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More Than Molds

Omega Tool Pushes Into PUR

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On the Cover

On-Site: Omega Tool Redefines the Role of Moldmaker in An Evolving Industry

Demonstration of the in-mold RIM PUR coating process, developed with KraussMaffei and Ruhl, is emblematic of the company's expanding range of capabilities and customer services.

By Matt Stonecash,
Associate Editor

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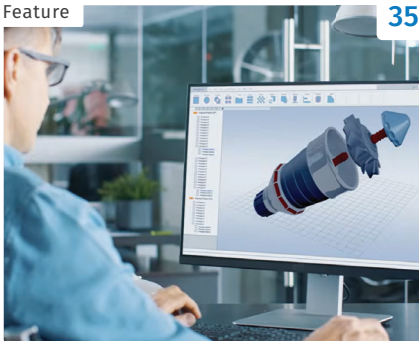
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By Mark A. Spalding and
Mike Rutkowske, Dow

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By Matt Stonecash,
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ABOUT THE COVER

Omega Tool's bay No. 3 featuring the large bumper fascia molds.
Source: Omega Tool. See story on page 28.

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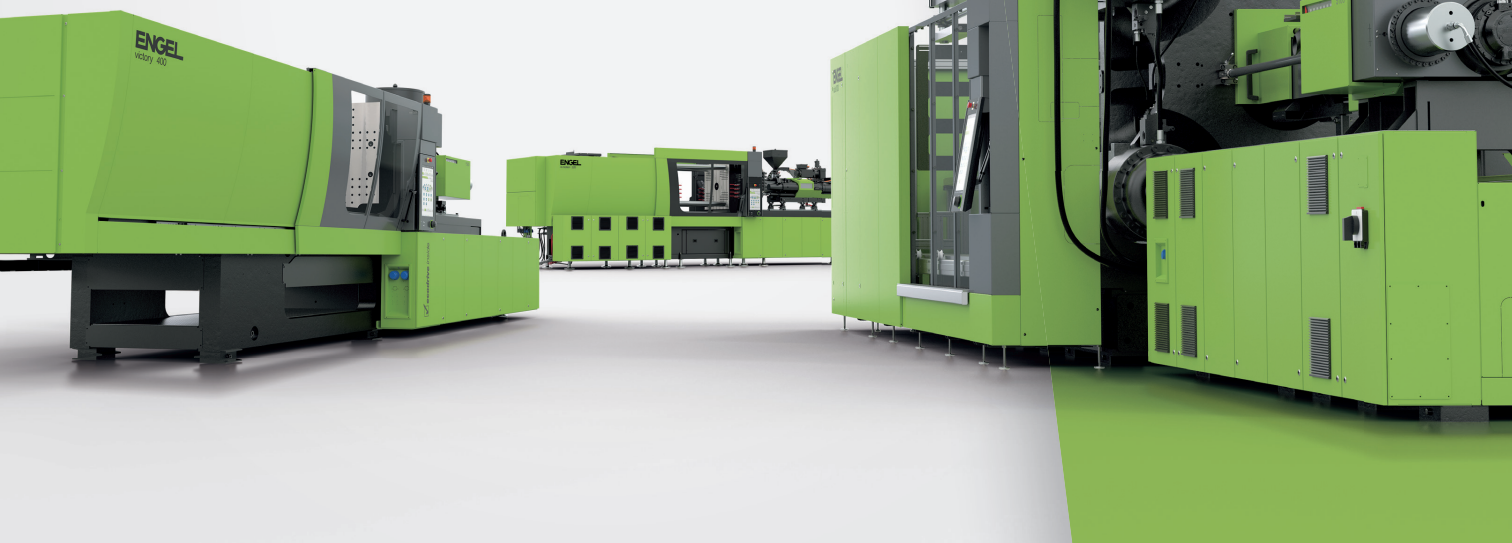


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Connecting Manufacturers with Actionable Intelligence

The geopolitical, economic and natural disruptions (extreme weather, pandemics) of the last few years suggest a new order. Manufacturing Connected reveals it.

As a before/after line of demarcation, 2020 is quite good. A nice round number marking

the start of a new decade that comes soon after the beginning of not only a fresh century but a new millennium.



Tony Deligio
Editor-in-Chief

Today, it's not just the unique numerical aspects of 2020 that make it prominent in our collective memories, it is the global pandemic that arrived in force early that year, and the sweeping changes it wrought on all aspects of our life, including how,

where and with what materials we manufacture things.

"Before Covid, there was a steady state," explains James Gaylord. "We were all kind of settled into what that was. During Covid, it was a race to build as many things as you could, as quickly as you could. Then it turned into, 'Well, that didn't work out. Now, what do we do?'"

Gaylord is senior director of sales for Tier 1 automotive supplier, The Axiom Group, Aurora, Ontario, which was the focus of our On Site plant tour story in July. Founded in Canada by tool-makers in 1987, it expanded capability-wise into injection molding and geographically into the U.S. and Mexico. Establishing posts in all three North American countries, Axiom followed the lead of many other automotive suppliers who were themselves mirroring the same transnational investments of OEMs. Today, supply disruptions — fueled by geopolitical tensions, extreme weather and questions over the role of new technologies, like artificial intelligence and digitalization — are forcing manufacturers like Axiom to reassess its approach to the market.

The pandemic's impact on manufacturing threw long-held assumptions out the window and confronted companies with many questions that still haven't been answered. In the years since, only more previously accepted maxims have been upturned with additional unanswered questions lingering around formerly



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settled concepts like just-in-time inventory, vertical integration, globalization, work in progress and more.

In times of such upheaval, those who successfully navigate from the chaos of now to the next "steady state" do so with real-time intelligence. *Plastics Technology's* parent company, Gardner Business Media, will provide manufacturers with that crucial intelligence via its reconfigured Manufacturing Connected platform. That platform is undergirded by the on-the-ground reporting and subject-matter expertise of its well-established brands serving the metalworking, additive manufacturing, product finishing, advanced composites and moldmaking communities.

This summer, Manufacturing Connected will relaunch as a daily intelligence platform built on the editorial foundation of those established Gardner publications and structured around the decisions manufacturing leaders actually face. It will connect signals across technology, supply chain, finance and policy so that owners, GMs and operations leaders understand what changed, why it matters and what to watch next.

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Haitian Partners with Hennecke to Enter PUR In-Mold Coating

Chinese injection molding machine manufacturer Haitian International has entered into a strategic partnership with Germany's Hennecke to further develop integrated polyurethane (PUR) injection molding and in-mold coating (IMC) technologies for the automotive and other industries. The company said in a release that the collaboration reflects the global automotive industry's acceleration toward greener and more premium manufacturing, utilizing single-process PUR coating to protect in-mold color and eschewing the need for post-mold painting.

By combining Hennecke's expertise in PUR processing with Haitian's injection molding technology, the partnership is designed to strengthen



Haitian's turnkey PUR paint-free offerings, according to Haitian.

Founded in 1945, Hennecke has more than 80 years of expertise in high-pressure PUR metering and mixing technologies, including high-pressure mix heads, precision metering pumps and in-mold coating.

Compared with traditional injection molding combined with post-mold painting, in-mold coating offers a more efficient process with lower emissions and more consistent quality, according to Haitian.

Haitian presented an IMC application during an open house at its newly opened Global Applications Center in Ningbo, China, molding and coating an automotive grille, using a PC/ABS substrate overmolded with PUR. The Hennecke pump and metering system are fully integrated into the molding machine's Keba controller.

Haidlmair Acquires TFM Slovakia

The Haidlmair Group, Nussbach, Austria, has expanded its international manufacturing base via the acquisition of Slovakian company TFM Slovakia. In a release, Haidlmair said this move strategically expands its CNC manufacturing capabilities while simultaneously strengthening the competitiveness of the entire group. Haidlmair is now composed of 11 companies across five countries with more than 600 employees.

TFM Slovakia, which was founded in 2009 as a subsidiary of an Austrian mold manufacturer before being spun off in 2024, operated as an independent family-owned business with 30 employees. Haidlmair says it will continue to function as an independent CNC contract manufacturer supporting



its existing customers. In addition, TFM Slovakia will take on more manufacturing services for the Haidlmair Group.

TFM Slovakia's capabilities include CNC milling and turning, as well as electric discharge machining (EDM). Haidlmair recently began construction of a brand-new greenfield facility in Greensburg, Indiana.

New Owners, New Name For Melt Filtration Innovator

Hitech has a new owner. The New Jersey-based supplier of continuous screen changers was sold in June to Machined Metals Manufacturing Group, Collegeville, Pennsylvania, which has supplied metal parts to extruder OEMs for more than 60 years. Machined Metals is also the parent company of Jennings International



Corp., a supplier of ram extrusion lines for fluoropolymers, and Extrusion Systems Inc., both also from Collegeville.

The company will be named Hitech Screen Changers and will be run by extrusion industry veteran Mike Mitchell, who also heads up Extrusion Systems Inc. Mitchell has been in plastics since 1988 and has held high-level engineering positions at both Welex Inc. (now part of Graham Engineering) and Davis-Standard. He has also worked on the processor side of the business as vice president of engineering for Delta Plastics, which makes farm irrigation films, can liners and other products.

Mitchell started Extrusion Systems in February 2020, where he focused on process consulting, retrofitting/rebuilds and complete system engineering.

Hitech was started in South Hackensack, NJ in 1969 by Dr. John Alroy, a Hungarian immigrant who had experience in both high-speed canning and plastics packaging, and his wife Veronica. Following his sudden passing 33 years ago, the company has been run by second-generation owner Aline Alroy, who joined the business in 1986. Hitech fully automatic continuous screen changers are in operation in virtually every type of extrusion process all over the world.

Alroy will stay on with Hitech through an unspecified transition period. Rod Crue, an engineer for 16 years at Hitech, will join the new firm as an employee. Hitech has also hired extrusion and melt-filtration veteran Randy Joubert as sales manager.

Effective with the sale, screen changer production will shift to Machined Metals' 28,500 square foot facility in Collegeville.

Terms of the transaction were not disclosed.

Polystyrene Production Site in Illinois to Close

INEOS Styrolution announced the permanent closure of its polystyrene production site in Channahon, Illinois, with decommissioning and an orderly closure process expected to be completed in the fourth quarter of 2026.

The site, located approximately 45 miles southwest of Chicago, has been in operation since 1960, has a production capacity of approximately 400,000 metric tons and currently employs approximately 100 people. The company says it recognizes the significant impact this decision will have on employees and their families and is committed to supporting affected employees throughout the transition.

"Persistent margin pressures continue to threaten the viability of our North American business as we face ongoing pressure from industry oversupply," says Steve Harrington, CEO of INEOS Styrolution. "Following a thorough evaluation of market conditions, industry utilization rates, the site's cost structure and long-term outlook, we have concluded that continuing operations at Channahon is no longer economically viable."

As part of its strategy to optimize its asset base, the company will transition North American polystyrene production from three sites to two, continuing operations in Decatur, Alabama, and Altamira, Mexico. The Americas Regional Development Center, currently located at the Channahon site, will remain and continue to support innovation and new market development across all styrenic product lines.

INEOS Styrolution says it remains committed to its polysty-



rene business and will continue to serve customers across North America with materials for applications in healthcare, packaging, appliances and construction.

"Its versatility, performance, efficiency and potential to support circular solutions make it an essential material across a wide range of applications," says Greg Fordyce, president of INEOS Styrolution Americas. "By concentrating production in fewer, more efficient assets, we are strengthening our ability to serve customers reliably while reinforcing our long-term competitiveness in a challenging market environment."

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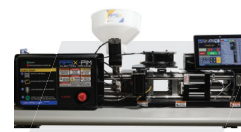
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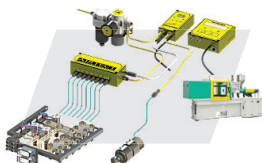
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PureCycle, IPL Schoeller Produce Recycled Grocery Container for Cleveland Kitchen

PureCycle Technologies and IPL Schoeller have developed polypropylene tubs and lids incorporating 25% post-consumer recycled content. Cleveland Kitchen, a fermented foods producer, will roll out the container nationally later this month. The 24-ounce container is designed to comply with recycled-content packaging mandates in New Jersey, California and other states moving forward with similar regulations.



The collaboration marks the first time a food-contact grocery container made with PureCycle's recycled polypropylene resin has reached full commercial production. The resin is produced through a dissolution recycling process that removes colors, odors, additives and other impurities that degrade traditionally recycled material. The resulting recycled content is GreenCircle Certified for recycled content and meets FDA food-contact requirements for a range of uses.

Cleveland Kitchen and other brand owners rely on high-volume rigid plastic tubs and lids for food, personal care and household products, and they are increasingly required to demonstrate post-consumer recycled content in their packaging supply chain.

"We have been wanting to incorporate recycled polypropylene into the right product in North America for several years. Our eye has been on the PureCycle resin due to its high quality, clarity and broad use cases," says Melissa Vettleson, IPL Schoeller sustainability and materials engineer.

Eastman Tritan Copolyester Supports BPA-Free Chocolate Mold Production

Cabrellon Srl is a long-standing Eastman customer using Eastman Tritan co-polyester in industrial chocolate mold applications. The Italian manufacturer is expanding its portfolio with BPA-free Eastman Tritan Renew copolyester — adding 25% certified recycled content to chocolate molds, certified by mass balance allocation.



For decades, polycarbonate was the default material for industrial chocolate molds. The European Commission has since adopted Regulation (EU) 2024/3190, which restricts bisphenol A (BPA) and related bisphenols in food-contact materials. Chocolate mold manufacturers and chocolate producers across Europe are seeking alternatives that preserve durability and operational efficiency.

Tritan and Tritan Renew are engineered to provide the performance that demanding food-contact applications require. This includes impact and shatter resistance, dimensional stability under repeated use, excellent mold release for intricate designs and dishwasher durability.

Tritan is cleared for food contact by both the U.S. Food and Drug Administration (FDA) and the European Food Safety Authority (EFSA). It is produced and supplied at commercial scale, giving mold manufacturers and brand owners confidence in reliable availability.

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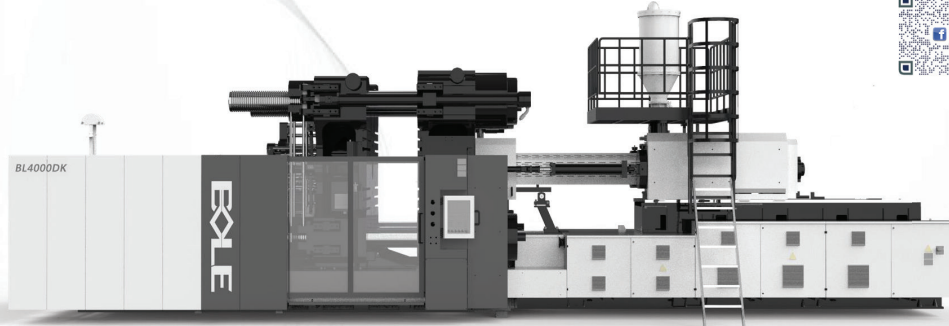


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Raman Spectroscopy Illuminates Elusive Recyclates

For sorting verification, lab instruments can identify polymer structures, even for black plastics.

The continuing development of NIR (near-infrared) sorting systems, including inline sorting that incorporates AI and RGB cameras, is helping recyclers extract more value. NIR sorting systems quickly probe bulk materials without requiring sample preparation, but they have a blind spot for black plastics.

By **Matt Stonecash**
Associate Editor

Commonly used in electronics housings, automotive components, and consumer goods, black plastics routinely slip past conventional sorting systems.

NIR spectroscopy identifies polymers by recording the intensity and wavelength of light that scatters off of a sample, and carbon black absorbs too much of that light for the detector to get a usable signal. Without reliable identification, they are typically diverted out of most recycling streams and sent to incineration or landfill, even when the underlying polymer would otherwise be valuable. Black plastics are recycled postindustrially, but the lack of effective sorting means they have to be of known composition or be recycled, mixed, into applications where mechanical requirements are modest.

Raman spectroscopy technology offers an approach that can circumvent this problem, based on subtler physics. When a sample is illuminated, most of the scattered light has the same wavelength as the laser (called elastic scattering) but a tiny amount undergoes an energy shift and scatters at a different wavelength (inelastic scattering). This shift, discovered by C.V. Raman in 1928, can be used to deduce the molecular bonds in the sample. Raman spectroscopy succeeds in analyzing black plastics because the high-powered laser increases the excitation that produces the signal, and because Raman scattering is at a different wavelength than the incident laser it can be distinguished and measured at higher

accuracy. For these same reasons, Raman spectroscopy can also be effective at analyzing transparent plastics.

A NEW TOOL FOR RECYCLERS

Canon is introducing a new instrument based on Raman spectroscopy technology, the TR-A100. The TR-A100 is a desktop instrument that will give quality teams access to detailed data on batch samples, including those containing black and transparent plastics. Says the company: "We believe we can support recyclers by helping them evaluate the purity and visualize the composition of plastics after the sorting process." The TR-A100 oscillates the laser irradiation position across the tray to prevent the high-power laser from heating and damaging samples during the longer measurement times that weak-signal materials require, thereby reducing the effective energy density at any single point. The system reports which polymer types are present and the proportion of target plastics in a measured sample. ▶



Canon TR-A100 instrument, which uses Raman spectroscopy to identify polymers. Source: Canon U.S.A.

