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Shifting Gears

Industrial Resin Recycling Drives Beyond Automotive

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ABOUT THE COVER John Sodini (left) and Trevor Houston (right) of Industrial Resin Recycling.
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An Uphill Journey

Proper end-of-life outcomes for plastics are possible, if we're willing to put in the work.

Tony Deligio
Editor-in-Chief

When Patrick Rutledge reflects on all the cleanups he's participated in over the last 17 years as a volunteer with the Friends of Woodland Park (FWP), his mind goes to Greek mythology and the tale of Sisyphus. Doomed to an eternity of pushing a boulder up a hill only to have the stone roll back down as he nears the summit, Sisyphus' toils were a punishment from the gods that made his name synonymous with tasks that are equal parts arduous and pointless. Rutledge acknowledges that the work, especially in the heat and humidity of Houston, is indeed hard, but since that first cleanup, the effort to de-litter Woodland Park has not been 100% fruitless.

"The park is 180 degrees since when we got started," Rutledge says, "but cleanups — it can be a Sisyphean effort to try and keep the trash updated." On October 14, Rutledge was joined by 47 volunteers in the most recent cleanup of Woodland Park. Held prior to the Plastics Industry Association's National Plastics Conference, it was organized by the Future Leaders in Plastics (FLiP).

Despite being in mid-October, temperatures that day reached 86°F, just four shy of the record. Before the cleanup, Rutledge offered a brief history of the park and walked volunteers through the dos and don'ts of extricating trash from along the Little White Oak Bayou Trail. He sported a white FWP baseball cap on his head and a moistened towel around his neck (his preferred method for staying cool in the south Texas heat) while wearing jeans — best safety practices call for full leg coverage. Ultimately, 51 bags of litter were gathered, with recyclables sorted from trash and delivered to Cyclyx for reclaim.

"It's amazing what floats," Rutledge observes. It's a month after the cleanup, and I'm speaking with him by phone to get his perspective on the efforts that day and what he's seen in the 17 years he's participated in trash pickups and other volunteer work as part of the FWP, going back to the group's foundation in 2007 coming soon after the centennial of the park, which opened on July 4, 1903.

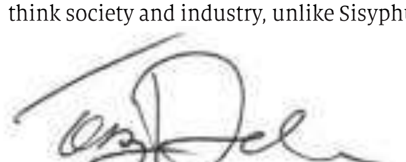
A portion of the bayou trail goes beneath Interstate 10, the Katy Freeway, which bulges in portions up to a gargantuan 26 lanes. When rain floods the interstate, all manner of trash floats its way to the bayou below, including one time, memorably for Rutledge, a Porta Potty. The relative seclusion of the park and its trails also makes it susceptible to dumping and the appearance of the stray mattress, child car seat or tire (the latter two of which were gathered by PLASTICS volunteers in mid-October).

Patrick Rutledge, far left, poses with the NPC Houston cleanup crew at Woodland Park. Source: Plastics Industry Association

After the PLASTICS cleanup, volunteers filled cone paper cups from two 5-gallon plastic water jugs to quench thirst and attempt to regain moisture lost to sweat in the heat. Rutledge says in year's past, the FWP would buy cases of plastic water bottles, ice them down and give those out to thirsty volunteers, but recently it purchased three of the water jugs and paper cups to fulfill the same purpose.

"The city doesn't have recycling in the park," Rutledge explains, "so when we had an event, we'd separate out all the recycling. We'd all take a portion of it, bring it to our homes and put it in our individual recycle bins. After a few cleanups, we said, 'Yes, we're recycling everything, but why are we bringing plastic bottles into our park while we're picking up plastic bottles and other debris from it?'"

Keeping Woodland Park clean, and the broader problem of plastic litter, can indeed seem Sisyphean. I suspect that just like the FWP volunteers, many of the folks reading this have found themselves tucking away and bringing home plastic bottles or other recyclables to their own recycling bins after consuming the items in public spaces that lacked recycling infrastructure. That's a small but significant act, and progress up the hill of addressing proper end-of-life outcomes for plastics. A step at a time; a cleanup at a time; a water bottle at a time, I think society and industry, unlike Sisyphus, can get up that hill. PT



PET Chemical Recycling Process Qualified and Commercialized

Axens, IFPEN (the French Institute of Petroleum) and JEPLAN announced the commercial launch of the Rewind PET Process, which will be marketed globally as a license package to Axens' customers.

Axens, IFPEN and JEPLAN formed a strategic partnership in 2020 to develop the Rewind PET chemical recycling process, which can be used to recycle all types of polyethylene terephthalate (PET) waste. With the support of the French Environment and Energy Management Agency (ADEME), this collaboration resulted in the construction, commissioning and startup of the semi-industrial Rewind PET unit at JEPLAN's plant in Kitakyushu, Japan, in September 2023.

The validation and commercial launch of Rewind PET follows the positive outcome of a year-long program of tests carried out in the demonstration unit to show its effectiveness in treating postconsumer PET. Axens now offers a complete Rewind PET license package, including basic process design, performance guarantees, supply of proprietary equipment and technical support for the startup, and operation of its customers' industrial units.

Rewind PET involves the continuous depolymerization of PET by glycolysis, followed by purification of the resulting monomer, BHET (Bis(2-Hydroxyethyl) terephthalate).

INEOS Styrolution to Close ABS Production in Addyston, Ohio

INEOS Styrolution will permanently close production of styrenic resins in Addyston, Ohio. The plant manufactures ABS and suspension SAN resins, which are used in a wide variety of applications and industries, including automotive, electronics, household goods, health care and construction.

"Over the past few years, we have seen the ABS market become increasingly competitive, particularly with growing competition from overseas imports," says Steve Harrington, INEOS Styrolution CEO. "After a thorough analysis, we concluded that the substantial investment needed to continue operations and achieve profitable cost competitiveness makes this site no longer economical. This difficult yet necessary decision is driven primarily by external market conditions and is not a reflection of the performance or dedication of our team in Addyston."

In recognition of the significant impact this decision will have on affected employees, the company says it is committed to respectfully supporting them through this transition.

Researchers Find Foaming Bioplastics Reduce Environmental Persistence

Scientists at the Woods Hole Oceanographic Institution (WHOI) tested a new version of cellulose diacetate (CDA), a biopolymer derived from wood pulp, and found it to be the fastest degrading bioplastic material to be tested in seawater.

In a paper published October 17 in *ACS Sustainable Chemistry & Engineering*, WHOI scientists Bryan James, Collin Ward, Chris Reddy, Yanchen Sun and Kali Pate describe their finding that foamed CDA material degraded 15 times faster than solid CDA, and even faster than paper.

"What excites me most about this study is its translational nature. This study is the culmination of years of research focusing on understanding the fundamental controls on CDA biodegradation in the ocean," Ward says. Ward served as senior author of the study. He and the WHOI team partnered with scientists from Eastman who contributed as co-authors and supplied materials for the study, with Eastman also providing funding.

The study involved monitoring both foamed and solid CDA in a tank of continuously flowing seawater from Martha's Vineyard Sound at a specially designed lab at WHOI. In this lab, the researchers are able to control the temperature, light exposure and other environmental variables to mimic the natural marine environment. After 36 weeks, the team found that the CDA foams lost 65-70% of their original mass.

According to the study authors, foam CDA is a potential replacement for Styrofoam and other plastic food packaging products that often leak into the ocean environment. Eastman is launching a compostable, lightweight tray made of foamed CDA, designed to replace plastic trays used in existing industrial food packaging.

"Embracing biodegradable materials for consumer goods is a critical step toward preserving our environment, reducing plastic pollution and fostering sustainability for future generations," says Jeff Carbeck, vice president of corporate innovation at Eastman.

SABIC Opens Ultem Resin Manufacturing Facility in Singapore to Meet Asia-Pacific Demand

SABIC announced the official launch of its new $170-million Ultem resin manufacturing facility in Singapore to produce the high-performance thermoplastic Ultem resin. The new facility is a strategic move to support SABIC's goal of increasing global Ultem specialty resin production by more than 50%, responding to the growing demand from high-tech and manufacturing industries in the Asia-Pacific region, including Japan and China.

Supported by the Singapore Economic Development Board (EDB), the new Singapore facility reinforces SABIC's commitment to localize a reliable supply of high-performance materials that support complex and demanding supply chain requirements.

Abdulrahman Al-Fageeh, SABIC CEO says, "We're excited to leverage SABIC's advanced manufacturing capabilities to produce one of the world's most advanced plastics in Singapore. The Ultem resin facility reflects our long-term commitment to the region's high-tech economies and advanced manufacturing sectors, supporting the growth of advanced applications. Singapore's widely networked trade agreements also provide us with competitive access to markets in the region."

Avantium's PEF Receives FDA Food-Contact Approval

The latest news from Avantium, the Dutch technology company developing renewable and circular alternatives to plastic, is that its 100% plant-based, recyclable polyethylene furanoate (PEF) has received Food Contact Notification approval from the U.S. FDA.

Food packaging is among the many applications for Avantium's plastic alternative to PET. The material offers a longer shelf life, which results in less food waste. Under this approval, Avantium's food contact grade PEF can be used as packaging for all food types except for infant formulas, foods with more than 15% alcohol, or human milk. A similar approval has already been received by the company for food packaging in the EU and the U.K.

Avantium's PEF is made of surplus food starch from feedstock such as wheat and corn. The company's flagship plant — designed to manufacture furandicarboxylic acid (FDCA), the main building block for PEF — officially launched this October. The company has already established agreements with brands looking to reserve specific amounts of PEF or the building block material, FDCA, in the future, including global brands such as LVMH, AmBev and Carlsberg.

Yizumi Opens Expanded Facility in Ohio

Yizumi-HPM, the U.S. subsidiary of the global Chinese machinery maker, has expanded operations in Iberia, Ohio, for the second time in seven years, nearly doubling its space to 44,000 square feet from the 28,000 square feet unveiled in 2017 when it moved operations from its longstanding base in Marion, Ohio.

Yizumi Chairman and CEO Richard Yan, who traveled to Ohio for the grand opening event, told *Plastics Technology* that the $11-million investment is in response to continued growth in the North American market, including 2024 when sales have risen 35% at a time when many injection molding machine suppliers have experienced weaker activity. In a presentation, Yan said U.S. revenue is approaching $25 million over the last two years. To further support that growth, the company opened a tech center in Greenville, South Carolina, and purchased land in Guanajuato, Mexico, for a planned facility there. Construction on that plant is slated to start this year and be completed in 2027.

In addition to providing a service center with machine and spare parts inventory, the expanded space will provide technical support, after-sales service, training, and mold testing and validation. Staffing includes 13 local technical service staff, with the company promising next- or same-day delivery for 90% of parts, with more than $2 million worth of parts inventory on hand in Iberia. In total, there are presently more than 30 employees in Iberia.

The new space will also enable the company to keep up to 40 presses in inventory compared to 15 to 20 in the past. The installation of a larger overhead crane, with double the lifting capacity of its predecessor, will also enable Yizumi to assemble full machines in Ohio.

Yizumi acquired the former HPM in 2011, and the company says (not including legacy HPM machines), it has an installed base of more than 200 Yizumi presses in the U.S. The company supplies plastic and rubber molding machines and automation, as well as an industrial 3D printing system, with die casting and thixomolding presses for metal forming.

In injection molding, it offers servo-hydraulic and all-electric machines, including larger two-platen lines, multi-component machines and high-speed systems designed for packaging. In the U.S., Yan said 60% of Yizumi's business is generated via sales of plastic injection molding machines. In 2023, the company generated $576.49 million in total sales, with $239.7 million coming from injection molding, $58.5 million in die casting and $13.5 million in rubber.

Nefab Opens Moldmaking Facility in Michigan

Packaging and logistics supplier Nefab announced that its PolyFlex subsidiary is opening a new, captive toolmaking facility in Grand Blanc, Michigan. This new site will enable PolyFlex to design, prototype and build tooling for injection molded products in one location. This new site pairs with PolyFlex's nearby Farmington Hills, Michigan, location, which specializes in injection molded logistics and transport packaging for the automotive industry.

A Nefab spokesperson explained to *Plastics Technology* that the company specializes in returnable and expendable plastic custom packaging solutions utilizing injection molding, thermoforming and urethane processes. "An example would be a piston has to ship from the Tier supplier to the OEM engine line," the spokesperson explains. "Our packaging would protect the piston during shipment, getting it from the tier to the OEM, and then the empty is returned to the tier supplier to be reused."

Advanced Drainage Systems Opens Engineering and Technology Center in Ohio

Advanced Drainage Systems (ADS), a provider of water management products in the stormwater and onsite septic wastewater industries, opened a $65-million ADS Engineering and Technology Center in Hilliard, Ohio, near the company's headquarters.

"The ADS Engineering and Technology Center is dedicated to product engineering, materials science — including recycled plastics — and manufacturing technologies with the express purpose of developing advanced stormwater solutions that manage water and protect our communities," says ADS President and CEO Scott Barbour. "Bringing our team of engineers, scientists and technicians together in this state-of-the-art facility allows new opportunities for collaboration and innovation in how we design and develop products, materials and manufacturing technologies to meet the stormwater management needs of customers and communities."

The ADS Engineering and Technology Center will include:

- A product development lab focused on the a product's full life cycle.
- A 90,000-gallon, closed-loop recyclable water system enabling ADS to replicate real-world conditions by sending water through products under scenarios the company can alter and control.
- A hydraulics lab that supports ADS' water treatment businesses, including separation, traditional filtration and low-impact development filtration.

Globeius Acquires Plastixs

Globeius (Miami, Florida) has acquired Plastixs LLC (Shrewsbury, Massachusetts), adding the distributor of manifolds, hoses, leak monitors, flow meters and related products. Mickey Blyskal, former owner of Plastixs, will stay on as general manager of the new entity, as will all current Plastixs employees, as they will continue to manage day-to-day operations.

Ernie Sosa, Globeius' president, says the acquisition will expand his company's product offerings and strengthen its position in the industry. Blyskal, who founded Plastixs 25 years ago, noted that both companies have unique strengths and product lines, serving a broad customer base across the U.S., Canada, Mexico, and Central and South America.

Globeius has focused on the import-export of products, giving Plastixs an opportunity to offer its products outside of the U.S. market, particularly in Latin America, a region where Plastixs has not traditionally been active but from where Globeius has grown.

A news release noted that Globeius and Plastixs will sell some common products, but that both companies have special lines they can cross-sell.

Farrel Pomini, Lummus Team on Pyrolysis Technology

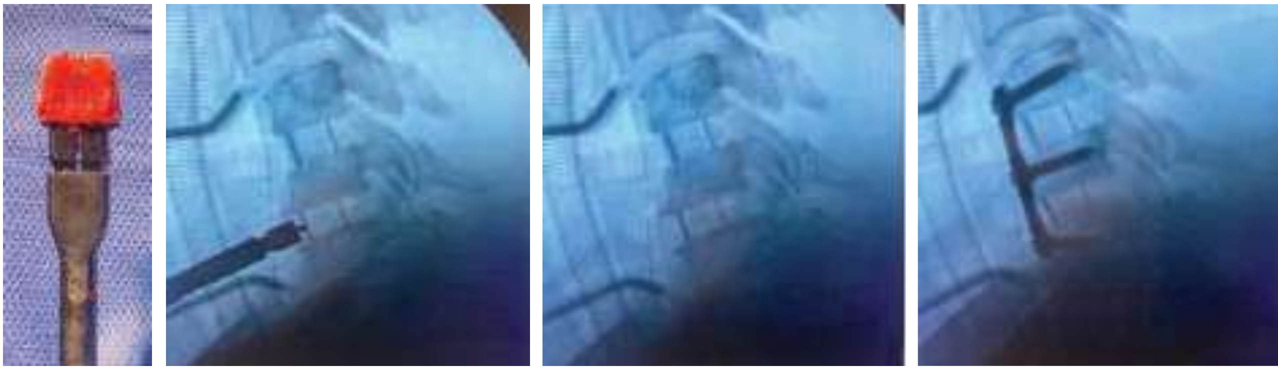
Farrel Pomini is partnering with Lummus Technology to develop a state-of-the-art plastic pyrolysis process.

The partnership is based on FARREL POMINI's Continuous Mixing Technology (photo), the Farrel Continuous Mixer (FCM), which the companies say has been playing an essential role in a pyrolysis process for plastics developed by Lummus. The process takes streams of postindustrial and postconsumer waste and converts them into gas, pyrolysis oil and pitch product. The FCM melts feedstock resins and homogenizes them under specific temperature and pressure parameters before material enters the pyrolysis section of the process. The resulting pyrolysis oil products can be further processed into traditional refining and petrochemical assets, and turned into monomers for new plastics production.

