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As our country is reopening quickly, and things begin to look more promising, life seems to be coming back! People are getting back on the road, new projects are piling up, and we’re even seeing shortages of materials around the world. When I look back at the period of time we just lived through, I am optimistic that the major hurdles are behind us and I look forward to the second half of my tenure as Chair of the SPE Thermoforming Division.

Our board continues to work to fulfill our mission of education, R&D and promotion. We recently funded a grant supporting plastics education for Detroit students via Ecotek Science at Work. We are currently reviewing student scholarships and plan to make several awards at the upcoming conference. Furthermore, the division is supporting the development of 22 PlastiVideo learning modules for the SPE Foundation. The video learning modules are grouped into five categories: Natural Plastics; Synthetic Plastics; Processes & Material Science; Take Action; and The Future of Plastics. All curriculum is aligned with Next Generation Science Standards and comes with supplementary materials to enhance the classroom experience. Our virtual resources are expected to increase our impact worldwide for years to come!

The SPE Foundation supports the development of plastics professionals by funding quality educational programs, grants and scholarships emphasizing science, engineering, sustainability, and manufacturing while working to create inclusive opportunities for students around the world. Many SPE chapters – and individuals - have contributed to the Foundation’s growth over the years. For more details, be sure to check out the Foundation’s Annual Report by clicking here on the digital edition.

In this issue of the magazine, we bring you a data-driven paper (pp. 14-24) from Aachen University in Germany where researchers analyzed the effect of plug surface roughness on part wall thickness. From North America, the folks at Closed Loop Partners share a wonderful new data visualization tool (pp. 28) that identifies recyclers and material recovery facilities specifically for thermoforms. Combined with a concise summary of the state of PET thermoforms in an article by Steve Navedo (pp. 30-32), readers can be sure that they are getting the most up to date information about this dynamic sector of the industry.

Summer is upon us, but September is not too far away. We are looking forward to welcoming everyone to Grand Rapids for a hybrid conference that will feature in-person sessions and panel discussions, a tradeshow floor, and live streaming events from Europe. In that spirit, we are working closely with our European colleagues who have postponed their bi-annual event until March 2022. For many years, our two groups have shared best practices, hosted each other’s delegates, toured factories, and built-up long-standing camaraderie.

Until we meet in September, stay safe, be well, and celebrate a bright future. The best is yet to come!
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C+K Plastics to Buy North Carolina Thermoformer

By Don Loepp, Plastics News


C+K is the stalking horse bidder for Piedmont’s assets, according to documents filed with the U.S. Bankruptcy Court in Charlotte. If another bidder exceeds C+K’s $1 million offer, then C+K will receive a break-up fee.

David Grice, vice president of sales and marketing for C+K, said the company plans to keep Piedmont’s factory open, and is a few weeks away from making an official announcement.

“C+K Plastics is excited to move into the Carolina market and work with the great customers at Piedmont,” Grice said.

Piedmont Polymers is a heavy-gauge thermoformer that focuses on the aerospace and transit sectors. The company was formerly the fabrication division of Charlotte-based sheet and semifinished product distributor Piedmont Plastics Inc.

Piedmont Plastics sold Piedmont Polymers to financial services company ARC Industries Inc. in 2018. According to court documents, Piedmont Polymers’ sales dropped from about $19.2 million in 2019 to about $11.6 million in 2020. Piedmont Plastics is the largest secured creditor, owed about $5.99 million.

Piedmont Polymers has 11 machines and 53 employees, and ranked No. 96 in the recent Plastics News survey of North American thermoformers.

C+K Plastics ranked No. 58, with sales of $30 million, 200 employees and 20 machines. The company does thermoforming in Metuchen and in Conyers, Ga.

Thermoformer Rohrer Has New Private Equity Owner

By Frank Esposito, Plastics News

April 6, 2021 - Rohrer Corp., a maker of plastic and paper packaging, has been sold to private equity firm Wellspring Capital Management LLC for an undisclosed price.

Wadsworth, Ohio-based Rohrer had been owned by ShoreView Industries of Minneapolis. ShoreView, along with company management, is selling the firm.

Rohrer makes thermoformed plastic consumer packaging and paperboard, including graphically intensive blister, skin, folding carton and clamshell packaging, officials said in a news release. The firm has annual sales of $200 million, with about half of it coming from thermoforming, and ranks as North America’s 27th-largest thermoformer, according to Plastics News data.