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According to Canon, the TR-A100 is aimed at two types of customers: companies that process industrial scrap generated by manufacturers, and recyclers handling post-consumer materials recovered from the market. In both cases, the intended role is material verification and purity checking rather than direct integration into an inline sorting line. Because confirming the final purity of sorted material is a step every recycling setup needs, Canon sees the device as relevant beyond just black-plastic-focused operations. The expected payoff for recyclers is more stable material quality, which in turn can support higher-value end applications and lift the market value of recycled output.



Chandrasekhara Venkata Raman, winner of the Nobel Prize in Physics, 1930. Source: Public Domain

LIMITATIONS AND CAPABILITIES

The analyzer does not quantify additive content or internal chemical concentrations, and additives such as flame retardants are outside the current identification scope, though Canon has indicated it may consider adding presence-detection features for additives based on future market needs. Some colored additives can complicate measurement if they fluoresce strongly under laser excitation, as that fluorescence can overlap with and interfere with the Raman scattering signal. While the system can flag the presence of fillers like talc, its core purpose remains polymer identification rather than full chemical characterization.

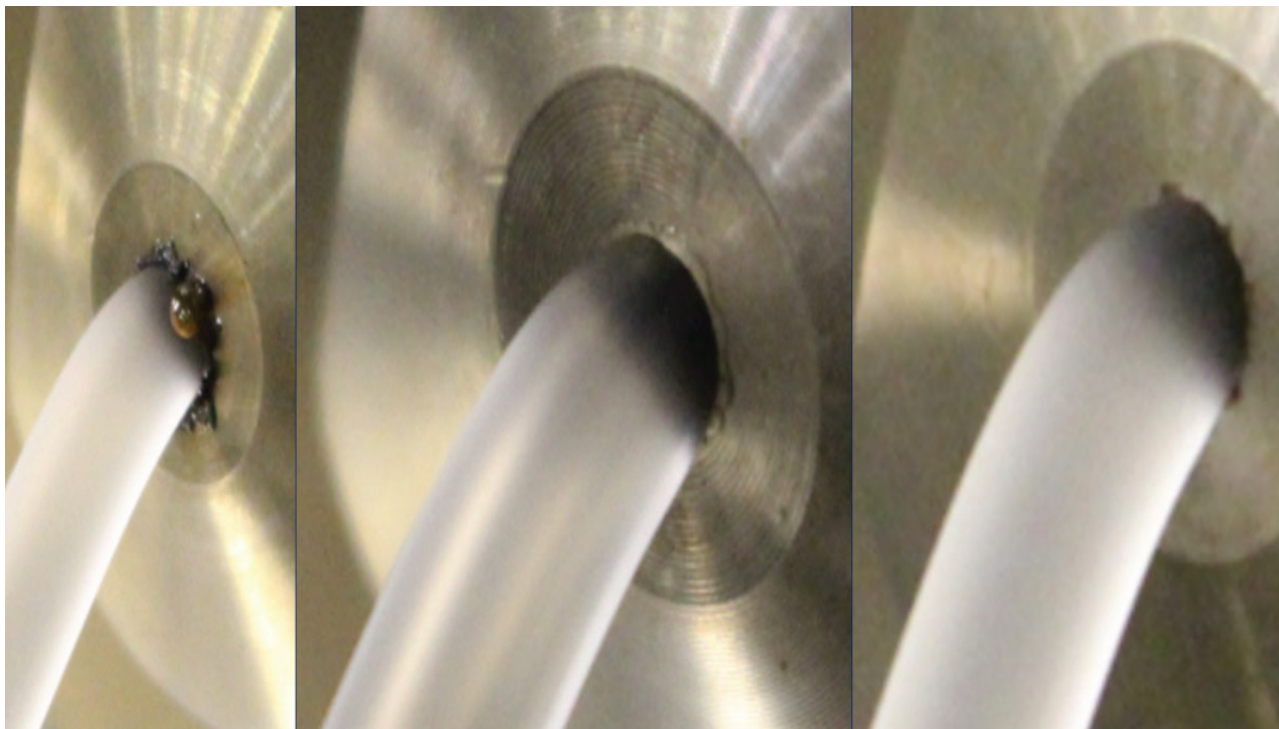
For recyclers, Canon is pointing to the opportunity represented by the supplies of black plastics that have historically been lost value. If those materials can be identified, sorted and verified to have consistent purity, they become candidates for reuse — expanding both overall material recycling rates and the range of end uses that recycled plastics can serve. PT



Black plastic regrind is often recycled but can be difficult for reprocessors to identify and verify when the material changes hands. Source: Matt Stonecash

PFAS-Free PPAs Are Advancing But Processing Adjustments Remain Critical

As non-PFAS polymer processing aids for blown film extrusion evolve, approaches to using them and maintaining equipment are as important as ever.



At left, extrusion without a processing aid shows significant buildup on the die; the center image shows processing with a fluorinated processing aid; and the image at right was produced while running a next-generation NF-PPA. Source: Borouge International

Per- and poly-fluoroalkyl substances (PFAS) continue to be a target of regulation in many jurisdictions. Producers of film processing aids continue to advance substitute chemistries to enable a transition away from fluoropolymers.

By Matt Stonecash
Associate Editor

Polymer processing aids in blown film extrusion enable high throughput and minimize downtime. The fluorine-carbon bonds in fluoropolymers are very strong, short bonds. Fluorine is highly electronegative, forming strong hydrogen bonds to the metal coating on the film die, providing a slippery, very stable, unreactive coating.

"If you think of the organic chemistry, the carbon-fluorine bond is one of the strongest that we have. And so when you subject them to high temperatures, they perform well and don't degrade," says Chris Gendy, additive technology scientist

at Nova Chemicals (now operating under the name Borouge International after its acquisition in March 2026). The low chemical reactivity, high thermal stability and the cross-compatibility of fluoropolymers make them difficult to replicate with other chemistries. PFAS alternatives are more complicated. Each family of substitutes has its own tradeoffs, and success depends on a plan that includes chemistry, processing and maintenance strategies.

Early developments in PFAS substitution in polymer processing aids (PPAs) focused on the problem of melt fracture. Melt fracture leads to the telltale sharkskin appearance in blown film. The addition of polyethylene glycol (PEG) and other additives can clear melt fracture. But at the high loading levels commonly employed, these alternative chemistries can cause other issues.

Screw slippage describes a situation where material fails to move forward along the barrel. This manifests in surging, an oscillation of extruder output which causes frost line instability and variations in film thickness. High concentrations of PPA can also cause print adhesion issues, as explained by Kyla Egerdeen, also an additive technology scientist at Nova.

“We had a customer that was running material beautifully during the day, with no concerns, but on films made during the night shift there were ink-adhesion issues. Upon investigation, it was determined that the night shift was spiking their lines,” says Egerdeen. More consistent, lower dosing of PPAs or using compounded formulations that already contain the PPA can help avoid the spikes that cause these issues.

Die lip build up is another challenge for non-PFAS processing aids (NF-PPAs). It can cause surface defects, gauge non-uniformity and bubble instability, which can in turn propagate into processing challenges downstream. According to Gendy, most of this material is actually not the processing aid itself but rather oxidized polyethylene. PPAs can initiate the degradation of polyolefins. “It’s not just about the stability of your NF-PPA, but it’s also about how it can impact the health of polyethylene,” he says. Stabilization additives can prolong degradation and thereby mitigate die-lip buildup.

Evolving chemistries, such as polyamide (PA) based

processing aids, can ameliorate these issues. They are more thermally stable and have higher affinity for metal surfaces. This enables them to function at lower dosing and reduces some of the side effects. Earlier chemistries required high dosage, but these new chemistries can come with a compatibility challenge.

In addition to mechanical antagonism, such as when abrasive agents physically scrape a coated metal surface, NF-PPAs can be subject to chemical antagonism. NF-PPAs of one type can interact chemically with another, and they can interact with chemistries commonly used as polymer additives. In testing conducted by Borouge, for example, the use of calcium stearate delayed the melt fracture clearing time of an NF-PPA by nearly 50 minutes. Gendy recommends changing NF-PPA chemistry or identifying a synergist to eliminate the effect.

PROCESSING ADJUSTMENTS CAN SMOOTH THE WAY

Egerdeen offers several processing practices that can help avoid quality problems with blown film when using NF-PPAs, in addition to the aforementioned dosing adjustments. Shut downs can be a time when material degrades as the equipment cools, so running another material without NF-PPAs can help mitigate the appearance of gels after startup. Specifically running a purge material can be a good option. This is especially important when changing materials and additive packages, as it is much more



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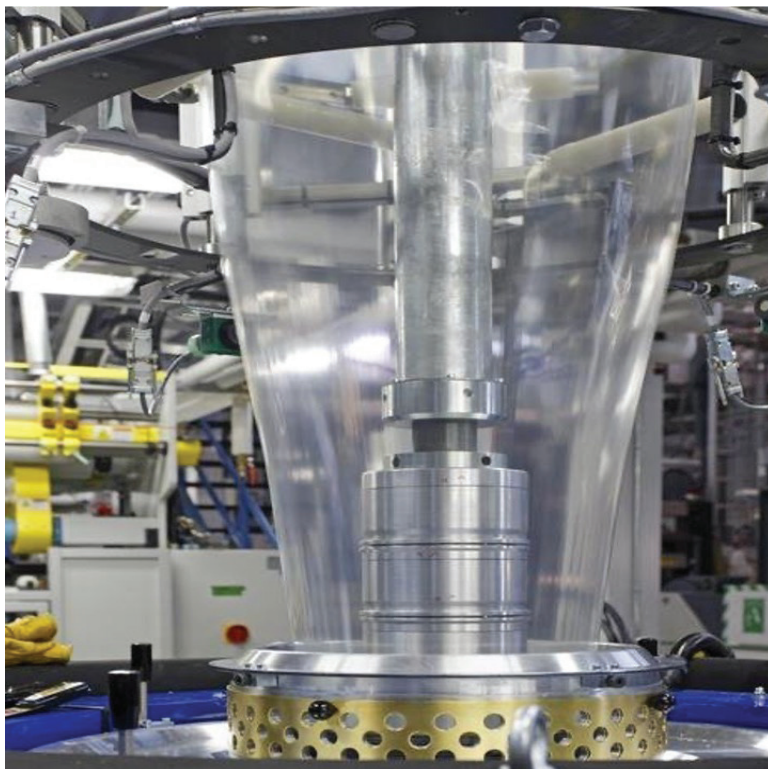
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common for non-PFAS additives to clash chemically. The same properties that make these additives coat surfaces well, also lead to antagonism.

Preventive maintenance becomes even more important. Cleaning cycles to remove material buildup from dies and other surfaces should be scheduled at higher frequency than would have been necessary with fluoropolymers.

As the industry continues to move away from fluoropolymer-based processing aids, success will depend on a holistic approach — one that combines the right chemistry with disciplined processing practices and a proactive maintenance schedule. Non-fluoropolymer PPAs have made significant strides, particularly with newer polyamide-based chemistries that operate effectively at lower dosages. But processors must be attentive to compatibility, dosing consistency and equipment cleanliness to realize their full benefit. A masterbatch incorporating Borouge International's NF-PPA is expected to be available in Q3 2026, offering film converters additional flexibility to tailor their strategies to specific processing needs. [PT](#)



Successful film production using NF-PPAs requires consistent manufacturing practices. Source: Borouge International

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EXTRUSION

What You Should Know About Transfer Lines

Design the transfer line as short as possible, target a wall shear stress of 20 to 30 kPa, use clam-shell type elbows, and make sure all pipes and connections are the same diameter.



By Xiaofei Sun and Mark A. Spalding

Transfer lines are pipes that connect the extruder to downstream equipment such as gear pumps, screen changers and dies, and are essential to every

temperature to increase for smooth bore extruders. For blown film processes, higher discharge temperatures will cause the maximum rate to decrease.

Resin degradation occurs in transfer lines due to stagnation regions in the flow path. These can be caused by ledges that occur when connections are made between slightly different diameter pipes, poorly designed elbows, and low shear stresses at the wall. For polyethylene (PE) resins, degradation appears as crosslinked material that can be a gel or black speck in a film product. The term 'gel' is commonly used to refer to any small defect that distorts a film product, reducing the quality of the film. Gels originating from poor screw design due to stagnant regions were discussed in previous issues of this magazine. Photographs of typical gels in PE films are shown in Figure 1.

TAKE CARE NOT TO CAUSE GELS

To reduce pressure consumption, designers commonly increase the diameter of the transfer line. This practice, however, can be a

extrusion line. This article provides guidance on the design of transfer lines.

Transfer lines must be designed to minimize pressure consumption while mitigating resin degradation. For example, a small-diameter transfer line will minimize resin degradation at the wall but can have a very high pressure consumption. Alternatively, a transfer line with a large diameter will have low pressure consumption but can cause the resin to degrade at the walls due to low shear stress at the wall. An optimal pipe diameter will have an acceptable pressure consumption while minimizing resin degradation.

It is a common practice to locate the extruder in a convenient place and use a long transfer line to connect the extruder to the die. Here, pressure consumption is directly proportional to the length of the pipe. If the pressure consumption is too high, a slightly larger diameter pipe is typically used.

Pressure consumption is inversely proportional to the fourth power of the radius of the pipe. Excessive pressure consumption across transfer lines will cause higher discharge pressures from single-screw extruders. The higher discharge pressure will cause the specific rate of the extruder to decrease and will cause the discharge

Excessive pressure consumption across transfer lines will cause higher discharge pressures from single-screw extruders.

root cause for gels and degradation for many materials including PE resins, because a larger transfer line diameter also decreases the polymer shear stress at the pipe wall. Wall shear stress is the driving force to renew the polymer layer adjacent to the transfer line's inner surface. This layer of polymer moves at a very low flow velocity. Without adequate wall shear stress, this polymer layer can stay on the

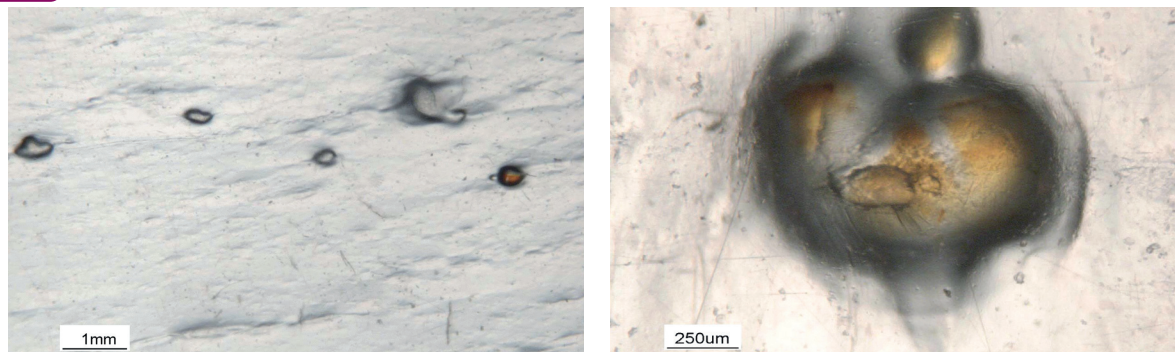
wall for extended periods, causing the resin to degrade and appear in the final product as gels. A transfer line can look perfectly fine from a pressure consumption standpoint and still be a major source of resin degradation and gels.

Experience in the field and by others has indicated that 20 to 30 kPa of wall shear stress (τ_w) is needed to maintain metal surfaces free of resin degradation, including the transfer line walls. Stresses less than 20 kPa decrease material renewal at the wall and increase the risk of resin degradation. Stresses higher than 30 kPa provide good material renewal at the wall, but



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FIG 1



Gels in PE films.

Source: (all) M.A. Spalding

pressure consumption will increase. In some systems, this can limit rate and increase the discharge temperature.

A simplified approach to estimate the wall shear stress in a transfer line is provided by equations (1) and (2), and the pressure consumption is provided by equation (3):

$$\dot{\gamma}_w = 4Q / \pi \rho R^3 \quad (1)$$

$$\tau_w = \eta \dot{\gamma}_w \quad (2)$$

$$\Delta P = 8 \eta L Q / \pi \rho R^4 \quad (3)$$

Where Q is the flow rate in g/sec, R is the pipe radius in cm; ρ is the melt density in g/cm³ at the temperature of the molten resin; $\dot{\gamma}_w$ is the shear rate at the transfer line wall in 1/sec; η is the shear viscosity at the resin temperature and shear rate ($\dot{\gamma}_w$) at the wall in Pa-sec; τ_w is the shear stress at the wall in Pa; L is the length of the pipe in cm; and ΔP is the pressure consumption in the pipe in Pa. The shear viscosity can usually be obtained from the resin supplier.

