional increases of 3-4¢/lb for this month, depending on the supplier.

Both Mike Burns, RTi's v.p. of PE markets, and *PCW* senior editor David Barry maintained that there were no market drivers supporting any price increase. On the contrary, they cited global trends to lower feedstock prices, led by falling oil prices, and healthy PE inventories. Burns noted that domestic inventories continue to exceed strong U.S. demand. Also, while exports were very robust at the end of 2018, a slowdown was expected from Asia due to slowing economies there and Chinese New Year, so that market conditions were likely to be uncertain until late February.

**Polyethylene Price Trends**




Barring either a major disruption in production or oil prices spiking, RTi's Burns foresees relative stability for PE prices through the first quarter, at least, if not for most of the year. *PCW*'s Barry noted that only a big uptick in oil pricing would support a PE price hike. He ventured that domestic demand would be strong in January, partly due to restocking and suppliers' push for price increases. He saw the downward pressure on PE as having played out and predicted flat to possibly higher prices in this first quarter. Both sources noted that 2018 ended with domestic PE supplies rising by over a 1 billion lb after major new capacity came on stream.

**Market Prices Effective Mid-January 2019**

| Resin Grade | ¢/lb |
|---|---|
| **POLYETHYLENE (railcar)** | |
| LDPE, LINER | 95-97 |
| LLDPE BUTENE, FILM | 78-80 |
| NYMEX 'FINANCIAL' FUTURES | 36.5 |
| FEBRUARY | 36.5 |
| HDPE, G-P INJECTION | 100-102 |
| HDPE, BLOW MOLDING | 93-95 |
| NYMEX 'FINANCIAL' FUTURES | 40.5 |
| FEBRUARY | 40.5 |
| HDPE, HMW FILM | 107-109 |
| **POLYPROPYLENE (railcar)** | |
| G-P HOMOPOLYMER, INJECTION | 74-76 |
| NYMEX 'FINANCIAL' FUTURES | 54 |
| FEBRUARY | 54 |
| IMPACT COPOLYMER | 76-78 |
| **POLYSTYRENE (railcar)** | |
| G-P CRYSTAL | 101-103 |
| HIPS | 107-109 |
| **PVC RESIN (railcar)** | |
| G-P HOMOPOLYMER | 83-85 |
| PIPE GRADE | 82-84 |
| **PET (truckload)** | |
| U.S. BOTTLE GRADE | 64-66 |

Commenting on the culmination of 2018 PE pricing trends and the spot market, The Plastics Exchange's Greenberg said, "In general, the need to export the vast majority of the new polyethylene production in the face of Chinese tariffs and falling oil prices required sharp discounts; and consequently, we saw the Houston/export discount vs. higher domestic prices grow to perhaps unprecedented levels."

## POLYPROPYLENE PRICES DROP FURTHER

Polypropylene prices dropped by another 8¢/lb in December, in step with propylene monomer contract prices, for a total decline of 18¢/lb in the last two months of 2018. There was no sign of the 3¢/lb profit-margin increase attempted by suppliers. Noted PCW's Barry, "It's hard to justify that kind of margin increase with monomer down to 42¢/lb and spot PP homopolymer at 54-57¢/lb." Prices in the first month of the year were likely to be flat or down by another 1-2¢/lb if monomer prices slipped a bit further, according to Scott Newell, RTi's v.p. of PP markets. Greenberg reported that spot PP availability was sporadic, with spot prices dropping a lot less than contract prices. "Resin sellers with inventory on hand have commanded and generally received most of the premiums they have sought."

**Polypropylene Price Trends**

| Homopolymer | |
|---|---|
| DEC | JAN |
| ▼ 8¢/lb | ◀▶ |

| Copolymer | |
|---|---|
| DEC | JAN |
| ▼ 8¢/lb | ◀▶ |

These industry sources generally saw stable prices, at least for January. Newell said that a lot will depend on PP demand and to what extent the monomer excess would be reduced with planned maintenance shutdowns in late first quarter. At the start of 2019, domestic monomer prices were the lowest in the world, while PP prices had dropped to about equivalent with European prices, yet about 10-15¢/lb higher than Chinese PP. Newell also noted that while PP imports were at record highs for fourth-quarter 2018, he expected imports to dwindle through the first quarter.