Officials said Rohrer’s sales have roughly tripled since 2009, when ShoreView invested in partnership with the Rohrer family. Under ShoreView, Rohrer completed four add-on acquisitions, made significant investments in production equipment and hired new senior leadership as part of a planned transition of family executives from day-to-day management to board roles, officials said.

Rohrer’s senior management team, including CEO Steve Wirrig, will continue to lead the business.

“We believe Wellspring shares our vision of delivering innovative consumer packaging solutions,” he said. “This partnership supports the continued growth of our business so we can provide industry-leading packaging solutions for our customers.”

Rohrer operates eight plants in the U.S. and Mexico. The firm was founded in 1973 and sells into several industries and end markets, including hardware, office supplies, batteries, consumer electronics, automotive aftermarket, consumer products and personal care.

Rohrer made a big move into plastics in 2018, when it bought Transparent Container Co. Inc., a major thermoformer based in Addison, Ill. That deal added six manufacturing sites and balanced out Rohrer’s sales into plastics and paper.

Wellspring also owns Paragon Films Inc., a maker of stretch films used to secure pallet loads during shipping. Wellspring
in early 2019 bought Paragon, of Broken Arrow, Okla., from Chicago-based private equity firm Wind Point Partners.

Financial firms FocalPoint Partners and Harris Williams advised Rohrer and ShoreView on the sale.

“This represents a high-profile deal in the packaging space as well as another important closed transaction for FocalPoint’s growing private equity advisory practice,” said Mike Del Pero, managing director of FocalPoint, which has offices in London, New York, Chicago and Shanghai.

### Acquisition of Packaging Specialist Miko Pac

**Plasteurope.com**

April 6, 2021 - German packaging group Paccor (Düsseldorf; www.paccor.com) has signed an agreement to acquire Miko Pac (Oud-Turnhout / Belgium; www.mikopac.com), the plastic packaging division of Miko Group (Turnhout / Belgium; www.mikogroup.be). With the acquisition, Paccor plans to strengthen its international reach, particularly in the fast-growing Asian market, with Miko Pac’s plant in Indonesia.

The acquisition, scheduled to be completed by Q2 2021, has been priced at approximately EUR 110m, according to Miko. The proposed transaction is yet to be approved by relevant competition authorities. Miko Group achieved a consolidated turnover of EUR 195.1m in 2020, with the plastic packaging department reporting turnover of EUR 107.3m and an EBITDA of EUR 18.4m.

Founded 45 years ago, thermoforming and injection moulding specialist Miko Pac employs around 500 people in Belgium, France, Germany, Indonesia and Poland. After the integration, Miko’s operational management will remain in the hands of its former co-owners and MDs, Kristof Michielsen and Karl Hermans.

In 2019, Paccor had acquired the majority stake in rigid barrier packaging manufacturer EDV Packaging (Barcelona / Spain; www.edvpackaging.com – see Plasteurope.com of 30.07.2019), and had recently announced plans to invest EUR 40m to meet the growing demand for sustainable packaging products (see Plasteurope.com of 15.02.2021).

Paccor CEO Andreas Schütte said, “Following the purchase of the EDV Packaging Solutions in 2019, our acquisition of Miko Pac is the logical next step in implementing our long-term business strategy and an excellent fit for our defined M&A strategy. Miko Pac’s innovative capabilities will further add to strengthen our ability to meet the needs of our customers.”

### Wisconsin Thermoformer Plastic Ingenuity to Open Utah Facility

**By Sarah Kominek, Plastics News**

April 14, 2021 - Wisconsin-based thermoformer Plastic Ingenuity Inc. is opening a new facility in Toole, Utah.

The company expects to add up to 96 new jobs to the area over the next 15 years, an April 8 news release by the Utah Governor’s Office of Economic Development said.

“Plastic Ingenuity has been searching for the right location to accelerate our growth for quite some time, and we believe we have found the ideal match in Tooele,” Sakif Ferdous, chief marketing officer, said in the release. “We investigated municipalities in seven different West Coast states, and Tooele stood out as having the right combination of access to a well-trained employee base, strong public education system, and a business-friendly environment.”

Cross Plains-based Plastic Ingenuity already has five plants and more than 700 employees. With $158 million in annual sales it ranks No. 20 for North American thermoformers according to Plastics News data.

### Plastics Industry Association Testifies on Proposed California Thermoformed Container Legislation

**By Deanne Toto, RecyclingToday**

April 14, 2021 - In February of this year, California Assembly member Phil Ting introduced AB 478, a bill that would require thermoformed plastic containers sold in the state to contain postconsumer recycled plastic (PCR) starting Jan. 1, 2024. The amount of PCR required would increase over time so that thermoformed plastic containers sold in the state would contain no less than 30 percent of this material as of Jan. 1, 2030.

