spe Thermoforming Quarterly®

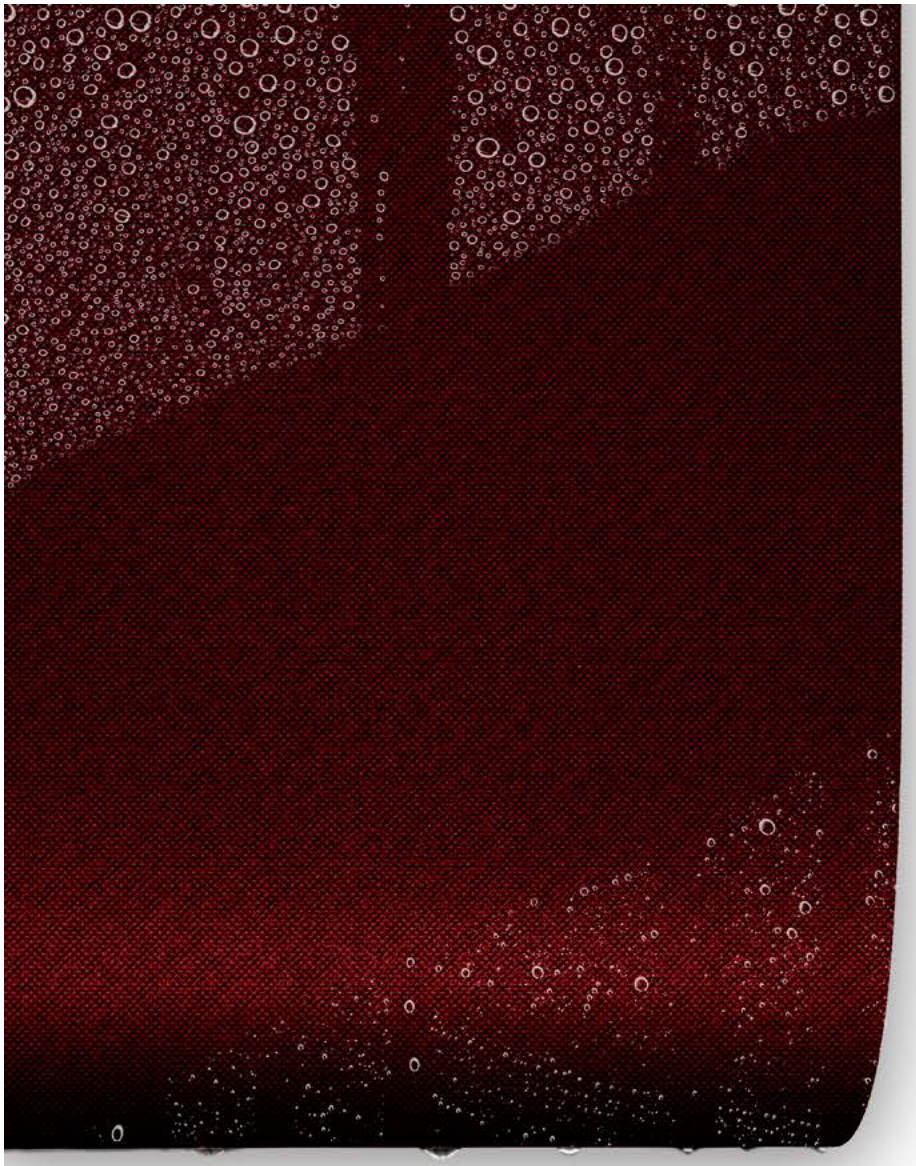
Second Quarter 2020 | Volume 39 | Number 2

A Journal of the Thermoforming Division of SPE

The New Face of Plastics

IN THIS ISSUE:

- 2019–2020 Plastics Manufacturing Survey Results
- Improving Thermoformability of iPP Through Multilayer Coextrusion



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It has been my honor...

Eric Short

to Chair the Thermoforming Division for the last 2 years. Working with respected colleagues to fulfil our mission of research, education, and promotion of the industry has been rewarding and challenging. I would also like to send a heartfelt thank you to the current and Emeriti Board Members, as well as their supporting companies and families. In time-honored tradition, I will now pass the gavel to Steve Zamprelli.

As I prepare to rotate to the position of Past-Chair, it's fitting to take a few minutes to reflect on some accomplishments and challenges during my tenure.

Financial Health

Our division remains one of the strongest in the SPE family. Due to the success of our conferences and prudent use of funds, we have been able to stay steadfast in challenging times. And boy, have they been challenging!

Who remembers the hurricane* that led us to cancel our Orlando Conference in 2017? That was a painful decision, but we persevered and carried over several speakers and participants to our first ever conference in Texas.

Flat conference attendance for the last several years suggested that some hard decisions had to be made. The board, in consultation with sponsors and members, made the tough call to move to alternating years.

Successful Programs

All that said, we've seen a nearly 800% increase in Student Memberships, due in large part to our successful RC Car Competition Race. It is incumbent upon all of us to ensure that student members graduate to become Young Professionals (YP) and ultimately lifetime paying members of the Society. SPE continues to underwrite student memberships and has recently expanded this support to include 2 years of YP membership.

With regards to the State of Industry, our Board, and the current global situation, I'd like to share a story that many don't know, but I believe is pertinent. On the eve of the 2019 Conference in Milwaukee, illness and travel issues threatened to cancel one of our hands-on workshops. A few critical volunteers banded together, literally working into the night, and put together workshop content from scratch, and presented their various sessions and papers to over 80 attendees. The workshop went off without a hitch: lots of positive attendee feedback attests to our efforts.

It's this banding together of scrappy and determined individuals that I reflect upon in times like these. This brand of determination and moxie is being displayed as companies shift production methods and materials in the midst of a pandemic. Our editor told me that there were simply too many examples of thermoforming companies rising to the challenge of PPE production to name them all! We offer a short summary on pp. 10-12, but we encourage you to send us your photos, stories, and anecdotes. We're not out of the woods yet…

As our cover illustrates, the face of thermoforming is changing yet remaining the same. I'm confident that we will emerge from this stronger, leaner, and nimbler. I'm looking forward to the next live event (what's that again?!) when we can swap stories of how our people solved tough problems under adverse circumstances.

So, join me in welcoming Steve to the hot seat! Let's continue the good work of thermoforming around the world! |

*Hurricane Irma!

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Thermoformer Direct Pack Buys Mexican PET Recycler

By Don Loepp, *Plastics News*

February 25, 2020 - Direct Pack Inc., an Azusa, Calif.-based packaging thermoformer, has acquired Atmosphera Verde SA de CV, a PET recycler in Guadalajara, Mexico.

The deal will help Direct Pack close the loop and use recycled PET thermoformed containers to make new containers, according to President Craig Snedden.

"We want them back. That's the point. Now we're taking in PET thermoforms," Snedden said in a Feb. 19 telephone interview.

The recycling business is being renamed Direct Pack Recycling. According to DPI, Atmosphera Verde has the capacity to recycle 40 million pounds of PET annually, including post-consumer thermoformed PET. Terms of the purchase were not disclosed.

Thermoformed PET sheet can be tough to recycle because of the difficult-to-separate labels on many containers. Snedden said Atmosphera Verde had a special process that can handle bales of PET with high percentages of thermoformed packaging. Snedden credited Juan Galvan, who started Atmosphera Verde and has now joined Direct Pack Recycling.

"It is all about the strong members of the team that make up DPI," Snedden said. "We've known Juan for a number of years, and we've been impressed with his capabilities as an efficient recycler."

Snedden said DPI's customers are excited about using post-consumer PET thermoforms as a feedstock for their products. Snedden noted that before the National Sword program, thermoformed PET containers typically were shipped to China to be recycled. In the past year, though, most have been landfilled. Now DPI is working with materials recovery facilities to collect thermoformed containers and send them to Direct Pack Recycling.

"Our approach to working with the material recovery facilities has been an incredible experience," Snedden said. He has personally visited MRFs and pointed out DPI containers in their bales.

"We're able to go into their sorting lines and say, 'Those are our containers; we want them back,'" Snedden said. "MRFs don't see that a lot, presidents of plastics companies visiting and taking ownership of the products that they make. They're fired up about it."

DPI is currently working with six MRFs, and Snedden plans to expand that network. DPI already has a line of containers with post-consumer content called Bottle Box. But the raw material for those containers was primarily sourced from easier-to-recycle PET bottles.

"If you want to truly be a steward of the industry, you have to know how your product is being handled after it is used," Snedden said.

Through his relationship with MRFs, Snedden said he's become an advocate for making all thermoformed PET packaging easier to recycle. That includes using labels and adhesives that are easy to remove in wash lines.

DPI has three plants that extrude and thermoform sheet. The plants are located in Sun Valley, Calif.; Rockingham, N.C.; and Guadalajara. The company has about 330 employees and makes foodservice, supermarket, produce and processor containers.

DPI started in 2006 and is owned by PMC Global Inc., a privately held management company founded by Phil Kamins, a longtime plastics industry veteran. PMC Global has a variety of plastics, packaging, chemical, manufacturing and finance businesses. PMC and its subsidiaries employ more than 3,500 worldwide. Plastics News estimates DPI's annual sales at $230 million.

Snedden credited Kamins for being his mentor and for encouraging DPI's move into plastics recycling.

"He's been really supporting our move into sustainable packaging and recycling," Snedden said. "The financial support of our parent company, and the mentorship of Phil Kamins, has been important to DPI's growth."

Adding in-house recycling fits into DPI's business strategy of offering customers a full menu of services. The company has in- house design and engineering, including a customer center at its headquarters in Azusa, Calif. It also has three tooling plants, plus a close partnership with a tooling supplier in Taiwan. Having in-house tooling helps DPI bring new products to market quickly, as well as control cost, Snedden said.

"The added link that makes us full circle is the DPR wash facility and our growing relationships with MRFs on a nationwide scale," Snedden said

Good Natured Products Inc. Acquires Shepherd Thermoforming & Packaging

BioplasticsMagazine.com

March 4 - Canada-based good natured Products Inc. announced 4 March that it has entered into a definitive agreement with the shareholders of Shepherd Thermoforming & Packaging Inc., a leading thermoformer with over 35 years' experience, to acquire 100% of Shepherd and all its real estate assets for CAD$9.5 million in cash.

The assets include machinery, molds and a 42,000 square foot manufacturing facility, all located on 2.31 acres of land in the Greater Toronto Area of Brampton, Ontario.