As an example, the shear stress at the wall of a transfer line and the pressure consumption were estimated as a function of rate and pipe diameter for a low density polyethylene (LDPE) resin with a melt index of 2.5 dg/min (190°C, 2.15 kg). The length of the transfer line was held constant at 1 m, which is a typical length in many applications. The processing temperature was set at 210°C. The estimates of the wall shear stress and pressure consumption as a function of pipe diameter and flow rate are shown in Figures 2 and 3, respectively. ➤

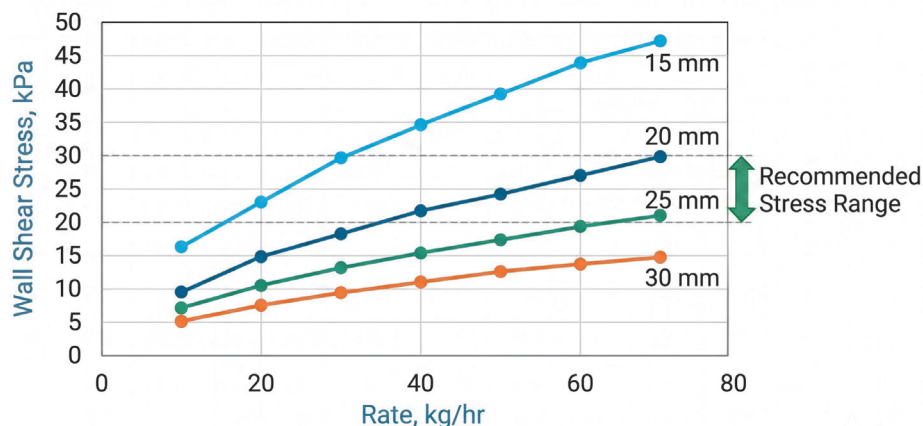
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FIG 2

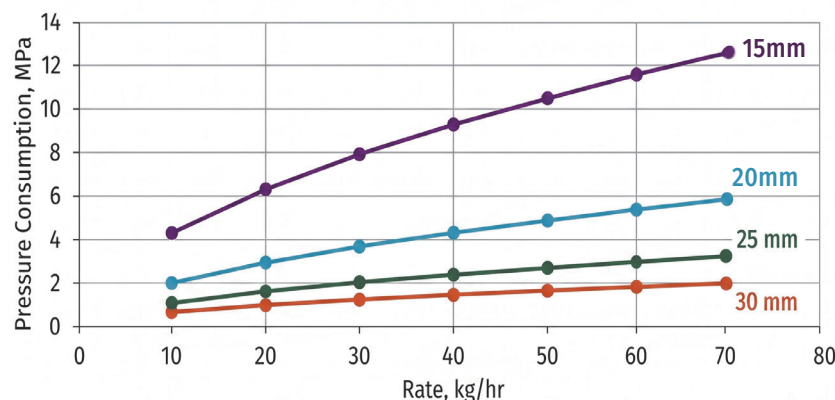


Shear stress at the wall as a function of transfer line diameter and rate for a 2.5 dg/min MI LDPE resin.

As expected, the shear stress at the wall of the transfer line increases with increasing rate and decreasing pipe diameter. As shown by Figure 2, the 15-, 20-, and 25-mm diameter transfer lines will provide wall shear stresses within the recommended range of 20 to 30 kPa for some of the rates explored. The choice of the diameter would depend on the rate of the process. As shown by Figure 2, a 20-mm diameter pipe has the greatest range of rates from about 35 to 70 kg/hr. A 30-mm diameter pipe would not provide adequate shear stress at the wall for the rates explored, and it would likely cause degradation for this LDPE resin.

The pressure consumption increased with increasing rate and decreasing pipe diameter, as shown in Figure 3. For the 20-mm diameter pipe and a rate of 60 kg/hr, the pressure consumption through 1 m of pipe is about 5.5 MPa (800 psi). Most designs can operate with this level of pressure consumption. If the process cannot manage this level of pressure consumption, then the designer must decide how to compromise the design by either going to a slightly larger diameter pipe or making the transfer line shorter.

FIG 3



Shear stress at the wall as a function of transfer line diameter and rate for a 2.5 dg/min MI LDPE resin.

CASE STUDIES IN BLOWN FILM

A blown film operation struggled with persistent gels for a LDPE film process. The screw was removed using the procedure outlined in the March 2025 issue of this magazine and was found to be free of degraded resin, verifying the screw design was acceptable and not the source of the gels. The transfer line connecting the extruder to the die was relatively long and had an inside diameter of 31.8 mm. Calculations indicated that wall shear stress was only about 8 kPa, well below the recommended range.

When the transfer line diameter was

reduced to 19 mm, the wall shear stress increased to 20 kPa. The result was an immediate reduction in gels without imposing unmanageable pressure consumption on the system.

In another operation, a highrate extrusion line processing a specialty styrenic resin used an extremely long transfer line to accommodate plant layout constraints. The diameter of the original transfer line was set at 76.2 mm, which is very large, to mitigate the high pressure consumption caused by the long transfer line. At this diameter, the wall shear stress was about 4 kPa. Material degradation was severe and caused black specks in the product. Redesigning the line with a 30-mm diameter transfer line increased the wall shear stress to 20 kPa, eliminating the degradation.

ELBOW DESIGN CONSIDERATIONS

Typically, 90-degree elbow flow channels are used to redirect transfer line flows. When elbows must be used, their design deserves the same level of attention as the transfer line diameter.

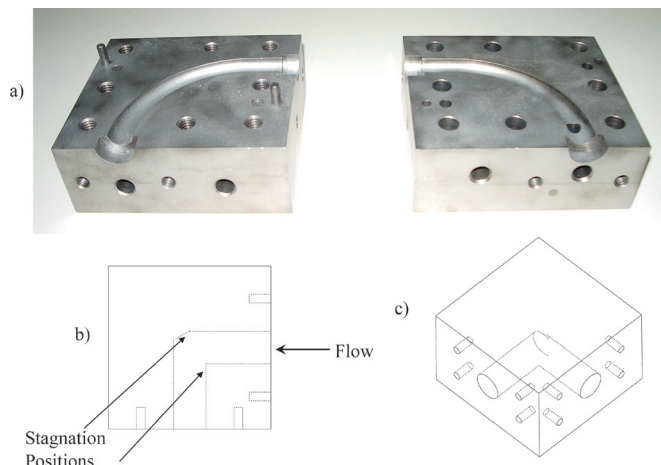
A common practice for fabricating elbows is to drill passages into a single block of steel, as shown in Figure 4b and 4c. At the meeting of the 90-degree flow path, two regions are stagnant and it can cause resin degradation for thermally sensitive resins. These stagnant regions are identified in Figure 4b.

A better approach is to use a clam shell design with a large radius elbow, as shown in Figure 4a. The bend radius is recommended to be at least five times the pipe diameter. This design keeps material moving along the wall and greatly reduces the risk of stagnation and resin degradation.

Since viewing the inside of transfer lines is not practical, the resin degradation

When elbows must be used, their design deserves the same level of attention as the transfer line diameter.

FIG 4



Schematic of two transfer line elbows: a) a properly designed elbow made by cutting half channels into two metal blocks using a ball end mill, b) a top view of an improperly designed elbow where a single block of metal was drilled from both corners, and c) oblique view of the improperly designed block. Resin degradation products are likely to form in the stagnation positions shown in b).

is difficult to observe. In most cases, the screw should be removed and studied for stagnant regions and resin degradation. If the screw appears clean and well designed, then in most cases the degradation is

occurring in the downstream equipment. This is an indicator that the transfer line design should be studied using the techniques described here. That is, design the transfer line as short as possible, target a wall shear stress of 20 to 30 kPa, use clam-shell-type elbows, and make sure all pipes and connections are the same diameter. ^{PT}

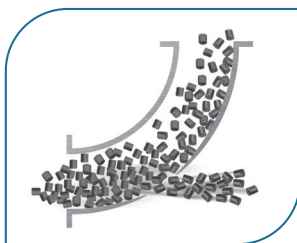
ABOUT THE AUTHORS: Xiaofei Sun is a research scientist in Packaging & Specialty Plastics and Hydrocarbons R&D at Dow Inc. in Lake Jackson, Texas. Through his 11-year career at Dow, his research has been dedicated to the development of polymer processing technologies, including single-screw extrusion, twin-screw extrusion, injection molding and batch compounding processes.

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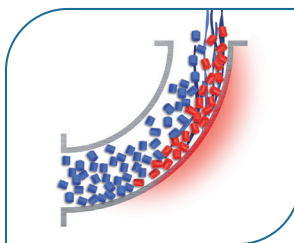
Mark A. Spalding retired after a 40+ year career at Dow Inc. in Midland, Michigan. He was a fellow in Packaging & Specialty Plastics and Hydrocarbons R&D. During his tenure at Dow, he has focused on development, design and troubleshooting of polymer processes, especially in single-screw extrusion. He co-authored Analyzing and Troubleshooting Single-Screw Extruders with Gregory Campbell. Contact: 989-636-9849; maspalding1@gmail.com.

2 PROBLEMS

Caused by Conventional Sweep Elbows
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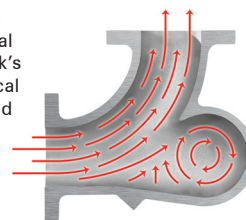


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INJECTION MOLDING

Velocity to Pressure Control — Considerations & Implications

Can machine responsiveness be improved through damping behavior, control-loop tuning or other control parameters for transfer-performance optimization?



By Umberto Catignani

A useful method to benchmark injection molding machines is to focus on the transition from the injection phase to the packing/holding phase. From an engineering standpoint, these values provide a quantitative indication of the machine's dynamic response capability during this transition and can be used to compare damping behavior, control-loop tuning and overall transfer performance.

Fundamentally, we should ask the

question: “What happened between the injection pressure at the end of injection and once the machine stabilized at the desired packing/holding pressure?” Additionally, the challenge isn't the pressure difference itself, per se, but rather, how fast can the machine reduce pressure without becoming underdamped, overdamped or oscillating.

There are multiple ways to control this transition, including hydraulic or plastic pressure, machine fill time, screw position and in-mold cavity temperature and pressure sensors. For the majority of injection molding processes, screw position is used as the primary method, with hydraulic or plastic pressure and machine fill time applied as secondary methods to prevent overpacking or what can be called a “parallel transfer scheme.” This screw position transition can have many names — switchover, cutoff, transfer position, and VP position — but for this article a more universal term, VPT (Velocity to Pressure Transfer), will be used.

VPT RESPONSIVENESS — METHOD 1

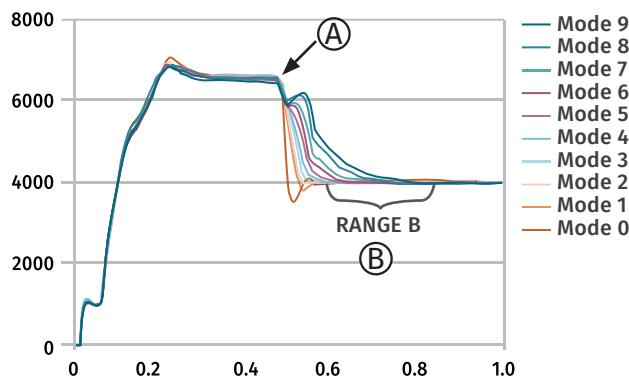
This methodology is considered the benchmark that's taught and used throughout the industry to determine the ability of the machine to transfer from velocity control to pressure control and completely stabilize at the packing/holding pressure.

For this study, the same eight-cavity cold runner mold referenced in the prior articles is utilized and has multiple rates of control for all process transitions. Experimental results are illus-

trated in Table 2, with 10 modes of packing control and a range of stabilization times and pressures denoted as point A and point B (Figure 1).

The ability to control packing rate with 10 settings is not common, however, multiple machines may have three modes of

FIG 1



Graph of machine plastic pressure observed during the injection and packing phases over multiple control modes. Source: (all) Umberto Catignani

“Soft”, “Standard”, and “Sharp.” It is highly suggested to investigate if the machine in question is capable of more than one mode of control and utilize this capability to your own advantage by performing the analysis put forward in this article.

Figure 2 shows the outputs for all 10 transfer modes. These outputs are used in Method 1 to calculate the pressure decay rate, defined as:

As an example, using Method 1 and mode 9, the following is noted:

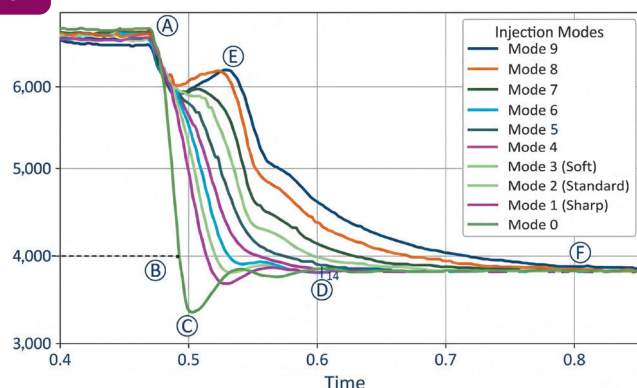
Injection Pressure at VPT = 6,800 psi

$$\frac{\Delta P}{\Delta t} = \frac{\text{Change in Pressure from VPT to Stabilization at Packing Pressure}}{\text{Change in Time from VPT to Stabilization at Packing Pressure}}$$



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FIG 2



Magnified section of multiple control modes from Figure 1.

Pack Pressure = 4,000 psi
 Pressure Drop (ΔP) = 2,800 psi
 VPT Time = 0.47 sec
 Pressure Stabilized = 0.85 sec
 Response Time (Δt) =
 $0.85 - 0.47 = 0.38$ sec
 Pressure Decay Rate =
 $2,800 \text{ psi} / 0.38 \text{ sec} = 7,368 \text{ psi/sec}$

SUMMARIZING THIS DATA FOR ALL MODES IS AS FOLLOWS: TABLE 2

Choosing a response mode of zero through three would be reasonable given that the same pressure decay rate is calculated. However, mode zero is severely underdamped, while mode three is slightly overdamped. A reasonable selection would be mode four, which yields neither an overdamped nor underdamped condition.

Modes six through nine show an overdamped response, prompting the processor to determine whether lower pressure decay rates can be utilized without compromising process stability.

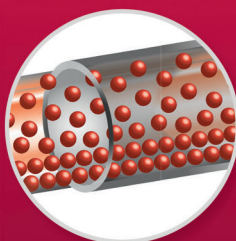
This method calculates the pressure decay rate but does not indicate whether the response is underdamped, overdamped or oscillating. As a result, it can be misleading because it reports a rate without describing the actual condition of the pressure response curve.

Assuming a processor has three control modes described by modes seven, five and zero and denoted on the ➤

Response Mode	ΔP (psi)	Pressure Stabilized (sec)	Pressure Decay Rate (psi/sec)
0	2,800	0.60	21,538
1	2,800	0.60	21,538
2	2,800	0.60	21,538
3	2,800	0.60	21,538
4	2,800	0.62	18,667
5	2,800	0.63	17,500
6	2,800	0.70	12,174
7	2,800	0.75	10,000
8	2,800	0.82	8,000
9	2,800	0.85	7,368

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controller as “soft”, “standard”, and “sharp”, the processor most likely would choose mode five as it is neither underdamped, overdamped or oscillating.

However, let's assume that there are not multiple modes of control, which is quite common, and data is observed as described by mode nine. Certainly, this extremely overdamped situation would be unacceptable since it would result in aggressive packing and potentially lead to overpacking, flash, excessive molded-in stress and perhaps a lack of dimensional repeatability.

VPT RESPONSIVENESS — METHOD 2

It should be apparent that the pressure decay rates calculated in method one do not sufficiently address the data represented, and based on the processor's interpretation, they can lead to significantly different documented and inferred capabilities. With this second method, we would like to determine the ability of the machine to transfer from velocity to pressure control, determining the ramp rate to the packing/holding pressure and then the time to stabilize at the packing/holding pressure.

The following theoretical curve with overdamped and underdamped situations can be used to provide additional data and context to this experiment while six data points identified as A

through F are noted on Figure 2 along with a stabilization time for both an underdamped (t_1) and overdamped (t_2) response. In using additional data points, we can better address the responsiveness of the machine and note the following:

- Point A is the start of the packing/holding phase at the VPT time.
- Point B is the time at which the pressure decay rate initially contacts the packing/holding pressure setpoint.
- Point C is when the maximum underdamped pressure is reached and its corresponding time.
- Point D is when the underdamped packing/holding pressure fully stabilizes at the setpoint.
- Point E is the max packing/holding pressure observed in an overdamped condition, neglecting the initial pressure drop to 6000 psi.
- Point F is when the overdamped packing/holding pressure fully stabilizes.
- t_1 and t_2 are the stabilization times for an underdamped and overdamped response, respectively.