The process' unique vertical reactor design creates a continuous process that ensures the highest quality pyrolysis with the widest range of post-use feedstocks. With no exotic metallurgy required or solid waste to manage, the process is flexible, efficient and cost-effective.

Lummus is a leading licensor of process technologies in clean fuels, renewables, petrochemicals, polymers and gas processing, and supplies life cycle services, catalysts, proprietary equipment and digitalization to customers worldwide.

Through its Green Circle business unit, Lummus provides an array of economically and technically sound products.



Curiteva's 3D printed implants are made from PEEK, a polymer with radiolucency that enables a clear view of healing on an X-ray. Source (All Images): Curiteva

PEEK Spine Implants Now in Production

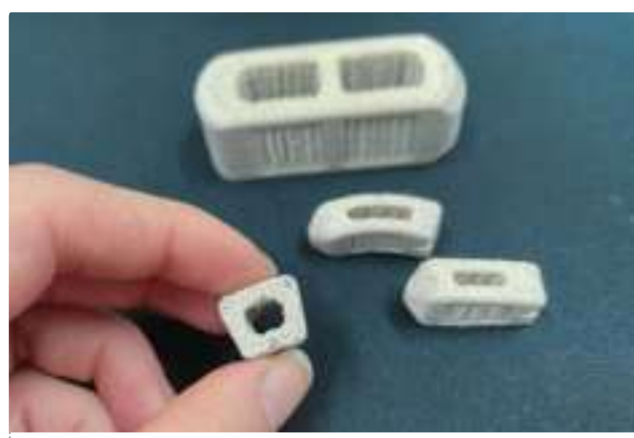
Medical device manufacturer Curiteva is producing two families of spinal implants using a proprietary process for 3D printing porous polyether ether ketone (PEEK).

By Stephanie Hendrixson
Executive Editor, Additive Manufacturing

Polyether ether ketone (PEEK) has been used in medical implants for more than three decades. The thermoplastic offers biocompatibility and mechanical properties similar to bone, making it suitable for spine cages, bone plates, orthopedic implants and more. As an added benefit, the material is radiolucent, meaning it does not appear in an X-ray — making it easier for the surgeon to monitor the patient's healing post-surgery.

But until recently, most PEEK implants were produced through machining or injection molding, which placed constraints on the geometry of these medical devices. Porosity is desirable in many implants, as it can enable the patient's own cells to grow into the device as the body heals, leading to better outcomes. Some porosity can be achieved by compression molding of PEEK, but this process does not enable precise control of the geometry and material properties all throughout the part.

3D printing offers an alternative. Huntsville, Alabama-based medical device company Curiteva now manufactures two different product lines of 3D printed PEEK implants for the spine. Its "Inspire" line of products for cervical and lower lumbar spine features porous structures achieved through lattice-based designs, and compressive strength throughout that is developed through the Fused Strand Deposition (FSD) printing process.



Curiteva achieved FDA clearance for its first 3D printed Inspire device, the cervical spine implant in the foreground, in 2023. In 2024, the company cleared a second family of lower lumbar implants, examples of which are shown here.

A 3D PRINTING PROCESS JUST FOR PEEK

PEEK's semicrystalline structure provides desirable mechanical and thermal properties, but also makes it more difficult to 3D print compared to molding, in which all the material is heated and solidified all at once. To 3D print PEEK, it must be heated a little at a time to temperatures above 400°C so the material can be extruded from the printer nozzle. As the polymer cools after deposition it forms the crystalline structure that provides its strength, a process that can also result in significant warping or shrinkage.

To take advantage of PEEK's material properties and counter their downsides, Curiteva uses a modified form of fused filament fabrication (FFF) or material extrusion 3D printing called Fused Strand Deposition. FSD is a proprietary process that was originally developed by Todd Reith under his company, Fossil Labs. Curiteva, which produces medical implants through multiple manufacturing processes, acquired Fossil Labs and its IP in 2020 in order to use FSD to produce its own products in-house. Reith joined the company as well, and serves as vice president of emergent technologies and additive manufacturing. While FSD is similar to the more common FFF technology, it has been tailored to both enable and take advantage of PEEK's unique material properties.

The PEEK filament undergoes a drying step before it is loaded into the 3D printers to produce implants.

"One of the most difficult things about printing PEEK is the large delta between the glass transition temperature and the melt temperature," Reith says. "The glass transition temperature is around 140 to 150°C, and the melt starts around 350 to 380°C. Because of that, the material wants to move quickly into a crystalline state. We have tailored our technology around the deposition so that we can slow down this crystallization process. We're actually pulling strands, much like you would glass or other materials."

Understanding PEEK and PEKK for 3D Printing

Both materials offer properties desirable for medical implants. Learn about the challenges they pose in 3D printing, and how manufacturers are overcoming them.

While standard FFF deposits filament at a consistent rate and diameter, the company's FSD printers actually stretch the softened PEEK filament as it is extruded. This action enables more control over the crystallization, enables better bonding between layers and gives the polymer strands the chance to properly align themselves, Reith says. The pulled-strand approach also creates tension inside each layer that improves the printed material's strength and durability.

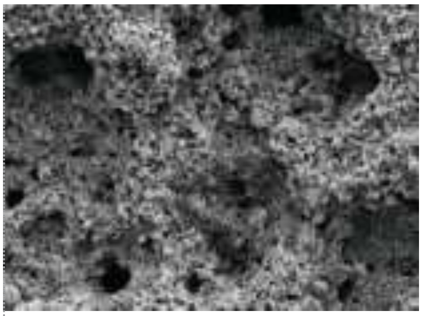
"Each layer can be put in compression," says Erik Erbe, chief scientific officer at Curiteva. "It is a toughening and strengthening mechanism. We achieve a compressive strength six times what is required for physiologic loads because of this 3D printing approach."

The FSD 3D printing process enables Curiteva to take advantage of PEEK's unique material properties as well as apply this polymer in new geometries. The layer-by-layer method of manufacturing enables novel porous structures that can extend throughout an implant, better enabling bone in-growth and healing.

3D PRINTED IMPLANTS IN PRODUCTION

Curiteva achieved FDA clearance for its first 3D printed PEEK product — the Inspire line of cervical spine implants — in 2023. About 30 different sizes and configurations are offered. These devices are used in patients with cervical disc degeneration or cervical spinal instability, and the 3D printed product was ►

3D printing enables each layer to be put in compression as it is deposited through FSD, and also makes possible novel porous structures that support osseointegration.



To support osseointegration, the hydrophobic PEEK recieves a coating of hydroxyapatite (HA, shown here close up) to make it more hydrophilic.

3D printed implant production takes place almost entirely inside this clean room at Curiteva's Huntsville, Alabama, facility. Parts leave to be coated in HA at a supplier, and then return for sterile packaging and storage. Nine FSD 3D printers can support the company's implant production, but the clean room has space for as many as 20 of these machines.

demonstrated to be equivalent to a predicate cervical interbody fusion system that the company machines from PEEK.

Achieving 510(k) clearance for the cervical spine implants took more than 18 months and close collaboration with the FDA because of the new manufacturing method. In the first year since clearance, around 50 surgeons have adopted the devices; more than 2,000 Inspire devices have been implanted in about 1,000 patients (with some having two or more implants), with no revision surgeries.

In early 2024, the company achieved clearance for a second product line of implants for the lower lumbar spine, this one consisting of more than 1,300 SKUs. Because of the groundwork laid with the earlier cervical line, the new lower lumbar implants were cleared in just 57 days.

Curiteva manufactures both spine implant lines at its production facility in Huntsville, Alabama, through FSD printers housed in a cleanroom environment. Each implant is printed one at a time to maintain precise control over its thermal history on FSD machines produced by Curiteva, using PEEK filament from Evonik. After printing, support structures are removed (consisting primarily of a "raft" that holds the part slightly above the build plate) and the parts are cleaned with isopropyl alcohol and annealed for stress relief.

Because the PEEK material is radiolucent and invisible to an X-ray, the next step in the manufacturing process includes machining to finish surfaces and to drill holes in each implant to install titanium marker pins for visibility. (One side effect of 3D printing versus machining PEEK is that there is far less material waste and expense. Curiteva sees only 2% waste from machining of these implants, which means that almost all of the PEEK it is purchasing as filament is used in the final part.) After another round of cleaning and laser marking, parts leave the clean room to depart to a supplier for a hydroxyapatite coating — a step necessary to make the naturally hydrophobic PEEK more hydrophilic, and therefore better able to support osseointegration. Finally, implants return to Curiteva for sterile packaging and are held in inventory until ordered.

Curiteva currently runs two 10-hour shifts per day, five days a week to meet its 3D printing production needs. Its nine production-qualified FSD 3D printers are enough to fulfill demand for the implants at the moment. However, the clean room can hold up to 20 printers, and the company anticipates scaling up in the near future. PT

PEEK Implants on The Cool Parts Show

Episode #63 of our video series on 3D printed parts explores Curiteva's cervical spine implants in detail.

We later caught up with Curiteva again after the clearance of the second device family for this **bonus episode,** focused on manufacturing these devices at scale.

ABOUT THE AUTHOR: Stephanie Hendrixson reports on 3D printing technology and applications as executive editor for *Additive Manufacturing*. She is also co-host of *The Cool Parts Show*, a video series that highlights unique, unusual and weird 3D printed parts, and co-host and creator of the *AM Radio* podcast. Contact Stephanie at: *SHendrixson@AdditiveManufacturing.media*.

AMRs and Cobots Target Inspection, Palletizing and Movement of Finished Goods

The same year it marked its 70th year in business, custom injection molder Hoffer Plastics (South Elgin, Illinois) — which routinely reinvests more than 10% of its annual revenue back into new equipment — prioritized automation in that CapEx with some stunning results.

By Tony Deligio
Editor-in-Chief

"When you look at our investment — our belief in reinvesting in the business — it's ultimately about making people's jobs easier," says Adam VanMeter, Hoffer Plastics automation project manager. "If you look at the way we're leveraging automation, it's really helping from a safety standpoint in ergonomics; we're getting quality improvements; and we're getting delivery improvements."

The company is also getting a productivity gain in its most cherished resource. "It's no surprise labor is tough to come by right now," VanMeter says, "and the labor we have, we'd rather upskill them and use their mindsets and their brains for more productive tasks than moving product around the facility."

Founded in 1953, Hoffer has grown into nine focused factories, covering 365,000 square feet, with more than 350 employees and 114 injection molding machines, running 24/7. The sprawling layout is not conducive to using fixed automation like conveyors for moving product around. The company has long deployed more traditional Cartesian robots to remove parts, runners and sprues from presses, but now it's finding uses for less traditional modes of automation, recently investing in autonomous mobile robots (AMRs) and collaborative robots (cobots), which together handle everything from inspecting parts to filling, palletizing and transporting boxes.

Hoffer Plastics deploys custom-designed autonomous mobile robots (AMRs) to ferry finished goods around its facility. Source (all images): Hoffer Plastics

"We're using automation such as autonomous mobile robots to move that product around and have our employees focus on more value-added activities as opposed to assembling boxes or putting them on pallets," VanMeter says.

The automation saves Hoffer's employees from lifting between 1.5 and 2 million pounds.

Hoffer's production includes several lines of proprietary products, and it targeted its Trust-T-Lok manufacturing line with multiple automation investments that have saved it more than 55,000 hours of manual labor. These include application of a cobot to provide inspection. This job was chosen based in part on its prolific production — 5,500 run hours annually across six injection molding machines. Previously, all that output would have been measured and inspected by hand. In the new automated scheme, the inspection is completed over the course of about four hours daily. Under the new process, Hoffer employees undertake a quick visual inspection; place parts into a tray that tracks cavity location; load the tray into a customized machine; start the program; and "walk away," VanMeter says. "They don't have to go through each part and measure the four or five different dimensions on each part because the robot takes care of all of that."

Here, the cobot's end effector acts as a caliper as well, gripping the part and simultaneously measuring it. Placing parts in different orientations, the cobot takes the measurements with that data exported to a CSV file. Because the product requires 100% inspection, these automated cells not only save Hoffer a tremendous amount of time and worker hours but also provide additional benefits. "In addition, the technology is becoming so much more advanced," VanMeter says. "These cameras are able to process the information so much faster without impacting our cycle times. That's where we've already achieved quite a bit of savings and continue to see a lot of opportunities going forward. The use of vision systems in-line in our assembly process is something that we continue to stress and implement wherever there's a practical return on investment."

PRODUCTION ON THE MOVE

As Hoffer sought out other operations where its workers were using more brute power than brain power, its attention settled on boxes — empty boxes that needed be filled and filled boxes that needed to be moved and palletized. In addition to deploying another cobot for palletizing of filled boxes, it added AMRs to simultaneously ferry filled and unfilled boxes to and from production and shipping.

The customized AMR consists of two layers, with the bottom layer storing full boxes for transport, while the top layer carries empty boxes. When in use, the AMR goes to the production cell to drop off the empty boxes in the front of the cell and then heads to the back of the cell to pick up the full boxes and deliver them to the palletizing cells.

Production is captured at the press by Hoffer Plastics' custom automation system.

The end effectors on this cobot serve double duty as grippers and calipers, measuring key dimensions of parts as it moves them.

Before the AMRs ever traveled through Hoffer, VanMeter and his team had to go through the facility with them and map out the floor. Once the AMR has the proverbial lay of the land, there's some initial instruction, but then there's basically full autonomy. "You have to program it step-by-step on what you want it to do," VanMeter says, "but you don't actually have to tell it where to go. You just tell it what you want it to do, and through the map and through what you programmed, it will find the most advanced, most effective route to get there."

The programming itself is also straightforward, according to VanMeter. "The programming is not crunching numbers at a keyboard," VanMeter says, "no scripting for the basic stuff. It's just selecting actions in the manual and telling it what you want it to do."

Individually, the production and boxes themselves are relatively light, but the aforementioned scale of the output raises the collective output to a different level. "We talk about an employee lifting a box or putting it on a pallet, and it doesn't seem like that much," VanMeter says. Over the course of a year, however, Hoffer calculated that the automation was going to save its employees from lifting between 1.5 and 2 million pounds. "I mean, it's astronomical," VanMeter says. "It really, really adds up."

MORE TO COME

Going forward, Hoffer has a Phase 2 for the project planned where it will automate the pickup and movement of finished kits for another job to set locations within the warehouse. In addition, it's also planning another automated QC vision inspection, with plans in 2025 to automate a different plant. That includes working with its customer to standardize on a box used to package production. "Standardizing with our customers on the box size will let us take full advantage of the automation," Jeff Klabunde, Hoffer's vice president of operations, says. "It's a win for them, a win for us and it's just going to make us that much more efficient."

Working alongside a new cobot inspecting parts or palletizing boxes, or passing a fully loaded AMR in a shopfloor aisle, VanMeter says Hoffer's employees are becoming more familiar, and welcoming, to their newest colleagues. "The vast majority of our employees have welcomed the automation with open arms," VanMeter says. He's been particularly impressed with the off shifts and their willingness to learn.

Klablunde says VanMeter's efforts to train multiple employees on each shift on how to perform important functions like resetting the robots has helped with buy-in and eliminated another time-consuming task from the employees' duties. Formerly the third-shift production supervisor for one of Hoffer's plants, VanMeter appreciates the steady efficiency the new automation brings.

"The automation has really allowed us to remove some elements of what I would refer to as 'firefighting' that we previously did," VanMeter says, "and now if our team members aren't firefighting, that gives them the time to do more continuous improvement, and it feeds upon itself, this continuous improvement engine, generating more and more productivity and efficiency gains." PT

Injection Molded Enclosures Plug into Potential Electric Vehicle Battery Applications

In partnership with material suppliers, Engel is proving out injection molded thermoplastic-based concepts for electric vehicle battery housings, utilizing production tools and dedicated machines at its large press factory in St. Valentin, Austria.

The tray features ribs and 37 metal inserts, and five standard fasteners molded into a single component. Source: SABIC

By Tony Deligio
Editor-in-Chief

In addition to exhibiting at The Battery Show this October in Michigan, Engel held an open house in Austria with stakeholders in November to show its progress toward replacing steel and aluminum in the emerging application of electrical vehicle (EV) battery enclosures.

Michael Fischer, Engel's business development manager for electrical mobility and smart panels, cites LMC Automotive's (now GlobalData Plc's) market forecasts to highlight the coming acceleration for the market. The powertrain composition ratio for global light vehicle sales report from GlobalData forecasts that the market share of internal combustion engines (ICE) will drop from 65.6% in 2024 to 22.3% by 2036, with battery electric vehicle's (BEV) share rising from 12.6% to 52.9% over that same time period. When you mix in plug-in hybrid electric vehicles (PHEV) and full-hybrid electric vehicles (FHEV), the potential is even greater. "What do all these — BEV, PHEV, FHEV — vehicles have in common?" Fischer asks, "They need to store electrical energy for the motors."