## POLYSTYRENE PRICES LOWER

Polystyrene prices fell 7¢/lb in December, and additional price concessions on the order of 3-5¢/lb were expected by both Robin Chesshier, RTi's v.p. of PE, PS and nylon 6 markets, and *PCW*'s Barry. Falling benzene contract prices were the key driver, with January contracts settling 27¢/gal lower at $1.83/gal. Lower butadiene and styrene monomer prices, along with seasonally slowed demand, also contributed.

**Polystyrene Price Trends**

| GPPS | |
|---|---|
| DEC | JAN |
| ▼ 7¢/lb | ◀▶ |

| HIPS | |
|---|---|
| DEC | JAN |
| ▼ 7¢/lb | ◀▶ |

However, both these industry sources saw a somewhat different scenario shaping up as early as this month, based on a potential rebound of benzene prices that would depend on both oil prices and the fact that benzene is perceived as being about 50¢/gal underpriced, noted Barry. He added that February 2017 saw a major increase in PS prices—up 8¢/lb, driven by a sharp upswing in oil and benzene tabs. Chesshier ventured that PS prices this month would be flat to slightly higher. Barry reported at 2018's end that spot prime GPPS was at 76-78¢/lb, 10¢ lower than in 2017, while spot prime HIPS was at 81-83¢/lb, down 12¢/lb in that same time span.

## PVC PRICES FLAT

PVC prices rolled over in December as they had in November, despite suppliers attempts to push through a 2¢/lb increase, which both Mark Kallman, RTi's v.p. of PVC and engineering resin markets, and *PCW* senior editor Donna Todd said had little chance of implementation.

**PVC Price Trends**

| Pipe | |
|---|---|
| DEC | JAN |
| ◀▶ | ◀▶ |

| Gen. Purpose | |
|---|---|
| DEC | JAN |
| ◀▶ | ◀▶ |

Both sources cited lower feedstock prices and seasonally low demand and expected these drivers to factor into continued flat pricing in January and potentially this month. Late-settling December ethylene contract prices were unchanged from November, and supplies appeared to be in good shape. Kallman foresaw fairly flat pricing for PVC in the first quarter, barring any unplanned production outages or increases in oil prices and/or demand.

He noted that after planned maintenance outages late last year, PVC suppliers were likely to ramp up utilization rates to the mid-80s to rebuild some inventory. Todd reported that in the past, January PVC price hikes (and the pipe price increases that inevitably follow) have not had a good track record of success.

## PET PRICES FLAT-TO-DOWN

Prices for domestic bottle-grade PET entering 2019 were in the mid-60¢/lb range—down from the wide spread of 68-75¢ /lb in early December. Demand is down due to typical seasonal factors, while PET imports from more than 50 countries are once again available to domestic buyers, according to *PCW* senior editor Xavier Cronin.

**PET Price Trends**

| Bottle Grade | |
|---|---|
| DEC | JAN |
| ▼ 3¢/lb | ◀▶ |

One PET resin distributor expected a potential "bounce" in PET prices last month, noting that some bloated supplier inventories were reduced in December for end-of-year book-squaring and other business reasons. Still, *PCW*' senior editor Xavier Cronin ventured that January PET prices would remain flat or possibly fall a couple of cents. As for this month, he expected prices to meander around 65¢/lb, barring supply disruptions due to logistical issues like bad weather creating delivery problems for truck-load and bulk-truck deliveries. PT

# Processors Report Lower Growth

## December index dips a point; year-end value ends above 55.

By Michael Guckes
*Chief Economist*

The Gardner Business Index (GBI) for Plastics Processing fell one point in December to 50.9 as production contracted and new orders were unchanged. The latest reading brings the average year-to-date reading to 55.3. (Values over 50 indicate expansion; values below 50 indicate contraction; 50 = no change.)

The index is 8.6% lower than in December 2017. Of the six components used to calculate the Plastics Processing Index, supplier deliveries moved it higher. All other components moved the index lower. December experienced a slight expansion in employment, no change in new orders, and contraction in production, exports and backlogs.

Data from the fourth quarter of 2018 indicate a general slowing of business conditions after experiencing more than 18 months of above-average growth rates. In general, supplier deliveries tend to lag production and new orders, both of which experienced record-breaking expansion in early 2018. For the first time since the fourth quarter of 2016, processors indicated a contraction in total production levels while also reporting a decline in backlogs. Essential to production levels are new orders, which showed no change in the month, suggesting that domestic orders are no longer more than offsetting the contraction in exports that started in August.

The index is based on monthly surveys of *Plastics Technology* subscribers.