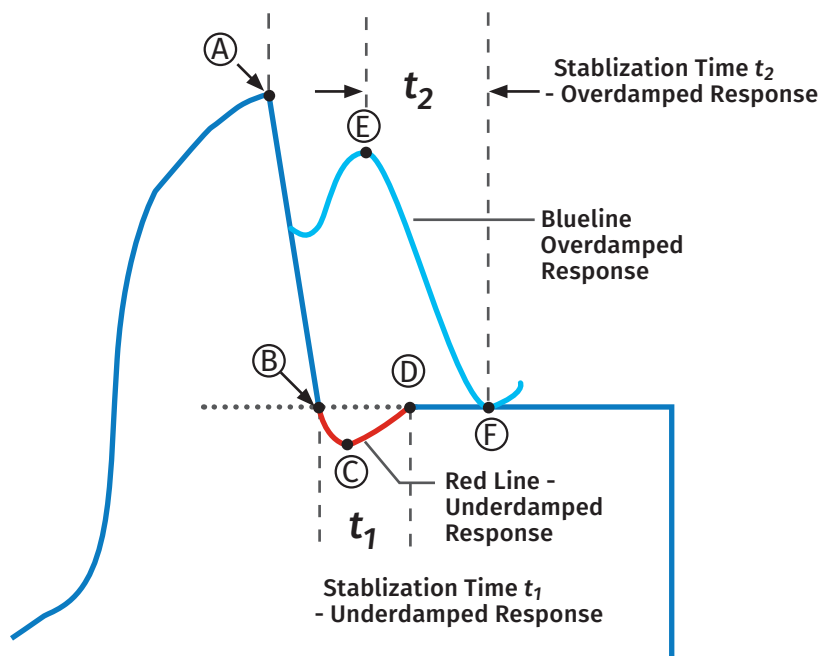
NOTEWORTHY OBSERVATIONS: POINT D

- Mode zero is a severely underdamped, reaching approximately 3,500 psi (point C) at nearly 0.03 second after VPT and stabilizes after approximately 0.65 second.
- For mode zero, the time to stabilize after initially crossing the packing/holding pressure is from point B to D, which is approximately 0.15 seconds and is denoted as the underdamped stabilization time: t_1 .
- Mode one is a slightly underdamped response which reaches approximately 3,900 psi at nearly 0.53 second — 0.06 second after VPT — and it stabilizes at approximately 0.60 second.
- Mode two is minutely underdamped and then in response becomes slightly overdamped to compensate.
- Modes zero through three stabilize.

DATA POINTS E AND F

- Modes eight and nine are severely overdamped with mode nine reaching an intermediate pressure of approximately 6,250 psi at nearly 0.54 second, which ultimately stabilizes at point F.
- The overdamped stabilization time, t_2 , for mode nine is measured between points E and F and is approximately 0.31 second (0.85 – 0.54).

FIG 3



Method two proposed template with a total of six data points to consider. The blue line represents an overdamped response, while the red line represents an underdamped response.

CAN WE DO BETTER?

Is it possible to achieve machine responsiveness as observed in mode zero without becoming underdamped or overdamped? This would be the best possible scenario as the pressure decay rate would be calculated from point A to B, which has a pressure drop of 2,800 psi over nearly 0.03 second, yielding a pressure decay rate of 93,334 psi/sec.

Is it possible to approach the maintenance department or the machine manufacturer and make such a request?

WOULD YOU CHOOSE MODE ZERO FOR ITS RESPONSIVENESS AND ACCEPT ITS UNDERDAMPED CONDITION?

In summary, the discussion has focused on treating the machine capability as a measurable process variable based on the potentially available control modes.

Even when no additional control modes are available, the data could prompt discussion with maintenance or the machine manufacturer about whether responsiveness can be improved through damping behavior, control-loop tuning or other control parameters for transfer-performance optimization.

For high-tolerance parts, such as medical devices, VPT responsiveness directly affects how consistently the transition can be controlled across material lots, plant conditions and other process

variables, ultimately helping to support dimensional stability and repeatability.

Both methods can be used to calculate VPT responsiveness; however, method 2 provides a more complete evaluation by including stabilization time. This allows the process engineer to move beyond simply documenting the observed response and instead use the data to improve process robustness, repeatability and control. In this way, VPT responsiveness should be treated as a measurable process variable rather than a fixed machine capability. [PT](#)

ABOUT THE AUTHOR: Umberto Catignani is president of Orbital Plastics Consulting Inc., a consulting firm that has more than 125 years of combined experience in scientific injection molding, training, material selection, part and mold design review, in-mold instrumentation, project management and equipment selection. Catignani is a past president of the Southern Section of the Society of Plastics Engineers (SPE) and has more than 30 years of hands-on injection molding experience. He has certified and trained hundreds of plastic professionals and served as an expert witness. Past employers include IBM, General Motors, Delphi Automotive and Husky Injection Molding Systems. Catignani earned a master's degree in Polymer Engineering from The University of Akron and a bachelor's degree in Materials Engineering from the University of Cincinnati. Contact: 404-849-6714; umberto@orbitalplastics.com.



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MATERIALS

Drop-In Materials: A Strategic Approach — Temperature Effects

Materials that look equivalent on a datasheet can behave differently in service, with small temperature changes producing large mechanical consequences.



By Richie Anfinson

The idea of a “drop in” material replacement is appealing for obvious reasons. When a polymer used in a product becomes too expensive, difficult to source, environmentally undesirable or otherwise problematic, the ideal solution is to substitute a new material. However, this would be impractical if the material change

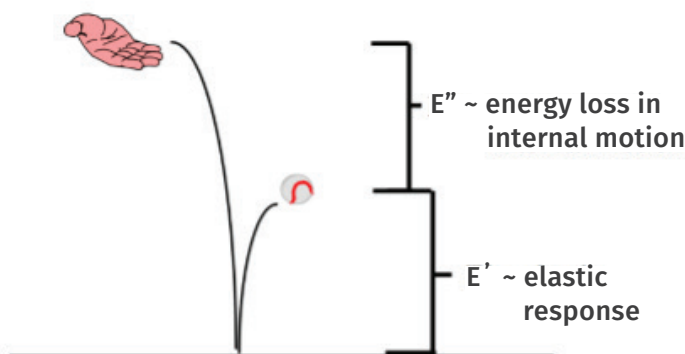
requires redesigning the part, modifying tooling or altering performance expectations. In practice, polymers rarely behave like true drop-in equivalents. Their properties are not fixed constants, but dynamic responses shaped by temperature, time, stress and processing history. Two materials that appear nearly identical on a datasheet can diverge dramatically in real-world performance.

This disconnect arises because polymers are fundamentally different from metals or ceramics. Their molecular mobility, thermal sensitivity and viscoelastic nature mean that small changes in formulation, processing or service temperature can produce large changes in mechanical behavior. Many drop-in failures do not stem from improper material family selection, but from an incomplete understanding of the viscoelastic behavior of the selected material. This article examines why datasheet values often mislead, why viscoelasticity is the central factor behind temperature-dependent behavior, and how engineers can evaluate materials more effectively. Finally, a recommended framework will be presented for assessing thermal performance in polymer replacements.

WHY DATASHEETS MISLEAD

Datasheets are indispensable for initial screening, but they are not real-world engineering data. They typically present mechanical properties measured at room temperature under short-term

FIG 1



Visco-elastic behavior of polymers is a mix of elastic response with viscous energy loss. Source: (all) Madison Group

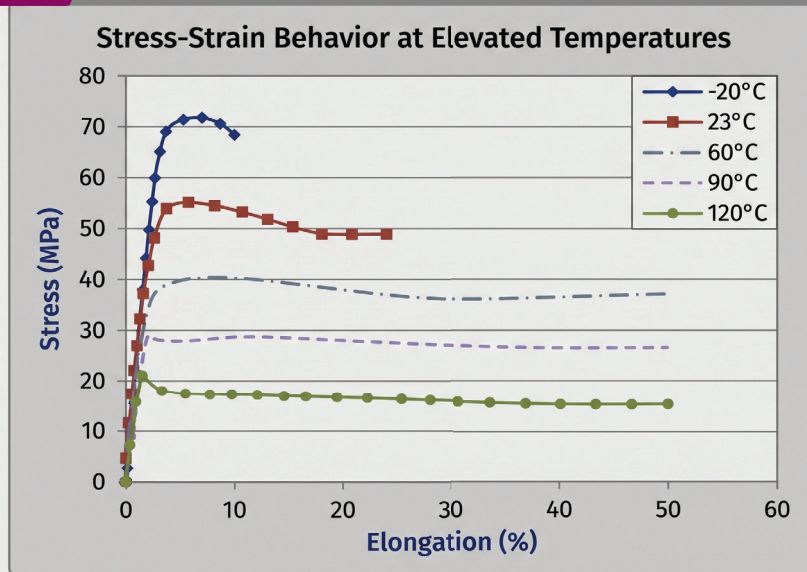
The deeper issue is that datasheets present polymers as if they were linear, temperature-independent solids. They are not.

quasistatic loading. These values are useful for comparing materials under identical test conditions, yet they reveal little about how a polymer behaves in the thermal environment where most failures occur.

A tensile modulus measured at 23°C, for example, provides no insight into how stiffness decays as temperature rises. A heat deflection temperature (HDT) value may suggest a material can withstand 95°C, but HDT is a short-duration bending test performed under specific stress conditions that rarely resemble real service loads. Even glass transition temperature (T_g), one of the most important thermal parameters, can be misleading because its value depends on the measurement method. A T_g measured by differential scanning calorimetry (DSC) often appears lower than the T_g measured by dynamic mechanical analysis (DMA), yet the DMA value is far more relevant for predicting mechanical softening.

The deeper issue is that datasheets present polymers as if they were linear, temperature-independent solids. They are not. Their behavior is governed by viscoelasticity (Figure 1), and viscoelasticity is inherently temperature dependent. Understanding viscoelasticity, and why it drives polymer performance, is the first step to understanding why datasheet values can mislead.

FIG 2



Tensile testing results showing stress-strain behavior of a material over a range of elevated temperatures.

ature and time govern molecular mobility and relaxation processes, the more meaningful question is not, “What is the modulus?”, but rather, “Under what conditions, and for how long, is the material expected to perform?” Adopting this perspective is essential for understanding polymer performance, and it naturally leads to the central concept that governs these effects: viscoelasticity.

Because viscoelasticity governs how stiffness, strength and dimensional stability evolve with temperature, it is the primary reason why polymers that appear similar at room temperature can diverge dramatically in real applications. This becomes immediately clear when shifting from abstract descriptions to real data.

The simplest demonstration comes from a single material tested at multiple temperatures (Figure 2). This graph shows the transition from a glassy/brittle material at -20°C to a very ductile

and malleable material at 120°C. Nothing about the polymer chemistry changed — just the temperature. Yet the mechanical identity of the material is fundamentally different in each case.

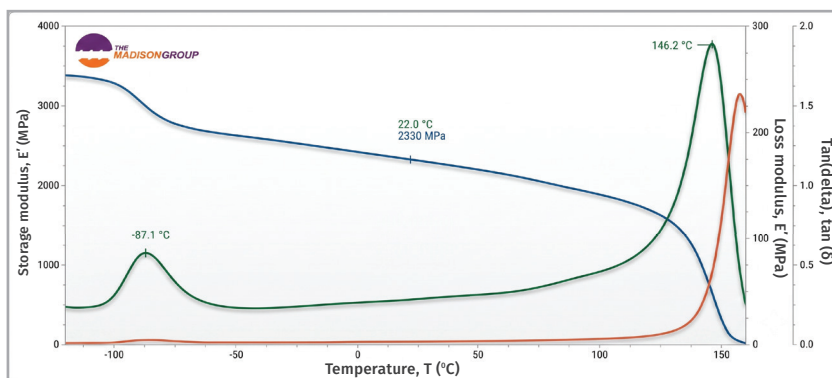
VISCOELASTICITY: THE ROOT OF TEMPERATURE-DEPENDENT BEHAVIOR

At the molecular level, polymer chains are long, flexible and entangled. Their motion is constrained but not fixed. When a load is applied, part of the deformation comes from stretching covalent bonds (elastic response), while another part comes from the rearrangement or sliding of chain segments (viscous response). While the specific viscoelastic behavior of a material is defined by the chemical structure of polymer, temperature is a major modifier to that behavior.

At low temperatures, chain mobility is restricted. The material behaves more like a glassy solid, with high stiffness and low molecular motion. As temperatures increase, segmental mobility increases, and the polymer transitions into a leathery or rubbery state. At sufficiently high temperatures, the material flows like a viscous liquid.

This continuous evolution of behavior is why polymers cannot be described by a single modulus or strength value. If you are asked to describe the mechanical performance of a polymeric material, your first instinct should not be to provide a list of room temperature properties. Since temper-

FIG 3 DMA analysis of Polymer Sample



A comparison of two PPO samples showed similar room temperature moduli but potential variations in composition that could affect performance.

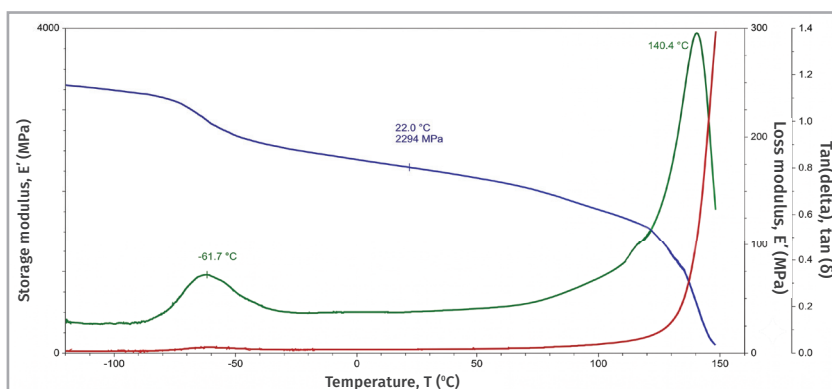
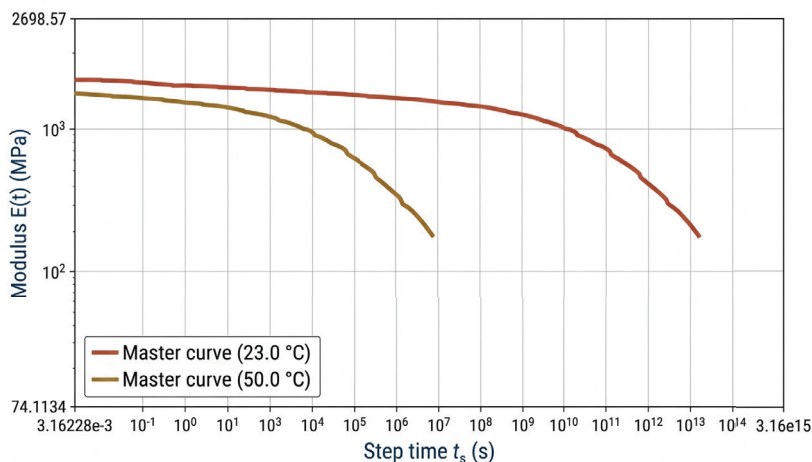


FIG 4 Materials Relaxation Modulus

Comparison of relaxation modulus master curves at two different reference temperatures (23.0 °C and 50.0 °C). The complex material behavior is highlighted by the multi-stage stepped relaxation response.

This is viscoelasticity in action. The mechanical response is inseparable from the thermal environment.

REAL-WORLD DIVERGENCE (DMA & CREEP)

Dynamic mechanical analysis (DMA) provides a broader view of this behavior. Consider two alloy grades of poly(phenylene oxide)/high impact polystyrene (PPE+HIPS) that share nearly identical tensile modulus values at 23°C. When their storage modulus is plotted across temperature (Figure 3), the curves track closely in the glassy region but begin to diverge as the materials approach the temperature extremes. The two materials differ in glass transition temperature. This would suggest that some variation in the relative proportion of PPO and HIPS in the alloy could affect the performance of the material. Additionally, there was a significant shift in the low temperature transition temperature, which suggested a fundamentally different impact modifier in the materials. These two differences — which would not be visible through just a datasheet review of the material — may result in performance differences in more extreme applications.

These effects extend beyond short-term mechanical testing. Long-term creep deformation is greatly influenced by temperature. Through DMA time-temperature superposition modeling, a master curve for an ABS material was constructed at room temperature (Figure 4). This analysis showed slow, predictable deformation accumulation over an expected service life. Constructing a second master curve at an elevated temperature just 25°C above room temperature reveals a dramatically different

The more meaningful question is not “What is the modulus?” but rather, “Under what conditions, and for how long, is the material expected to perform?”

picture. The same stress produces faster strain accumulation, and the time required to reach a given deformation shrinks by several orders of magnitude. Time-temperature superposition makes this relationship clear. Increasing temperature accelerates molecular relaxation processes, effectively shifting the creep curve leftward. What appears to be a stable material at room temperature may deform unacceptably under the same load when the temperature rises only modestly. This information is rarely provided by suppliers for real engineering design and material selection.

Together, these examples illustrate the central truth: viscoelasticity is not an abstract concept but the governing principle behind polymer performance. It explains why materials that look equivalent on a datasheet can behave differently in service, why small

temperature changes can produce large mechanical consequences and why evaluating polymers requires more than room-temperature short-term measurements. Understanding viscoelasticity is essential not only for predicting performance, but for avoiding the

false confidence that datasheet values can create.

KINETIC REALITIES: THERMAL DEGRADATION AND ADDITIVE EFFECTS

While viscoelasticity explains how polymers soften and deform with temperature, thermal degradation explains chemical changes. Degradation can occur even below T_g or melt temperature (T_m), and it often accelerates mechanical failure.

Thermal degradation is often treated as a secondary concern, yet it plays a central role in how polymers age and ultimately fail. Even well below a material's short-term decomposition temperature, heat begins to activate chemical pathways that gradually alter the molecular structure. Chain scission reduces molecular weight and accelerates creep, while crosslinking can increase brittleness and diminish ductility. Oxidative reactions — driven by heat, oxygen and mechanical stress — generate radicals that propagate through the material, leading to discoloration, embrittlement and loss of toughness (Figure 5). Hydrolysis adds another degradation pathway in polyesters, polycarbonates and polyamides, where moisture and heat combine to break the polymer backbone.