Battery enclosure tray and cover on display at moldmaker Siebenwurst showcasing the scale of the parts. Source: SABIC

As a proof of concept, Engel, in collaboration with material supplier SABIC and sustainable product development firm Forward Engineering, developed an OEM-specific, high-voltage battery enclosure (HVBE) based on one already in production for Volkswagen's ID.4 electric sport utility vehicle. "The goal is to deliver an innovative, cost-effective and flexible scale solution for future EV battery enclosures," Fischer says.

This concept HVBE consists of a three-piece structure, including an injection molded cover and tray affixed to a structural steel underbody panel. The top cover is composed of three primary elements in a sandwich design in which a 1.9-mm thick layer of flame-retardant Stamax PP material is molded between two 0.3-mm organosheets inserted onto the A and B halves of the tool, which was built by Christian Karl Siebenwurst GmbH & Co. KG (Dietfurt, Germany).

Run on an Engel Duo 5500 combi M at the company's tech center in St. Valentin, the cell utilizes an easix 6-axis robot with a dual-sided end-of-arm-tool (EOAT) to pick up two 50% glass-filled polypropylene (PP) organosheets and place them on either side of the tool, with the Siebenwurst mold holding the sheets in place and maintaining space between, which is then filled by a 7.5-kg (16.5-lb) shot of UL-verified flame-retardant Stamax PP from SABIC.

Around the outer edge of the finished part, there's only the molded Stamax, while the rest of the 9-kg (20-lb) component features the sandwich structure. In the field, the top cover is tasked with containing any potential thermal runaway of the battery, preventing any potential fire originating in the cells from spreading through the vehicle. Specifically, the material must withstand the UL 2596 thermal runaway test. SABIC has proven out that a 4-mm thick sheet of flame-retardant Stamax 30YH570 can pass the test, which combines pressure, ablative force, heat and fire, with temperatures up to 420°C and internal pressures of 250,000 kPA (36,000 psi).

Trials with the mold and process began in August, and Engel outfitted the Duo 5500 combi M with a third injection unit for flexibility in future trials. For this process, the machine utilizes a 190-mm (7.5") diameter screw with an L/D ratio of 25.

This cover goes over the injection molded tray, which features ribs and molded-in fasteners for mounting connections and load transfer to the car's underbody panel or body in white. Fischer says the basic concept for the tray was to integrate as much as possible into a single molded component. To that end, the design features 37 metal inserts and five standard fasteners that are insert overmolded into the final part. Automation is used to load the inserts and fasteners into another Siebenwurst tool. Testing on the tray, which has a design that features molded-in cooling circuits for the battery, has been running since April 2024, utilizing an Engel duo 4000 press.

While steel and aluminum currently dominate the sector, Fischer does point out some thermoplastic encroachment in the space. Specifically, Lucid Motors' Lucid Air BEV features a one-shot insert-molded module housing, featuring insert molding of a contactor plate and applying a 20% glass-filled Lexan 3412ECR polycarbonate (PC) from SABIC. This component is molded by Plastikon Industries. Fischer and Engel maintain that thermoplastic enclosures — particularly when multiple components and features are integrated via molding in one shot — provide an attractive cost position for OEMs and their suppliers. In addition, if the carbon footprint of aluminum and thermoplastics are weighed in these parts, PA has 2.1 kg of CO_2 equivalent for a kilogram of material, while cast aluminum comes in at 6.8 kg of CO_2.

WHAT'S REQUIRED

The opportunity is big both in the potential quantity of parts, but also in the individual size of these components, with Fischer saying future enclosures will measure 8 by 5 feet — a challenge to mold with the simplest materials. "We're talking about shot weights that are going up to 75 kg with different, heavily filled materials," Fischer says. These include PP and polyamides (PA), filled with glass fibers in ranges from 30 to 50%. Parts going up to 3 square meters in size, would require clamp forces up to 11,000 tons.

Siebenwurst built the molds for the battery tray (pictured) and cover. Source: Siebenwurst

In addition to its validation and research work with SABIC and Forward Engineering, Engel is also collaborating with Envalior on battery housing concepts, targeting PA structures, as well as fully or partially integrated organosheets or UD tapes, metal inserts for connections and integrated ribs for impact resistance.

In addition to outstanding mechanical properties, many of these materials and components will need to offer electromagnetic shielding (EMS) and flame-retardant (FR) capabilities. For the trays the hold the battery cells, long-glass fiber PP with FR V0 rating would be the base materials, with UD tapes, rods and organosheets applied as needed. The module housing and control box would use glass-filled PC and short-glass-fiber-filled PA and PP. Here too, the components need FR V0 rating and EMS. For the cover and the tray, postmold behavior, including potential warpage, must be considered. Fischer says in addition to helping meet the FR requirements, the organosheets also alleviate potential warpage.

PLASTICIZING CONCEPTS AND PROCESS REQUIREMENTS

Fischer says a standard 3-zone screw for materials reinforced with short glass fibers can be applied, while for long glass fiber materials (like SABIC's Stamax), screws with geometries especially designed for maintaining fiber length should be used. He adds that two injection units for these parts can provide more flexibility and, given the shot volumes that need to be prepared, keep screw diameters in more conventional ranges.

As another means of maintaining longer fibers, Fischer says a two-stage process — where glass fibers are added into the melt in a second screw after a primary screw has prepared the materials — is an option. Engel's own internal tests of such a 2-stage process showed significant increases in fiber length compared to single-stage plasticization, with fiber lengths measured after the nozzle. Fischer notes that this two-stage concept also opens the door for the introduction of regrind and recycled material into these parts. In terms of injection pressure, forces equal to or greater than approximately 22,000 psi are need with a metering stroke of 1.5 to 2D, or one-and-a-half-to-two-times the screw diameter. Use of a sequentially valve-gated hot runner system, with cascading injection across multiple gates, is also suggested.

"Based on testing, Engel remains open material wise," Fischer says. "I personally believe it must be cost-effective and fulfill all the needs from the OEM. We're preparing for all relevant materials. Different materials will have different properties, and these will be reflected in the design."

INJECTION MOLDING

PART 1 OF 2

Bulk, Solid and Melt Density: How to Calculate These Values and Why They Matter

How much resin is contained within a bucket, gaylord or hopper? That depends on the bulk density — a figure you need to learn how to calculate due to its impact on everything from storage and conveying to drying and molding.

Knowledge of three types of densities related to plastic material is required in injection molding. These types are: bulk density, solid density and melt density. This two-part article will discuss each of these and provide an easy way to calculate these densities. As a basic definition, density is quantified as how closely the molecules of the material are packed together. The closer they are, the higher the density or, in other words, there are more molecules in a given volume. The measuring unit is weight per volume, which is discussed below.

By Suhas Kulkarni

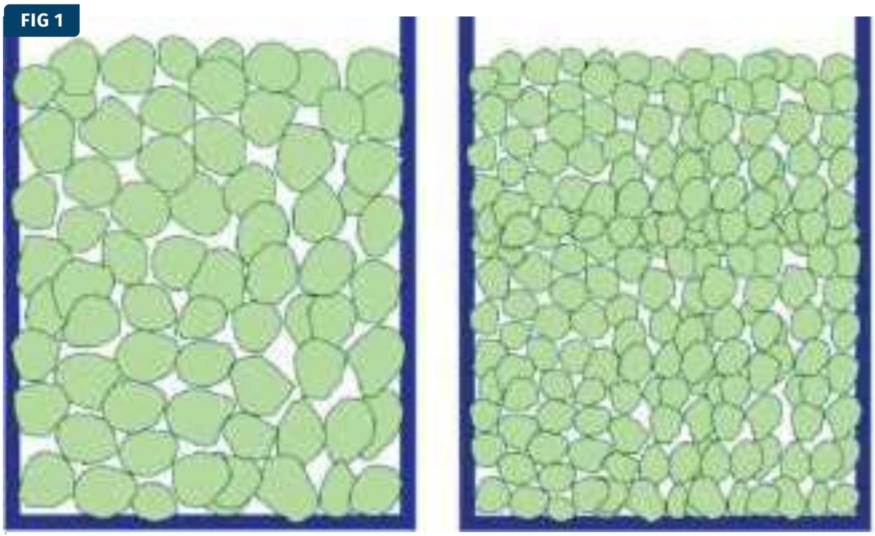
Bulk Density: Resin is usually supplied in pellet form from the material supplier. These pellets can have different shapes, ranging from spherical beads to somewhat flattened beads to simply cut extrudates forming small cylinders. The bigger the pellets are, them more empty space there will be between them. The size therefore causes a difference in the total weight of the plastic in a given volume. For example, consider the same grade of ABS supplied in smaller size and larger size pellets as shown in Figure 1.

The weight of the total plastic with the smaller pellets will be more than the one with the bigger pellets. Please note that this is true with pellet sizes used in injection molding, extrusion, blow molding and similar processes but should not be used for any materials supplied in any other form.

Bulk density is defined as the amount of raw material present in a given volume and is most commonly measured in pounds per cubic feet (lb/cu ft) or kilograms per liter (kg/l). The reason for these units will become clear after an explanation of why bulk density is needed. Bulk density is also given in grams per cubic centimeter (g/cc), but that can often be confusing and also not very accurate when used in calculations — think about the number of digits required after decimal place. The method of calculating the bulk density is very simple.

- Take a container, such as a bucket, and calculate its inner volume.
- Weigh the container.
- Fill the container with plastic pellets and weigh the container again.
- Calculate the weight of the plastic pellets by subtracting the empty container weight from the full container weight.
- Divide the weight of the pellets by the container volume to get the bulk density value, so that: Bulk density = Weight of the plastic / Volume of the container.

FIG 1



The weight of plastic will change based on the size of the pellets. Source: FimmTech

As an example in Figure 2, a bucket with a diameter of 11.5 inches was filled with acrylic pellets to a height of 12.5 inches. Using the formula:

V = 0.785 × D × D × H

where D is the inner diameter of the bucket and H is the inner height of the bucket, the volume of the filled bucket is 1297.7 cubic inches or 0.75 cubic feet. After

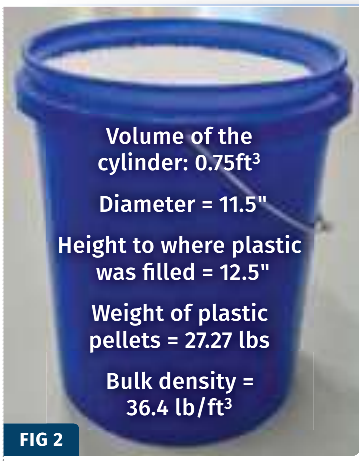


FIG 2

Based on the size of the pellets, the weight of the plastic will change.

the weight of the bucket was subtracted from the weight of the bucket full of plastic, the weight of the pellets was calculated to be 27.27 lbs. Based on the calculation above, the bulk density of these pellets is 36.4 lb/ft^3.

The size and shape of the pellets play a major role in bulk density. There is no correlation between the bulk density and solid density of the material. (We will be discussing solid density in the next part of this two-part series.) The value of the bulk density is an important number to consider when sizing hoppers, dryer hoppers and storage silos. Every hygroscopic resin has a minimum and maximum recommended drying time. Based on the required throughput per hour, a calculation will be needed to have a minimum and maximum size (volume) of the dryer. Here the bulk density should be used for the calculation. Dryer manufacturers will size their equipment based on bulk densities.

Gaylords are of standard sizes and a material manufacturer needs to know how many gaylords will need to get shipped to a customer to deliver a certain amount of material. If the customer orders 1,000 pounds, then the lower the bulk density means the higher the number of gaylords that will be required, with the reverse true as well. Transportation costs could get impacted, as will the storage space required in the warehouse.

Pellet sizes are very important for the conveying of the resin not only through the lines from the dryers to the machine feed throat but also for feeding into the machine and on to the feed zone of the screw. Consider micromolding machines where screw diameters can be as small as 15 mm. The pellets must fall into the feed section via gravity and then get conveyed further. A larger pellet size may not fall all the way into the feed section causing blockages and/or inconsistency in molding. In the second part of this series, we will discuss solid density and melt densities. PT

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EXTRUSION

What You Need To Know About Melt-Temperature Measurement in Single-Screw Extruders

Measuring the discharge temperature is not so simple, especially when using thermocouples positioned in the transfer line just upstream of the die.

By Mark A. Spalding

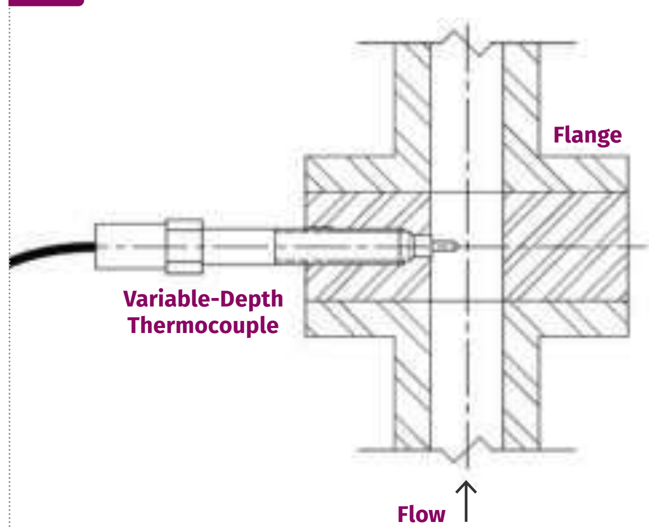
To be profitable, a single-screw extruder must operate at the maximum rate while discharging at a specified pressure and temperature. Measuring the rate and discharge pressure from an operating extruder is easy and straightforward. Measuring the discharge temperature, however, is not so simple, especially using thermocouples positioned in the transfer line just upstream of the die. This configuration is used widely for commercial extrusions. The difficulty occurs due to the high thermal conductivity of the surrounding metal and the low thermal conductivity of molten resins.

A variable-depth thermocouple positioned in a transfer line and through a flange is shown in Figure 1. The thermocouple measures the temperature at the junction at the tip of the probe. The temperature at the tip of the probe depends on thermal conduction and convection in the local region. Thermal conduction depends on the thermal conductivity of the material.

The transfer line should not be used as a method to decrease the discharge temperature from an extruder.

Metals typically conduct heat very well and have a high thermal conductivity, while polymers are good insulators and have very low thermal conductivities. The sheath of the probe is typically made from stainless steel while the transfer line is constructed from carbon steel. The thermal conductivity for stainless steel is 17 W/(m °C) and for carbon steel it is 52 W/(m °C). The molten plastic flowing in the transfer line, however, has a thermal conductivity of about 0.25 W/(m °C). (W/(m °C) is the unit of measure for thermal conductivity.)

FIG 1



Schematic of a variable-depth thermocouple positioned in a flange of a transfer line. Source: Mark Spalding

Thus, the thermal conductivity for the surrounding metal is between 70 and 200 times higher than that for the molten resin. Because of this wide difference in thermal conductivities, the junction of the thermocouple is highly influenced by the transfer line temperature and to a lesser level from the molten resin.

Scan for more expert advice in extrusion.

This measurement problem is clearly identified with a series of experiments. These experiments were performed using a 1.25-inch diameter single-screw extruder connected to a 25-mm diameter transfer line. The conditions of the extruder were held constant with a rate of 15 lbs/hr. of LDPE at a screw speed of 60 rpm. The transfer line pipe was maintained at either 183°C or 220°C.

The temperature profile of the flowing resin in the transfer line was measured using a plastic bridge constructed using a high-temperature resin (not shown). The bridge was positioned across the flow stream, and it was designed to eliminate energy conduction through the thermocouple device. It was positioned in the middle flange in Figure 1. Thus, the bridge device contained several thermocouples and measured the actual temperature of the flow, and virtually eliminated the thermal conduction problem.

The bridge was too fragile to be used in commercial operations. The transfer line carbon steel pipe was controlled at a temperature of 183°C. The radial temperature profile from the bridge device is shown by the "actual profile" line in Figure 2. Here the profile is parabolic with the lowest temperature being at the wall at 198°C, and the temperature at the center of the pipe at 233°C. This profile occurred because the extruder was discharging at a temperature near 233°C, and the transfer line was in a cooling mode with the pipe temperature at 183°C. The flow velocity in the downstream direction was parabolic and symmetric to the pipe axis.

Polymers are good insulators and have very low thermal conductivity.