Michael Guckes is the chief economist for Gardner Intelligence, a division of Gardner Business Media, Cincinnati. He has performed economic analysis, modeling, and forecasting work for nearly 20 years among a wide range of industries. He received his BA in political science and economics from Kenyon College and his MBA from Ohio State University. Contact: *(513) 527-8800*; *mguckes@gardnerweb.com*. Learn more about the Plastics Processing Index at *gardnerintelligence.com*.

### GBI: Plastics Processing

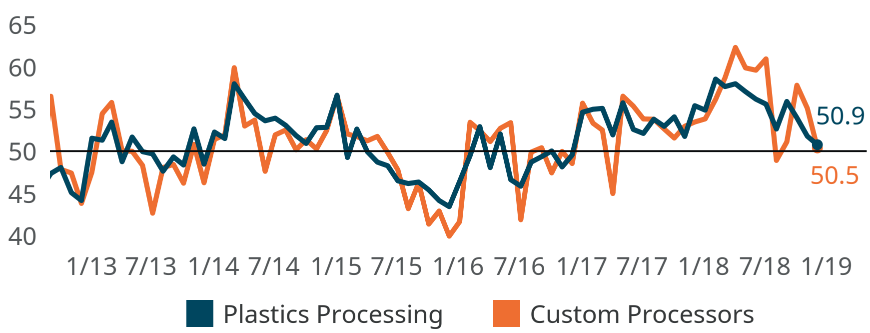



**FIG 1**

**The Plastics Processing Index indicated slowing growth in December as growth in supplier deliveries was largely offset by weak production, backlogs and exports.**

### Plastics Processing: Production & New Orders (3 MMA)

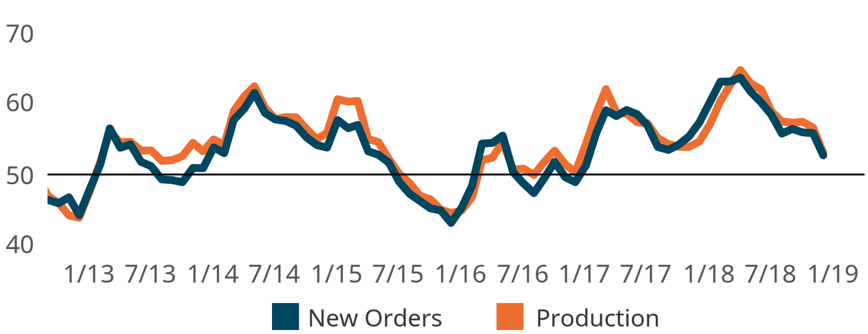



**FIG 2**

**New orders and production ended 2018 at their weakest in two years after setting new or near-record highs in the first quarter of the year.**

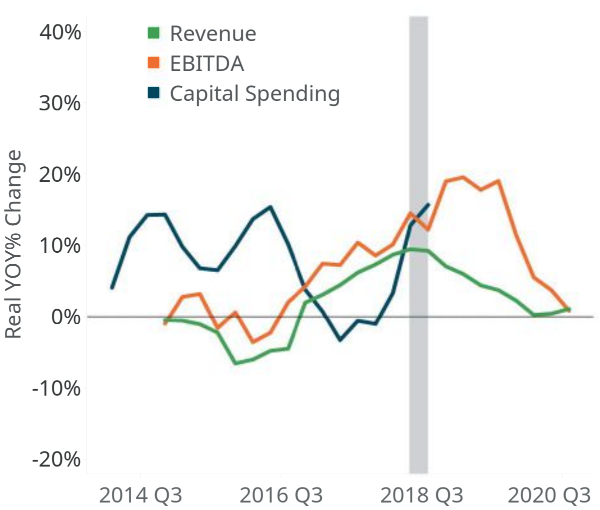
# Packaging Growth Points to Strong 2019

## As the plastics industry adjusts to 2018's higher orders volume, capital expenditures in the industry have increased significantly.

By Michael Guckes
*Chief Economist*

Using the financial data submitted to the Securities and Exchange Commission (SEC), along with forecasts provided by major Wall Street brokerages, Gardner Business Intelligence (GBI) has compiled financial results for 17 publicly traded firms in the containers and packaging industry to assess the current and future state of the industry. The results reveal an industry that has experienced eight consecutive quarters of revenue and earnings growth through the third quarter of 2018.