A complicating factor is that degradation behavior is

strongly influenced by additives, which are rarely disclosed on datasheets. Stabilizers, antioxidants, UV absorbers and processing aids determine how quickly a polymer consumes its protective chemistry. Two materials with identical relative thermal indices (RTI) may age very differently if one contains a robust antioxidant package while the other relies on minimal stabilization. Pigments, fillers and residual catalysts can further accelerate or inhibit degradation in ways that are formulation specific and invisible in published property tables.

This hidden chemistry is one of the most significant risks in drop-in replacements. A polymer may match the incumbent grade in every listed property yet degrade more rapidly under the same thermal load, leading to earlier onset of creep, loss of impact strength or brittle failure. Without understanding how the material responds to heat, and how its additive package supports that response, datasheet comparisons provide only a partial and often misleading picture of long-term performance.

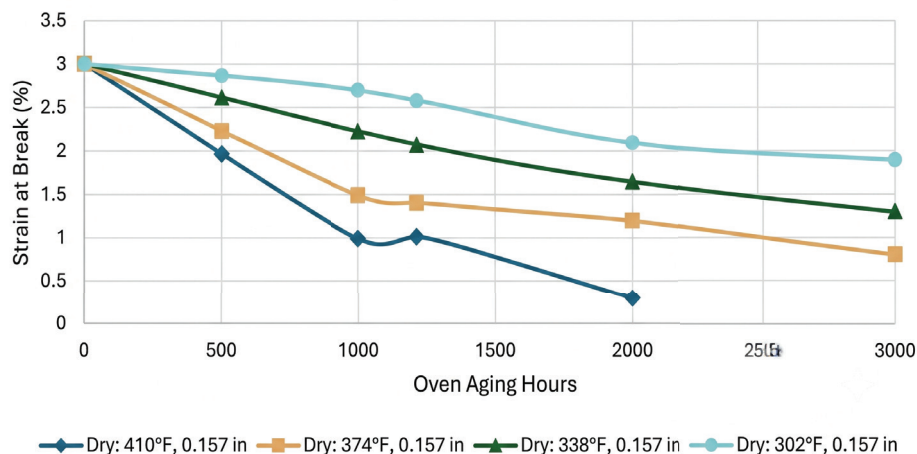
A STRATEGIC FRAMEWORK FOR ENGINEERS

To avoid such failures, engineers must adopt a more comprehensive approach to evaluating polymer replacements. Rather than relying on room-temperature, short-term datasheet values, the evaluation should focus on how materials behave across the relevant temperature range and over the expected service life.

A robust framework begins with understanding the thermal environment of the application — both steady and transient conditions. It continues with identifying the failure modes most sensitive to temperature, such as creep, relaxation, warpage or thermal aging. From there, the emphasis shifts to obtaining or generating the data that matters. Based on the application, these could include modulus-versus-temperature curves, stress-strain behavior at the temperatures of interest, creep and relaxation behavior at temperature, thermal cycling and thermal-aging performance. This data provides a more complete picture of how the material will behave in service.

Finally, real-world validation is essential. Testing parts

FIG 5 Oven Aging Time vs. Strain at Break



Oven aging of a polyamide 66 material shows reduction in toughness over exposure time.

Understanding viscoelasticity is essential not only for predicting performance, but for avoiding the false confidence that datasheet values can create.

under realistic loads, temperatures and cycling conditions reveals interactions between material behavior and part geometry that no datasheet can capture. The goal is to define a “thermal performance envelope” for each candidate material with a range of temperatures, stresses and durations, which the material can reliably perform.

Drop-in material replacement is rarely as simple as comparing datasheets. Polymers are viscoelastic, thermally sensitive materials whose properties evolve with temperature, time and processing history. Room-temperature, short-term mechanical values cannot predict long-term

performance in real applications. Viscoelasticity is the central factor behind this discrepancy and understanding it is essential for making informed material choices.

By focusing on temperature-dependent behavior, viscoelastic response and thermal degradation, engineers can build a more reliable framework for evaluating polymer replacements. This approach reduces the risk of field failures, improves product reliability and ensures that material substitutions are technically sound and economically justified. **PT**

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By Matt Stonecash



Omega Tool Redefines the Role of Moldmaker in An Evolving Industry

Mold production bay at Omega Tool.
Source (all images): Matt Stonecash

Demonstration of the in-mold RIM PUR coating process, developed with KraussMaffei and Ruhl, is emblematic of the company's expanding range of capabilities and customer services

Founded in 1981, Omega Tool Corp. has expanded well beyond its origins as a mold builder, taking on a broader role in how automotive parts move from design to production.

Today, Omega supplies tooling to Tier 1 auto suppliers and OEMs, specializing in medium-to-large format molds for automotive parts: large panels, grilles, liftgate assemblies, fenders, etcetera. A large proportion of the bumper fascias rolling out on new cars are born in molds made by Omega.

Traditionally, the toolmaker sold tooling, manufactured and delivered it, and the molder manufactured their parts. But Omega's close partnership with suppliers to the auto industry have led it to reach far beyond that role, developing as a program execution partner and technology leader.

SOLID FOUNDATION IN MOLD BUILDING

The tool shop at the company's production facility in Ontario, just a few miles south of Detroit itself, is dominated by a collection of CNC machines. Molds produced by Omega average around 30 tons, according to Greg DeFrancisco, director of sales at Omega.

Each year Omega reviews its capabilities in toolmaking and looks at areas to improve; in the past year, a three-axis boring mill was replaced with a five-axis boring mill. Besides the greater flexibility, it also provides greater capacity: the rotating tables all have limits to what size of a block can be put on the table. Some are embedded in the foundation, eliminating the rotation capability but increasing the weight limit to 132,000 lbs.

A Stratasys F3300 FDM (fused deposition modeling) 3D printer provides additive manufacturing for prototypes and custom fixtures. "We can evaluate concepts earlier, optimize manufacturability and accelerate development decisions before production tooling is finalized" says Delko Prebeg, COO at Omega.

The Stratasys is also useful for growing lightweight end-of-arm tooling (EOAT). Allen LeRoux, automotive applications engineer at Stratasys, showed an example EOAT printed in nylon with 30% long-strand carbon fiber. "This tool was way over-engineered, it weighed around 350 pounds total with all the mechanisms on it, and we were able to cut 150 pounds off. That decreased cycle time by almost 10%," says LeRoux.

For Omega, custom fixturing includes support for downstream activities that the company has incorporated to support customers through mold validation and beyond. "It's not just a tool shop anymore; we're a program execution partner," says Prebeg. "That's about adding services to improve value to the customer: we do design, development and manufacture of the tool, and then we can also verify part dimensions and appearance."



Greg DeFrancisco explains how the cobot station with custom fixturing is used to assemble finished parts.

EXPANDING THE SCOPE OF WORK: VALIDATION, ASSEMBLY AND FINISHING

Omega has expanded the scope of its activities to meet the needs of validation. Parts can be molded, painted and tested for fit. All of this is risk management for each program: if additional tooling work is needed, it's best to do it before that 30-ton mold is shipped a thousand miles.

The facility has a 4,500 kN and a 4,000 kN (505- and 450-ton) KraussMaffei injection molding machine. The OEM-certified paint line is a natural extension: dimensions change through the painting process, which involves washing, drying, manual or robotic painting and baking. There is also an automated assembly station for validating the fit of the finished parts.

Thanks to these capabilities, Omega can make-ready parts when needed. For unique, lower volume programs, Omega makes production parts in numbers that might be inconvenient for Tier 1 suppliers. ►

Each year Omega reviews its capabilities in toolmaking and looks at areas to improve.



The 4500-kN (505 tons) KraussMaffei press outfitted for the Colorform PUR coating process.

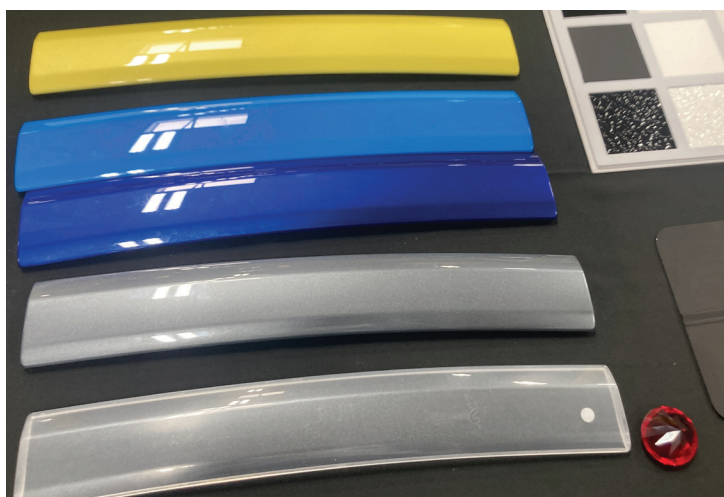


Demonstration parts molded at Omega. These parts have been intentionally short-shot with the in mold coating to illustrate the coating process, with progressively longer shots from right to left.

CLASS A FASCIA WITH LARGE FORMAT MOLDING AND PUR

The technological capabilities of Omega also enable exploring something new, like RIM (Reaction Injection Molding) using KraussMaffei's Colorform technology for PUR (polyurethane) in-mold coating (IMC). Recently commissioned and showcased at an open house, Omega's Colorform cell is now running demonstration parts.

The cycle time in development tooling is currently about six minutes, beginning with the substrate shot to form the main part. The mold opens and a dedicated robotic arm descends to flame treat the surface. This activates functional groups on the surface and raises the surface energy to promote adhesion. Then the platen rotates, and the mold closes again for the injection of the PUR components (supplied by Rühl): isocyanate, polyol and color. A Kuka robotic arm (including 3D-printed end effector) removes the final part.



Parts displayed by Rühl at the open house show the bright and glossy finishes achievable with PUR coating. At top right are some examples of textured surfaces.

The machine is connected to large bank of temperature control units to independently maintain each tooling component at the optimum temperature. The PUR requires a higher temperature to prevent freezing, since the shot begins to cure as soon as the reactive components mix.

The result is a tough exterior coat that can be applied in a single step, with a finish that is textured or smooth and color matched or transparent. Finishing parts this way eliminates the time, transportation and loss associated with painting. It can also provide functional benefits. Rühl demonstrated the self-healing properties at the open house using a heat gun, noting that "healing" of surface scratches would be equivalent to about 10 hours in sunlight. The first candidates for this process will be parts

likely to come into contact with keys, rings or other scratch hazards.

Textures or even logos can be applied by the mold itself, since they will not be covered by subsequent processes. Trends in vehicle lighting could be an application for 2-component transparent PUR coats. "We're envisioning that next generation vehicles may be incorporating lighting in the fascia and exterior components," says DeFrancisco.

The most used substrate materials for Omega's market segment are PC/ABS (polycarbonate/acrylonitrile butadiene styrene) and TPO (thermoplastic polyolefin). TPO is a more flexible material that provides resilience on parts of the exterior likely to see contact, like the bumper. But it is also more prone to showing marks on the appearance side from movements on the B-side. Knowing this would make it more more challenging to work with, Omega started with TPO.

"When you're developing something you might as well develop the most challenging scenario, after that everything else falls within those lessons learned," says Prebeg.

Based on the crowd at the open house, interest in the technology is strong. Originally planned for 75-100, the event drew around 350 registrants, including representatives of several vehicle brands and their suppliers.

The PUR IMC program at Omega Tool showcases the latest expansion of a range of capabilities, part of the company's efforts to evolve and expand the envelope of what can be done for the customer before a mold ships: reducing handoffs, compressing development time and pushing as much validation as close to the source as possible.

"Our whole philosophy is to be able to minimize customers' risk and the time needed to develop and execute a program launch," says Prebeg. "Omega is preparing itself for the next generation of vehicles and parts." PT

Shredding Thin Film: How to Do It Right

Plastic film has a reputation as one of the toughest materials to shred, but with the right equipment, process, and maintenance, virtually any film can be processed efficiently.

The challenge isn't the film itself, it's how the material behaves inside the shredder. Films that stretch heavily or self-feed tend to wrap the rotor and cause jams, while materials like stretch wrap actually ball up and shred more like a rigid purging.

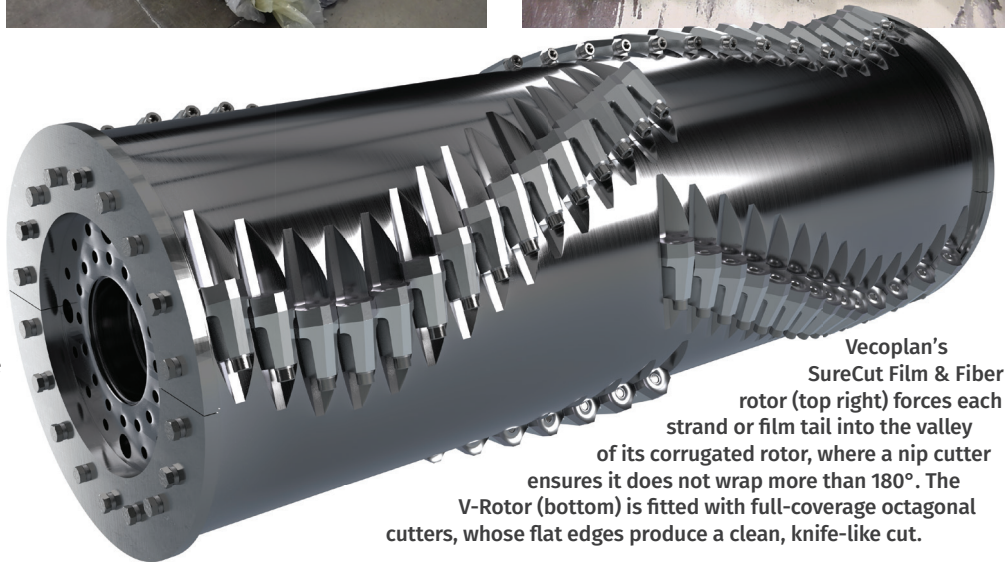
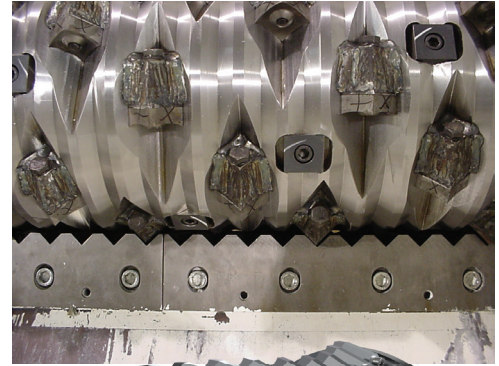
The deciding factor is the rotor. For self-feeding films such as woven PP super sacks, a specially designed film rotor is required to cut every strand before it can wrap 360° around the shaft. Vecoplan offers two solutions built for exactly this problem.

The **SureCut Film & Fiber rotor** uses a corrugated design that forces each strand or film tail into the rotor's valley, where a nip cutter ensures it never wraps more than 180°. By cutting each tail at the source, self-feeding is minimized and production stays steady.

For the most demanding applications, Vecoplan's **VIZ line of shredders** uses a newer rotor that incorporates full coverage of octagonal cutters arranged side-by-side in a V configuration. The flat cutter surface delivers a knife-like cut, eliminating stretching and tearing along with the friction heat that comes with them. The result is a machine that can process films others cannot.

Beyond rotor selection, a few operating fundamentals keep thin-film shredding efficient:

- **Feed rate.** Stretchy materials should be fed slowly and ramped up gradually while monitoring the rotor for signs of wrapping.
- **Cutter sharpness and tolerance.** Sharp knives with tight clearance to the counter knife cut cleanly rather than ripping, which reduces wrapping risk.



Vecoplan's SureCut Film & Fiber rotor (top right) forces each strand or film tail into the valley of its corrugated rotor, where a nip cutter ensures it does not wrap more than 180°. The V-Rotor (bottom) is fitted with full-coverage octagonal cutters, whose flat edges produce a clean, knife-like cut.

- **Zero-tolerance screen.** A screen set so close that the cutters lightly groove it on startup prevents material buildup behind the rotor.
- **Temperature control.** Water-cooled rotors keep friction heat in check and protect against meltdowns. Vecoplan machines can come pre-drilled for cooling so it can be added when an application calls for it.

With the right rotor selection and disciplined maintenance, thin film doesn't have to be a material to fear.



Scan to learn more or visit
short.ptonline.com/vecoplan

Nine-layer blown film line at Dow's Pack Studios facility in Freeport, Texas. Source: Dow

Consider the Incumbent Resin Effect When Purging Your Blown Film Dies

Be thorough to purge all the previous resin from your blown film line during transition to a new resin to avoid gels and other impurities.

Most polyethylene (PE) blown film lines produce many different types of products, meaning they're not dedicated to a single product running a single resin. When changing the line over, the extruder, transfer line and spiral mandrel die must be essentially free of the incumbent resin to produce the product. Otherwise, some small fragments of the incumbent resin — poorly mixed into the new resin — may discharge from the die and get labeled as gels. This is especially important for the incumbent resin sloughing off the transfer line and die channels.