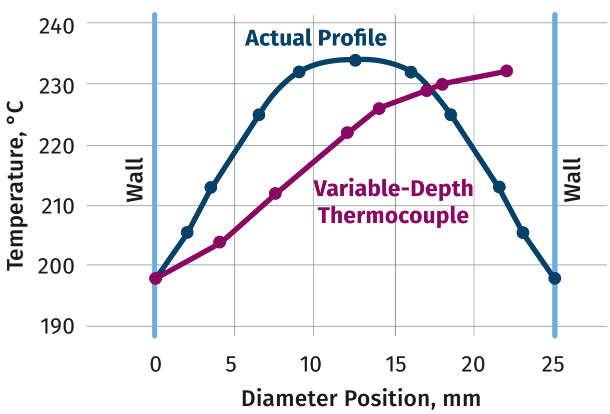
Next, a variable-depth thermocouple was positioned in the transfer line as shown in Figure 1. The temperature at the junction was measured as a function of the insertion depth, as shown by Figure 2. Here, the measured temperature increased as the probe was inserted deeper into the transfer line. The maximum temperature was at an insertion depth of 22 mm at 232°C. Commercially, melt temperature measurements are obtained using probes that are flush mount to the wall. For this experiment, the temperature near the wall was measured at 198°C. This measurement is clearly in error as the bulk of the material is at a temperature near 233°C.

Moreover, the actual temperature from the bridge device at 22 mm into the stream was measured at 213°C. A high level of thermal conduction through the sheath of the variable-depth thermocouple, however, provides an incorrect measurement at

232°C at the probe junction. At 22 mm into the stream, the conduction through the sheath, however, provided a good estimate of the bulk temperature. Insertion of a thermocouple 90% across a flow stream is commercially impractical, especially for larger diameter pipes. The forces from the viscous flow can be high enough to bend the probe.

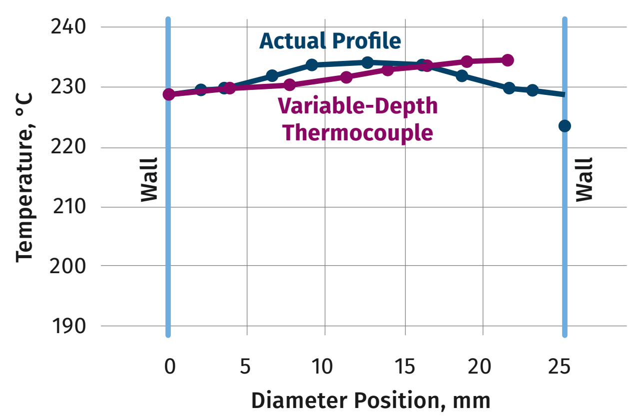
ature profile was parabolic with the maximum temperature of 234°C at the center. The profile is considerably flatter than that shown in Figure 2 with a pipe temperature of 183°C. It is obvious that the thermal gradients are very small. A pipe temperature of 220°C did not induce the high level of cooling that was observed for a pipe temperature at 183°C.

FIG 2



Actual temperature profile and the profile measured using a variable-depth thermocouple positioned in a transfer line. The transfer line pipe was controlled to a temperature of 183°C.

FIG 3



Actual temperature profile and the profile measured using a variable-depth thermocouple positioned in a transfer line. The transfer line pipe was controlled to a temperature of 220°C.

The transfer line pipe temperature was then increased and controlled at 220°C. The operation of the extruder was unchanged and thus the extrudate should be at the same temperature as before. The actual temperature profile was measured using the bridge device and it is shown in Figure 3. The inside wall temperature was 229°C, and the actual temper-

The variable-depth thermocouple measurements were nearly linear from 229°C at the wall to a maximum temperature of 235°C at a depth of 22 mm. For a commercial transfer line with a flush-mount thermocouple, the temperature would be reported at 229°C, a temperature close to the bulk temperature of 233°C. A variable-depth thermocouple that would be inserted 4 mm into the flow would report a temperature of 230°C. The probe experiences less thermal conduction from the transfer line pipe, and it provides a better measurement of the resin flow.

The transfer line should not be used as a method to decrease the discharge temperature from an extruder. As shown in Figure 2, a considerable level of thermal gradients was developed in the flowing resin during cooling. The gradients will affect the viscosity of the resin and possibly distort the shape or thickness of the product coming out of the die. Instead, the transfer line should be controlled near the bulk temperature of the extrudate, minimizing thermal gradients at the die. Because the bulk temperature of the extrudate is typically not known, it should be occasionally measured using a handheld thermocouple in the extrudate exiting the die. The transfer line pipe temperature should be controlled near this temperature.

> ***Measuring the melt temperature using a thermocouple positioned in a transfer line is standard in the industry.***

Measuring the melt temperature using a thermocouple positioned in a transfer line is standard in the industry. Even though the method can provide measurement errors, it is used because it is simple, low cost and safe. Many times, the melt temperature can be measured using a handheld thermocouple probe by sticking it into the extrudate stream. It can take a minute or more to get the probe at the temperature of the extrudate. Sometimes the downstream equipment such as rolls can prevent the safe measurement of the extrudate. In this case, the extrudate temperature should be measured using an infrared (IR) gun.

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TOOLING

Best Practices for Engraving Cores and Cavities

Consider depth, font style, artwork size, polarity and location when engraving.

Engraving encompasses lettering, lines, ornaments, logos and other types of identification or other markings of a plastic part.

Bruce Catoen

Engravings in the mold represent a one-time cost. So, in the long run, the cost of the finished product is less than the cost of applying labels to the molded product or printing the parts. However, an engraving on the molding surface will have limitations such as color, depth, size and location (see Figure 1).

If labels are applied in a separate operation, add this cost to the product's cost. In-mold labels are vibrant in color but slightly more expensive than standard multicolor dry offset printing. In either case, the cost of the labels (or ink and additional equipment) must be added to the part cost.

Remember that the same product could be used for different end-user applications. For example, containers of the same size could be used to sell different chemicals to different manufacturers. In both cases, applying labels after molding would make more sense rather than changing mold components for a different engraving.

Whether to use engraving throughout, labels alone or a combination of both should be decided based on the quantities of pieces to be produced and the required flexibility in each case. As a general guideline, the cost of the molded product increases approximately as follows:

- Engraving: Negligible amount
- Printing: By five to 10%
- Labeling: By 15 to 30%

Assuming the decision has been made to engrave the parts, the following rules of thumb and best practices should be considered when engraving your cores and cavities.

FIG 1

Example of engraved products. Source (all images): Carl Hanser Verlag Munich

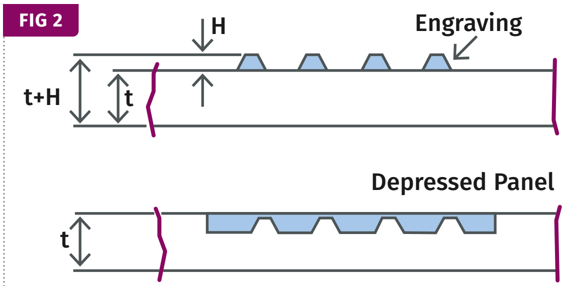
DEPTH

It is important to understand engravings that are to appear depressed (appearing engraved) in the surface of the product are created by raised features in the mold. Conversely, raised features in the product are created by depressed (engraved) features in the mold. It is fairly easy to engrave into a steel surface, but very time-consuming and costly to create engravings projecting from a surface.

The only time it may be necessary to have the engraving depressed in the product is when the lettering will be filled with paint after molding for better readability, special effects or artistic designs, usually associated with high-quality products, such as cosmetics containers.

Engravings should be no deeper than H=0.25 mm (0.01 inch). The width of the engraving should be 1.5-2 × the depth, and the engraving should have an angle of 30 degrees on all walls for ease of ejection and visibility (see Figure 2).

FIG 2



(Top) Raised engraving on top of a product. (Bottom) raised engraving in a depressed panel. t = Wall thickness of the product; H = Height (depth) of engraving.

FONT STYLE AND SIZE OF ARTWORK

To be readily legible, the minimum size of molded-in lettering is eight points, but six points could be used in exceptional cases. The recommended depth is 0.08 to 0.13 mm (0.003 to 0.005 inch).

In all cases of engravings, it is also important to consider the cost of removing the burrs (by hand or mechanically) after cutting the steel to prevent unsightly, fuzzy outlines of the engravings on the molded products.

POLARITY

We shall define positive engraving as any engraving that will appear readable to the user. Negative engraving is the inverted image, for example, as ordinary lettering would appear in a mirror. Most engravings are viewed from the outside of the product (top, side or bottom), regardless of whether the plastic is opaque, transparent or translucent. In all these cases, the engraving must be negative to appear in the molded piece as readable (positive).

This is important where the features of the engraving may not be so obvious, such as the case of logos or trademarks, which may appear to the casual observer as symmetrical but may have some asymmetrical features, which the user must see in the proper orientation (polarity).

In some products molded from transparent or translucent plastics, the required lettering or marking could be molded on the inside of the product so the user can read it through the plastic. In these cases, the engraving must be positive in the mold steel (see Figure 3).

FIG 3

Gate pad engraving in steel and in the bottom of a molded container.

LOCATION SELECTION

The product designer usually places the lettering, lines or symbols at locations where they are best suited for the end user, but occasionally, such engravings could be difficult for the moldmaker to produce in the location specified. This could be where engraving inside a pocket in the mold would be difficult or even impossible and would require inserts or EDM with special electrodes.

In some cases, the engraving could be too close to the edge of the mold steel, thereby increasing the risk of early failure of the mold steel due to stress cracks. A minimum of two mm between any engraving and the edge of the mold steel is suggested.

WALLS AND BOTTOMS OF PRODUCTS

Engravings can be on the cavity wall or on the core (they could also be on inserts in either the cavity or core). In either case, the engraving must be designed so the part will easily be released from the cavity during mold opening and ejected from the core.

OUTSIDE OF THE PRODUCT (ENGRAVED CAVITIES)

Containers usually require markings on the outside of the sidewalls or in the bottom. Markings at the bottom are often required to show trademarks, patents, product identifiers, batch identifiers, dates of manufacture or others. Engravings on the sides are ►

occasionally required (usually with transparent or translucent plastics) to indicate liquid levels inside a container.

Engraving into the bottom of a cavity is usually not difficult to manufacture, especially if most of the bottom of the cavity is an insert in the cavity block (Figure 3). Alternatively, it is not too difficult or costly if inserts with the required engravings are placed either in the solid cavity bottom or within a large cavity bottom insert (creating inserts within an insert).

However, serious challenges can arise when laying out the cooling circuits in such complex cavity bottoms. Good cooling in the gate area is very important for fast molding cycles, and inserts make it more difficult to lay out efficient cooling channels. A poorly cooled cavity bottom, especially near the gate, will result in a longer molding cycle.

FIG 4

Tumblers engraved on the outside.

In this case, the preferred method is to have a solid insert for much of the cavity bottom. If changes are required in the engraving, changing the bottom is not too difficult or expensive. However, this may result in having and storing several different bottoms for the cavity for the various applications or end users of the product, which are also costs to be considered.

Mechanical engraving in the bottom of deep cavities is difficult because long, unsupported engraving cutters must operate at a slower speed for the required accuracy and cleanliness of cut. Long EDM electrodes can be used, although they are slow and expensive. However, this method has the advantage that it can be done even after the cavity is finished.

As it cools inside the mold, the injected plastic shrinks away from the cavity wall. If the depth of engravings into the cavity walls is not too deep, there is usually no problem with ejection. As the product shrinks toward the core, it will not hang up in the cavity as the mold opens.

However, the clean withdrawal of the molded piece from the cavity also depends very much on the draft angle of the sidewall, the wall thickness of the product in this area and the type of plastic used.

Any engraving (by chip removing or EDM) in the sidewall inside a cavity, especially in a small one, is very difficult and expensive. Shallow engravings burnt with EDM are easier to achieve. Still, there is the problem of matching the engraved electrodes to the shape (curvature) of the cavity wall so the depressions created with EDM are uniform both in depth and appearance, and do not exceed the critical depth beyond which the product cannot pull out of the cavity. The suggested maximum depth is 0.1 mm (0.004 inch) or even less for difficult cases, such as those explained in the following points.

Walls with heavier thickness enable deeper engravings because they shrink more and let the product withdraw more away from the cavity. The greater the shrinkage factor, the easier the engraved portion pulls away from the cavity.

The greater the taper of the sidewalls, the easier the product will pull out of the cavity. Engravings in sidewalls with tapers of less than approximately 5 degrees are more difficult to withdraw than from walls with larger tapers.

Hard plastics such as PS will offer more resistance than more flexible plastics such as PP if they are caught by the edge of too deep a depression. This will show up as drag marks on the part. However, many molds successfully produce even thin-walled PS products with decorations on their outside walls.

The angle and shape of the sides of the engraving within the cavity's sidewall must offer little resistance as the mold opens, and the edge of the engraved projection in the product slides past the engraved depression in the sidewall.

Any deeper engravings in the side walls or where there is not enough draft angle will require the designer to place the engravings either on moving side cores in the cavity or on split cavities. Both methods would require more space and much larger molds and add considerably to the mold cost. Such molds will usually also potentially produce more scrap, require longer molding cycles, and thereby increase the cost of the product even more.

Figure 4 shows heavy-walled tumblers engraved with an artistic pattern on the outside, produced by engraving (texturizing) the inside of the cavity. This engraving is not deep enough to require a split cavity.

INSIDE OF THE PRODUCT (ENGRAVED CORES)

Engravings on the sides are often required with transparent or translucent plastics — for example, to indicate liquid levels inside a container (measuring cups, vials and more). The markings are usually lines indicating the proper height and lettering to identify the values. Such products are made mostly from clear PS, SAN, acrylic or PC with low shrinkage factors. This makes it relatively easy to calculate the dimensions where the measuring lines should be located. If such products are made from high-shrinkage materials, such as PE or PP, the high shrinkage factor makes it more difficult to predetermine the proper location for the level markers.

In such cases, especially if the accuracy of the measuring lines is important, it may be necessary to finish the mold first, complete with the lettering, but to engrave the measuring lines only after the mold has been tested and run on an optimal cycle because the volume of the container can vary substantially when operating at different operating conditions of the mold.

> ***"Engravings in the mold represent a one-time cost. So, in the long run, the cost of the finished product is less than the cost of applying labels to the molded product or printing the parts."***

Except for very stiff plastics (such as PS, SAN or PC) — or sometimes for air ejection of softer plastics — lines and lettering on the core present fewer problems because the plastic will stretch during ejection and let the plastic slide out of the engravings. This is possible because the cavity has already moved away from the product at the time of ejection, and there is ample room for the plastic to stretch during ejection.

However, the deeper the engraving, the more important it is to ensure the sides of the engravings are tapered and/or rounded sufficiently to enable easy sliding out of the engravings. The draft of container sidewalls can be quite small. A 1-degree taper could be acceptable, as long as the engraving is not too deep and the side of the engraving in the direction of the ejection is smooth and chamfered or rounded.

Engraving into the side of a core is usually not difficult to achieve. The depth should be 0.1 mm, but less is recommended for small draft angles (less than 1 degree) of the core. While it is feasible to produce raised engraving on the core, it is extremely difficult to machine and then finish the molding surface of the core, and the mold would, therefore, be very expensive.

The top of the core can be a good location to engrave the cavity number. This is easy to produce and is frequently done in technical products and enclosures. The designer must be sure it can be easily read. If it is to be read from the inside, the engraving must be negative, whereas if it is to be read from the outside (through the plastic), the engraving must be positive.

Using these simple suggestions and reminders can make the markings on your mold effective, eye-catching and low-cost.

Note: This article is based on information from the "Injection Mold Design Handbook," Carl Hanser Verlag Munich, 2021. To learn more practical tips and guidelines for good mold design, visit *hanserpublications.com* or Amazon.

ABOUT THE AUTHOR: Bruce Catoen has more than 35 years of experience in the plastics industry and served as the chief technology officer for Milacron and Mold Masters, and as a senior executive at Husky Injection Molding Systems. Catoen is the named inventor on more than 50 patents and is the author of the books "The Injection Mold Design Handbook" and "Selecting Injection Molds." Through his consulting business, OASIC consulting, Catoen advises clients on technology developments, business strategy, leadership and acquisitions. In addition to consulting, He also serves on two not-for-profit boards.

Using a Melt Flow Indexer to Test Your Pressure Transducer

The MFI tester enables collection of meaningful pressure data in transducers in a relatively short time, providing realistic measures of the response time of a pressure transducer. This information is critical in the interpretation of pressure data measured in an extrusion process.