The bill would authorize CalRecovery to conduct audits and investigations regarding containers’ PCR content and take
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enforcement action against a producer to ensure compliance. Producers violating the legislation would be assessed annual administrative penalties for violating the requirements of the proposed legislation.

In response to the legislation, Shannon Crawford, the director of state government affairs at the Plastics Industry Association, Washington, testified before the California State Assembly Natural Resources Committee. In the remarks she prepared for delivery, Crawford writes that while the association’s members “strongly support the use of recycled content” and that “legislating minimum requirements may be beneficial if done appropriately,” the association had some concerns regarding the legislation as proposed.

“While this bill would develop end markets for plastic materials, there should be an equal emphasis on improving the collection and sortation of these materials to get more plastics to these markets,” Crawford writes. “Unfortunately, our analysis indicates there will not be sufficient recycled content to meet the mandates of this legislation. We hope to work with this committee and other stakeholders to increase the availability of recycled content in the state to meet the goals of this bill.”

One barrier she notes is food safety regulations for the use of PCR in food-contact packaging. She adds that the association released industry guidance to ensure recycled plastic packaging meets and exceeds U.S. Food and Drug Administration compliance requirements.

“Additionally, we are developing a ‘best practices’ workbook for recycled content usage in manufacturing,” Crawford states. “The workbook will educate the industry on the benefits of recycled content usage as well as assist companies in reaching their sustainability goals.”

Despite these efforts, Crawford says “a significant gap” remains “between how much recycled content exists and the requirements of this bill.”

Instead, she suggests “this committee focus on advanced sortation and collection technologies,” citing the Pacific Northwest Demonstration Project, which used secondary sorting to increase the amount of recyclable material captured.

“We would be happy to work with this committee and other stakeholders to advance solutions that would increase the availability of recycled content in the state,” Crawford adds.
There is no substitute for the experience we’ve gained by rolling up our sleeves and working through improvements at every stage of thermoforming technology for over six decades. From process design through putting high-output machinery on the floor, innovation is in our DNA.
Solegear changed its name in 2017 as it transitioned from a biopolymers engineering firm to a producer of consumer products and packaging. The company’s products now include plant-based home organization products, bioplastic industrial supplies, medical packaging and compostable food containers.

A year ago, Good Natured bought Brampton, Ontario-based Shepherd Thermoforming & Packaging Inc. At that time, Good Natured CEO Paul Antoniadis said: “If the brand or company sells petroleum-based products, we intend to convert them to a range of plant-based materials.”

That effort continued. In December, Good Natured acquired IPF Holdings Inc., which does business as Integrated Packaging Films, for C$16.7 million (US$13.7 million). IPF extrudes sheet for customers in the electronics, retail, industrial, food and medical packaging markets.

The Ex-Tech and IPF purchases are expected to almost double Good Natured’s sales to about C$66.8 million (US$54.8 million).

However, Good Natured reported a loss of C$7.19 million in the year that ended Dec. 31, compared with a loss of C$3.47 million the year before.

The company said the Ex-Tech acquisition also will increase Good Natured’s capacity to produce rollstock of compostable polylactic acid and plant-based PET “to support organic growth and conversion of existing and future petroleum-based acquisition targets.”

Good Natured said it expects to close the deal by June 30 and the current Ex-Tech management team will join Good Natured.

Family-owned Ex-Tech’s officials hold about 5 million shares of Good Natured. Emily Pichon, Ex-Tech chair and majority owner, said the family intends to retain those shares.

“We have witnessed firsthand, over the past several years, the tremendous growth we’ve achieved with Good Natured and also benefited as material owners,” Pichon said in a May 5 news release.

“We believe now is the perfect time for the two companies to fully integrate. Given the significant growing demand for environmentally responsible materials and the greater scale and influence we can achieve together, combining forces creates tremendous value in our industry, as well as for all of us as owners.”

Alleghany Capital Corporation Announces Formation Of Piedmont Manufacturing Group, LLC And Its Acquisition Of Wilbert, Inc.

NEW YORK, May 11, 2021 /PRNewswire/ -- Alleghany Capital Corporation (“Alleghany Capital”), a wholly-owned subsidiary of Alleghany Corporation, today announced that it has formed a new wholly-owned subsidiary, Piedmont Manufacturing Group, LLC (“Piedmont Manufacturing”), to acquire Wilbert, Inc. (dba Wilbert Plastic Services and referred to herein as “WPS” or the “Company”), a provider of injection molded and thermoformed parts and multi-component assemblies for original equipment manufacturer (“OEM”) customers in a range of end-markets. Operating out of three facilities in the Southeast and one in the Midwest United States, WPS provides OEM customers in the industrial, commercial, transportation, recreational, medical, and other industries with a full range of product design and engineering, injection molding, thermoforming, painting, assembly, logistics, and inventory management capabilities.