Shepherd designs custom packaging including engineering, mold production and final product manufacturing for both thin gauge and heavy gauge applications. Their customers include several Fortune 500 companies located throughout eastern Canada and the northeast United States. Shepherd operates six different thermoforming lines as well as two CNC machines at its fully integrated design, mold manufacturing, testing and manufacturing facility.

"After nearly doubling our revenues in 2019, this transaction marks another significant milestone in the company's growth trajectory. The acquisition enables us to increase our production capacity and expand our plant-based packaging assortment to meet the needs of more customers," said Paul Antoniadis, CEO of good natured.

"Whether it be through existing moulds available at the Shepherd facility, or the ability for us to expand on the development of custom packaging solutions, one of our largest growth sectors, our production capacity and assortment has now increased significantly."

Paul went on to add "the strategic location of Shepherd's facility also provides good natured with a strong and easily accessible entry point into Ontario and eastern Canada, as well as the northeastern United States."

Paul concluded by saying, "We're delighted to welcome Mark and Todd Shepherd and the entire Shepherd team to the good natured® family. We share a common vision to be leaders in the development and adoption of sustainable, planet-friendly packaging solutions in North America, so the combination of our collective expertise, people and manufacturing capability further positions the Company to execute against this ambition.

Shepherd generated average annual revenue of over CAD$5.5 million and average annual adjusted EBITDA of CAD$420,000 in the prior three fiscal years. Completion of the Share Purchase remains subject to financing and a number of customary closing conditions in favor of good natured and TSX Venture Exchange approval. The acquisition is expected to be accretive during the current fiscal year. The bioplastics manufacturer is completing the final stages of financing required to close the share purchase with its financial partners, including Business Development Bank of Canada, under the terms and conditions of its previously announced BDC financing from June 2019.

"We are very excited to partner with good natured® and continue the legacy of our business that was started in 1984 by our father Barry Shepherd," said Todd Shepherd, President of Shepherd Thermoforming & Packaging Inc. "Our customers are increasingly requesting plant-based alternatives, so joining together with good natured®, as we have on several projects over the past four to five years, will accelerate our ability to meet this growing demand."

The closing of the transaction is expected to be not later than April 30, 2020.

Oman to contest antidumping ruling on PET exports to US

Conrad Prabhu, *Oman Daily Observer*

March 8, 2020 - MUSCAT - Oman's authorities are understood to be preparing to mount a response to a recent "preliminary determination" made by the US Department of Commerce in its antidumping investigations centering on imports of polyethylene terephthalate (PET) sheet from the Sultanate. The United States is an important market

for exports of Omani PET sheet, which is widely used for general packaging applications, including dairy items, and thermoforming food packaging applications. Around $200 million worth of Omani produced PET sheet was shipped to US markets in 2018. Almost all of this volume came from Salalah-based Octal Petrochemicals, one of the world's largest producers of PET sheet for the global packaging industry.

On February 26, the US Commerce Department ruled that PET sheet imports from Oman, as well as South Korea, were violative of American antidumping laws. Dumping occurs when companies sell an imported product at less than fair value. The antidumping petition against the Sultanate's PET exports was brought by three American PET manufacturers — Advanced Extrusions, Ex-Tech Plastics, and Multi-Plastics Extrusions. In issuing its preliminary determination, the US authorities calculated a preliminary dumping margin of 2.78 per cent for mandatory respondent Octal Petrochemicals, while assigning a preliminary dumping margin of 2.78 per cent to all other producers/exporters in the Sultanate.

In contrast, preliminary dumping margins calculated for Korean PET exporters were considerably higher. Octal had previously rejected the antidumping claim, insisting that its exports to the US market are based on its "competitive cost structure". In addition to mounting its own defense against antidumping charges, Octal also banks on legal and diplomatic assistance provided by the Omani government, represented by the Ministry of Commerce and Industry, to forcefully push back against such claims.

rPlanet Earth Growing with Second California Plant

Stephen Downer, *Plastics News*

March 15 - Integrated PET recycler and packaging company rPlanet Earth LLC is establishing its second thermoform recycling facility.

"We have leased 48,000 square feet here in Vernon, Calif., and are conditioning the building already," Octavio Victal, rPlanet Earth's director of sustainability, told Plastics News by email March 12. He said the Vernon-based company is raising $7 million for the project. "We are almost fully funded between some low-interest loans and [an] angel investor."

Most of the machinery, he added, will be imported from Germany. "With this virus shutdown, we might see a slight delay. We are expecting to have equipment here by October. The facility, he said, will produce 4 million pounds per month of post-consumer thermoformed flake.

According to Victal, the angel investor mentioned has a 20 percent stake in Green Impact Plastics SA de CV, where Victal is president and CEO in Ciudad Juárez, across the border from El Paso, Texas. Green Impact claims it was the first PET reclaimer recycling post-consumer thermoform PET packaging in the Americas.

Victal intends to sell Green Impact to the rPlanet Earth group. He has been working on a system to process post-consumer PET thermoforms for the past three years. rPlanet Earth opened its first PET thermoform recycling facility in Vernon last year. The plant is running at full capacity, reprocessing 3 million pounds a month, Victal said.

"We [rPlanet Earth] have been sending post-consumer bales from curbside programs in California to the plant in Ciudad Juárez and returning the flake to rPlanet Earth for further processing. In California, we solid-state the flake, extrude and thermoform containers with high content of PCR [post-consumer resin] from thermoforms."

Interest in the concept is on the rise, Victal said, "but we are now facing an even bigger challenge than actually building the technology."

Thermoforms "are not widely accepted in curbside programs," he explained, "so in many cases they end up directly in landfills. The consumer is confused as to where to throw them. There is no ISRI [Institute of Scrap Recycling Industries], APR]Association of Plastic Recyclers] bale spec for the material.

"Because it has no CRV container value [California Refund Value], states that have a bottle bill have little to no interest in making them a bale. SPC [Sustainable Packaging Coalition] just downgraded the recyclability of this packaging.

"We are putting together a group of stakeholders to get some of the above solved but we also want to get the industry behind it. With the second facility I'm building in California we are going to be able to recycle a lot of thermoforms and pull from various locations in the U.S. We would love to see more people engaged in what we are doing." |

The Face of Thermoforming

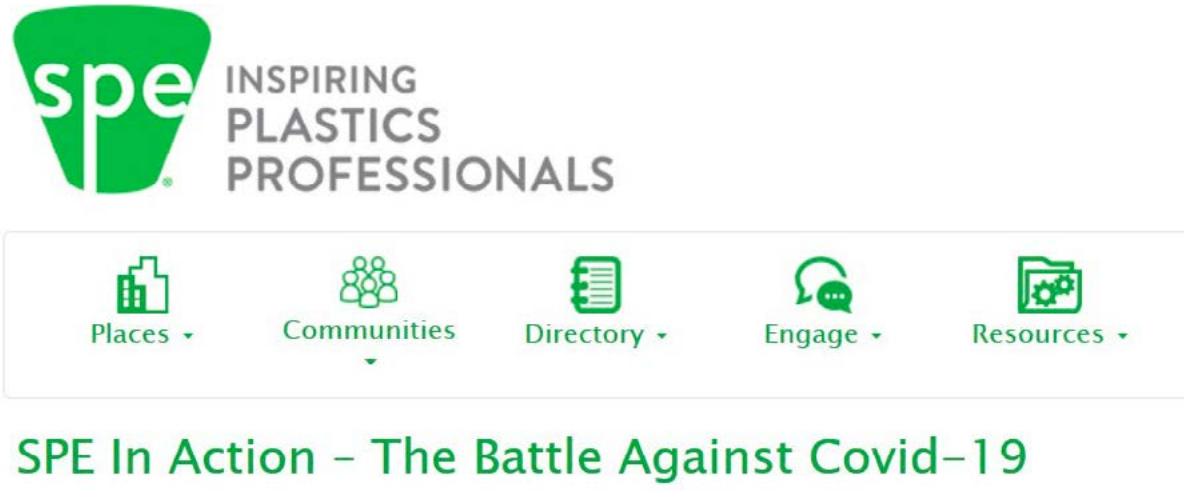
Editor's Commentary

It is not stretch to say that the world has changed since our last issue. Much ink has been spilled about COVID-19 and it will be some time before we can make sense of the short- and long-term disruptions to life and business. For those of us in the plastics industry, at least two comments can be made with certainty: one, plastics are an indispensable part of modern life; two, social and political pressures against certain types of plastics have abated. This commentary will focus on the former, but it would be mistake for the plastics industry to forget about or abandon what led to such an increase in global awareness of the impact of plastic waste on the environment.

In each issue of Thermoforming Quarterly, we carefully select articles from around the world where thermoforming is featured. Sometimes these are related to business activities such as M&A news; sometimes they are local stories about apprenticeship programs. This quarter, it has been almost impossible to keep up with the amount of "thermoforming in the news" given the massive outpouring of production support for health care workers. Machinery, tooling, and materials are all in high-demand, with most workers deemed essential.

An acute shortage of face masks at the outset of the crisis led a global scramble to understand spun-bond fibers and associated techniques for manufacturing N95 masks, in particular. What everyone quickly realized was that supply chains had become fragile, with a heavy dependence on China. The race to develop local sources illustrated how flexible and innovative thermoforming suppliers could be. Anyone reading LinkedIn or posts on SPE's "The Chain" would have learned quickly how PET material supply can dry up. SPE itself unleashed the power of crowdsourcing by opening up its platform to all plastics professionals. Designers, entrepreneurs, engineers, procurement officers, and sales people all piled in to ask and answer questions about how plastics can help in the struggle against the virus.

We cannot do justice to all of those companies who contributed internationally or locally, but all of us in thermoforming should be incredibly proud to be part of an industry that nimbly and effectively delivered innovation solutions to those on the front lines of health care. The following segments are just a few examples of cooperation and innovation from around the thermoforming world.



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Companies such as 3M and Honeywell were arguably household names already, but their brands received a major PR boost over the past three months. Though 3M uses an in-house proprietary forming process, Honeywell expanded production thanks to quick-delivery machines from Hyannis, MA-based OEM SencorpWhite.

"We're on a mission to fill orders and do our part," said Sencorp Marketing Manager Scott Boyson. "We're lucky to be in a position to be able to help—we take a lot of pride in that." The company is continuing to build other machines that serve the health care industry, including those that sterilize medical devices and produce equipment for hospital pharmacies. "It is not without its challenges, but we are here to help," said Keith Blackwell, thermoforming supervisor at Sencorp.

In Madison, WI, Placon Corporation built on the region's strong ecosystem to create a "Face Shield Alliance".