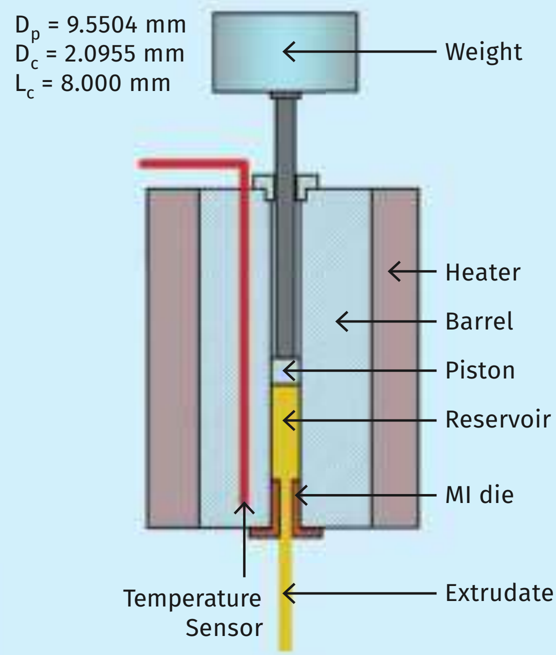


FIG 1

Melt flow indexer.
Source (all images): C. Rauwendaal

By Dr. Chris Rauwendaal
Rauwendaal Extrusion Enginnering

The measurement of pressure is the most critical measurement in extrusion. The pressure in the extrusion die determines the output of the extruder and pressure variation causes output variation. A pressure-time trend plot enables quantitative determination of the stability of the extrusion process. Pressure feedback control enables more stable extrusion.

In addition, pressure measurement is critical to safety in extrusion. Extreme pressures can occur in the extrusion process that can lead to serious accidents. For that reason, operating an extruder without pressure measurement is extremely unsafe. Extruders should be equipped with automatic shutoff. This feature will shut off an extruder automatically when the pressure reaches a critical value.

For these reasons, it is important to make sure that your pressure transducer is working properly and capable of measuring process variation correctly. The extrusion process is susceptible to short-term pressure variation. Short-term here refers to pressure variations that occur within one second. In fact, these short-term pressure variations occur in every extrusion process. To capture these variations, the pressure transducer has to have a fast dynamic response.

This article describes a simple test method for pressure transducers that uses a melt flow indexer (MFI) modified to enable testing of pressure transducers.

The extrusion process is susceptible to short-term pressure variation.

The MFI is a commonly used test apparatus to determine the flow behavior of a molten plastic. It is basically a ram extruder where plastic is extruded by placing a weight on top of a plunger (Figure 1).

The MFI has a heated barrel. Plastic pellets are placed inside the barrel and heated until the plastic is molten and at the required test temperature. At that point, a weight is placed on top of the

FIG 2

Discharge end of a modified MFI.

plunger. This weight pushes the molten plastic out of the melt index die as a single strand with a diameter of about 1-2 mm.

The MFI value is the amount of plastic extruded in 10 minutes. The amount is expressed in grams. A melt flow index of 3 indicates that 3 grams of plastic is extruded in 10 minutes. A high MFI value (for example, 10 g/10 min.) indicates a low-viscosity plastic and a low value (for example, 0.5 g/10 min.) indicates a high-viscosity plastic. The term “fractional melt” plastic is used for plastics with an MFI value less than 1.0 — these are high-viscosity plastics.

FIG 3

Incióna data collection system.

The black box at the bottom is the actual data collection system. The box on top is the power supply. The measurement data is sent to the cloud. The data is collected and displayed using Grafana. This is a multiplatform, open-source analytics and interactive visualization web application. The data was downloaded as a CSV file for more detailed analysis in Excel.

The pressure on the transducer is determined by the total plunger weight and the piston diameter. With the total plunger mass (M_p in kg) and the piston diameter (D_p in meters), the pressure (P in Pascals) is determined from the following expression:

$$P = 12.5\ M_p/D_p^2$$

MELT FLOW INDEXER MODIFIED TO TEST PRESSURE TRANSDUCERS

In this study, an MFI was modified to enable testing of pressure transducers. The MFI die was removed and replaced with an adaptor with a port for a pressure transducer. The MFI was filled with a high-viscosity silicon oil with a viscosity of about 500 Pa. This viscosity is close to that of a typical extrusion-grade plastic. The consistency of this oil is similar to that of silly putty.

The pressure transducer is placed in the adaptor and a weight is placed on top of the plunger. The weight determines the pressure exerted on the pressure transducer. Figure 2 shows a photo of the actual MFI discharge end. The MFI was purchased on Amazon for less than $2,000. The brand name of the MFI was not clear. The instructions suggested that the MFI was made in China.

A few issues were encountered in the testing of pressure transducers. It was found that large weights (5 kg and heavier) caused leakage because the clearance between the piston and the cylinder was too large. This was fixed by making a custom piston with a large outside diameter to prevent leakage. It was also found that the temperature sensor was not functioning in the MFI. In addition, the temperature sensor did not fit properly in the sensor well in the cylinder. As a result, the MFI could not be heated. This was fixed by installing a new RTD temperature sensor and drilling the hole of the sensor well to a diameter that ensured a good fit of the temperature sensor.

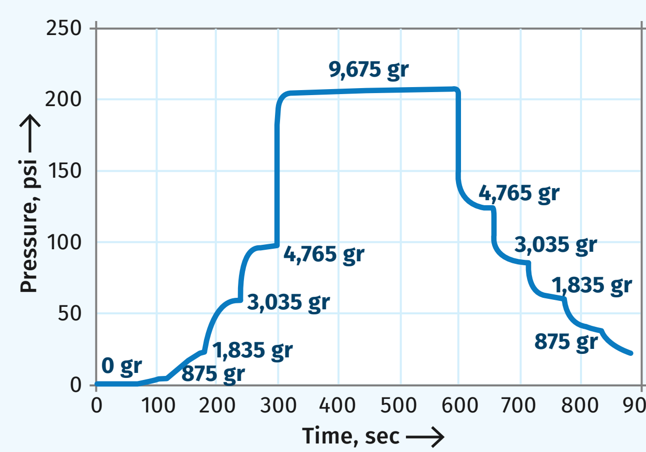
The pressure measurements were collected by an Incióna data acquisition system. Figure 3 shows a photo of the Incióna data collection system. Incióna is a specialized engineering and manufacturing services firm based in California.

Five weights were available for the pressure transducer testing, 0.875 kg, 0.960 kg, 1.200 kg, 1.640 kg and 5.000 kg. By adding a second weight on top of the first weight, the weight increased from 0.875 to 1.835, to 3.035, to 4.675, to a maximum of 9.675 kg.

The pressure transducer that was tested was a combination pressure/temperature sensor made by Terwin, model 2076JNN10MSP268 with a range of 0-20 bar (0-3,000 psi).

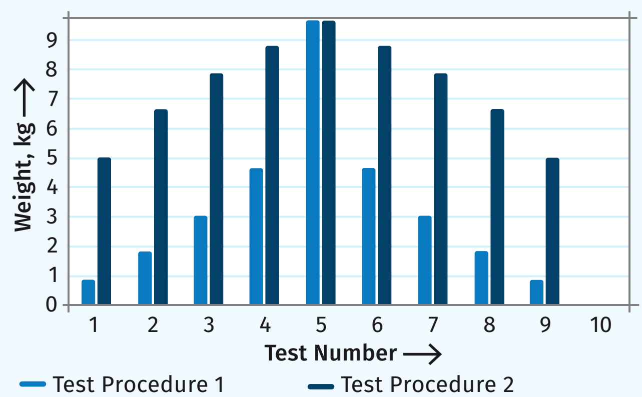
This is a “fill-free” transducer, meaning there is no fill liquid; therefore, no concern about mercury inside the transducer. In this transducer, there is a mechanical connection between the first and second diaphragm with a cylindrical rod. This transducer was selected because of the fast response time reported by the supplier. The response time specified by the supplier was less than 2 milliseconds.

FIG 4



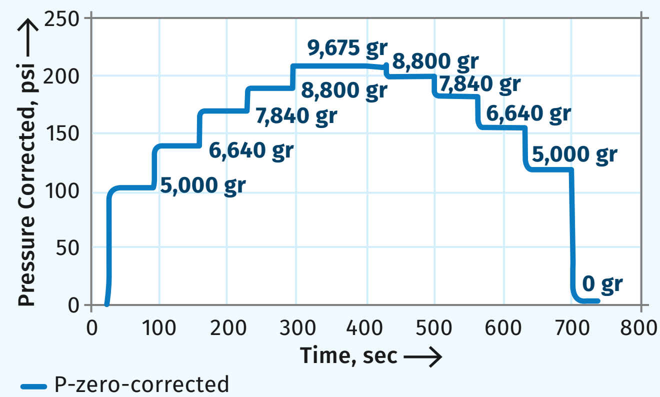
Pressure vs. time in test procedure 1.

FIG 5



Test procedures 1 and 2 showing weight vs. test number.

FIG 6



Pressure vs. time in test procedure 2.

TEST PROCEDURE 1

The pressure transducer was tested by placing increasingly larger weights on the plunger. Each pressure was maintained for 1 minute. When the maximum weight (9,675 grams) was reached, the pressure was maintained for 5 minutes. Then the weight was removed one by one, again maintaining each pressure for 1 minute. Thus, the pressures were ascending in the first 300 seconds, kept constant for the next 300 seconds and descending for the last 300 seconds.

ANALYSIS OF TEST DATA OF TEST PROCEDURE 1

The measured pressure versus time graph is shown in Figure 4. Pressure is plotted along the vertical axis in psi, time is plotted along the horizontal axis in seconds. The pressures increase in five steps over a period of 300 seconds. Each pressure is maintained for 1 minute. The maximum pressure is reached after 300 seconds. This pressure is maintained for 300 seconds and then weights are taken off with again each pressure maintained for 1 minute.

Make sure your pressure transducer is working properly and can measure process variation correctly

Figure 4 shows that when the 875-gram weight is added, the pressure increases slowly over the 1-minute period and does not reach a steady value within 1 minute. A similar pattern occurs when the second 960-gram weight is added. When the third 1,200-gram weight is added, the pressure gets close to reaching a steady value after 1 minute. When the fourth 1,640-gram weight is added, the pressure almost reaches a steady value after 1 minute.

When the fifth 5,000-gram weight is added, the pressure reaches a steady value in about 30 seconds. This pressure is maintained for 300 seconds. This data shows that a steady pressure value is reached in less than 1 minute only when the 5,000-gram weight is added. For all other weights, it takes longer than 1 minute for the pressure to reach steady value.

These results indicate that for pressures below 100 psi, the response time for the transducer is longer than 1 minute. The response time for pressures increasing to 200 psi is reduced to about half a minute. Interestingly, the response time specified by the supplier was less than 0.002 second. This means that the measured response time is about 4 to 6 orders of magnitude greater than the specified values — a disturbing discrepancy!

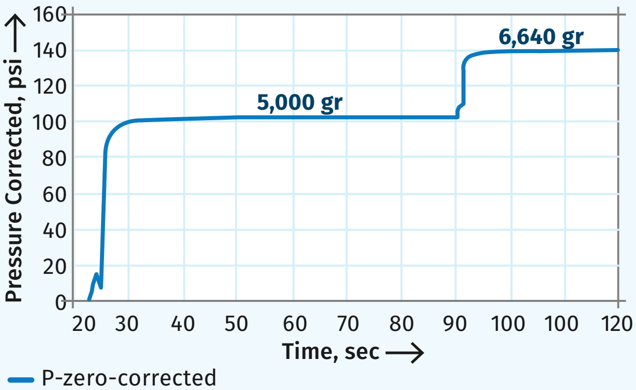
The pressure-time curves for the descending pressure more or less follow the curves for ascending pressure with regard to the time it takes to reach steady values. In descending pressure, the steady values deviate from those obtained with ascending pressure. For instance, with a weight of 4,675 grams the steady pressure in ascending mode is about 100 psi and 130 in descending mode. That indicates considerable hysteresis in the pressure measurement.

TEST PROCEDURE 2

In the second test procedure, the pressure transducer was tested by starting with the largest weight (5,000 grams) and then placing increasingly smaller weights on the plunger. Each pressure was maintained for 1 minute. When the maximum weight (9,675 grams) was reached, the pressure was maintained for 2 minutes. Then the weights were removed one by one, again maintaining each pressure for 1 minute. The two test procedures are shown in Figure 5 as a bar chart.

Figure 6 shows pressure versus time test procedure 2, revealing a different pressure-time pattern for procedure 2 compared to procedure 1. With an increase in weight from 0 to 5,000 grams, the pressure levels off in about 20 seconds. With an increase in weight

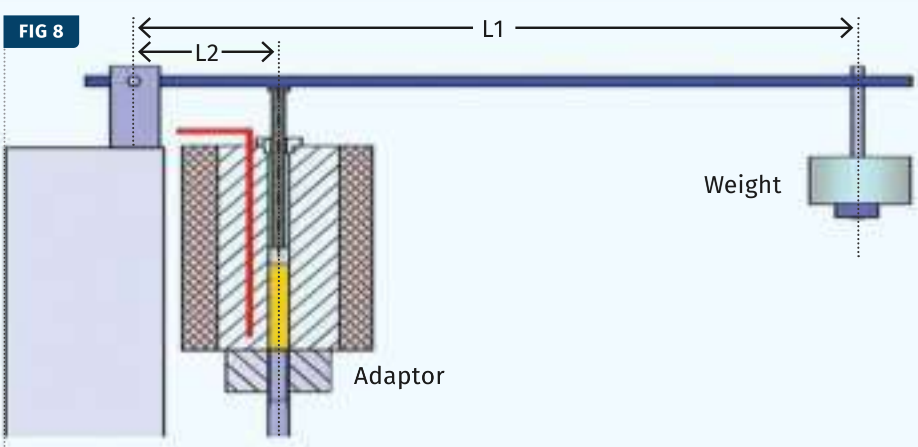
FIG 7



Pressure vs. time for the first 120 seconds.

from 8,800 to 9,675 grams, the pressure levels off in about 5-10 seconds. With procedure 1, the response times ranged from 30 seconds to more than 1 minute. With procedure 2, the response times ranged from 5-20 seconds.

FIG 8



Force magnifier.

Clearly, the measured response times depend strongly on the sequence of weights added or removed from the plunger. It should be noted, however, that even with the lower response times measured with procedure 2, the measured values are still orders of magnitude higher than the specified values. Figure 7 shows pressure vs. time for the first 120 seconds of procedure 2.

When the 5,000-gram weight is added it takes about 2 seconds to add the weight as shown by the peak between 23 and 25 seconds. The pressure increases rapidly between 25 and 26 seconds and then levels off over the next 10 seconds. If we define the response time as the time for the sensor reading to reach 99.3% of the total step change, the response time is about 10 seconds.

The response time specified by the supplier of the pressure transducer is 0.002 second. This is three to four orders of magnitude faster than the measured response time using the melt flow indexer.

FUTURE WORK/CONCLUSIONS

The MFI tester is limited in the pressures that can be generated in the cylinder. The maximum pressure is about 200-250 psi (1.4-1.7 MPa). Higher pressures can be created using the lever principle.

Figure 8 shows how the force on the plunger can be magnified by placing a weight a distance L1 from a pivot point with the plunger a distance L2 from the pivot point. This arrangement enables the force to be magnified by a factor L1/L2. A realistic value of L1/L2 is 5.

The slow response time of the pressure transducer tested makes it difficult to analyze short-term pressure variations in the extrusion process. In this context, short-term variations are fluctuations that occur within one second. These short-term variations occur in every extrusion process. It is critical to have a measurement system that enables detection of these short-term variations. For that reason, it is important to obtain good data on the response time of pressure transducers used in the extrusion process. Pressure transducers with response times greater than 1 second are not suitable for determining short-term pressure variations in the extrusion process.

The melt flow indexer provides a convenient method to test pressure transducers. MFI testers are widely available and they are inexpensive. The MFI tester enables collection of meaningful pressure data in a relatively short time. It provides realistic measures of the response time of a pressure transducer. This information is critical in the interpretation of pressure data measured in an extrusion process.

ABOUT THE AUTHOR: Dr. Chris Rauwendaal is a well-known author, lecturer, researcher, entrepreneur and consultant in the field of extrusion. He holds numerous patents and has written more than 200 articles and 7 books related to extrusion, mixing, injection molding and statistical process control. A fellow of the Society of Plastics Engineers (SPE), he is the developer of the CRD, VIP and ASM mixing technologies that utilize strong elongational flow to improve mixing in extrusion and molding. Rauwendaal also developed the HHT (high-heat-transfer) extruder screw designed to improve cooling in foam tandem and other extrusion operations. In 1990, he founded and is still president of Rauwendaal Extrusion Engineering. Rauwendaal was inducted into the Plastics Hall of Fame in 2024. Contact: *530-269-1082; chris@rauwendaal.com; rauwendaal.com.*

Sheet Extrusion, Thermoforming Tips for PLA/aPHA Blends

Biopolymers like PLA and PHA are able to meet sustainability goals while also delivering the performance attributes needed in rigid food packaging. Here's what testing has shown.