David Van Geyzel, President and Chief Executive Officer of Alleghany Capital, commented, “We are pleased to announce the formation of Piedmont Manufacturing as our
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eighth platform company and are excited about its acquisition of WPS. We look forward to supporting Greg Botner, President and Chief Executive Officer of WPS, and his dedicated team of over 600 employees as they continue to provide their customers with essential components and services for products that consumers use every day. Consistent with our quasi-autonomous operating model, Greg and his senior management team will continue to lead the Company post-closing and the transaction will not impact WPS’s day-to-day operations.”

Udi Toledano, Chairman of Alleghany Capital, added, “Although WPS has a shared history with and remains a supplier to Wilbert Funeral Services, Inc. (“WFSI”), an Alleghany Capital portfolio company, the two businesses are distinct, with very different capabilities and customers. As a result, there are no plans to combine WPS and WFSI, which is reflected in the formation of Piedmont Manufacturing as our fifth platform company in Alleghany Capital’s Industrial segment.”

Greg Botner, President and Chief Executive Officer of WPS, stated, “We are delighted to partner with Alleghany Capital to build Piedmont Manufacturing into the leading industry platform for value-added products, services, and technology. We are committed to delivering outstanding results to our customers, and this partnership will enhance our ability to further expand our customer base and provide our dedicated employees with even greater opportunities for growth and advancement.”

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Influence Of The Plug Roughness On The Wall Thickness Distribution In Plug-Assisted Thermoforming

Dennis Balcerowiak M.Sc.; Prof. Dr.-Ing. Christian Hopmann; Dr.-Ing. Martin Facklam
Institute for Plastics Processing (IKV) at RWTH Aachen University

Abstract
Thermoforming enables the cost-effective production of thin-walled packaging products. Pre-stretch plugs are used to adjust the resulting wall thickness distribution of the formed parts such as cups. Due to the friction and adhesion of the plastic material to the pre-stretch plug, the material is less stretched in areas having contact to the plug than in areas without contact and accordingly the wall thickness distribution is influenced. In addition to a wide range of process parameters, such as sheet temperature, stretching distance or the activation time of the forming air, the surface roughness of the pre-stretch plugs has an influence on the wall thickness distribution. In order to estimate the resulting wall thickness distribution of the formed parts, the influence of the surface roughness on the resulting wall thickness distribution was analyzed at the plugs geometries and thus stretching conditions of the sheet.

Introduction
Thermoforming is one of the most important technologies to manufacture thin-walled products. Beside technical products like interior parts of cars a large part of packaging products is produced by thermoforming due to thin wall thicknesses and thus a low material input. However, 70 to 90 % of the product costs of a thermoformed cup are still related to the material [1, 2, 3, 4]. In this context, material-efficient production is an essential goal of technological process optimization to increase the efficiency and sustainability of the whole thermoforming process [2, 5, 6]. The material-efficiency can be increased by using pre-stretch plugs during forming after the heating of the plastic sheet. The resulting wall thickness distribution of the parts can be homogenized and thus, thinner sheets can be used. By defined stretching of the material when using plugs, thin wall thicknesses that are critical for mechanical and barrier properties can be avoided. Thicker areas of the parts can be thinned more. Locally over engineered areas of the product can also be prevented [2, 3, 4, 6, 7].

A high variety of different wall thickness distributions are shown in numerous publications on plug-assisted thermoforming. The shown wall thickness distributions are barley to compare because of different mold geometries and thus various pre-stretch plug geometries. In addition, different process parameters like sheet temperature, stretching speed of the sheet and pre-stretching distances are used [7, 8, 9, 10, 11, 12, 13, 14].

It can be stated, that especially the design of the pre-stretch plugs and the sheet temperature have a significant influence on the resulting wall thickness distribution [7, 8, 9, 10, 11, 12, 13, 14]. Apart from the stretching distance and speed the plug’s surface roughness influences the resulting wall thickness distribution as well [9, 10, 15].