"I reached out to some of my trusted peers in the industry and described our production process," said Dan Mohs, Chairman and CEO. "We had already scaled up multiple facilities, so why not reach out externally and assist an alliance partner ramp up production?" Dan Joyce, President and CEO at Portage Plastics and Randy Gordon, President and CEO at Paradise Plastics welcomed the opportunity and rose to the challenge to get much needed PPE face shield subcomponents to the Ford Motor Company for assembly.

In Europe, toolmaker Gravolab (Campulung Muscal, Romania) engineers designed, built and perfected in less than two weeks a complete set of tooling to producing millions of shields per week.

"We stopped using expensive and complex face-shields, for GravoLAB's new X2 design, which is by far more light and more practical than everything we tested", says Roxana Serb of Stomatologycal Clinique "Clinica 32" of Bucharest, Romania. Simplicity is a competitive advantage. The design consists of two components: a flexible thermoformed support belt with a wide range of adjustable sizes, and the transparent visor film. These two parts are joined together with a click system – inspired from single use clamshell packaging.

The economic fallout of the pandemic continues to develop. Those predicting the future do so at their peril. For now, plastics are rightly being recognized for their critical role in human health and safety. We cannot, however, neglect end-of-life considerations, even if we cannot see around the next corner. |

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2019–2020 Plastics Manufacturing Survey Results

Editors Note: Published in February 2020, we are grateful to Ray Products for giving us permission to reprint their annual manufacturing survey results in their entirety.

Executive Summary

In the sixth annual plastics manufacturing survey conducted by Ray Products, respondents showed a clear preference for domestic manufacturing; placed concerns about price and quality as top considerations; and provided some unique data on shifting trends in process selection, as well as overall plastics manufacturing utilization.

Key Findings

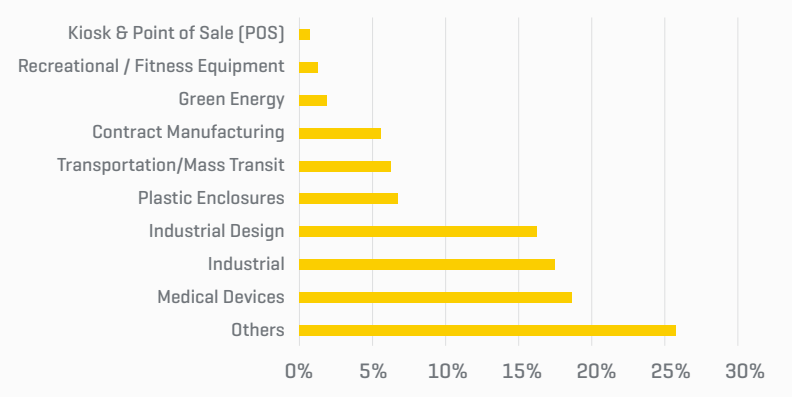
- Just **13.2%** of manufacturers say they're happy with offshore plastics manufacturing.
- Respondents said that **quality is the #1 thing they look for** in a plastics manufacturer, followed by engineering support and price.
- Respondents peg their biggest challenges as **total project cost**; followed by issues with quality, such as part-to-part repeatability and proper fit in multi-part assemblies.
- While **the majority of respondents (59%) expect their plastics manufacturing volume to stay steady**, those who expect to undertake **fewer projects (23%)** outweigh those who expect to undertake **more projects (18%)** in the coming year.
- Respondents indicated that **they used thermoforming a bit more this year** than last year, while ***injection molding took a notable (38%)*** dip in popularity.

Who We Surveyed

Our survey brought in over 200 responses from engineers, industrial designers and manufacturing professionals representing a range of industries — from medical device manufacturers to companies in the transportation sector, contract manufacturers and more.

84% of our respondents had been involved with at least one plastics manufacturing project in the past year, and 30% had been involved with more than five over the past year.

What industry are you in?



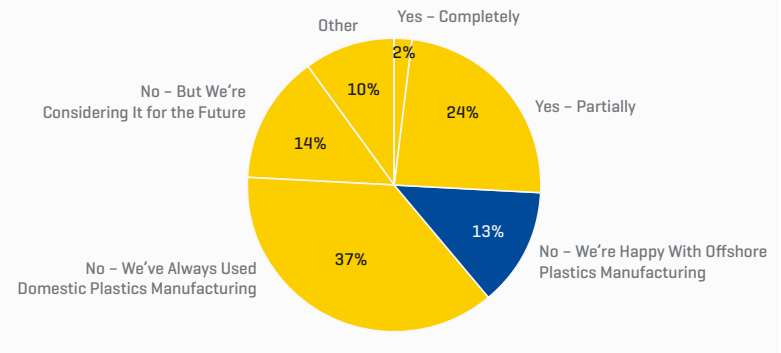
Overseas Plastics Manufacturing is Utilized Less Than Half The Time, and Not Popular

On average, respondents reported that 56% of their manufacturing happens in the United States, a dip of 9% from last year. But, when pressed for their opinions, the manufacturing industry professionals in the survey aren't happy about it.

Just a paltry 13% of respondents indicated that they were happy with their overseas plastics operations, with no plans to reshore operations.

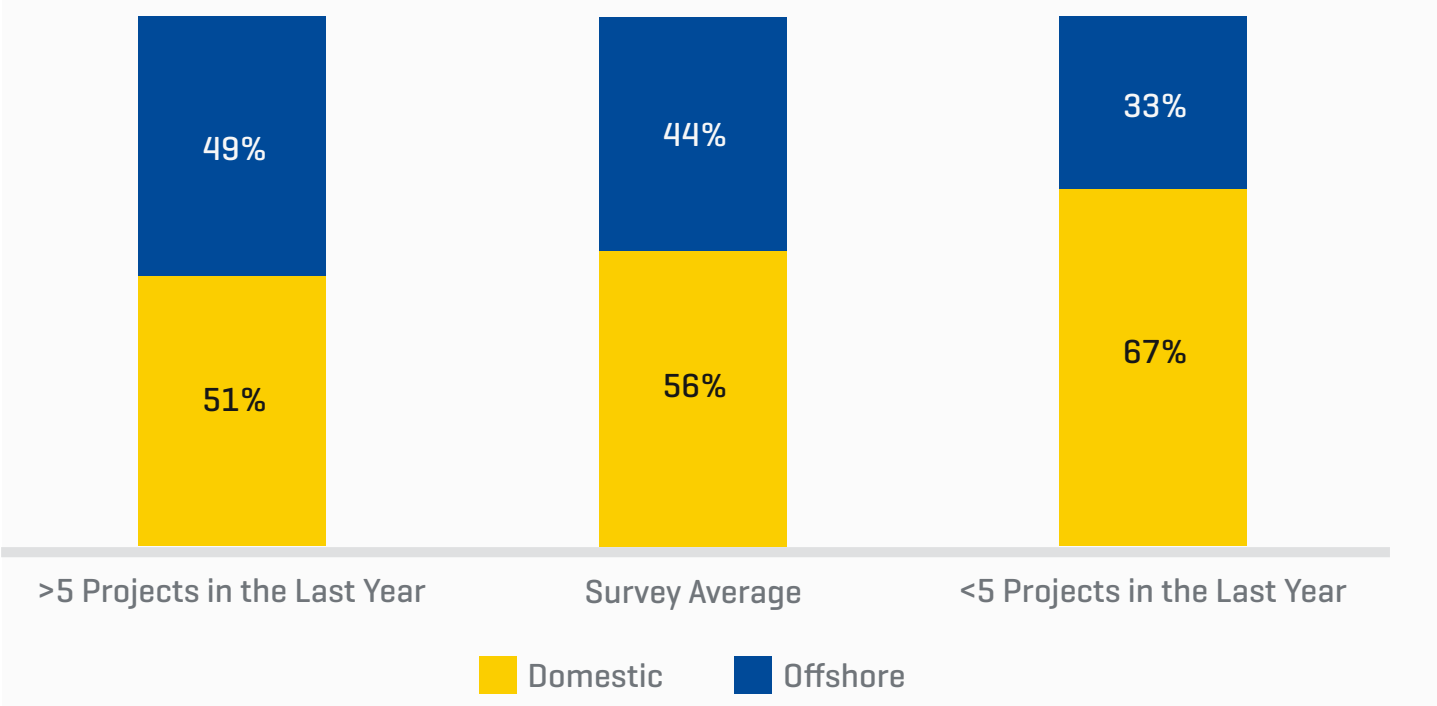
These numbers closely mirror sentiment from past years, which shows that when manufacturers utilize overseas plastics manufacturing, they tend to do so begrudgingly.

Have you reshored any of your offshore plastics manufacturing in the past?

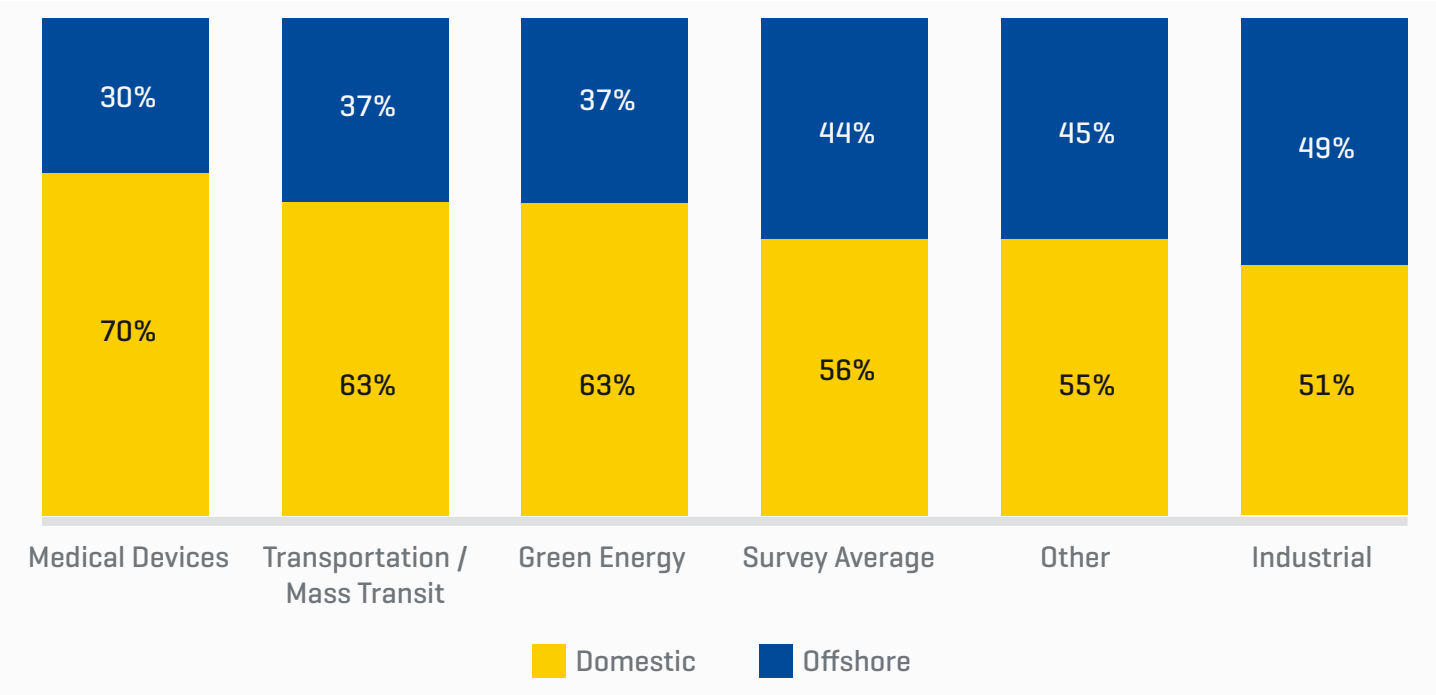


This year's survey data also shows that manufacturers who undertake more projects learn the value of domestic manufacturing. Respondents who were involved with more than five plastics projects in the last year estimated that 67% of their operations occurred domestically. In contrast, those with five or fewer projects estimated that only 50% of their projects happened in the United States.