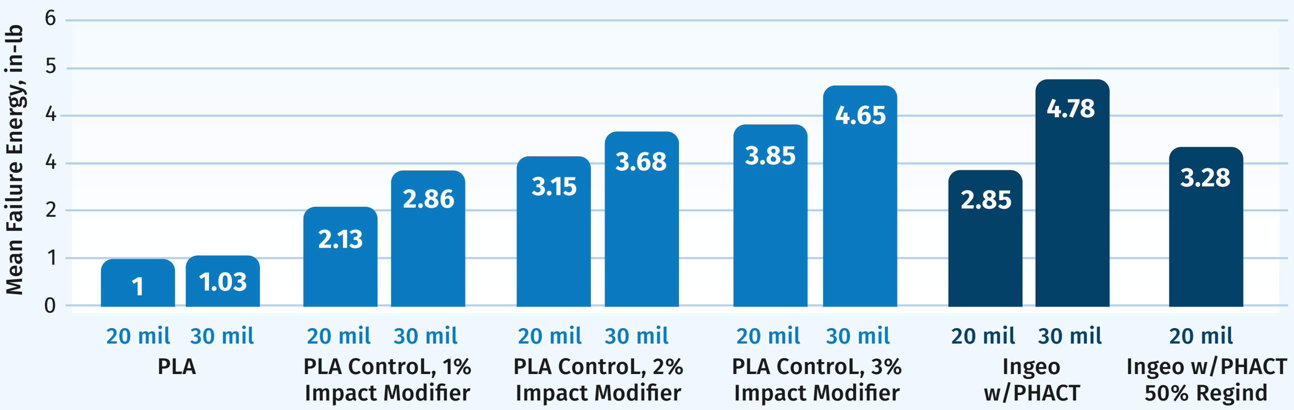
By John Licata, Eunhye (Grace) Lee, and Andrea Auchter
CJ Biomaterials, CJ Biomaterials and NatureWorks

The demand for sustainable packaging solutions is on the rise as consumers and environmentally conscious organizations continue to look for ways to reduce plastic waste and their carbon footprint. Across the plastics packaging supply chain, companies are also facing increasing pressure from both consumers and governments to develop eco-friendly alternatives that minimize waste going to landfills and climate impact. Biopolymers like PLA and PHA are able to meet these sustainability goals while also delivering the performance attributes needed for use as rigid food packaging suitable for commercial-scale adoption.

PLA is an ideal material option for sheet extrusion and thermoforming because of its strength and performance benefits. Produced from annually renewable resources, NatureWorks' Ingeo

FIG 1

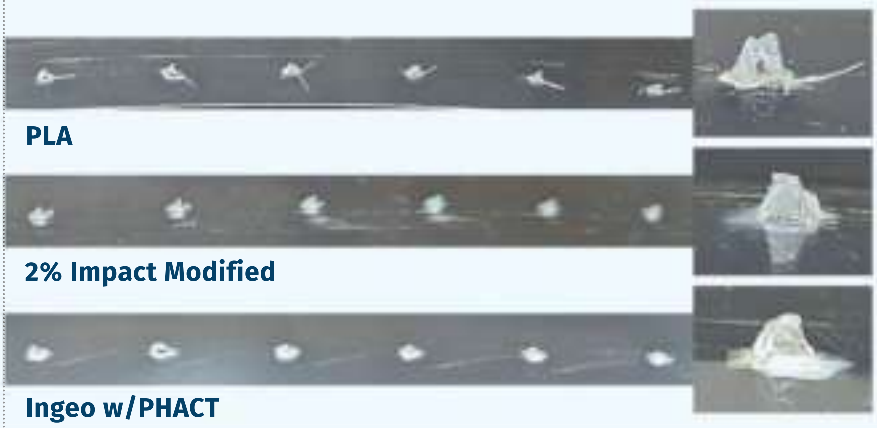
Gardner Impact, 20, 30 mil Sheet



Gardner Impact Testing (ASTM D5420) on 20 and 30 mil sheet shows improved toughness with addition of PHACT aPHA to Ingeo PLA compared with generic PLA alone and the use of acrylic modifiers up to the 1% limit set by third-party compostability certifications. Source: CJ Biomaterials

PLA appeals to brands and consumers wanting third-party certified safe, compostable, 100% bio-based, low-carbon packaging materials that enable the diversion of both food scraps and packaging into the expanding industrial composting infrastructure.

FIG 2



The Ingeo PLA/PHACT aPHA formulation exhibited a noticeable reduction in rail chipping due to its greater durability.

Combining CJ Biomaterials' PHACT aPHA with Ingeo PLA for thermoformed food packaging enhances mechanical performance (tear resistance and puncture toughness), accelerates the rate of biodegradation and compostability, and maintains transparency, clarity and bio-based content. PHACT PHA and Ingeo PLA are also both cleared for food contact use by the U.S. Food & Drug Administration (FDA) via its Food Contact Notifications (FCNs).

This article examines the use of blends of aPHA and PLA, and how they enhance the thermoforming process for packaging. It will also briefly touch on semicrystalline PHA (scPHA), a promising advanced biopolymer that offers greater strength and temperature resistance for more demanding packaging applications.

PLA/aPHA provides energy savings from processing at lower temperatures.

PUTTING THE PLA/aPHA BLEND TO THE TEST

Ingeo PLA has been used commercially in extrusion and thermoforming for over two decades, and is valued for its stiffness, formability and transparency. However, early rigid PLA packaging applications relied on nonbio-based acrylic modifiers to meet requirements for impact strength. At certain levels, though, these modifiers do not meet the criteria of current third-party compostability certifications, so a new bio-based solution was needed.

In 2023, NatureWorks and CJ Biomaterials announced a joint collaboration designed to accelerate the development of new materials that leverage the unique properties of CJ Biomaterials' PHACT A1000P PHA technology and NatureWorks' Ingeo PLA. Through the partnership, the two companies developed new PLA/PHA formulations that could meet the impact resistance benchmarks required by automated food packaging lines while maintaining 100% bio-based content, transparency and clarity, and the ability to use reclaimed trim scrap in processing. This new product solution can also meet the increasingly rigorous compostability standards for safety and degradation rates.

Extruding conventional polymers requires higher processing temperatures compared with biopolymers. The PLA/aPHA system provides energy savings from processing at lower temperatures. Typically, PLA temperatures on an extruder require a processing temperature range of 410-430°F, while Ingeo with PHACT will process at 390-410°F, resulting in further energy savings. As a further benefit, throughput is slightly increased by approximately 4% compared with generic PLA.

Combining aPHA with PLA enhances toughness. On its own, PLA is a strong and glassy polymer with excellent stiffness, though it can benefit from enhancements for improved impact strength. PLA has a Tg of approximately 130°F, meaning it remains in a glassy state at room temperature, while aPHA has a Tg of approximately 5°F, which enables it to display rubber-like properties. When aPHA is dispersed as small particles into a matrix of PLA, it acts like a little rubber ball. When impact propagates, it will encounter one of these rubber-like and tough characteristics of PHA, which will effectively stop its propagation. This rubber-like property also improves its durability, enabling the PHA to absorb the force of external pressures.

Adding 10% aPHA to PLA results in a material with 5 in/lb mean failure energy (MFE) as measured with Gardner impact testing on a 0.031-inch thick sheet. This can help prevent damage during transportation or accidental drops of the thermoformed articles and ensure the packaging can endure impacts produced in automated food packaging systems.

The new material was tested for its durability at multiple thicknesses. Subjected to Gardner impact testing (according to ASTM D5420), the PLA/aPHA blend demonstrated improved toughness when tested with 0.020-inch and 0.030-inch sheets compared with a PLA-only solution. For the 0.020-inch sheet, the PLA solution recorded an impact failure of 1.00 in-lb. The PLA/aPHA blend raised that level to an MFE of 2.85 in-lb. Testing on the 0.030-in. sheet, the MFE of PLA alone at 1.03 in-lb increased to 4.78 in-lb with the PLA/aPHA blend (Figure 1).

In thermoforming, PLA/aPHA blends stand out as a sustainable solution for rigid food packaging.

The material also exhibited a noticeable reduction in rail chipping, further demonstrating its greater durability (Figure 2).

A critical aspect of reducing costs and increasing the circularity of materials in extrusion and thermoforming is the ability to reintroduce trim scrap back into the extruder in the form of reclaim while still meeting performance targets for the final packaging. Unused material left over from cutting parts out of extruded sheet is ground into flake, recrystallized and dried, then reintroduced into the extruder feed.

When testing how the PLA/aPHA blend performed using regrind, the material held up well. Instead of regrinding sheet to feed the extruder, pellets were prepared that had undergone one to five passes (or heat histories) through a W-P twin-screw extruder and were blended to simulate 50% and 70% regrind content. The goal was to have clarity of 90% or greater and haze less than 10%. When the PLA/aPHA material was approximated at a 50% and 70% regrind level, it met the performance goals, recording clarity of 94% and total haze of 10% (Figure 3).

FIG 3

Formulation	Thickness, (mil)	YI D1925 [C/2]	Total Haze, %	Internal Haze, %	Clarity, %
PLA	30.8	17	7	3	97
PLA control, 2% impact modifier	30	12	8	6	99
Ingeo w/ PHACT	31	11	12	7	90
Ingeo w/ PHACT 50% Regrind	20	15	10	8	94
Ingeo w/ PHACT 70% Regrind	20	17	10	7	94

Incorporating regrind of the PLA/aPHA material met targets for clarity >90% and haze <10%.

By blending aPHA with PLA, processors can create a more workable material that both enhances processing and improves the overall performance of the final packaging solution. In the last year, CJ Biomaterials also developed the general-purpose masterbatch PHACT MA1250P-2, which enables the addition of a PHA/PLA masterbatch into a PLA system on a single screw extruder with no twin screw needed. Both NatureWorks and CJ Biomaterials offer resins that are packaged pre-dried and sealed in barrier packaging so they can be tested prior to the capital investment of a drying system, as Ingeo and PHACT must be dried prior to use at commercial scale.

POSITIVE ENVIRONMENTAL IMPACT OF PLA/APHA BLENDS

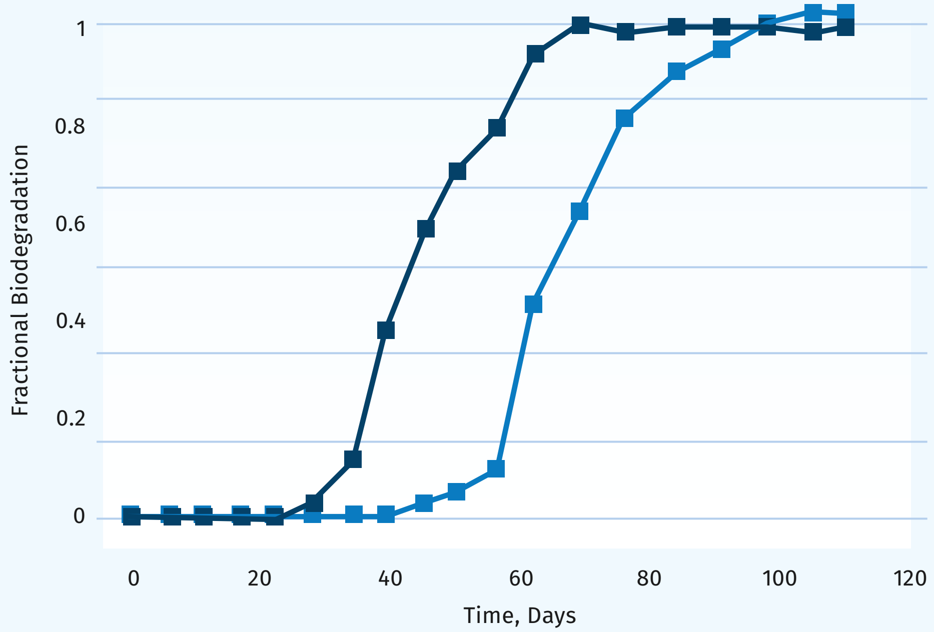
In the thermoforming space, PLA/aPHA blends stand out as a sustainable solution for rigid food packaging. Using these two certified bio-based polymers increases the use of annually renewable feedstocks, reduces the carbon impact of materials and decreases the use of fossil-fuel feedstocks.

As certified compostable materials, Ingeo PLA and PHACT PHA can create packaging that does not create persistent microplastics in the environment and help enable the diversion of food scraps away from landfills and into compost. Food degrading in landfills is the third largest source of methane emissions in the U.S. In contrast, creating and using compost improves soil health and biodiversity. These cumulative benefits for our climate are why the composting and compostable products industry are adopting science-based certifications that ensure compostable products are nontoxic and properly degrade in industrial compost environments.

In the U.S., the Biodegradable Products Institute (BPI) is the leading third-party certifier of compostable products. BPI's certification is based on ASTM standards D6400 and D6868 that set pass/fail criteria for the disintegration, biodegradation and ecotoxicity of compostable materials. These standards were modeled after compost conditions, documented in the U.S. Composting Council's (USCC) composting handbook, needed to safely compost food waste and produce stable, high-quality compost. In addition to standards-based testing, BPI requires that submitted products are free of PFAS and other fluorinated chemicals. Both Ingeo PLA and PHACT PHA have passed this testing and carry BPI certification.

Recent legislation in the state of California has significantly increased the amount of food scraps being sent to industrial composters in the state. In response, composters in California have accelerated their composting processes outside best practices to accommodate the increased volumes of food scraps. In turn, this has created demand for faster degrading compostable products.

FIG 4 **Industrial Composting of PLA (Influence of aPHA)**



Testing completed at CJ Blossom Park with TÜV SUD Lab Accreditation for Acceptance of Client Testing (A.C.T.) on biodegradability and industrial compostability shows that aPHA/PLA formulation accelerates biodegradation to meet 60-day time frames.

Completed biodegradation testing shows that the new PLA/aPHA formulation can biodegrade within 60 days at industrial composting temperatures (Figure 4). Early results from a field disintegration study in an industrial aerated static pile show that the Ingeo with PHACT solution has a high probability to degrade within the 60-day time frame under field conditions. PT

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Eunhye Lee is the group manager of polymers application R&D at CJ Biomaterials. She received her Ph.D. in polymer engineering from Osaka University and has more than 10 years of experience in conducting research on biopolymers. In particular, she has led application studies on biopolymers such as PLA, PHA and PGA. Recently, she published several papers on the behavior of polymer properties and the use of biopolymers. Eunhye is now conducting research on improving the physical properties of PHA biopolymers and compounds, including tuning rates of biodegradability. *339-999-2693; grace.lee@cj.net.*

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By Matt Stonecash
Associate Editor

Industrial Resin Recycling Diversifies by Looking Beyond Automotive

Recycler equips for new business in medical, housewares and carpeting.

Bob (left) and Trevor Houston (foreground) with a benchtop press in the IRR laboratory. Source: Matt Stonecash

Just about an hour's drive northwest of the Motor City, Industrial Resin Recycling (IRR) was built on the auto industry. It's still a major part of the business, and truckloads of molded parts roll in every week from Tier 1 automotive suppliers (suppliers that work directly with OEMs), but today IRR is equipped to handle a much wider range of products from a variety of sources.

IRR has been in business for over 35 years, reprocessing automotive materials and adding extrusion capabilities in the mid-1990s. At that time, IRR began using impact modifiers to alter the mechanical properties and create a higher performing recycled compound. The company has two facilities in Michigan, positioning it near automotive component manufacturers that are its biggest suppliers. About 30% of IRR's business is part of tolling arrangements, the rest is sold into other applications.

ADAPTABLE LOGISTICAL INFRASTRUCTURE FOR AN INDUSTRY IN FLUX

IRR has a fleet of seven trucks and a large collection of trailers, enabling the company to pick up recyclable materials on call and even leave trailers at suppliers' facilities to be filled. Howell, Michigan, serves as the company's headquarters and size reduction facility, where scrap material is collected, disassembled, shredded, ground and washed. The grounds measure 5 acres, giving IRR the flexibility to store large quantities of scrap material

Operator configures MAS extruder settings.