### Containers and Packaging Industry Actual and Estimated Results




**As revenue growth slows starting in 2019, EBITDA growth is also expected to slow in the quarters afterward. However, projections do not show revenue or earnings growth falling below 4% until the third quarter of 2019 and second quarter of 2020 respectively. This suggest that containers and packaging will grow faster than the overall economy for most of 2019.**

Total inflation-adjusted revenue and earnings growth during this time were 12.6% and 18.6% respectively. In 2018's third quarter, the container and packaging industry achieved year-on-year revenue growth—known as the "12/12" rate of change—of 9.2%. Earnings before interest, taxes and depreciation (EBITDA) achieved a 12/12 growth rate of 12.2% during the same period. These strong results enabled the industry to achieve a profit margin not seen since the Great Recession of 2007-2009.

The industry's financial success in recent years has also been well captured by the Plastics Processing Index—another GBI index (see p. 65)—which measures fundamental business conditions as reported by plastics processors. Among the six components that constitute this index, 2017 and 2018 data indicate an industry that has rarely expanded faster. The index since 2017 has been driven in large part by growth in new orders, production, and supplier deliveries. Backlog data collected since the first quarter of 2018 suggest that the industry has struggled to raise production levels sufficiently to match new orders growth, resulting in significant expansion of backlogs in the current calendar year.

> ***Packaging experienced eight consecutive quarters of growth through the third quarter of 2018.***

As the plastics industry adjusts to 2018's higher new orders volume, capital expenditures in the industry have increased significantly. The 12/12 rate of change ending in the third quarter of 2018 saw capital expenditures rise by 16%. Similarly, the supplier deliveries component of the Plastics Processing Index experienced unprecedented expansion in 2018. Since May, supplier deliveries were the fastest expanding component of the Index.

Using the aggregated financial forecasts provided by Wall Street analysts for the firms used in this study, the industry in 2019 and 2020 is expected to see continued but slowing growth in revenues after climaxing sometime during the second half of 2018. As revenue growth slows, EBITDA growth is also expected to slow in the quarters afterward. Aggregated projections, however, do not show revenue or earnings growth falling below 4% until the third quarter of 2019 and second quarter of 2020 respectively. This suggests that containers and packaging will grow faster than the overall economy for most of 2019. PT

**ABOUT THE AUTHOR:** Michael Guckes is the chief economist for Gardner Business Intelligence, a division of Gardner Business Media, Cincinnati. He has performed economic analysis, modeling and forecasting work for 20 years among a wide range of industries. Guckes received his BA in political science and economics from Kenyon College and his MBA from The Ohio State University. *mguckes@gardnerweb.com*

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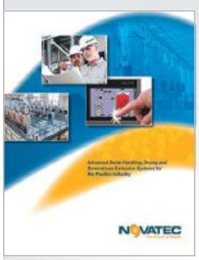


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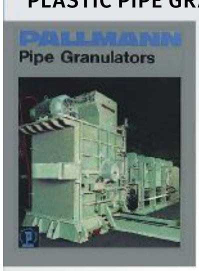


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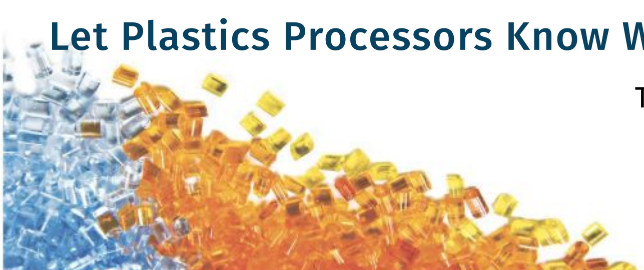

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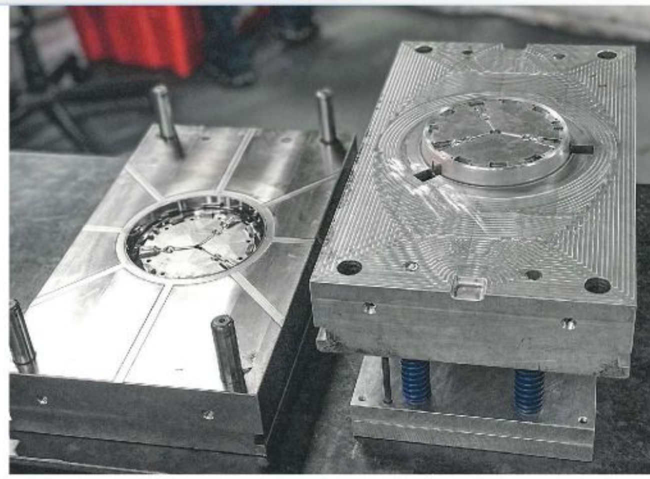
# Aluminum Tooling Answers Hard Questions

Check your preconceptions about aluminum production tooling at Phoenix Proto's door.