About what percentage of your current plastics manufacturing operations happen in the United States?



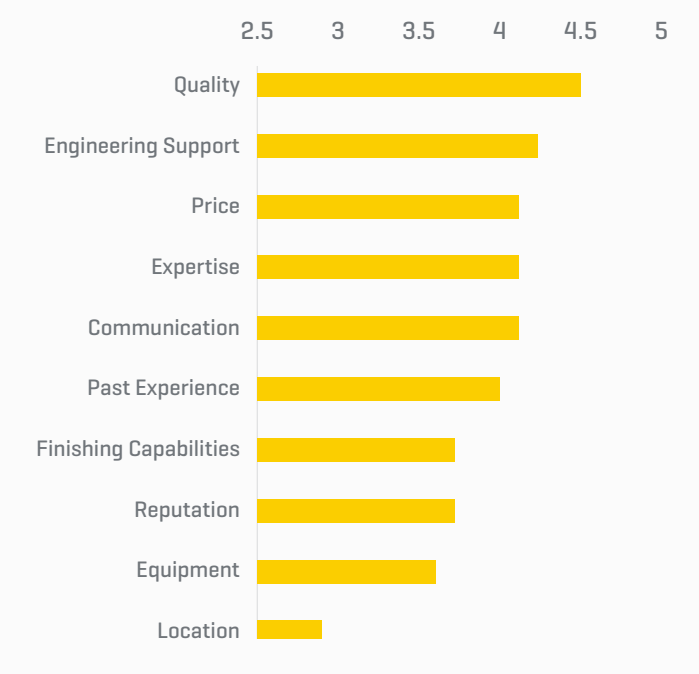
There are also several industries in which quality and aesthetics are top considerations, which show a clear preference for domestic manufacturing. Industries like medical device manufacturing, transportation and green energy all reported a higher-than-average preference for domestic manufacturing.



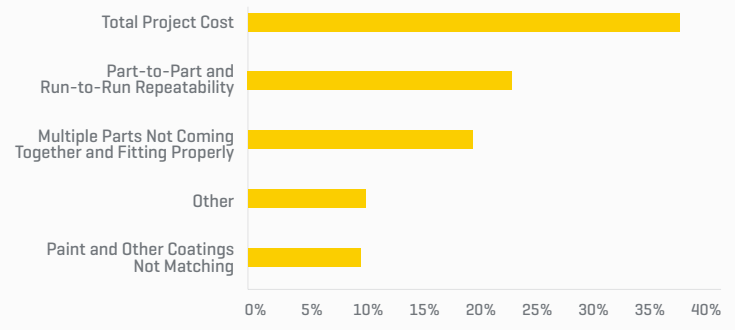
Respondents Looking For More Quality, Less Cost

When asked for their top priority in selecting a plastics manufacturer, respondents overwhelmingly put "Quality" at #1, something they've done every year since we started asking that question in our annual survey. In the same question, respondents ranked price as the #3 priority. However, when we asked the same question in a different way, respondents put concerns with price at #1.

In choosing a plastics manufacturer, how important are each of the following characteristics?



What are the biggest processing challenges for the parts you are receiving today?



After total cost, the next two items on the list — part-to-part repeatability and multiple parts not coming together properly — are common complaints we hear from customers coming from partners who don't make quality and technology a priority. These issues with quality and price are also factors we frequently see driving customers to pressure forming from other processes, including other thermoformers.

Changes In Process Popularity

This year marks the sixth year we've been asking respondents to list the processes they currently use.

While there's always some variation in the population who takes the survey, which causes variation in the processes they report, it's interesting to look at overall trends in process popularity.

The most notable change in this year's chart is a dip in popularity for injection molding. For the past four years, we've seen the percentage of survey takers indicating that they use injection molding steadily climbing: from 59% in 2015; up to a high of 73% last year. However, in our 2019–2020 survey, that number dipped significantly to 45%. Overall, that represents a 38% YoY dip in popularity for injection molding.

More Experience Leads to a Stronger Preference For Domestic Manufacturing

Credible studies have predicted continued growth in the injection molding sector through at least 2023, so time will tell if this dip in the injection molding usage reported in our survey represents a one-time anomaly or is part of a bigger trend.

The increasing use of sheet metal is another trend we're keeping an eye on. Like thermoforming, sheet metal generally has a considerably lower startup cost than injection molding. There may be some manufacturers who are selecting sheet metal for its lower startup costs

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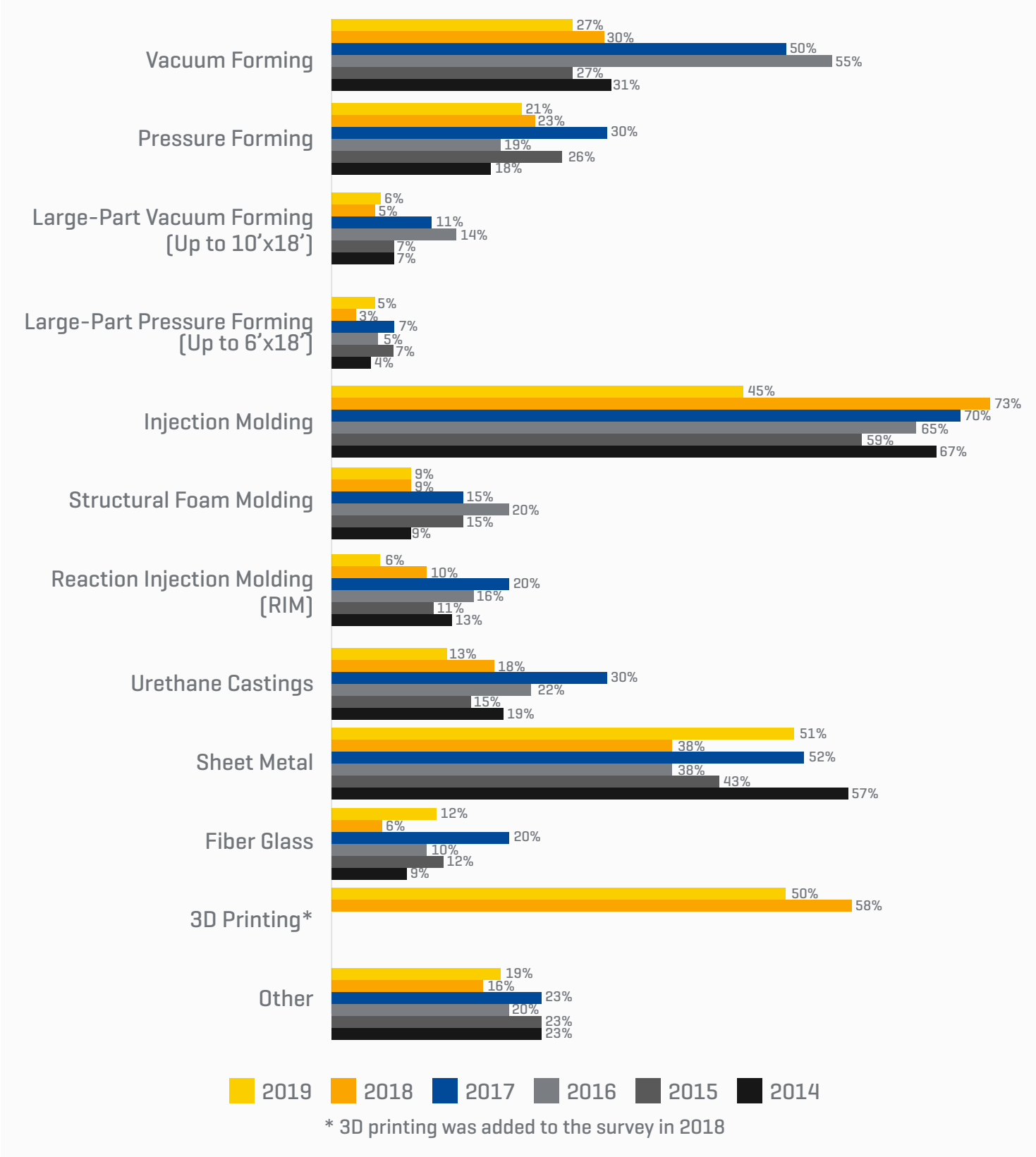
Which of the following processes does your company currently use?