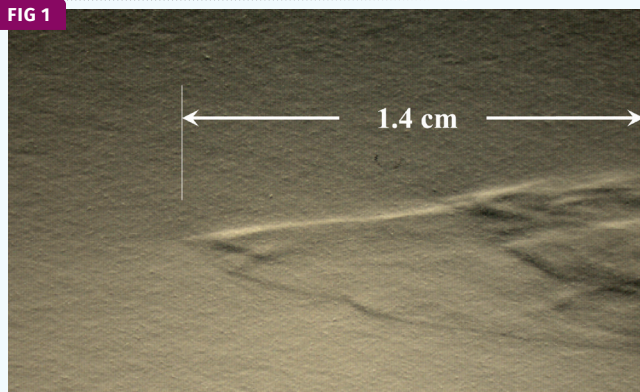
By Mike Rutkowski, Dow, and Mark Spalding

For example, a trial was scheduled where a challenger resin was going to replace the incumbent resin for a film product. The challenger resin provided better film properties and potentially higher line rates. The challenger resin had a melt index (MI) — slightly higher than the incumbent resin.

The line had a long run using the incumbent resin. At the trial's start, the challenger resin was added to the feed hopper on top of the incumbent resin, and the process continued under standard operating conditions.

The line produced quality film using the challenger resin. Periodically, however, large gels were observed in the film. A photograph of a gel is shown in Fig. 1. A gel is defined as anything that

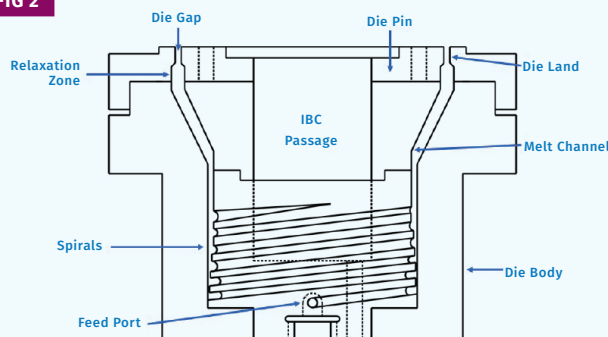
FIG 1



The leading edge of a large gel in the film made from the challenger resin. Source: (all) M.C. Rutkowski.

creates an optical defect in the film. The leading edge of the gel was over 1.4 cm in length and produced an acute thickness variation. The gel was very long and extended about 10 cm in the machine direction. It was hard to believe that this gel originated in the extruder because of its large size. A typical screw for blown film is designed with a barrier melting section and a Maddock mixer. A large resin fragment could not survive the flow path through the barrier section and Maddock mixer and still be the size shown in Fig. 1.

FIG 2



Schematic of a monolayer blown film spiral mandrel die showing the spiral grooves, die land, die gap, and the internal bubble cooling (IBC) passage.

Large gels continued to appear in the film throughout the short duration of the trial. After 40 minutes of running time, plant personnel stopped the trial and labeled it and the challenger resin failures because of the large gels.

Dow analyzed the gels and determined they were not cross-linked. They melted at nearly the same temperature as the challenger resin. The resin within the gel could not be identified since the incumbent and challenger resins were nearly identical, except for small changes in MI.

As previously mentioned, the gels did not originate from the screw channels because they were very large and would have been mixed into the matrix resin by the barrier melting flight and the Maddock mixer. The most likely source of the gel material would be the incumbent resin stuck deep in the spiral grooves of the die. The spiral grooves are used to distribute the molten resin evenly around the die. A schematic of a monolayer spiral mandrel die is shown in Fig. 2. Resin deep in the grooves would be difficult to purge, especially with a challenger resin that is slightly higher in MI and given the short duration of the trial.

At the switch to the challenger resin and during the purging process, pressure at the entry of the die pushes out the more viscous incumbent resin. The process is very effective for the main sections of the spiral mandrel die. Deep in the spirals, however, the challenger resin will struggle to push out the older and more viscous incumbent resin. Once most of the incumbent resin is out, the resin deep in the grooves will be purged by shear stress.

Ideally, a shear stress of 30 kPa at the metal wall is needed to purge this incumbent resin out of the spiral grooves. The level of stress during normal steady-state operation at startup may not be high enough to purge the deep grooves quickly. Here, the incumbent resin periodically sloughs off the grooves and creates a gel like what's shown in Fig. 1. Thus, the resulting performance will be a prolonged transitional process in which the film is periodically contaminated with gels. These disruptions are typically observed during most material transitions, but they can become erratic or intermittent and focused in specific flow areas around the circumference of the bubble.

METHODS TO PURGE INTERNAL DIE PASSAGES

To purge the incumbent material quickly, plant personnel may consider methodologies that focus on these troublesome areas of the internal die passages. When rheological and compositional properties of the materials are very similar, minor changes to the process conditions can aid in decreasing this transitional time. One example of a process modification is the use of a technique known as the "disco purge method." The method was named by John Vansant of DuPont in the early 1980s when disco music was popular.

The disco purge method uses a more active approach to purging by applying variations in rate, discharge pressure and shear stress to purge older resins. Rate changes are conducted over time intervals and reflect percentages of the maximum allowable screw speed. This maximum value is determined based on existing process limitations such as pressure, screw speed and bubble stability.

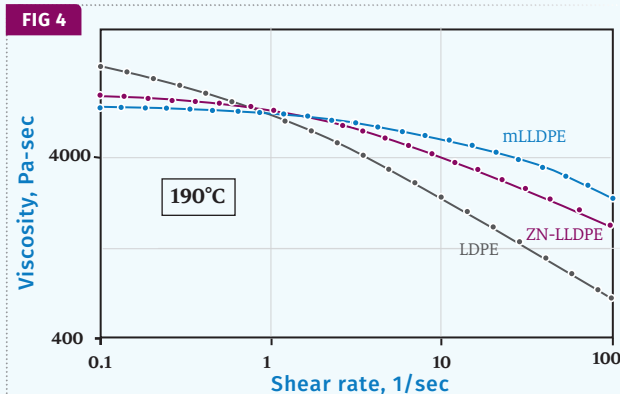
FIG 3



Stacked pancake die spiral flow channel (die split for cleaning).

For example, the minimum and maximum screw speeds for stable running would be determined first, such as 10 and 80 rpm, respectively. Next, the interval speeds would be set at 30, 50 and 70 rpm as outlined in the table. The extruder would be operated by increasing and then decreasing the screw speed, according to the sequence schedule provided in the accompanying table. This table provides a general guideline for screw speed variations but should not be viewed as a strict procedure.

If gels are observed exiting the die at elevated levels for a specific screw speed, it is recommended to maintain that screw speed until the gel occurrence rate has lessened or diminished. The periods of low screw speed should not be overlooked as they allow for the molten resins to intertwine prior to the next increase in rate.



Shear viscosity for three different types of 1 dg/min MI PE resins at 190°C.

Most recently, coextruded blown film equipment manufacturers have begun incorporating automated control features for this type of purging process designed to maintain overall rate and bubble stability by alternating high- and low-rate periods in multiple extruders. Care must be taken to perform this purging procedure during monolayer blown film extrusion to avoid significant process instabilities. Extruder adjustments often require matching process changes, such as bubble cooling and line speed. A monolayer line will also have a higher minimum screw speed to maintain overall bubble stability since the loss in rate cannot be offset by a complementary layer.

For typical commercial blown film rates, a uniform appearance within the film should be apparent within 30 to 60 minutes. If gels or flow inconsistencies like those previously described are observed, a modification to the disco purge method is recommended. To increase the viscosity and shear potential of a challenger resin, elevated levels of antiblock additives can be blended during the variable rate purging process.

These inorganic compounds, which are commonly used for commercial blown film extrusion, include silica and talc. Inclusion rates will vary depending on severity of the flow instabilities, but a general guidance of 1 to 5 wt.% active compound has shown to be effective in restoring uniform bubble appearance. These concentrations include the existing levels of antiblock present within preformulated challenger resins and will likely require adjustments to variable purge maximum screw speed.

Although the discussion has focused on spiral mandrel die designs, the same principles apply to stacked or “pancake” dies. Spiral flow channels, as shown in Fig. 3, are present within each layer and have been designed based on a specific polymer’s rheological characteristics. As material viscosity varies based on process requirements, resins can generate wide ranges of shear stress to these flow paths and struggle to purge these surfaces effectively.

When considering resin viscosities, it is important to keep in mind that the MI does not tell the full story for polyethylene materials, as they behave as non-Newtonian fluids in the molten state. Fig. 4

shows the viscosity measurements of three common types of PE resins at increasing shear rates at 190°C. These common types are low-density polyethylene (LDPE), heterogeneously catalyzed (Ziegler-Natta) linear low-density polyethylene (ZN-LLDPE), and homogeneously catalyzed (e.g., metallocene or post-metallocene) linear low-density polyethylene (mLLDPE). Each material has a MI of 1 dg/min (190°C, 2.16 kg), and this singular viscosity point can be identified by the convergence of the curves at a shear rate of approximately 1 1/sec.

However, shear rates within commercial blown film dies exceed 25 and sometime 100 1/sec. At these higher shear rates, the viscosity can vary greatly between PE resins and must be considered when developing transition and purge procedures. For example, the mLLDPE in Fig. 4 would easily purge out the other resins at high rates and shear rates while the LDPE resin would purge out the ZN-LLDPE and mLLDPE resins better at lower rates and shear rates.

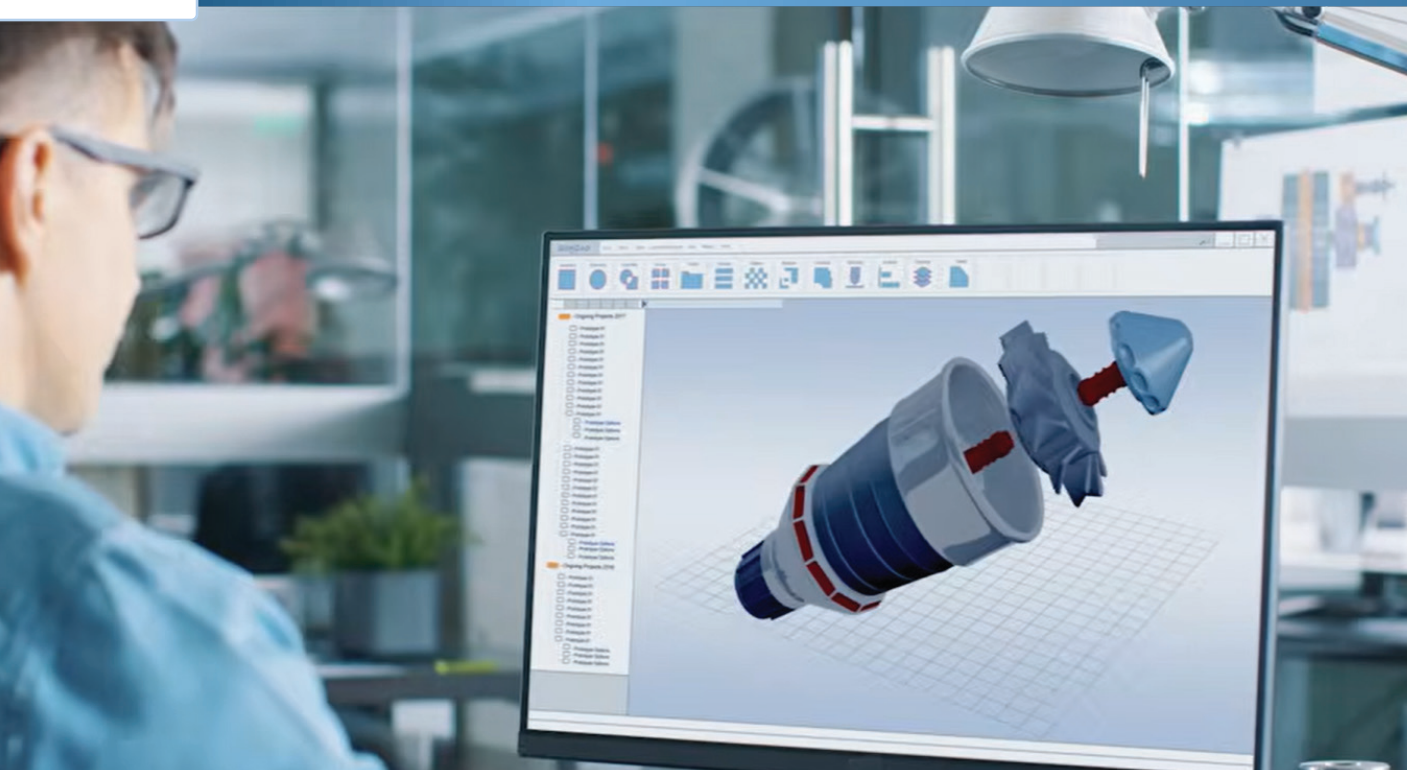
This is a clear case of the incumbent resin effect where process issues caused gels in a challenger film. Since the gels only appeared after the switch to the challenger resin, the challenger resin gets blamed for the defect and is labeled as unacceptable. Here, the process issue is the incomplete purging of the spiral mandrel die with the challenger resin. The incumbent resin effect was described in the July 2024 issue. That article centered on screw design defects that allow the incumbent resin to crosslink and carbonize. When the process is switched over to the challenger resin, the challenger resin causes crosslinked gels and black specks to release from the screw. These defects are blamed on the challenger resin rather than the defects in the screw design. ▶ PT

Screw speeds and durations for a disco purge cycle where the minimum and maximum screw speeds are 10 and 80 rpm, respectively.

Sequence	Duration, minutes	Screw Speed, rpm
1	1	30
2	1	80
3	1	50
4	1	10
5	1	70
6	5	15

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Artificial Intelligence Approaches Expedite Engineering Workflows

Physics-aware AI tools can expedite product design iterations. Source: Neural Concept

Machine learning models narrow down solutions in synthesis, compounding, product design and more.

Machine learning is an old concept — the idea that software algorithms can mimic human intelligence by analyzing data for patterns and making predictions. Algorithms can learn by optimizing their statistical model based on the error between predicted values and target values. Deep learning uses artificial neural networks with multiple layers to model more complicated patterns in data. In the past 10 years, faster graphics processors have unlocked their potential to create useful tools that save time and labor.

By Matt Stonecash
Associate Editor

New machine learning algorithms are very good at modeling complicated phenomena and getting reasonably good answers in a fraction of the time previously possible. Large language models (LLMs), a subset of deep learning models, learn from textual data and have gotten so good at language tasks that they are now creating about half of the internet. But advances in AI technology have enabled other tools, tools more suited to tackling problems in science and engineering, including in plastics. These tools hold promise for businesses looking to expedite their workflows and

conduct exhaustive but rapid solution discovery.

In traditional engineering and applied science, theoretical models are used to simulate a problem and calculate a solution. The model is refined iteratively as data is collected to better understand the relationship between inputs and outputs. Statistics can help set up trials that reduce uncertainty and examine the interactions between multiple factors, but each additional factor, or independent variable, increases the number of trials. The resulting time and expense of R&D forces a narrow approach that can miss the best solutions.

The potential of AI is removing limits on the number of trials that can be done, expanding the number of scenarios that can be modeled, and eliminating guesswork.

DATA MODELS EXPLORE INFINITE POSSIBILITIES IN MATERIAL DISCOVERY

Inverse polymer design, made possible by machine learning, turns materials development on its head. Rather than trying and testing ➤

polymers to find the right fit, researchers start with desired properties and use algorithms to develop structures that are predicted to meet them. The possible solutions go far beyond any supplier catalog, encompassing an infinite variety of combinations.

Ying Li, a professor at the University of Wisconsin, researches the effectiveness of AI algorithms for polymer design. Li and collaborators screened tens of thousands of hypothetical polymer structures to find new polymers for dielectric capacitors. In capacitors for high-temperature applications, the necessary polymers need both a high electric band gap and a high Tg: two properties that are often inversely related. Algorithms trained on known data sets from existing polymers can screen hypothetical polymer structures, identifying those that are likely to exhibit desired properties.

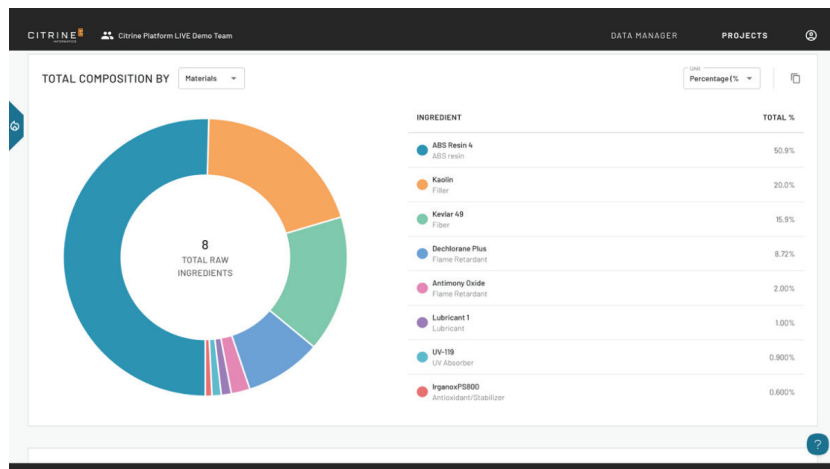
By screening outside the space of existing polymers, novel candidates with high performance characteristics can be identified for synthesis and testing. Screening nearly 50,000 polysulfates, the machine learning model was able to identify a polysulfate polymer structure with a unique combination of high Tg, electric band gap value and dielectric constant that can be synthesized, at least at lab scale.