The "a" and "b" sides of an aluminum production tool, with the left side featuring a hard surface coating.

By Tony Deligio
*Senior Editor*

The year 2018 marked four decades in aluminum production tooling for Bob Lammon, CEO of injection molder and moldmaker Phoenix Proto Technologies, Centreville, Mich. Nonetheless, the continued skepticism his company's core competency arouses yet today is in many ways unchanged from the late 1970s. The hardened-steel tooling crowd has same queries and assumptions.

*Can you hit the same tolerances in aluminum that you can in steel?* Yes. *Is it stable?* Yes. *Will it move?* No. *Can you do a revision in aluminum?* Yes. *Can you weld aluminum?* Yes, it laser welds. *But you can't achieve a Class A surface finish in aluminum.* Yes, you can. *You can't do side actions.* Actually, you can. *You can't run 100,000 parts or 1 million shots.* Yes, you can.

The chrome-plated PC/ABS part made from this hard-coated aluminum tool features a Class A surface finish.

"I'll take a couple brief-cases of parts to show customers," Lammon explains. "A lot of them like to touch and feel and see the parts, and they're like, 'Hey, that's impressive. Did that come off of aluminum?'"

Started in 2008, Phoenix Proto works exclusively in aluminum and always has (except for one brief lapse into tool steel). It runs many of the molds it builds in-house on its seven injection molding machines, which range in clamp force from 55 to 385 tons. Tool production resides in the front of its facility, including seven CNC machining centers, three of which are high-speed with spindles running at up to 42,000 rpm. Tool making is lights out, thanks to an automated pallet system. The bulk of the 40-person staff—28 employees—work in the tooling department, building 300 to 400 molds annually. The remaining 12 staff are occupied with molding and quality. A proposed 20,000-ft² expansion would give Phoenix room for 15 presses and expand its CNC department.

For a brief time, Phoenix Proto produced some steel tooling, before returning to its wheelhouse in aluminum—a move that pleased employees. "When we were building in steel, and I said, 'We're going back to 100% aluminum,' my employees were like, 'Yes!'" Lammon recalls.

Part of aluminum tooling's appeal for Phoenix Proto employees, and definitely its customers, is the enhanced pace of manufacturing an aluminum tool. "You can build an aluminum tool so much faster," Lammon says, "and the parts that come off the tool—they look like parts that come off a hardened steel production tool."

The speed factor derives partially from the relative ease with which aluminum can be machined compared with hardened steel. Spindle speeds and feed rates are higher with aluminum, which also allows cutting in some instances where steel would require EDM, eliminating the time and cost of making an electrode. For tools running harsher plastic materials, or to extend mold life, Phoenix Proto has some aluminum molds hard coated, working with Bales Metal Surface Solutions.

Aluminum tooling doesn't fit every project, but the number of applications it potentially could fit is significant. "There's a lot of project life out there that fits 100,000 parts or less," Lammon says. "Tons of products. Is aluminum a choice for running millions and millions of shots? No—go with hardened steel. But how many companies are out there that want 5000, 25,000, 100,000 parts? Those are prefect for aluminum."

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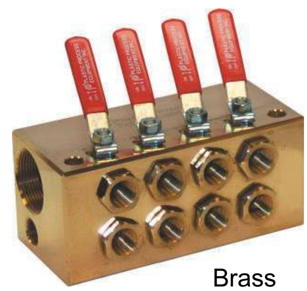


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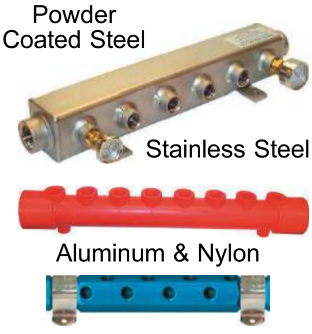


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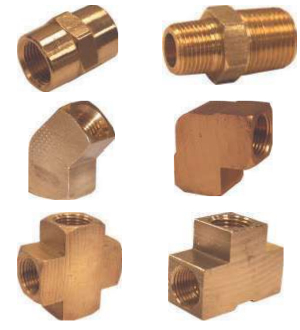

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