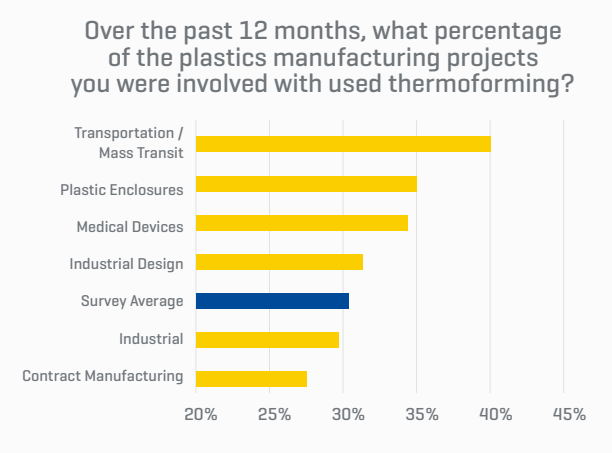


* 3D printing was added to the survey in 2018

Thermoforming Popularity By Respondent Industry

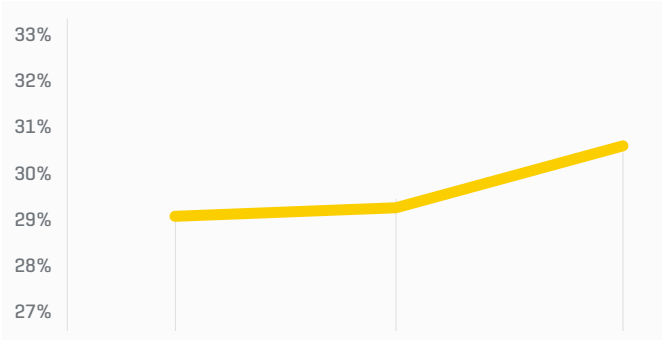
Our survey found that some industries utilize thermoforming at a higher frequency than others. Most notably, transportation, makers of plastic enclosures and medical device manufacturers all reported utilizing thermoforming at higher-than-average rates.

Over the past 12 months, what percentage of the plastics manufacturing projects you were involved with used thermoforming?



Additionally, respondents reported a slight increase in their overall utilization of thermoforming in the past two years.

Over the past 12 months, what percentage of the plastics manufacturing projects you were involved with used thermoforming



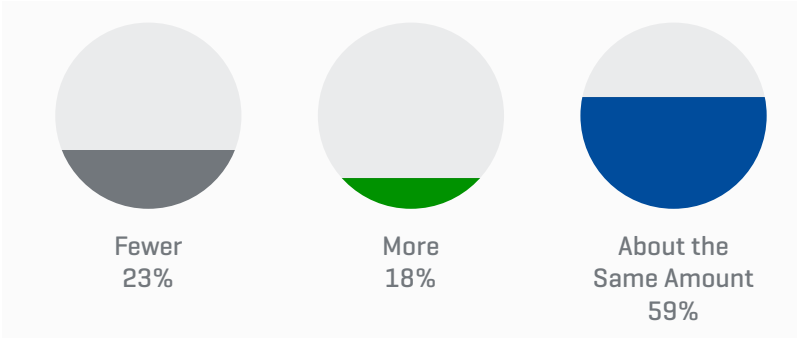
As a whole, this data on thermoforming utilization doesn't come as a surprise to us. We often say that there's no one right process for every project. Our personal take is that while thermoforming isn't the right process for every project, it also likely suffers from a lack of awareness. There are likely many more projects that would be a good fit for thermoforming, but thermoforming just isn't considered as an option.

Respondents Point to a Slight Overall Dip in Total Plastics Manufacturing

For the first time since we started conducting the survey, our respondents predicted an overall decrease in the number of plastics manufacturing projects they expect to undertake in the coming year. 59% of our respondents indicated that they expect to undertake roughly the same volume of projects in 2020 as they did in 2019, but for the first time, respondents who expect to undertake fewer projects (23%) outweigh those who expect to undertake more projects (18%) in the coming year.

Industry analysis **has predicted** a 4% CAGR for the global plastics industry through 2025, so this is another area where we'll wait and see if our survey data is showing an anomaly or a longer-term trend.

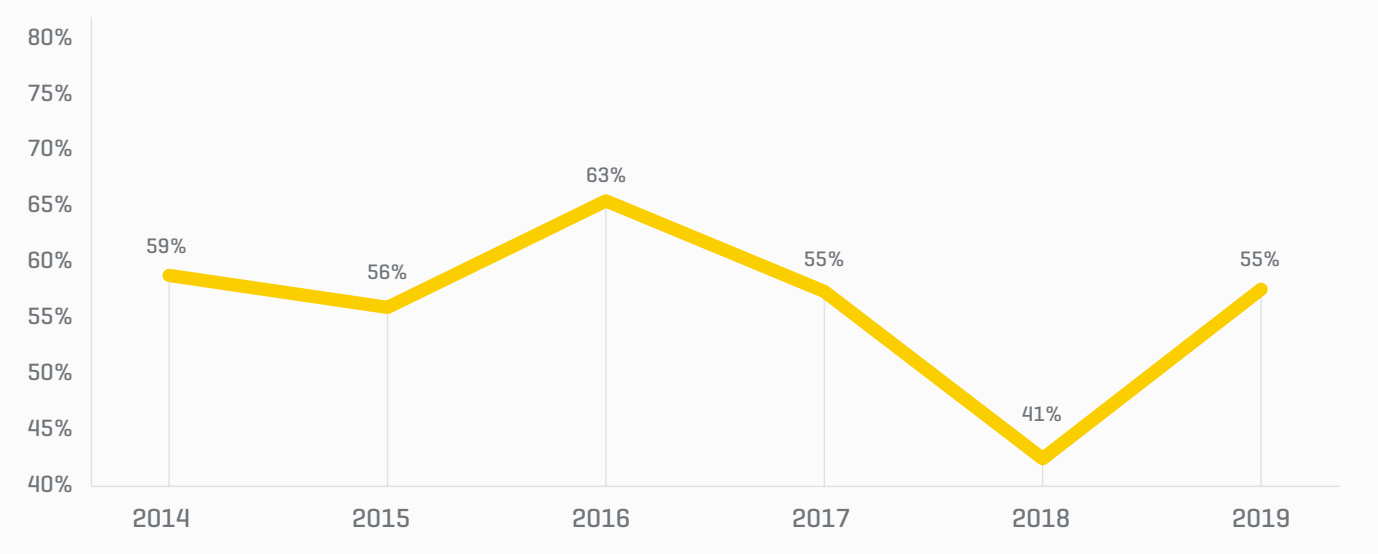
Compared to the last 12 months, how many custom plastics manufacturing projects do you expect to undertake over the next 12 months



Concern With Recyclability on the Rise

After several years of dipping, our respondents' concern with 100% recyclable plastics was once again on the rise this year. This concern hit an all time low in our 2018 survey, with just 41% of respondents indicating that 100% recyclability was important, but climbed back up to 55% in this year's survey.

Is 100% recyclability important to you

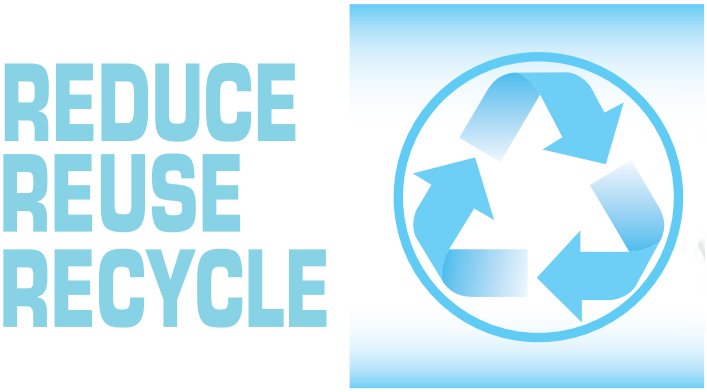


In other ways, it delivered the unexpected: a concern that overall, plastics manufacturing could dip in the coming year, a not insignificant downturn in injection molding utilization, and an increase in concern over recyclability after three years of decline.

Now, we've done all we can to help you peer into the future of 2020. We'll check back next year to see if these trends have continued, or if we're in for another year of change. |

What We Learned, What We Can Expect

In some ways, the data from our 2019–2020 survey reinforced what we already knew. People who utilize plastics manufacturing want it all: the best quality, lowest prices and part-to-part repeatability. They want partners they can depend on, and convenience to go along with them. They prefer manufacturing domestically, but feel that sometimes there's a case to be made for going into markets with lower labor costs (even though we might take issue with that stance).



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Improving Thermoformability of iPP Through Multilayer Coextrusion

Laryssa Meyer, Alex M. Jordan, University of Wisconsin – Stout, Menomonie, WI Kyungtae Kim, Bongjoon Lee, Frank S. Bates, Christopher W. Macosko, University of Minnesota, Minneapolis, MN Ehsan Behzedfar, Lakehead University, Thunder Bay, Ontario Olivier Lhost, Shaffiq Jaffer, Yves Trolez, Total S. A., Feluy, Belgium

Abstract

While the flow forces governing primary melt-based polymer processing techniques, such as extrusion and injection molding, have been extensively studied, characterization of forces in secondary processes such as thermoforming is limited. In this work we utilize multilayer coextrusion to create an extruded film with 100s of alternating linear low density polyethylene (LLDPE) and isotactic polypropylene (iPP) layers; and by extension, 100s of interfaces. The combination of LLDPE, iPP, and these interfaces decreases the elastic storage modulus (E') and broadens the rubbery plateau observed via dynamic mechanical analysis (DMA). The broadening of the rubber plateau is correlated with an observed improvement in LLDPE/iPP multilayer thermoformability compared to the homopolymer LLDPE and iPP films.

Introduction

Due to its low cost and rigid mechanical properties, isotactic polypropylene (iPP) makes an excellent candidate for packaging applications. However, it is notoriously difficult to thermoform due to its low melt strength. Some applications use high molecular weight (low melt index) iPP for thermoforming. [1] Macauley et al. have shown that incorporating nucleating agents improves the thermoformability and extensional processing of iPP. [2] A number of other researchers have utilized reactive extrusion to create long chain branched iPP to improve thermoformability. [3,4] Specifically, Münstedt and colleagues correlated the improved thermoformability to strain hardening behavior observed during transient extensional viscosity measurements.

In our previous work we have been able to achieve strain hardening behavior in iPP melts by exploiting the interfacial tension that exists in multilayer polymer films. [5,6] Additionally, we have probed the adhesion between various iPP and polyethylene grades; finding excellent adhesion and mechanical properties when a metallocene catalyzed iPP is combined with a metallocene catalyzed linear low density polyethylene (LLDPE). [7-10]. Here we build on our previous work with polyolefin interfaces and multilayer coextrusion to exploit the immiscible metallocene LLDPE/iPP interface to create multilayers of LLDPE/iPP for thermoforming with excellent interlayer adhesion and mechanical properties. Coupled with previous improvements in barrier properties observed in multilayer films, [11,12] this work could represent a significant improvement in thermoformed iPP packaging.

Experimental

Two polyolefins were used in this study either from Total or Exxon. Both LLDPE (Exxon Exceed 3518, MFI = 3.5 g/10 min, ρ = 0.918 g/cm3) and iPP (Total MR2001, MFI = 25 g/10 min, ρ = 0.905 g/cm3) were used as received.