MAS extruder with magnetic separator system and melt filter. At left are collected patties of scrap from the melt filter, which will be reprocessed to extract usable polypropylene.

for processing. This enables the recycling operation to build up inventory when available, and work through it when supply is scarce, such as it was during the COVID-19 pandemic.

At its Fowlerville facility, just 10 miles away, recycled materials are further processed to make new pellets. The newest addition there is an MAS conical twin-screw extrusion system with an automatic self-cleaning melt filter. This system is run at 4,800 pounds per hour and could run higher on cleaner materials, but running with imperfect material is where its capabilities shine.

According to Bob Houston, founder and owner at IRR, the system has saved a lot of time and labor previously associated with stopping the line to clean screens. The MAS system detects pressure changes that indicate the screen is becoming occluded. Automatically, a scraper passes over the screen removing the contamination. Because some plastic is removed along with the debris, the resulting patty can be processed again to extract additional valuable polypropylene. John Sodini, general manager at IRR, says the extrusion system has increased output by around 80%.

IRR is currently refurbishing its 8-inch Davis Standard extruder, which will be mostly dedicated to recycling polystyrene. This activity will bring the screw/barrel gap back to optimum and will also include a controls upgrade. One of the areas IRR is expanding into is clothes hanger recycling, which is a mixture of PP and PS. Throughput on the polystyrene line, when placed back in service, is expected to be 3,500 lbs per hour.

Recycling automotive products remains a very important business for IRR. According to Trevor Houston, vice president of sales at IRR, the company processes a minimum of 80,000 lbs of fuel tanks every week. The HDPE, EVOH-lined tanks occasionally end up misshapen in the blow molding process. The tanks are pressurized and the pressure decay monitored. If they fail the leak test, they become scrap. After being recycled at IRR, these postindustrial gas tanks can become material used in plastic decking, drainage pipes and agricultural products.

EXPANDING BEYOND AUTOMOTIVE

In recent years, the company has been growing and diversifying its capabilities, looking beyond the automotive industries both for growth and to ameliorate the impact of events in one industry. "Over the last two years, we've been able to increase our capacity by 50%," Trevor Houston says. "We're getting into different things now, such as hangers, trying to expand out of automotive." Some examples include polypropylene trim parts, postindustrial syringes, vials, pill bottles and even hospital gowns. ►

These gas tanks, composed mainly of HDPE, will be recycled for sale into a variety of applications.

In this dispenser pump application, the polypropylene pump is ground up with the metal spring still inside. The metal pieces are removed through additional processes.

Black recycled polypropylene pellets are produced at IRR for a variety of applications.

An illustration of variability in the automotive industry is the recent pullback in electric vehicle (EV) programs. For example, Ford recently announced it is pausing production of the F150 Lightning EV pickup truck, to bring production in-line with lower demand than expected. The pause and reduced production is in turn expected to impact Ford's suppliers, the molding operations that also supply scrap to IRR.

"In addition to the fact that we've increased our capacity, we're trying to augment where there's a fluctuation in the segments — and all of them fluctuate for the most part," Sodini says.

IRR is also expanding into materials such as commercial carpeting and household goods. IRR's Piedmont, Alabama, facility is key to this move. There, IRR is starting up a new line purchased from NGR for processing carpeting and other materials. The line features a large water-cooled shredding system, feeder and extruder. Piedmont is about 90 miles from Dalton, Georgia, the "Carpet Capital of the World." The company is developing a technique for removing the hard filler materials from carpet backing.

DELIVERING CONSISTENT QUALITY

Bob Houston attributes the company's longevity in a challenging market to the consistent quality of its materials and services. With the new recycling equipment online, the company estimates capacity at around 50 million pounds per year, and rejection rate is less than 4% across the company.

"We test every box coming off the line; we make mold plaques to make sure there is no contaminant. Then we do a blend, and we test the blend as well," Trevor Houston says. "So each box from the time it comes in the door to the time it leaves, is tested three times." Lab capabilities include melt index, moisture analysis, FTIR, molding and extrusion of test samples, as well as mechanical properties testing.

One of the biggest challenges has come from contamination of incoming material. Contamination can take the form of the wrong type of plastic, or it can be something more serious — such as bolts and other hardware that can wreak havoc on size reduction equipment. IRR must work in cooperation with suppliers to make sure these materials don't get slipped into the feedstock by a careless worker. "The culture has changed at molding plants," Bob Houston says. "It used to be, 'Well you're the recycler; you're supposed to catch it,' and now they want to use it as a profit center, as a recovery point — which is sometimes shared with the employees now."

Since 2008, the ISO 9000 standard has provided the framework for the quality systems at IRR. Each year, the company is audited both internally and externally to keep the certification up to date. "It truly has made us a better company," Bob Houston says. "If someone asks for some documentation, it's accessible. We have the weight of every box."

IRR is currently expecting to imminently receive Green Circle Certification, a third-party program that certifies sustainable business operations and products. The company is also working toward A2LA certification for its laboratory. IRR offers reprocessed and compounded PP, reprocessed engineering resins and post-consumer content PP and PS. All products are made with recycled plastic, with no blending of virgin resin.

The plastics market is a moving and unpredictable target, but IRR is preparing to adapt to future conditions as they arise. "We've seen a shift, and we have capacity now to augment our market with health care and other consumer goods. When — I'm going to say when — auto picks up again, we will be ready to increase our output," Sodini says.

Keeping Up With Technology

INJECTION MOLDING

Compact Solution for Two-Component Molding

Zahoransky Automation and Molds GmbH has introduced what it calls internal mold handling as an alternative for core-back, rotary table or index plate technologies normally applied for multicomponent injection molding. The company says internal mold handling enables high output in a smaller space by automatically reducing the cavity pitch distance before the second material is injected. Commercially proven, an internal mold handling tool is already used in the production of applicator caps for continuous glucose measurement devices.

This application features a special applicator so patients can attach the device to themselves with minimal effort. Used for the correct application of the devices and for storage, the applicator is sealed with a screw cap molded using two-component injection molding with a polypropylene (PP) shell and a thermoplastic elastomer (TPE) seal. The cap's screw thread means the parts cannot just be ejected from the mold but must be unscrewed.

Zahoransky said core-back or turntable methods were ruled out by the customer from the outset, noting that use of a standard index plate would have been possible but not ideal in terms of footprint and machine efficiency, as space is limited in the production hall.

To meet the challenge, Zahoransky paired its Z.Warp offering for fully automatic 2K molding, with the new internal tool handling. That system features a gripper arm, sitting on a mold-integrated handling unit, which removes the initial PP part and places it in the mold for TPE overmolding. Importantly, before the half-finished part is inserted and the second material is overmolded, the cavity pitch distance is reduced, so that at changeover, the distances between the cavities are automatically reduced or adapted to the optimum requirements. The finished caps are then removed by a six-axis robot in parallel with the injection molding process, enabling the cycle time to be significantly optimized.

BLOW MOLDING

All-Electric Stretch-Blower for up to 3L PET Bottles

Making its public debut at the BrauBeviale 2024 show in Nuremberg, Germany, is an all-electric, linear, two-stage stretch-blow molding machine with two cavities and production of PET bottles from 0.2L to 3L at up to 3,500 bph. The model APF-Max 2L is the latest addition to the APF-Max series from PET Technologies of Austria. The "2" indicates the number of cavities; there are also APF-Max models 3, 4, 6 and 8. The "L" designation stands for "large" and indicates capacity to blow bottles up to 3L, vs. around 2L for the standard models. APF-Max machines are all-electric, except for the pneumatic APF-Max 2.

Key features of the APF-Max 2L include energy efficiency, thanks to its all-electric design and NIR heating system, which is said to provide faster heating of PET preforms with lower energy consumption, as well as providing a shorter oven for a smaller overall footprint (approximately 11.3 × 8.8 × 6.2 ft.). In addition, the machine has two-step air recovery, enabling the blowing air (up to 40 bar) to be used for preblowing the next bottle.

The machine is also said to provide quick mold and product changeovers, and capability for hot filling and processing 100% rPET. It has a B&R PLC controller and accepts preforms with neck finishes from 18 to 38 mm.

ENGINEERING RESINS

High-Performance Nylons that Bridge Gap Between Nylons 6/66 and PPA

BASF launched two high-performance nylons within its Ultramid Advanced PPA portfolio that are said to bridge the gap between nylons 6 and 66. Ultramid T6000 (PA66/6T) is a high-temperature, nonhalogen flame-retardant nylon (nylon blend 66/6T) that is said to outperform nylon 66 in mechanical and dielectric properties in the presence of humidity and at elevated temperatures. It boasts easy processing similar to standard nylon with low tool corrosion, and testing shows that mold temperature has no significant influence on the mechanical properties.

T6000 shows high flowability and opens up new, colorful possibilities with even white color shades for miniaturization parts with electrical protection. Ultramid T7000 is a nylon/PPA blend that is said to surpass nylon 66 in mechanical properties, especially in the presence of humidity up to a temperature of 176°F/80°C. This blend boasts high stiffness and strength, which makes it a perfect metal replacement — plus it has the added value of a smooth surface finish and dimensional stability.

TESTING

Extrusion Plastometer is Modular, Easy to Clean

The Mflow Extrusion Plastometer from ZwickRoell is a modular instrument that cuts the time it takes to perform tests. The new instrument measures both the melt mass flow rate (MFR) and the melt volume flow rate (MVR), while guaranteeing reliable and reproducible test results — both crucial for the quality assurance of plastic products.

In its basic configuration, the Mflow performs tests according to method A for MFR and method B for MVR. Its modular design enables it to be modified to the specific needs of the plastics industry, with expandable features such as a cleaning function and a pneumatic weight-lifting unit with pegging function which eliminates the need to move weights manually. These enhancements provide greater adaptability and ensure the melt flow tester remains future-proof for evolving laboratory demands.

A key innovation of the Mflow is the reduction in cleaning time of up to 30% between tests. This is achieved due to improved accessibility and optimized surfaces, enabling successive tests to be carried out faster.

The Mflow's design prioritizes ergonomics, providing an optimized working position, simplifying the process of filling the specimen material, and reducing physical strain on the operator.

The integrated touch display and LED status indicators support intuitive operation, whether used with or without a PC. With the new Mflow, ZwickRoell is setting new standards in plastics testing. The combination of time efficiency, ergonomic design and flexible modularity makes the Mflow an indispensable tool in modern testing labs in the plastics industry and significantly contributes to increased productivity.

ADDITIVES

Light-Blocking Additive for PET Dairy Packaging

A light-blocking additive developed and launched by Avient is said to enable blocking of 100% of visible light in monolayer PET dairy packaging. ColorMatrix Lactra LX Light Blocking Additive is suitable for ultrahigh-temperature liquid dairy containers, which have longer shelf life requirements and are often stored under ambient conditions. In addition to preserving the quality of dairy products and helping to extend shelf life, this solid masterbatch additive also delivers a bright white color.

Lactra LX UV additive is also said to offer the advantage of versatility in container designs and shapes, enabling product differentiation over other rigid packaging solutions (such as multilayer HDPE containers) and enhancing consumer convenience with easy-to-pour options. It also provides the opportunity for lightweighting, reducing overall cost without sacrificing performance.

TOOLING

Ejector Delay Unit for Two-Stage Demolding

Hasco's new Z1725/... ejector delay unit enables efficient demolding and separation of sprues via two-stage ejector demolding where the consistent delay is ensured by an individual pocket depth and the ejector assembly. Hasco says this enables the sprue and molded part to be cleanly separated from one another through a coordinated ejector movement.

Hasco says the new delay unit not only improves process reliability but also the quality of the end products. Production downtimes are reduced and maximum flexibility is provided because the units can be used without any minimum stroke requirements. Ejector sizes from 2 to 5.9 mm enable a variety of applications in different production processes.

The ejector delay unit works by transferring axial forces through friction between the plastic sleeve and the drill-hole wall. This friction force can be adjusted by a conical, self-securing screw and adapted to the specific requirements. The plastic sleeve should sit approximately 3-mm deep in the location hole. The precise position of the ejector pin is secured by a flattened circular pocket. The desired delay is integrated into the pocket depth of the ejector package. The ejector delay can also be retrofitted into existing tools.

MIXING

Versatile, Cost-Effective High Solids Mixer

Ross' model HSD-15 High Speed Disperser features an air/oil hydraulic lift with telescoping cover to enable operators to mix different batch sizes and prevent stratification while keeping the vessel covered all throughout the mixing cycle. This helps to contain dusts and vapors for improved operator safety and cleanliness.

The 12-in. disperser blade operates up to 1,590 rpm to induce vigorous turbulent flow within a low-viscosity batch, creating a vortex into which dry ingredients can be poured for fast wetting. The blade speed may be changed as the batch thickens or increases in volume to maintain the vortex and rate of material turnover. The cover has a 1/3 hinged port for the easy addition of powders into the 150-gallon stainless steel mix vessel.

Easily operated from a 7-inch HMI display, PLC controls enable operators to program and run recipes based on speed, time and hydraulic lift raise/lower cycles. Safety limit switches prevent operation of the mixer while in the raised position or without a mix vessel in place.

FEEDING

Gravimetric Feeder is Compact, Easy to Clean

The Model MSV gravimetric feeder from Thayer Scale pairs a rugged, economical volumetric feeder with a low-profile, mass-counterbalanced scale, resulting in a gravimetric feeder that provides highly responsive feed-rate control and accuracy in a small form-factor package. It reportedly offers precise rate control for free-flowing pellets and granules. Its design is compact, easy to clean and economical, providing flexibility and efficient use of floor space.

The new MSV feeder includes Thayer Scale's low-profile cable scale, which utilizes a micro-lever system that counterbalances the tare weight, resulting in load-cell utilization significantly higher than other options. The higher load-cell utilization provides numerous benefits, including higher accuracy, typically 0.25% of feed rate, fast responsiveness to changes in set point or material density fluctuations, resulting in higher accuracy material delivery and the elimination of "dead zones" common in gravimetric feeding applications.

Higher load-cell utilization also enables the MSV feeder to operate with longer gravimetric cycles, requiring fewer refills and a lower percentage of the gravimetric cycle operating in volumetric or "settling" mode.

The system is designed to operate with the Thayer Scale Differential Screw solution, enabling consistent, pulse-free delivery of material across a wide operating range.

HEATING & COOLING

Temperature Control Unit (TCU) Modulates Heat Output in Real Time

Delta T Systems says the heart of its new Smart Series TCUs is the Vari-Heat adaptive control engineered to dynamically modulate heat output in real time. By automatically adjusting to system demands and environmental conditions, Delta T says Vari-Heat ensures temperature stability and enhanced energy efficiency. Specifically, the control prevents temperature overshoot for smooth and gradual heating transitions.

The Smart Series TCUs are also Industry 4.0 ready, offering a range of communication options, including remote start/stop and the ability to adjust the temperature set point from any location. The unit logs up to seven days of operational data, giving users insights into system performance.

Ramp and soak recipes enable users to manage temperature variations for more complex processes. Equipped with a flow meter and temperature and pressure sensors, the system continuously monitors performance, issuing high and low warnings, and fault notifications.

The Smart Series TCUs also come standard with electronically modulating cooling valves for more accurate flow control than conventional solenoid valves. This valve design also minimizes risks such as undershoot and water hammers.

MATERIALS

Expanded Line of 'Super' Soft TPEs for Medical Devices

Kraiburg TPE has extended its range of 'super' soft thermoplastic elastomer (TPE) compounds by additional hardness degrees. The Thermolast M series, designed for medical devices, is an extension of the company's next-generation Supersoft TPEs first launched in mid-2021. Their specific properties make these TPEs particularly suitable for prostheses and orthotic devices.

The soft material is characterized by hardness values ranging from 30 to 50 Shore 00 and/or 45 to 70 VLRH. While TPEs in this hardness range tend to oil out and produce sticky surfaces, Kraiburg TPE's extremely soft compounds are said to make a convincing impression with their pleasantly dry and velvety feel. Combined with their elastic properties, these TPEs are often used for applications with one-sided compressive loads such as orthopedic damping elements. Tests in accordance with the ISO 10993-10 standard also confirm that permanent contact with the skin surface does not lead to and/or cause allergic reactions.

ADDITIVE MANUFACTURING

Formlabs Form 4L and Form 4BL Print Expand 3D Print Volumes

Formlabs' large-format Form 4L and Form 4BL 3D printers offer the speeds of the Form 4 printer but with larger build volumes. The Form 4BL is the biocompatible version of the 4L and similarly scales up the capabilities of the Form 4B.

Built on the company's low force display (LFD) print engine, Form 4L delivers a 99% print success rate. The system is designed to enable large-scale parts but also smaller parts at high volume.