According to Li, the best algorithms move beyond pure data science approaches to incorporate domain knowledge. Grounding models in polymer chemistry, such as group combination theory, helps build models that can make more accurate predictions. “Even a well-trained model can completely fail, unless the feature engineering is encoded with the physics of the polymers,” says Li. “So polymer chemistry plays a very critical role, because polymers are intrinsically very complicated.” Li presented this work in February at the Society of Plastics Engineers (SPE) International Polyolefins Conference.

PHYSICS-AWARE AI FOR PLASTICS COMPOUNDING AND RECYCLING

Engineers are often tasked with optimizing formulas, plastic compounding is one example. Like polymer discovery, the design space is expansive and the ability to explore it is limited by time and resources.

The traditional approach is design of experiments (DOE); the strategic selection of factors and treatment levels for trials and statistical analysis of data to understand the effects. But the number of necessary trials increases exponentially with the



Screenshot of Citrine platform results, showing a polymer compounding formulation. Source: Citrine

We will move progressively to a world where AIs are removing engineers from lower-level manual tasks to higher and higher levels of the design tree.

number of factors (or ingredients). A full factorial DOE requires 1^f trials for 1 levels of f factors, this means that a compound with just 6 ingredients would require 729 trials if we set 3 levels: high, medium and low.

“DOE is great if you have one to five variables,” says Hannah Melia, director of marketing at Citrine, an AI software company that works with compounders and other materials & chemical companies, “but a compounder might look at a hundred different fillers and flame retardants, and they will have to pick a small

number to test. They might have a good hunch. But every time they run an experiment it can cost thousands of dollars.”

AI models can expedite the process by partially replacing experimentation with simulation, but training data in these situations is often very limited.

“80% of the customers that come to us have fewer than 100 data points,” says Melia. AI

algorithms trained on limited data can fail to make useful predictions. “Sometimes, the data set can be sparse as well as small. Maybe they ran an experiment and didn’t measure this property or that. So you have to work out how to do AI on small data. And that’s hard.”

Here again, the incorporation of domain knowledge becomes important.

Physics-aware models such as Citrine’s bridge this gap in data by leveraging human smarts. The solutions generated are constrained by the relevant domain knowledge of scientific theory, ignoring solutions that are physically impossible or otherwise unworkable.

Citrine’s platform uses rules input by experts in conjunction with the training data to arrive at a predictive model. It then uses that model to predict the best options for the user. This can

be the best combination of solvents for a chemical recycling process; the best ingredients for a new polymer compound; or even the optimum processing parameters. Companies can use these predictions as a starting point, circumventing the numerous trials that would otherwise be required.

The user can narrow it down further by adding business constraints, avoiding certain additives for regulatory reasons, or constraining the processing temperature for example. The model will generate a list of possible combinations, and the user will select a few to take to the lab and test (the compounds are ranked by the likelihood of meeting application requirements).

“After those experiments are done, data can be input back into the model to improve it. We typically see that on the third iteration you hit your targets,” says Melia.

EXPLORING MORE OF THE DESIGN SPACE FOR BETTER PRODUCTS

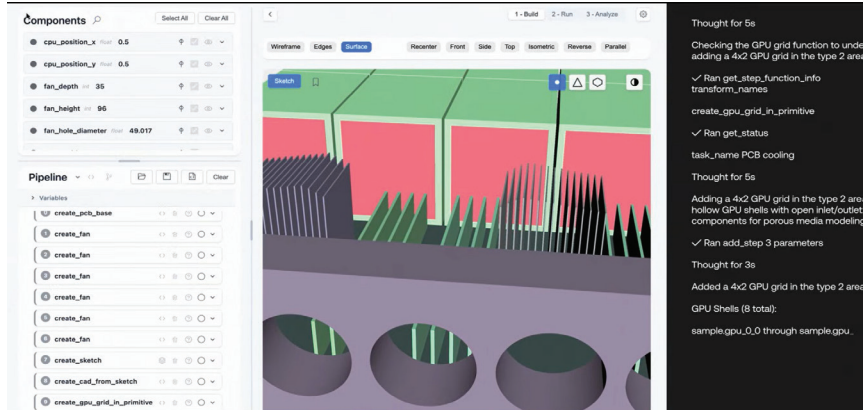
What constitutes another space of infinite possibility and finite data? Product design. Rapid prototyping technologies have sped up the prototyping process and made it more cost effective. At the same time, simulation has helped reduce the need for prototyping iterations. But even the tasks of building a virtual model and simulating the product performance place a low limit on the number of possible iterations. Machine learning technology can lift that cap. It can iterate on known performance and generate simulations of design possibilities.

Neural Concept's Design Copilot tool is built to accelerate exploration by helping engineers navigate design spaces efficiently. It uses generative models trained on simulation data to generate new geometries. Engineers input constraints via natural language or by point and click, and the system generates hundreds of options.

“If I’m designing a PCB (printed circuit board), I have to take into account geometric constraints, cooling, warping and so on. I can use my intuition, make a design and check, then iterate again and again. Or, I can just use AI to generate many, many variants and design from there,” explains Pierre Baqué, founder of Neural Concept.

According to Baqué, this approach is particularly good at enabling robust design processes. The system can generate designs that are less sensitive to variation, for example due to effects of changing temperature on material properties, by simulating multiple designs and find the one that performs the best across varying inputs.

Manufacturing variation, during injection molding for



Results of a PCB design operation in Neural Concept. Source: Neural Concept (adapted from video).

example, is another potential source of uncertainty that can be planned for using new AI tools. “If I am manufacturing a part, and there are small variations compared to the nominal shape, I want to be able to evaluate on the fly what the impact on performance will be,” says Baqué.

Design Copilot integrates with existing modeling and design packages, enabling customers to pull data from different sources into their workflow.

TECHNOLOGICAL CHANGE REQUIRES ORGANIZATIONAL CHANGE

The incorporation of these tools into business processes does not take long, as the interfaces are graphical and easy to interact with. When Citrine asked customers to fill out a survey, they reported an average of 6.5 days to upload data and run the first model, with the first technical win coming at an average of 25 weeks. It seems certain that these tools will speed development times and lead to better products, less certain is the impact on the workforce.

“The engineering software space is going to change dramatically over the next five years,” says Baqué. “We will move progressively to a world where AIs are removing engineers from lower-level manual tasks to higher and higher levels of the design tree.”

Traditionally, those lower level tasks have been the proving ground for early career engineers who move on to become leaders and decision makers. Automating those tasks could mean longer educational programs, more emphasis on creative thinking, and fewer entry-level jobs.

“It’s not just in engineering, but across all fields. There is a clear challenge, a question for our society and for every company: How do we build up new talents?” says Baqué.

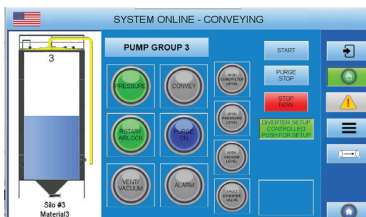
Successful adoption of advanced AI tools has a technical aspect, but also an organizational aspect: It requires a strategic vision that addresses the impact of the tools on the workforce.

“In every really successful situation we have seen, leaders take ownership of this transformation, including reorganization and skill development,” says Baqué. [PT](#)

MATERIAL HANDLING

Control Platform Streamlines Railcar Bulk Material Handling

AEC's new VacTrac Atlas Series control platform offers advanced control and monitoring of bulk material handling systems. The Advanced Transfer & Loading Automation System (Atlas) is designed to manage pumps (vacuum or pressure), diverter valves and inventory devices.



The platform is modular and can control one or multiple bulk material transfer systems from a single interface. Remote connectivity options enable integration with SCADA systems, while the control platform simplifies system operation and improves efficiency. The system is designed for railcar unloading and high-throughput in-plant transfer systems.

The icon-based graphical interface provides intuitive navigation and system monitoring, while customizable component labeling and role-based password protection help simplify operation and safeguard system data, AEC says. At the core of the system is an Allen-Bradley Micro850 PLC paired with a 10" high-resolution color touchscreen HMI. Operators can set parameters, monitor conveying performance, view pump and diverter valve status and track silo fill levels and available capacity in real time.

Optional features of the VacTrac Atlas Series include:

- Remote audible-/visual-alarm assembly
- NEMA 4-rated outdoor enclosure
- Low-vacuum system shutdown
- Secondary remote HMI display
- Protocol converter — Modbus RTU to Modbus/TCP
- MiVue for data collection and analysis

INJECTION MOLDING

Battery-Powered Hot-Tip Sprue Cleaner

Plastic Process Equipment (PPE; Macedonia, Ohio) has added a portable battery-powered hot-tip sprue cleaner to its offerings. The company says replacing a cord with battery power lends mobility to the sprue cleaner and enables use on multiple injection molding machines without the restriction of a power cord. When energized, the tip heats up to 350°C (660°F) within 30 seconds. Working time per charge is more than 35 minutes, and the cleaner can be recharged more than 500 times. The product comes with three thread-on interchangeable brass tips to handle a variety of different sprue types. These tips can slide on and off the head end and are secured in place with a locking collar. In addition to a charging cable, the cleaner includes a head safety cover. PPE previously offered a plug-in version with a 7-ft power cord and 110V 200W heater element.



MATERIALS & ADDITIVES

PPS for Higher Thermal Shock Resistance in EV Busbars

Envalior has developed Xytron M5080ET, a new polyphenylene sulfide (PPS) compound for overmolding busbars in electric vehicles. The impact-modified compound is designed for busbars that must withstand temperatures above 150°C and resist stress cracking during thermal shock.

The material addresses rising temperatures in electric vehicle (EV) powertrains, driven by higher operating voltages, stronger currents and more compact assembly designs. These conditions increase the thermal shock-resistance requirements for overmolded busbars, such as those used in power control units or electric drive axles.

"Our compound is developed to ensure that, throughout the entire service life of the vehicle, the busbars are not impaired in their function by stress cracks and do not cause short circuits that lead to the failure of the entire assembly," says Arthur Rieb, business development manager at Envalior.

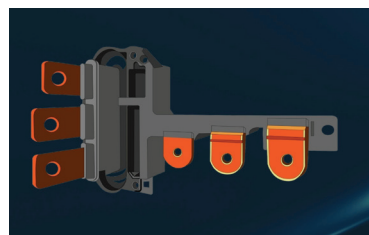
The PPS compound is reinforced with 50% by weight of a glass fiber-mineral mixture. According to Envalior, it has been approved by several customers, and various development projects for series production have been completed.

In EVs, busbars conduct electricity between the high-voltage battery, control unit, drive and charging unit. They are made of copper and overmolded with plastic for electrical insulation. Because the thermal expansion of copper and plastic typically differs significantly, stress cracks can form in the plastic during abrupt temperature changes.

The new compound's thermal expansion is closer to that of copper, even perpendicular to the melt flow direction and glass-fiber orientation, and this stability is maintained at high temperatures, reducing the risk of stress cracks, according to the company.

"Tests conducted at Envalior have shown that our new compound exhibits more than 70% higher stress crack resistance in thermal shock tests at temperatures between -50°C and 180°C compared to similar PPS compounds. This is supported by the fact that the weld lines in the component, which are created by converging melt fronts, are around 17% stronger than in comparable materials," Rieb notes about the new compound.

Xytron M5080ET achieves a V-0 classification in the Underwriters Laboratories 94 flammability test using a 2-mm test specimen thickness. The compound exhibits high volume resistivity and high dielectric strength before and after aging, even at elevated temperatures. Its creep resistance and low water absorption support dimensionally stable components, enabling the creation of compact assembly designs, the company reports.



MOLDS & TOOLING



A-Level Surface Finish Mold Cleaner

Slide Products, Wheeling, Illinois, is offering a new acetone-based mold cleaner intended for maintaining clean A-Level mold surfaces. The Zero Film Mold Cleaner comes as a high-pressure aerosol that can also flush away diamond compound polish and stubborn contaminants in high-end manufacturing processes.

Containing zero abrasive materials and requiring no wiping, Zero Film Mold Cleaner enables mirror-finished molds to be maintained without risking scratches. In addition to high efficacy, the

low-VOC acetone-based formula features almost instant evaporation and leaves no residue, ensuring the mold is production ready in seconds. Slide Products notes that this item represents a formulation update to the recently discontinued X-EMPT Mold Cleaner.

Zero Film Mold Cleaner is available as an aerosol in a case of 12 cans or as a bulk liquid in 1-, 5- and 55-gal containers. Slide Products provides free training, technical support and samples for its customers and their mold-maintenance programs.

HEATING & COOLING

55-Gal Drums of Heat-Transfer Fluid

Plastixs is now selling 55-gal drums of Paratherm heat-transfer fluid.

Paratherm heat-transfer fluid is used in many industries, including food, plastics, chemicals and pharmaceuticals, and is designed to operate at high temperatures while maintaining thermal stability. It is available in various formulations, including:

- **HE:** High-temperature food-grade performance. Operating range 37-600°F.
- **NF:** Food-grade with exceptional thermal stability. Operating range 24-630°F.
- **LR:** Food-grade solution with extreme low-temperature control without water or glycols. Operating range -112-450°F.
- **OR:** Oxidation inhibiting for systems exposed to air and oxidation. Operating range 40-500°F.
- **LC:** Cleaning fluid for hot oil temperature control units to clean system while it operates. Operating range 52-550°F.
- **MR:** Single-fluid, food-grade solution for heating and cooling. Operating range -37-580°F.

Plastixs is stocking 55-gal drums of Paratherm at a distribution facility in the central U.S. for fast distribution nationwide. Paratherm is still available from Plastixs in the original 5-gal pails. Totes and bulk volumes are also available.



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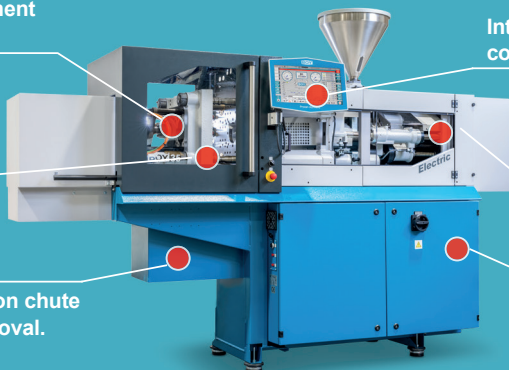
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COMPOUNDING

Strand Pelletizer Boosts Throughput

Maag Group's new generation of underwater strand pelletizing systems, the M²-USG is reportedly designed to provide improved process stability, higher throughput and consistent pellet quality. Design improvements are combined with advanced sensor integration to help compounders achieve more reliable production and improved operational efficiency, according to Maag.

The system is engineered to promote maximum system availability (>99% OEE) and stable production processes, Maag says. Reduced downtime and minimized scrap rates help lower operating costs while improving overall plant profitability.

At the core of the system is a newly developed M²-USG cutting head, designed to simplify operation and maintenance while minimizing the risk of operator error. Maintenance procedures can largely be performed without tools, and cleaning times have been significantly reduced, allowing operators to return to production faster, says Maag.

In pelletizing, incorrect settings can cause strand adhesion, unstable cutting conditions and ultimately production interruptions. The M²-USG addresses these challenges with a series of targeted design optimizations that Maag says help compounders maintain stable, efficient and sustainable production.

To improve startup reliability, a newly developed scraper combines high operating speed with gentle strand handling. The strands are cut sequentially at the die plate and fed into the strand guide section and the cutting head with a controlled time delay. This is designed to significantly reduce the risk of strand sticking, clogging or excessive startup waste, resulting in faster and more reliable process ramp-up.

An optimized water film on the startup table is designed

to prevent turbulence and reduce the risk of strands sticking together. Transport water is injected immediately after cutting, preventing potential blockages inside the cutting head, even when processing high-temperature polymers or challenging materials such as polycarbonate. The result, according to the company, is smoother machine operation, improved process stability and increased system availability.

The new cutting head features a compact design with improved sound insulation. The rotor diameter has increased from 162.5 to 200 mm, while the number of blades has increased from 30 to 36. This upgrade is said to enable significantly higher throughput while extending service life by 20%. A stable cutting gap promotes consistently high pellet quality and reduces maintenance

requirements and spare-part consumption, further lowering operating costs.

The M²-USG is available in machine widths of 600, 900 and 1200 mm. At the 600-mm width, the system achieves throughputs of up to 13,000 kg/hr (PET), while the 1200-mm version

reaches up to 24,000 kg/hr —

significantly exceeding the performance of previous models, Maag maintains. This higher capacity allows processors to achieve the same output with smaller machine sizes, reducing both capital investment and installation footprint.

Integrated sensors continuously monitor key parameters such as vibration, temperature, flow rates and pressure. Any deviations are immediately detected and reported, including via remote monitoring, helping operators prevent process instability and scrap creation.