Multilayer LLDPE/iPP (50/50 vol/vol) films were fabricated via coextrusion. The coextrusion technique is described in great detail elsewhere [11]. Briefly, one extruder was fed LLDPE while a second extruder was fed iPP. Each extruder fed to a metered gear pump before going to a 20 layer feedblock. The 20 layer system was passed through 5 layer multipliers that double the number of layers in the flow with each multiplication device so that the calculated final number of layers was ~640.

Multilayer LLDPE/iPP films, as well as LLDPE and iPP controls were cut to rectangular strips (30 mm × 6 mm) for DMA (TA Instruments Q800) characterization. Temperature sweeps were conducted at a rate of 20 Hz (strain = 0.1%) over the range 25 °C to 180 °C at a rate of 2 °C/min. A minimum of 3 specimens were tested for each sample for reproducibility. Strain direction was parallel to the extrusion direction of the films.

For thermoforming, multilayer samples were cut into 75 × 75 mm squares. The heater setting on the thermoforming apparatus (Formtech Inc.) was set to full power, and film temperature was monitored by an independent

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thermocouple. Samples were formed at a vacuum level of -30 mmHg over a custom form. The form had a 38 mm diameter base and 13 mm diameter top with a constant 60° taper.

Results & Discussion

Examining the elastic storage modulus (E') from each DMA temperature sweep revealed a very sharp transition from flexible solid to molten liquid in the high melt index iPP homopolymer, which is indicative of poor thermoformability (Figure 1). This abrupt change in state is defined by the narrow range of temperatures where E' drops from 100 MPa to 10 MPa, which is defined a "semimelt" state. In this range of E', the sheet has enough flexibility to permanently form and set upon cooling, but still remains solid. Although LLDPE is also semicrystalline by nature, the transition from flexible solid to molten liquid occurs much more gradually. Coupling this behavior with the high melt index, it would seem that LLDPE homopolymer is a good candidate for thermoforming. However, do to its flexibility it is not necessarily a desirable candidate for thermoformed packaging. The LLDPE/iPP multilayer film exhibits a much more gradual transition from flexible solid to molten liquid with a much more gradual change in rubbery plateau than iPP homopolymer. It is also worth noting that both the iPP and LLDPE/iPP multilayer E' decrease below 10 MPa at the same temperature, 166 °C. This gradual transition suggests the LLDPE/iPP multilayer may be a good candidate for thermoforming.

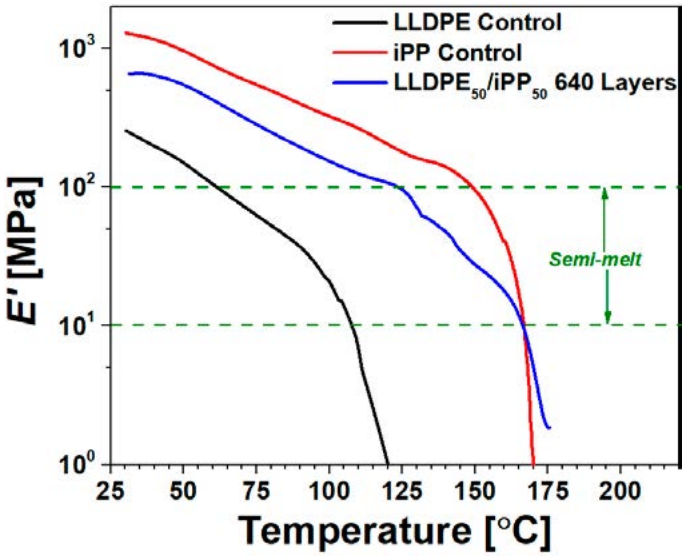

Figure 1. DMA temperature sweeps of LLDPE and iPP homopolymers as well as the LLDPE/iPP multilayer film.

By completing the initial thermoforming trials at two temperatures (112 °C and 121 °C) it is possible to screen for thermoformability. It is clearly seen that even though iPP has a high E' at these temperatures, the films rupture during the forming process. (Figure 2) After rupturing, it is not possible to achieve a good vacuum draw and the parts are of unusable quality. The temperature of 112 °C is at the highest range of temperatures that appear in the "semimelt" window for thermoforming LLDPE, while 112 C is below the low end of the semi-melt window for the LLDPE/iPP multilayers. Minor defects that appear as local thinning are visible in the LLDPE control film. The LLDPE/iPP multilayer thermoforms qualitatively well, although the edge definition of the formed cone has some defects, likely due to the high E' at 112 °C. When the temperature is increased to 121 °C, E' for the LLDPE control is ~1 MPa, while it is ~100 MPa for the LLDPE/iPP multilayers and approaching the semi-melt temperature range. It is clearly seen in Figure 2 that the edge definition of the thermoformed multilayer has improved significantly, with further improvement possible at higher temperatures. The local thinning visually observed in LLDPE at 112 °C significantly worsened with the increase in temperature to 121 °C.

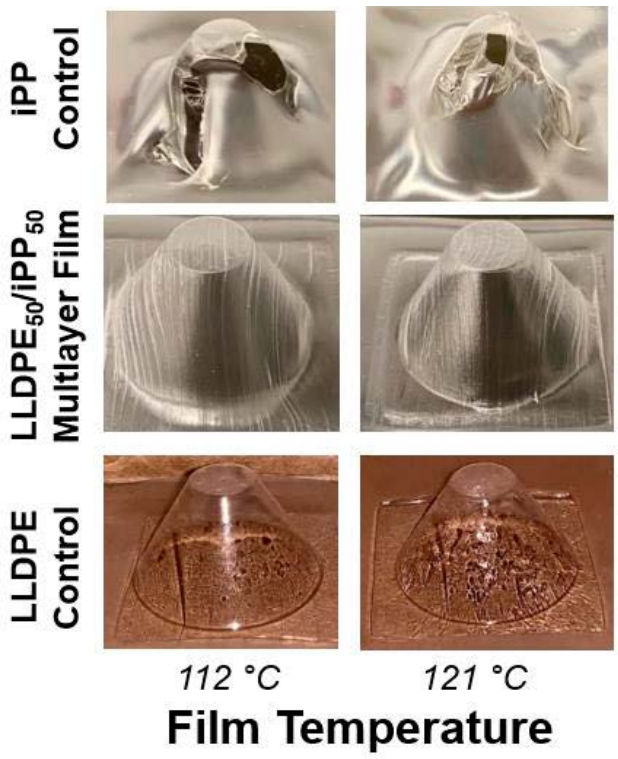

Figure 2. Thermoforming trials for iPP, LLDPE/iPP multilayers, and LLDPE films at 112 °C and 121 °C.

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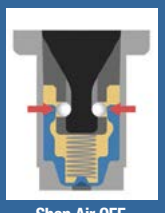

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Conclusions

Dynamic mechanical analysis was used to screen a LLDPE/iPP multilayer film for thermoformability. Based on the range of temperatures and E' measured, two thermoforming temperatures were selected for initial trials. The iPP selected had very poor thermoformability due to its high melt index. Although the selected LLDPE formed into a cone, its inherent flexibility and large number of observable defects suggest it is also a poor packaging candidate. The LLDPE/iPP multilayer film exhibited a significant improvement in thermoformability. Coupled with the excellent adhesion previously observed between metallocene LLDPE and metallocene iPP and resulting improvement in blend mechanical properties, this architecture appears to be very promising for packaging applications.

Acknowledgements

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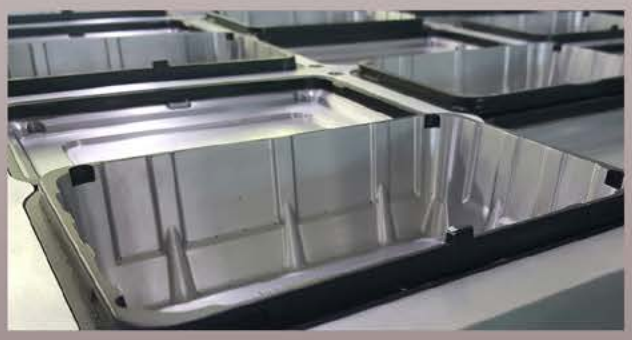

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Short-Run Molds from Bioplastics

Consumers increasingly demand more sustainable products and, fortunately, this trend is being increasingly supported by novel material developments, among other measures. The consumer products industry, such as packaging, toys, etc. is conscious about achieving European environmental targets and users demands. Therefore, they are focusing their efforts in decreasing their environmental impact through different routes such as technology optimisation, new products conception or biomaterial implementation. Nevertheless, bringing new products to market requires an important investment in both cost and time, and this is even more difficult when introducing innovative materials which are totally new for the company.

The product development cycle of new consumer goods can be greatly accelerated thanks to the additive manufacturing (AM) technologies, which allow the production of prototype moulds which are quicker and cheaper than conventional ones. Owing to the advances in AM materials and technology, these prototype moulds can be used for the production or even the customisation of short series of final products, ready to test or to sell.

The Innovative Materials and Manufacturing area of AIJU has been researching on these two lines during the last 15 years: biomaterial developments for AM or conventional processes, and AM prototype moulds, collaborating with different consumer product companies in the conception and launching of new products. Considerable progress has been made in the understanding of the possibilities of current AM polymeric materials, design limitations and optimization of manufacturing parameters, achieving the manufacturing of moulds to produce pre-series or short series of thermoplastic parts.

These parts are no longer considered as prototypes but as final products, where the materials and properties are identical to those obtained through a large-scale conventional manufacturing process, but in very short timeframes and at a lower cost. Moreover, new bioformulations based on biodegradable or biobased polymers filled with natural additives, such as cellulosic fibres, almond shell or CaCO3 from eggshell, have been successfully processed with the developed AM moulds.

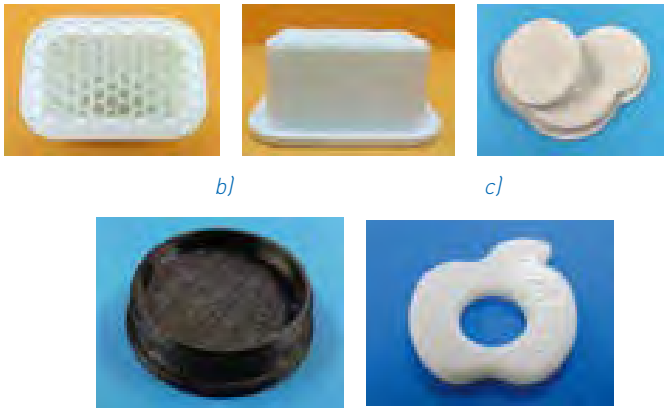

Fig. 1: Thermoforming prototype moulds manufactured by AM technologies and materials: a) laser sintering DTM 2500 plus equipment with PA12 and PA12+Aluminum, b) FDM DT600 with ABS filament and c) Stratasys® PolyJet J750 with acrylic resin

In the case of polyamide moulds, it is worth highlighting that the intrinsic porosity of the sintered parts facilitates the vacuum step without the need of machining vacuum channels in the mould.