According to Formlabs, the Form 4L features print speeds up to 80 mm/hr., enabling large-scale prints in under six hours. The build volume is nearly five times larger than the Form 4, and the machine can print thousands of parts per day at low cost per part. A new cartridge design, implemented in the Form 4L, reduces plastic waste by 63% and delivers faster resin dispensing.

The Form 4L is compatible with at least 23 materials, offering choices for application-specific properties such as durability, rigidity, biocompatibility and flame-retardant characteristics.

"We believe in driving innovation forward by providing the freedom and flexibility users need to bring their ideas to life. Form 4L will enable users to solve bigger problems and bring big ideas to life at lightning-fast speeds, regardless of scale or complexity," says Formlabs CPO Dávid Lakatos.

Agostino LoBello, product design engineer at Radio Flyer, is pleased with the updated printer. "The speed and dimensional accuracy have made a big difference in our shop," LoBello says.

Additionally, Formlabs introduced new printer accessories, two new selective laser sintering (SLS) materials, five new PreForm features and new postprocessing solutions. Formlabs also announced it is opening up its developer platform to enable more freedom and flexibility.

Prices Drop for All Five Commodity Resins

While PE price reductions were not as apparent, they too were following the year-end price trajectory of PP, PS, PVC and PET.

By Lilli Manolis Sherman
Contributing Editor

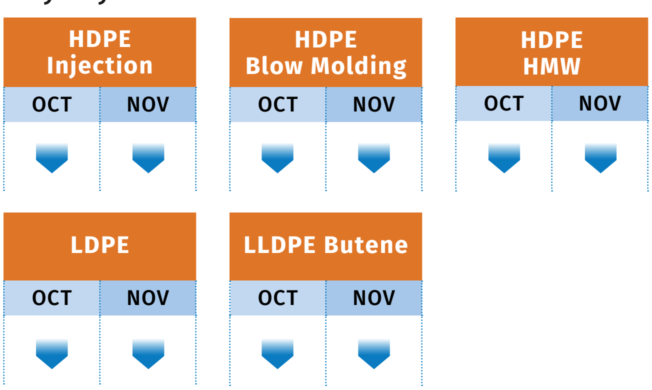
Prices of four out of the five commodity resins were on a downward trajectory heading into December, and polyethylene (PE) resin prices were also reported on that same path, as industry deals were being reported. Overall, it was a buyer's market for all five resins with some stocking-up activity taking place before year's end. This is in anticipation of overall firmer pricing, including historical first-quarter price increases for PE and PP. Key factors include scheduled plant turnarounds, weather-related or other global event supply disruptions, and the potential for a strike by the International Longshoreman's Association (ILA) against the nation's East and Gulf Coast ports in mid-January, if contract negotiations fail.

These are the views of purchasing consultants from Resin Technology Inc. (RTi); senior analysts from Houston-based PetroChemWire (PCW); CEO Michael Greenberg of The Plastics Exchange (TPE); Scott Newell, executive vice president polyolefins at distributor/compounder Spartan Polymers; and Mike Burns of Plastic Resin Market Advisors.

Market Prices Effective Mid-November 2024

Resin Grade	¢/lb
POLYETHYLENE (railcar)	
LDPE, LINER	68-70
LLDPE BUTENE, FILM	65-67
HDPE, G-P INJECTION	65-67
HDPE, BLOW MOLDING	63-65
HDPE, HMW FILM	68-70
POLYPROPYLENE (railcar)	
G-P HOMOPOLYMER, INJECTION	60-62
IMPACT COPOLYMER	63-65
POLYSTYRENE (railcar)	
G-P CRYSTAL	94-96
HIPS	99-101
PVC RESIN (railcar)	
G-P HOMOPOLYMER	55-57
PIPE GRADE	53-55
PET (truckload)	
U.S. BOTTLE GRADE	60-62

Polyethylene Price Trends



PE PRICES FLAT, THEN DOWN

PE prices in October once again rolled over and — while suppliers both reduced their price increase nominations from 5¢/lb to 3¢/lb and pushed them up to November — such upward trajectory was unlikely, according to PCW's associate director for PE, PP and PS, David Barry; TPE's Greenberg; Mike Burns of Plastic Resin Market Advisors; and Kevin Mekaru, RTi's senior business leader commodity plastics.

Moreover, buyers were pushing for a decrease. This, after PE prices increased a total of 13¢/lb this year. "Processors are still steadfast in resisting any increase for October contracts and are instead rallying support for an overdue price drop supported by record upstream resin inventories; the unwinding of the summer ethylene rally; reduced export PE prices; and softer spot domestic levels," TPE's Greenberg reported.

Nearly all sources anticipated that prices had the potential to drop by 3-5¢/lb in the October-November time frame, bottoming out in December, if suppliers lowered plant operating rates. RTi's Mekaru ventured that PE prices could drop 3¢/lb each in October and November. "In general, it is a very low-growth environment toward year's end, with lots of spot deals taking place," Mekaru said.

PCW's Barry noted that processors are seeing suppliers as very eager to move material, and some end users are saying that PE prices are now back to first-quarter 2024 levels or even lower, with deals being offered. He ventured that PE contract prices no longer reflect actual prices.

Weighing in, Plastic Resin Market Advisors' Burns noted that suppliers need to cut export prices and export as much of the significant inventory buildup that took place the two previous months by early December. He saw processors as being able take advantage of "this aggressive year-end opportunity to pre-buy inventory and reset the 2025 contract price." He also cautioned of first-quarter price increases, which over the last nine years have averaged 5¢/lb. This, due to year-end exports depleting inventories; processors restocking in January; and scheduled ethylene and PE plant turnarounds.

PP PRICES DROP, THEN BOTTOM OUT?

PP prices dropped 6¢/lb in October, after the September 4¢/lb decrease, in step with propylene monomer, and there were expectations for another 2-3¢/lb decrease in November, according to PCW's Barry, Spartan Polymers' Scott Newell, TPE's Greenberg and Paul Pavlov, RTi's vice president of PP and polyvinyl chloride (PVC).

Polypropylene Price Trends

Homopolymer	
OCT	NOV
▼ 6¢/lb	▼

Copolymer	
OCT	NOV
▼ 6¢/lb	▼

Noted PCW's Barry, "Demand for PP is more distressed than that of PE, partially because there is so much of lower cost global PP resin and finished goods. North American PP prices have been so volatile and it slows down PP demand." He ventured that December prices could be flat, and also a time where processors may stock up with lower cost resin and in anticipation of firmer prices in the first quarter. These sources all concede that propylene monomer prices would bottom out this month and also said that PP prices typically move up during the first quarter.

Spartan Polymers' Newell noted that propylene monomer prices will "chase" PP demand. "Monomer inventory is still a little tight. I think there is real potential for processors to see some good deals in December, in anticipation of higher prices."

TPE's Greenberg saw the September decrease as too little, noting that U.S. resin sales stalled as contract buyers pushed off orders into October in anticipation of another decrease. He reported that as October contract negotiations heated up, it appeared to be time "to rip off the Band-Aid and implement the full remaining decrease that is intrinsically apparent given spot propylene monomer levels."

RTi's Pavlov noted that PP demand overall was very good compared to 2023, until prices began to decline in September. These sources cited the strongest markets this year as those of extruded sheet for thermoformed packaging and some nonpackaging, as well as injection molded caps and closures.

Newell noted that flexible film, particularly BOPP, showed a surprising double-digit growth this year. Past years for flexible film have been neutral to negative in terms of demand, he said.

PS PRICES DOWN

Polystyrene (PS) prices in October appeared to be on the way down by 3¢/lb, having rolled over for the sixth consecutive month in September and had potential to drop a bit more in the November-December time frame, according to PCW's Barry and RTi's Pavlov.

Polystyrene Price Trends

GPPS	
OCT	NOV
▼ 3¢/lb	▼

HIPS	
OCT	NOV
▼ 3¢/lb	▼

Key factors included lower benzene and ethylene prices, and supply/demand fundamentals. Pavlov noted that plant operating rates in fourth quarter were down to about 65%. According to Barry, the implied styrene cost based on a spot formula (30% ethylene, 70% benzene) was down about 4¢/lb over most of October.

A trajectory change in this flat-to-down scenario cited by both sources was the potential for higher crude oil prices due to global events, which would result in higher benzene prices.

PVC PRICES DOWN

PVC prices dropped 1-2¢/lb in October, having rolled over in September, despite suppliers' failed attempt to pass a 3¢/lb increase, according to RTi's Pavlov. He ventured that PVC prices would be flat, if not down a bit more, in the November-December period. He characterized the market as having slowed in both domestic and exports demand, along with higher supplier inventories, with new capacity being brought onstream by Formosa expanding domestic supply. This, after the suppliers enjoyed an 11% increase in domestic and exports demand within the first half of the year.

PVC Price Trends

Pipe	
OCT	NOV
▼ 2¢/lb	▼

Gen. Purpose	
OCT	NOV
▼ 2¢/lb	▼

Meanwhile, the first hearing of an antitrust class action lawsuit — that alleges several PVC pipe manufacturers (including Westlake Polymers, which makes both resin and pipe) have conspired to artificially inflate, fix or manipulate the price of finished PVC pipes sold in the U.S. — was taking place in late October.

PET PRICES DROP

Polyethylene terephthalate (PET) prices dropped by 3¢/lb within the September-October time frame, based on lower raw material formulation costs, and were expected to drop by another 2¢/lb in the November-December time frame, according to RTi's Mekaru. He noted that paraxylene/terephthalic acid feedstocks were expected to remain flat, and the market has more than ample supply, both in terms of domestic production and well-priced imports, with relatively soft demand.

PET Price Trends

Bottle Grade	
OCT	NOV
▼ 3¢/lb	▼

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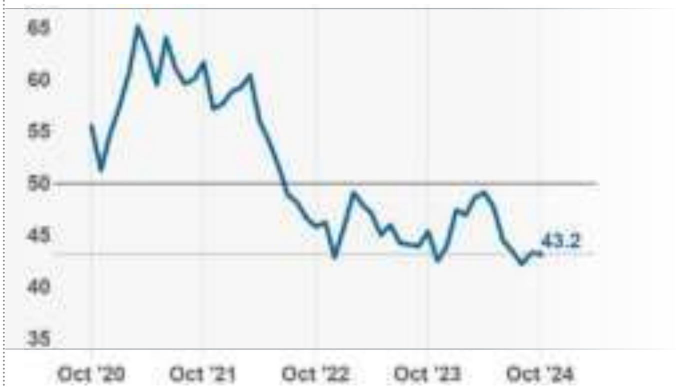
Plastics Processing Index Remains Virtually Unchanged

Future business indicators rose again this month, but other inputs changed only slightly.

FIG 1 Gardner Business Index (GBI): Processing



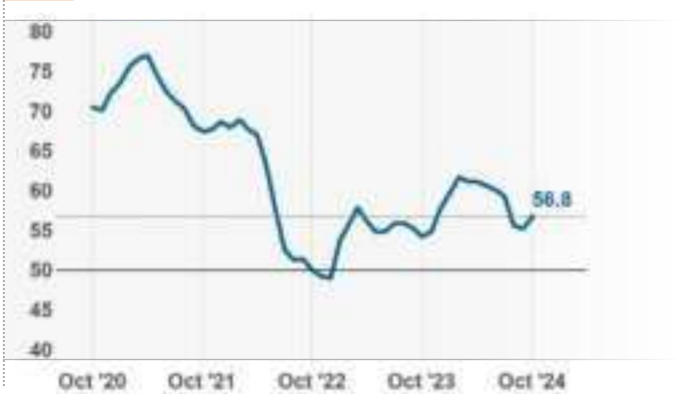
The GBI is an indicator of the current state of plastics processing. Over 50 is expansion. Under 50 is contraction.

FIG 2 GBI Components Scorecard: Plastics

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

Shade = distance from 50 (darker shades are further from 50)
Direction = change (Pointing up is better)

FIG 3 Future Business Index: Plastics Processing



Numbers in Perspective

Business data can be viewed with a "half-glass full" or "half-glass empty" perspective. The GBI Plastics Processing Index remained virtually unchanged in October at 43.2, matching September's month-over-month reading and the three-month moving average. While it has stayed below the 50-growth threshold, it has not significantly declined from the recent six-month low of 42.2 in August.

By Perc Pineda

The production component of the GBI showed slight improvement in October, increasing from 40.9 in September to 41.1. However, the three-month moving average reflects continued weakness in plastics production. Optimism remains, however, as the future business component of the index has shown two consecutive months of improvement.

As a sector closely tied to economic growth, the 2.8% real GDP increase in the third quarter — particularly the 3.7% rise in personal consumption expenditure, including 8.1% growth in durable goods, 4.9% in nondurable goods and 2.6% in services — indicates that demand for plastics and plastics products has held steady.

Last year, 87.6% of plastic products went toward personal consumption, and that percentage is likely to be similar this year. Weakness in residential construction, driven by high interest rates, partly explains reduced plastics manufacturing. Elevated inventories also restrain production growth.

The Federal Reserve cut rates in November by 25 basis points, bringing the Fed funds rate to a target range of 4.50%–4.75%. Lower interest rates should reduce risk aversion in the business sector, stimulating investment in new products and projects. PT

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, industry research, statistics, trends and forecasts. He produces PLASTICS' two annual flagship publications — *Size & Impact* and *Global Trends* — and trademarked the Global Plastics Ranking. Read his views and insights on the economy and the plastics industry at *plasticsindustry.org*.

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VIDEPLAST INDUSTRIA DE EMBALAGENS LTDA — STATE OF SANTA CATARINA, BRAZIL

Packaging Converter Adopts PE-Based Vacuum Skin Packaging (VSP) for Food Applications

Videplast and ExxonMobil collaborated on the development of this cost-effective VSP film solution that contains no ionomers.

By Lilli Manolis Sherman
Contributing Editor

Brazilian packaging converter Videplast worked with ExxonMobil to come up with a cost-effective and optimal vacuum skin packaging (VSP) product for a variety of food applications that offers reduced film thickness while still providing superior performance and containing no ionomers.

As a leader in Brazil's packaging sector, Videplast's diverse product portfolio encompasses stretch and shrink films, special heavy-duty bags and high-performance films tailored to meet a broad spectrum of packaging needs across multiple industries.

VSP combines a high-barrier thin film with a premade tray, with these components then sealed in a vacuum chamber. The vacuum softens the film, enabling it to conform to the shape of the tray and creating an airtight seal around the product. The VSP film encapsulates the food product and becomes like a second skin, eliminating almost all package atmosphere.

"We identified an opportunity in both the national and international markets to develop a differentiated structure for the VSP film," says Leonardo Nunes da Silva, Videplast R&D manager. "Furthermore, by creating a unique structure in the market that does not contain ionomers, we anticipated an opportunity for us to offer our customers a high-performance, cost-effective solution."

According to the partners, this technology has been growing in recent years and is trending up in the near future, mainly due to the greater number of people living alone or in smaller families. As a result, there is a greater desire for smaller portions and single-serve packaging for goods like meat, cheese, fish and seafood, which require high-performance and visually appealing packaging solutions.

Videplast had previously produced a VSP with an ionomer-based solution, but it proved too expensive and was not commercialized. ExxonMobil provided Videplast with a proposed structure featuring its new performance LLDPE Exceed XP 7052ML, which offers multiple benefits. The seven-layer barrier film also included performance LLDPE Exceed XP 6056 as well as H-EVA and EVOH, resulting in a high-quality, durable film with excellent barrier properties.

Videplast's VSP film utilizing ExxonMobil's Exceed LLDPE resin features optical properties that enable better product visibility. Source: ExxonMobil Chemical

The potential for significant cost savings by reducing film thickness and eliminating the use of ionomers is a key benefit. Videplast sees the opportunity for a 20% thickness reduction. In its first demonstration, the company is using PET trays (though cardboard and EPS trays were also under evaluation), with practical tests on meats and cheeses underway.

In addition to being easy to process, this film structure boasts enhanced protection from food spoilage, leakage and contamination, ensuring product safety and quality. Moreover, by removing air and providing a tight seal, the packaging extends the shelf life of perishable goods. The tight seal created by the packaging also helps prevent freezer burn, while outstanding optical properties enable better product visibility and improved aesthetics in vertical displays.

Videplast manufactures the VSP film utilizing advanced processing techniques to ensure optimal performance and consistency in the final product. The vacuum pack process involves optimal thermoformability and a high oxygen barrier, ensuring effective vacuum sealing and extended freshness.

Noting that the collaboration with ExxonMobil was key, Leandro Barcarolo Martinoto, R&D manager, says, "Our motto is 'Engagement makes the difference.' The progress achieved in the VSP project generates high expectations. The implementation of VSP has the potential to generate substantial long-term savings." PT

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