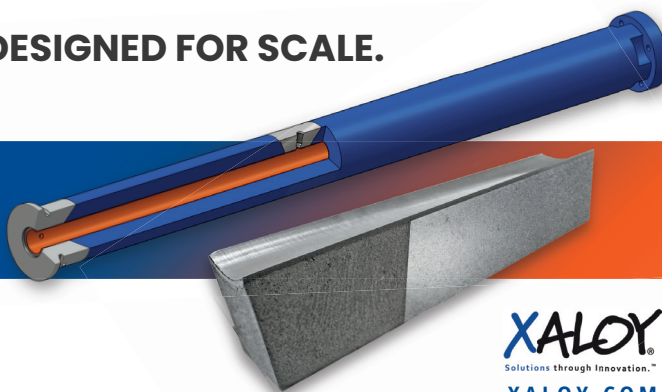
A camera system monitors strand flow, while compressed air consumption is also tracked. Energy-efficient reluctance motors contribute to lower energy consumption and an improved sustainability footprint.



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TESTING & INSPECTION



Automated Microscope Simplifies Inspection

Nikon Corp. has launched the Eclipse LV100AMS, a one-click automated microscope designed to simplify industrial inspection and quality control. Built on Nikon's established industrial microscope platforms, the LV100AMS combines fully automated inspection with AI-powered image analysis, which the company says enables manufacturers to improve consistency, increase inspection speed and strengthen confidence in inspection outcomes.

Manufacturers today face growing challenges such as labor shortages and increasing throughput demands, making consistent inspection quality difficult to maintain. To address these issues, Nikon developed the LV100AMS to automate the entire inspection workflow from image acquisition to analysis.

Key features include:

- **One-Click Automated Inspection:** Manual inspection is highly dependent on operator skill and consistency, making it difficult to maintain stable quality at scale. With one-click execution, even complex inspection routines and advanced image analysis run automatically, eliminating operator-to-operator variation and reducing human error, says Nikon. This is designed to enable repeatable, standardized inspections across shifts and sites, improving yield, lowering rework rates and reducing training time.

- **Integrated Motorization, Automated Imaging and AI-Driven Analysis:** Disconnected inspection steps and manual interpretation can slow down workflows and introduce variability. By integrating motorized control, automated image acquisition and AI-powered analysis into a single system, the LV100AMS is said to provide consistent, objective results with minimal operator influence. This is intended to increase throughput, support scalable inspection strategies and provide greater confidence in quality decisions.

- **Customizable Automated Workflows:** The LV100AMS allows manufacturers to design customer-specific inspection workflows tailored to their products, processes and inspection conditions. This flexibility is designed to enable inspection approaches not achievable with conventional microscopy, helping manufacturers adapt to new products, design changes and evolving quality standards.

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Commodity Resin Prices Drop

Sharp decline for polyolefins with overall downward trajectory for PS, PVC and PET.

By **Lilli Manolis Sherman**
Contributing Editor

Following an initial agreement upon a U.S.-Iran ceasefire framework at press time, the prices of five commodity resins trended downward heading into the third quarter with the sharpest drop initially seen on the polyolefins front. The potential for a significant drop in polystyrene (PS) prices was underway, with downward movement for both polyvinyl chloride (PVC) and polyethylene terephthalate (PET) likely. Barring major resin production disruptions, including those that may surface during hurricane season, a return to prewar supply/demand fundamentals was projected, with price corrections to the major spikes of the early second quarter underway.

Below are the views of purchasing consultants from Resin Technology Inc. (RTi); David Barry, associate director of polyethylene (PE), polypropylene (PP) and PS for Dow Jones Energy (formerly OPIS's PetroChemWire); Michael Greenberg, CEO of Resintel, the market intelligence service of The Plastics Exchange (TPE); Scott Newell, executive VP polyolefins at distributor/compounder Spartan Polymers; and Mike Burns of Plastic Resin Market Advisors.

Addressing polyolefins' price trajectory, Greenberg says that going into July, "The decline is not occurring in a straight line. Lower prices are stimulating demand, and resin availability is not unlimited across every grade. Producers are also throttling back reactor rates to prevent the large May inventory builds from becoming more burdensome. Still, buyers currently possess the leverage, and the market has moved from debating the size of June increases to considering how far contracts might ultimately decline this month and over the summer."

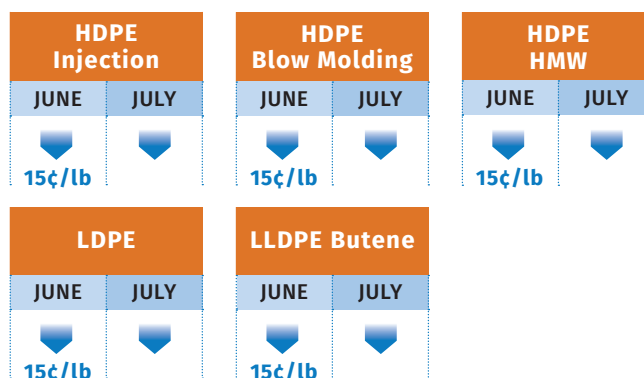
PE PRICES DROP

Having rolled over in May, PE prices were heading down by double digits in June, with market estimates of a 15¢/lb decline, according to Barry, Greenberg, Burns and Kevin Mekaru, RTi's procurement director for commodity resins. These sources generally concur that further declines are underway. "It's been a waiting game for processors," Mekaru says. "I don't think we have ever seen such

Market Prices Effective Mid-July 2026

Resin Grade	¢/lb
POLYETHYLENE (railcar)	
LDPE, LINER	81-83
LLDPE BUTENE, FILM	77-79
HDPE, G-P INJECTION	81-83
HDPE, BLOW MOLDING	79-81
HDPE, HMW FILM	81-83
POLYPROPYLENE (railcar)	
G-P HOMOPOLYMER, INJECTION	61.5-63.
IMPACT COPOLYMER	66.5-68.5
POLYSTYRENE (RAILCAR)	
G-P CRYSTAL	104-106
HIPS	110-112
PVC RESIN (railcar)	
G-P HOMOPOLYMER	54-56
PIPE GRADE	55-57
PET (truckload)	
U.S. BOTTLE-GRADE	75-77

Polyethylene Price Trends



huge price fluctuations in such a short period of time." Going into May, PE prices had risen by a total of 45¢/lb.

"Processors have been running down their inventories, so we expect to see stronger demand in third quarter," Barry says. Meanwhile, he notes that some resin suppliers have reduced

export prices to pre-war levels, with as much as a 30¢/lb drop in some markets. These sources also expect plant operating rates to be reduced from the 90s, percentage wise, to the mid 80's. According to Burns, PE inventory levels can only be reduced by substantial exports. "Suppliers will need to meet lower global price points to achieve this action," Burns explains, noting that processors should continue to buy as needed given the emergence of downward price pressure and high supplier inventory levels.

Going into July, Greenberg believes market fundamentals have shifted. "Most PE producers still have June increase nominations of 10-20¢/lb in place," Greenberg says, "but spot fundamentals no longer support those initiatives. Elevated inventories, falling ethylene costs, weak export pricing and improving availability have materially changed the conversation." Greenberg sees the export market as remaining the principal source of weakness amid expanding production capacity.

PP PRICES DROP

After dropping 7¢/lb in May, PP prices fell another 8.5¢/lb in June, tracking the movement of propylene grade monomer (PGP), which settled at 43.5¢/lb, with a further decline in prices expected through the third quarter, according to Barry, Greenberg, Newell

and Mekaru. These sources venture that additional decreases could potentially wipe out the 30¢/lb increases implemented by suppliers.

Barry notes that spot PGP prices averaged 7-9¢/lb lower going into June, and he believes the petrochemical industry is likely to return to 'pre-war' levels of being oversupplied. Along with the other sources, Barry says that suppliers received a lot of push-back for their 7¢/lb non-monomer increase passed in April. Newell thinks that margin expansion was passed "during a panic time, but we're returning to market

fundamentals of too much supply and not enough demand." Mekaru adds: "We have not seen the demand rate going up in the last couple of months after the surge that brought it up to 91%. It is now heading down." Growth through May averaged about 6.5%, year-to-date, but as these sources note, this was largely attributed to prebuying, making it difficult to zero in on "true demand". These sources also anticipate that plant operating rates will drop from the mid-80s, percentage wise, to as low as the high 70s.

"Many processors continue to believe PGP and resin have further downside, and there is little incentive to build inventory while upstream costs remain in retreat," Greenberg says. "PP should continue to follow monomer lower unless domestic demand improves materially or another production disruption changes the balance."

PS PRICES UP THEN DOWN

Prices of PS moved up in May between 8-10¢/lb, bringing the total increases since March to about 29-30¢/lb, according to Barry and Brian Balboa, RTI's senior business unit leader for PS and PVC. Suppliers sought an additional 3-5¢/lb in June, but these sources doubt implementation success, primarily due to poor supply/demand fundamentals. This is underscored by INEOS' closure of its Illinois plant, reducing it to production in Alabama and Mexico, while both AmSty and Total are looking for buyers. Balboa thinks suppliers may push through a 2¢/lb increase in line with the June benzene contract, which rose to \$4.91/gal. However, spot benzene prices have been sharply declining with a "dramatic" drop in July benzene contracts expected to result in a significant drop in PS prices — potentially reaching double digits. The implied styrene price based on a spot formula (30% ethylene, 70% benzene) was down almost 13¢/lb through June, according to Barry.

PVC PRICES FLAT TO DOWN

Prices of PVC, following their 8-9¢/lb March-April surge, remained largely flat through May and June, though suppliers were out with June 4¢/lb price hike, according to Balboa. He largely ties this to overall lackluster demand and some supplier inventory build-up, and he speculates there's the potential for a slight decrease of 2-3¢/lb within the July-August time frame. He notes that key feedstock prices were trending down and domestic suppliers were still feeling some pressure from China's aggressive global PVC exports spree.

PET PRICES UP, THEN DOWN

Prices of PET moved up a total of 1-2¢/lb in the May-June time frame, but that increase was generally expected to be gone within the July-August time frame, according to Mekaru. He attributes this trend to raw material cost formulations, which were leveling off in step with crude oil prices declining significantly. There has also been a bit of constraint on some imported PET due to higher freight and transport costs, though some attractively priced imports are still playing a role in the market. He characterized domestic demand as relatively soft during the traditional busier season. [PT](#)

Polystyrene Price Trends

GPPS	
JUNE	JULY
 2¢/lb	

HIPS	
JUNE	JULY
 2¢/lb	

PVC Price Trends

Pipe	
JUNE	JULY
	

Gen. Purpose	
JUNE	JULY
	

PET Price Trends

Bottle Grade	
JUNE	JULY
 2¢/lb	



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Plastics Processing Slips Again in June but Remains in Growth Range

The GBI Processing Index contracted another 1.1 points in June, but the market is now in its sixth straight month above the 50-point growth threshold.

FIG 1 Plastics Processing Index



The Gardner Business Index (GBI) measures the current state of plastics processing activity through survey responses covering new orders, production, backlog, employment, exports and supplier deliveries. A reading above 50 indicates expansion; below 50 indicates contraction.

FIG 2 Components Scorecard

	Change vs	
	Month Ago	Year Ago
Supplier Deliveries	▲	▲
New Orders	▼	▲
Production	▼	▲
Backlog	▲	▲
Employment	▲	▲
Exports	▲	▲

The GBI Components Scorecard reports the monthly change rate of primary plastics processing market factors contributing to the overall monthly index reading.

FIG 3 Future Business Index



Numbers in Perspective

The GBI Processing Index eased to 55.5 in June but remained above the 50-point threshold for the sixth consecutive month. The production component followed a similar pattern, declining 5.5 points to 53.7, signaling that plastics processing continues to expand broadly in line with the overall economy. The improvement in the GBI employment outlook component reinforces this view,

suggesting that manufacturers remain cautiously optimistic about labor demand despite the moderation in overall activity.

The downside risk to plastics processing in the short term remains concentrated in energy and material costs. Although crude oil prices declined to \$70.1 per barrel for West Texas Intermediate (WTI) and \$73.4 per barrel for Brent on the last trading day of June, the recent run-up in energy prices is expected to continue having residual effects throughout the industry's global supply chain, particularly through higher material costs. The most likely source of relief would be a rapid normalization of supply conditions rather than weaker demand, allowing input costs to ease without undermining production activity.

The increase in the GBI supply component, shown in the chart, reflects the resilience of the industry's upstream supply chain. Year-over-year growth in U.S. domestic plastics materials and resin production in both Q1 and Q2 helped mitigate the impact of global material shortages, supporting more stable input availability for plastics processors. With the outlook for U.S. industrial production remaining positive in 2026 and 2027, plastics manufacturing is more likely to remain on a steady-to-growth path than otherwise.

ABOUT THE AUTHOR: Perc Pineda, Ph.D., chief economist of the Plastics Industry Association (PLASTICS), is an industry thought leader and PLASTICS' primary expert and spokesperson on the U.S. and global economy, providing industry research, statistics, trends and forecasts. Read his views and insights on the economy and the plastics industry at plasticsindustry.org.

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Benchtop Press Pushes Part Designer into Production Molding

What began as a design idea for a new vinyl applicator product eventually became an entrée into injection molding for Scott Decker and WrapOn Tools, using APSX'S bench-top press.

When Scott Decker initially pictured a new vehicle wrap vinyl applicator product for WrapOn Tools, Asheboro, North Carolina, he knew it would require extensive design and development before becoming a reliable production part.

By Tony Deligio
Editor-in-Chief

Vehicle wraps — adhesive-backed vinyl films applied directly over a car's exterior paint — provide a reversible, cost-effective alternative to a custom repaint. WrapOn Tools designs, manufactures and distributes products specifically for the vehicle wrap industry.

One of its top-selling products today was Decker's idea back then — the patent-pending KnifeTucker tool. Designed to help installers tuck vinyl around edges during the finishing stage of a vehicle wrap, the KnifeTucker replaces the industry standard — snap-off blade knives — giving installers a built-in tucking tool that stays attached to the knife for faster, more precise film installation.

FROM PRINTING TO MOLDING

Attempts to use 3D printing for the KnifeTucker produced parts prone to fracturing along the striations created in printing's layer-deposition process, according to Decker. He next experimented with a "homemade" injection molding press, using plans from a Swiss company. While that machine proved the product's concept, it was only able to mold two to three parts every 10 minutes — a production rate that couldn't keep up with demand.

As WrapOn Tools continued seeking a practical means to move from small-volume prototyping to higher-volume production, it landed on APSX LLC, Blue Ash, Ohio, and its compact, economic benchtop plastic injection molding systems. The APSX-PIM machine measures 43 by 10 by 15 inches, plugs into standard wall outlets and does not require a water-coolant system.

"I actually think I found APSX by searching online for affordable CNC machines," Decker tells *Plastics Technology*. That search pointed WrapOn towards the APSX Spider CNC Mill — a product



WrapOn Tools' KnifeTucker replaces traditional clip-on industry-standard knives.

APSX produced at the time — which WrapOn purchased and uses to machine single-cavity tooling for the KnifeTucker from aluminum.

The company ultimately also purchased an APSX-PIM V1 injection molding machine, featuring five tons of clamp force and a 30-cm³ shot size. Getting production up and running, like the machine itself, was a relatively light lift. "Installation was really just pulling it out, powering it up and taking out all the shipping stops," Decker says. "In probably 20 minutes, we were able to fire it up, get it warm and have it ready for the first test shots."

WrapOn notes that the aluminum molds it uses enable rapid re-machining for dimensional refinements, and the ability to accommodate 3D-printed trial inserts for early-stage validation. Users can inject and evaluate parts and on the same day, update the CAD model, re-machine the cavity and return to molding in hours.

While the APSX-PIM can process a range of thermoplastics — from polypropylene (PP) and polyethylene (PE) to nylon and polycarbonate (PC) — WrapOn knew what it wanted in a resin for its product. "We had a pretty specific material type we were looking for," Decker says, noting the company sought a pre-dyed flexible plastic. "We ended up landing on a HDPE, which has worked really well for our application."

Once the process was dialed in, business partner and equipment operator Josh Lambert was able to produce a batch of four parts in about 90 seconds, with approximate output of 200 parts/day. The parts require little post-production work, allowing them to be boxed and shipped within minutes of coming off the machine.

Today, WrapOn still uses the same APSX-PIM machine it purchased in 2020. The company has several KnifeTucker variations, including the original model, the KnifeTucker Slim and versions designed for specific knives. "At one point, we made a master mold so we could swap out inserts," Decker says, "but now that we've gotten more efficient with the mill, we just machine a new mold for each product." PT



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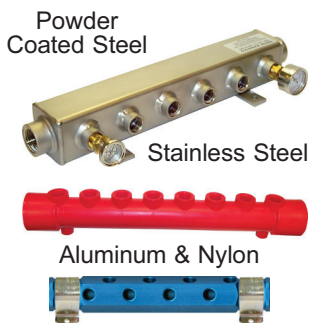


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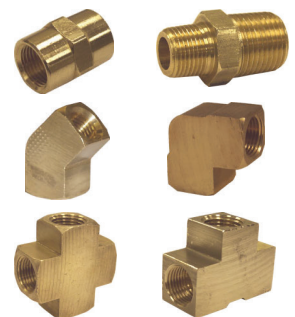
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