Another remarkable characteristic of these moulds was the as-produced surface texture, which is reproduced in the thermoformed parts. A surface finishing can be applied to the moulds in order to produce smoother cavities. However, companies liked the result, as sometimes the moulds are specifically textured to get this type of aesthetics.

Polyjet technology works with a high printing resolution of 30µm, thus the moulds presented a very high surface quality compared to the FDM moulds, as can be seen in Fig. 1, in which the surface finishing was not so good according to the quality required by the final packaging

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and, in this case, post-processing is necessary. Mechanical properties of the moulds were satisfactory in all cases and the thermoforming process was carried out successfully by using PET material, ending in a series of product ready to use, as can be seen in Fig. 2. Other biomaterials, such as bioPET (30 % biobased content by weight) or PLA sheets can be used for the thermoforming of these products.

Fig. 2: Products manufactured by using the AM thermoforming moulds with PET.

Editor's Note:
This article is adapted from the original which appeared in Bioplastics Magazine (Mar/Apr 2020). It was provided by AIJU, Innovative Materials & Manufacturing Area (Alicante, Spain). For more information about AIJU, please visit www.aiju.es. |

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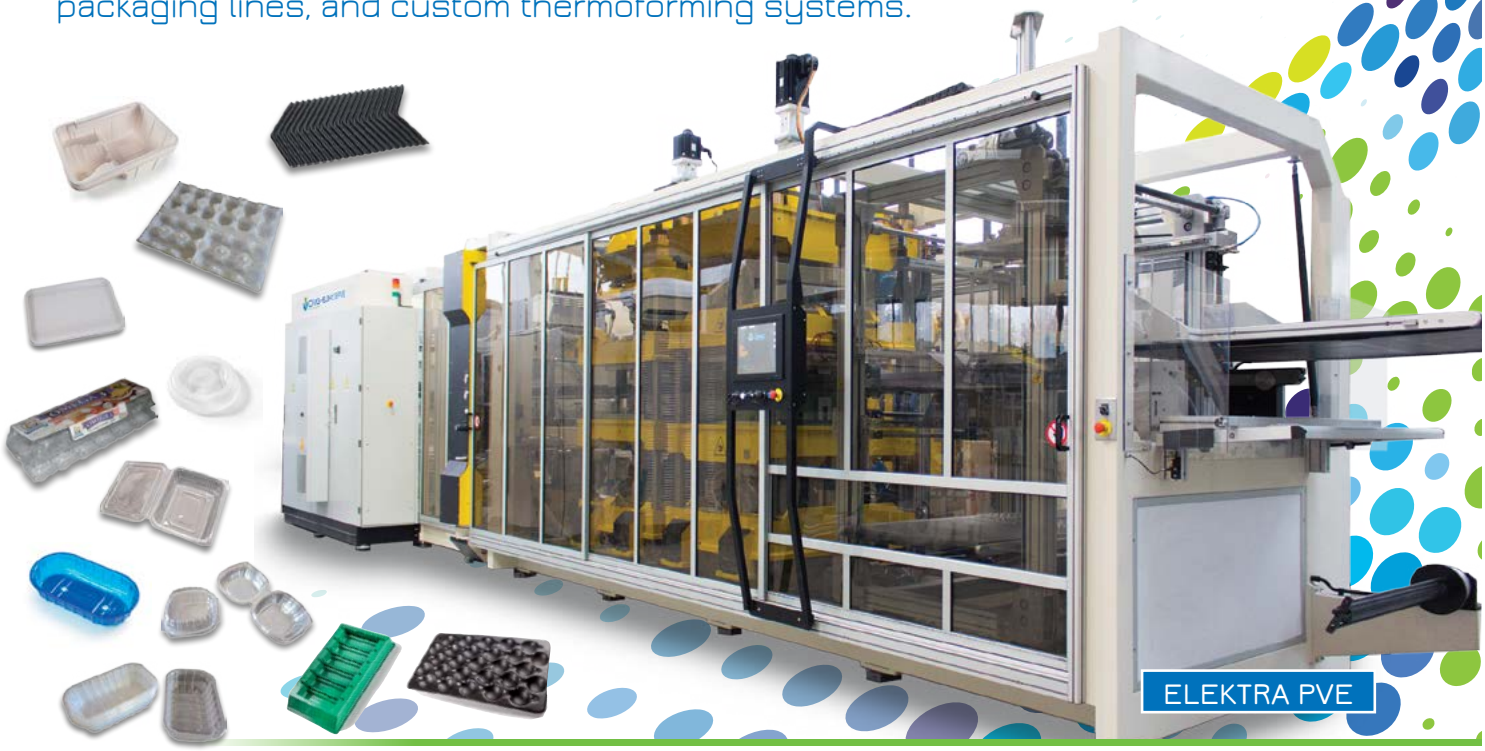

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New and Returning SPE Thermoforming Division Board Members Announced

By Laura Pichon, Membership and Nominating Committee Chair
SPE Thermoforming Division Board of Directors

Members of the SPE Thermoforming Division answered the call for the election of the board of directors! During the Winter board meeting in Point Clear, Alabama, I reported on the election results that were collected with the assistance of SPE Headquarters.

Board positions are voluntary and held by those who work in the thermoforming industry. Held each year, elections are conducted on a rolling three-year cycle. Active SPE Thermoforming Division Members who have shown interest in the board, attended our conference and board meetings, and volunteered on committees are eligible.

Interested in learning more about the board? Please contact me:

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SPE Thermoforming Division to Connect with Public Transportation Professionals

Following the 2020 SPE Thermoforming Conference®, the SPE Thermoforming Division Board of Directors announced its decision to hold its conference every other year. The next conference will be held September 20-22, 2021, in Grand Rapids, Michigan.

"Our challenge as a board is to develop creative strategies to continue to fulfill our mission during the non-conference years," said Eric Short, SPE Thermoforming Division Chair, in a press release.

During its February board meeting, the Board discussed different strategies to spread the good word about thermoforming to the masses. As a result of those meetings, the Division will take that message to the industry – the transportation industry!

Enter APTA: the American Public Transportation Association (APTA), which holds a triennial tradeshow attracting 15,000+ transportation industry professionals. APTA's TRANSform Conference & Expo (https://aptaexpo.com) will be held at the Anaheim Convention Center, October 11-14, 2020.

The Division has reserved a booth (#9236), and opportunities to showcase your company will soon be available. "As a Division, we expect to learn more about the transportation industry's needs, and we look forward to the opportunity to educate APTA Expo attendees on the benefits of and value proposition offered by the thermoforming process," said Short. |

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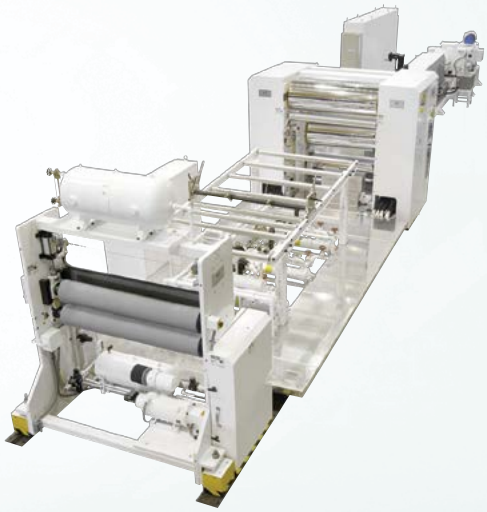

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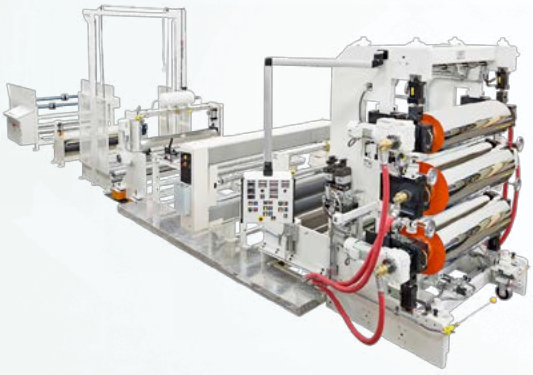

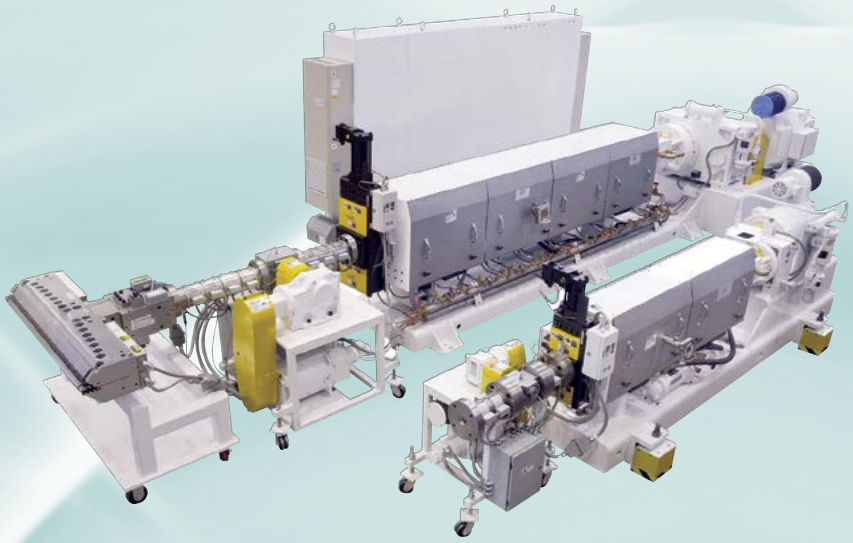

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Richard (Dick) Muhlenthaler (1911 – 2020)

By Bill Bregar, *Plastics News*

Contributions from Jack Schrieffer, Dale Mulenthaler, and Ray Mehta

Richard (Dick) Muhlethaler, a thermoforming pioneer who founded Arrem Plastics Inc. in 1945, has died at the age of 108, six days shy of his 109th birthday.

Born in Newark, N.J., in 1911, Muhlethaler earned a mechanical engineering degree from the Newark College of Engineering. He started Arrem Plastics in Chicago, and later relocated to Addison, Ill.

He was a charter member of the Chicago Section of the Society of Plastics Engineers. He received awards from SPE and the Society of the Plastics Industry Inc., now the Plastics Industry Association, honoring him for innovation, design and execution. The awards included several recognitions for the top part of the year.

In 1959, Arrem began pressure forming to replicate mold detail on the formed part, making Muhlethaler a pioneer in that process. In the 1960s the company began forming parts with undercuts for the lighting industry, using advanced forming and tooling techniques. The parts with undercuts were often used to conceal the metal lighting fixture so that only the formed diffuser was visible, creating a "free floating" effect.

Muhlethaler held two U.S. patents. One was for an all-plastic lighting fixture enclosure that used undercuts to create an integral latching system to seal the enclosure. The second patent was for a two-sided, pressure-formed lens with an optically effective prism on the inside and outside of the lens without using matched metal dies or "coining" the plastic material.

Arrem later used undercuts combined with the pressure forming of etched textures from the tool surface and tight radii (of less than 1/16 of an inch) to form parts that rivaled the appearance of injection molded parts, but with lower tooling costs and shorter lead times. These parts were widely used for high-end applications such as enclosures for medical test equipment — helping to usher a big market for heavy-gauge thermoforming.

According to people who knew him, Muhlethaler allowed every Arrem employee a level of self-determination to decide the best course of action for the long-term good of the company, without interference from him. He shunned the limelight, they said.

An avid golfer, he hit a hole-in-one when he was 83 years old.

Editor's Note: Contributors for Richard (Dick) Muhlethaler Memorial

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Bill Bregar, PN Senior Reporter

***Plastics News* Report**

Editor's Note: Many of us who attended the annual Thermoforming Conference would have recognized Bill Bregar, both in-person and in-print. His coverage of our event was sharp and balanced, always capturing the intricacies of new parts and novel processes. The outpouring of warmth and compassion for a man who was dedicated to his craft is testament to his life and work. We reproduce here the original obituary published by his colleagues at PN.

Ashtabula, Ohio — Bill Bregar, who spent 31 years reporting on the plastics industry, died April 5 of an apparent heart attack at age 58.

Bregar was a plastics industry star, known for his extensive industry knowledge and long list of sources and friends.

He joined Plastics News as a staff reporter shortly before the publication's launch in 1989. His beats changed a few times, but Bregar is best known for his years of experience covering plastics machinery. Initially he covered building and construction, and he has long been one of the publication's experts on injection molding, thermoforming and rotational molding. He was promoted to senior reporter in 1996.

Even from the start, Bregar was the staff's resident historian. He interviewed and profiled new members of the Plastics Hall of Fame, almost always in person, and he's written obituaries for many plastics industry leaders.

Bregar has also coordinated Plastics News' annual Processor of the Year award for two decades, which has involved visiting and judging dozens of North America's top plastics processors.

He has been honored numerous times for reporting and writing excellence, with awards from organizations including the American Society of Business Publication Editors, the Press Club of Cleveland and the Detroit Society of Professional Journalists. One recent story, a feature on Procter & Gamble's Imflux molding technology, won both SPJ and Azbee honors.

Bregar wrote the popular Heavy Metal blog on PlasticsNews.com, where he wrote about machinery and workforce issues, and personal experiences. He also wrote a monthly column on best practices.

Bregar grew up in Kirtland, Ohio, and was a 1979 graduate of Kirtland High School, where he worked on the school newspaper, played tennis and performed on the drums in the marching band. He was a 1983 journalism graduate of Ohio University, where he played in the marching band and participated in Students for Peace.

He had five years of daily newspaper reporting experience before he joined the trade press, initially as an associate editor of *Restaurant Managementmagazine.*

Bregar was a resident of Ashtabula, and he lived in Akron, Ohio, for many years. His wife Nancy died in 2019. He is survived by his adult children, Sam and Molly, his first wife Susan, his mother Betty and his brother Terry. |

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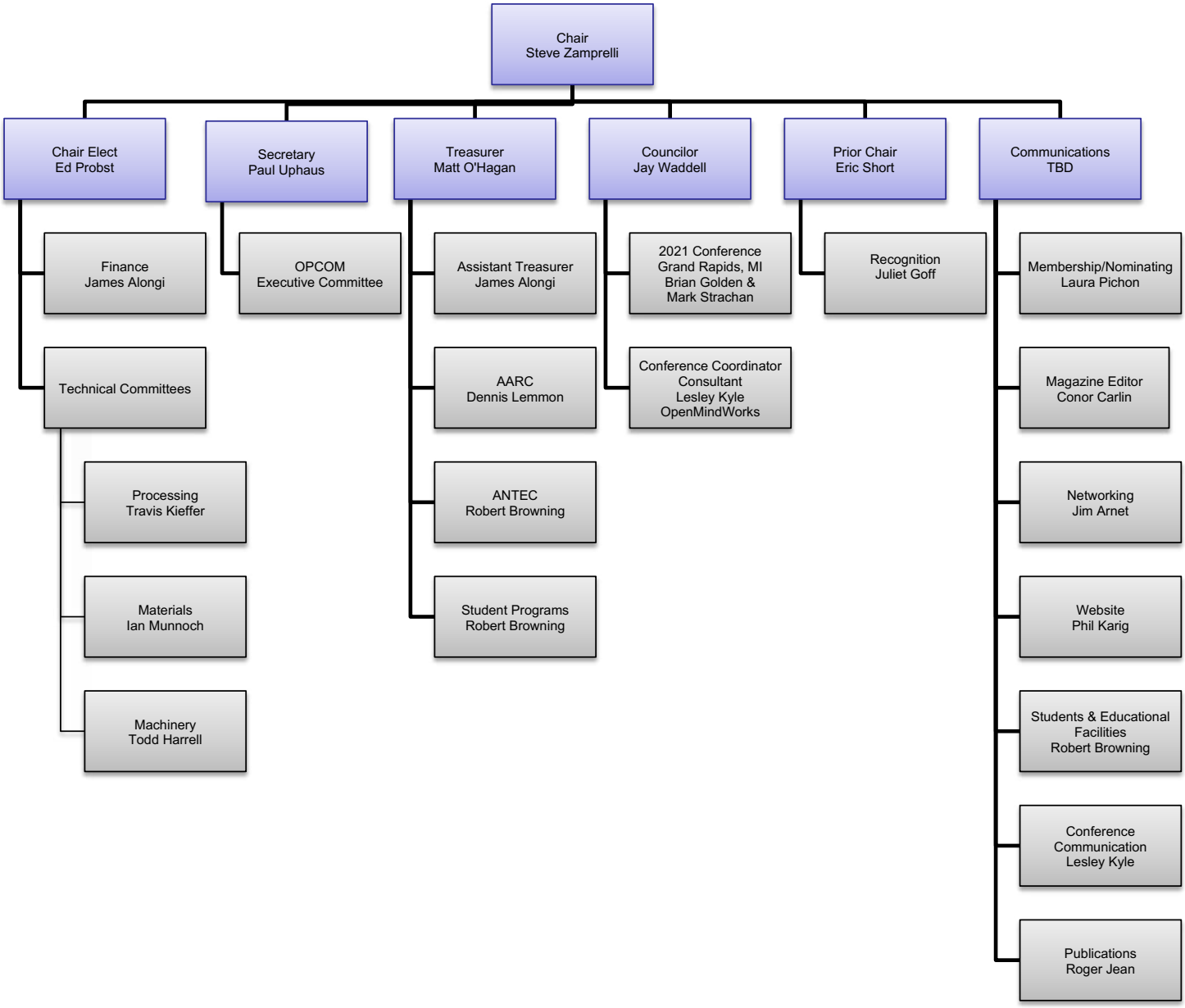
2020 THERMOFORMING DIVISION ORGANIZATIONAL CHART



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PTi Provides Sheet Extrusion Line to Laminex for COVID-19 Face Shields

Pictured left to right: Brian Winton– PTi Director of Sales; Robert Prewitt– Laminex Plant Mgr., TX; Alejandro Jimenez– Laminex Plant Mgr., MX; Jesus Avelar– Janfrex Sales Agent, MX; Tom Limbrunner– PTi SVP Apps and Tech.; Matt Banach– PTi SVP Sales

The system includes a HVTSE® (high vacuum twin screw extruder) Model 85mm-52D DryerLESS™ extruder, G-SERIES® GSVD661824 sheet take off unit and an ACW6640/2 dual position differential shaft winding system that will be utilized in the production of PPE (COVID-19 related personal protection equipment). It offers an output capacity of 2,200 pph (1,000 kg/hr) with a gauge range of 8 – 60 mils at sheet widths up to 60 inches, winding 2-up.

PTi's new HVTSE® dryerless sheet extrusion demo system complete with material handling thru 2-up winding provides Laminex a quick, high quality entre' into PET sheet markets.

PTi and its Mexico based sales agent Grupo Janfrex (Janfrex.mx), began working together as recent as last October and six months later have successfully sold its first line together. The buyer of the line, Laminados Extrudios Plasticos, also known as Laminex (Laminex.mx), is one of the largest suppliers of extruded sheet in Mexico with an extensive product offering.

Laminex was founded during the Mexican economic crisis of 1993 and prides itself with noteworthy achievements made over the years and during various challenging economic periods, including those recently brought on as a result of the global pandemic of the Coronavirus, oil price market collapse, etc.

Laminex desired PET sheet extrusion technology that would permit them to compete with anyone in the marketplace. With PTi's unique and advanced technologies represented in the HVTSE® DryerLESS™ system purchase, Laminex's objectives were soon realized. The system's capability provides Laminex the added flexibility to run many resins from one line and features a twin screw extruder that operates under high vacuum to eliminate the need for drying and crystallizing PET/PLA feed stocks, while removing moisture up to 12000+ ppm (more than twice the normalized undried moisture levels for this geographic region). This technology also allows processing up to 100% regrind materials– a critical component for energy savings and recycling.

Precision machinery offering high production rates, combined with flexible resin capabilities and supported by a professional, responsive equipment partner like PTi, will help Laminex ascend to the next level as a leading producer of extruded sheet throughout the entire North American markets and perhaps beyond.

Laminex's ProTG™ high quality face shields provide PPE to the healthcare industry and individuals alike for protection in the battle against the COVID-19 pandemic contagion.

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–Harry Lincoln

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