Besides the surface roughness of the plugs the sheet temperature has a particularly high influence on the plug/sheet-interaction. When the sheet temperature is increased nearby the glass (amorphous polymer) or crystallite melting temperature (semi-crystalline polymer), the coefficient of static and sliding friction increases only slightly. If the temperatures of the phase transformations are reached and exceeded, the coefficients of friction increase strongly, so that the sheets adhere more to the plugs. The determination of the coefficients is complex and unreliable especially at high sheet temperatures [9, 15].

Due to the difficult determination of the resulting friction coefficients between the plug and the used plastic material depending on the sheet temperature and the plug roughness, simulating the thermoforming process is demanding. The simulated wall thickness distributions often differ from the resulting wall thicknesses when tests are carried out [13].

Facing this background, the aim of investigations of IKV is to analyze the influence of the plug roughness on the resulting wall thicknesses. The shown study explains the influence of the surface roughness while using two different plug geometries.

Materials and Methods
The trials are carried out on the thermoforming machine Kiefel KD 20/25, Kiefel GmbH, Freilassing, Germany.

The used plastic material is polystyrene (67,5 % HIPS, 30% GPPS, 2,5 % titanium dioxide masterbatch) and is commonly
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used in packaging applications. The sheets have a thickness of 0.8 mm and are produced by W.u.H.

Fernholz GmbH & Co. KG, Meinerzhagen, Germany. Per experiment five cups are produced.

The chosen plug geometries depend on the thermoforming mold. The mold and thus the thermoformed cups produced have an opening diameter of 60 mm, a depth of 40 mm and a draft angle of 4°. Different pre-stretch plugs are designed, based on the construction guideline of Schwarzmann [2] and Hopmann et al [14, 16, 17]. Further information on the construction guideline, the design specifications and the design procedure can be found in.

The plug geometry and the variations are shown in Figure 1. Using the described mold leads to a default plug geometry with a wall angle of 4° and a 3 mm radius (4°R3) on the bottom of the plug [2]. The radius connects the flat bottom of the plug and the side wall. The varied plug exhibits a wall angle of 8° and a radius of 9 mm (8°R9). The 8°R9 plug is chosen based on the most homogeneous wall thickness distribution of the produced cup [14, 16, 17].

![Image](image_url)

**Figure 1: Selected pre-stretch plugs and measuring locations of surface roughness to analyze the influence of different plug surface roughnesses [14, 16, 17]**

The used plug material is the syntactic foam Hytac W (manufacturer: CMT Europe BV, Waalwijk, Netherlands). The plugs are produced on an engine lathe with a rotational speed of 560 rpm. The feed of the chisel is performed by hand. The plugs have been processed with different types of sandpaper of Würth GmbH, Künzelsau, Germany. The chosen grain sizes of the sandpaper are 180, 400, 1000 and 2000 and lead to different surface roughness of the plugs.

The resulting roughness are measured with a confocal microscope VK-X200 of Keyence Corporation, Osaka, Japan. The resulting roughness $R_a$ is analyzed on different locations of the plug: The bottom location (center), the edge location and the location of the side wall of the plug (see Figure 1). Per location five measurements are carried out.

Beside the plug geometries and their surface roughness the process parameters like pre-stretching distance (plug displacement), plug speed, delay in activation of the compressed forming air and sheet temperature have an influence on the resulting wall thickness distribution. The used process settings are kept constant and are shown in Table 1. Only the sheet temperature is varied between 120 °C and 130 °C.

**Table 1: Constant process settings of the thermoforming trials [14, 16, 17]**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>entity</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-stretching distance</td>
<td>[-]</td>
<td>94.5 % of the mold depth</td>
</tr>
<tr>
<td>Plug velocity</td>
<td>[mm/s]</td>
<td>273</td>
</tr>
<tr>
<td>Delay in compressed air activation</td>
<td>[-]</td>
<td>after 100 % of pre-stretch distance</td>
</tr>
<tr>
<td>Forming pressure</td>
<td>[bar]</td>
<td>5</td>
</tr>
<tr>
<td>Time of forming pressure</td>
<td>[s]</td>
<td>3</td>
</tr>
<tr>
<td>Plug temperature</td>
<td>[°C]</td>
<td>35</td>
</tr>
<tr>
<td>Sheet temperature</td>
<td>[°C]</td>
<td>120/130</td>
</tr>
</tbody>
</table>

The emitter settings are adjusted with the aim of a homogeneous temperature distribution on the sheet. The sheet’s temperature and gradient are measured with a contact thermometer (testo 992, Testo SE & Co. KGaA, Lenzkirch, Germany).

The local wall thickness is measured over the entire cup cross-section using a Magna Mike 8600 of Olympus Deutschland GmbH, Hamburg, Germany. The facing values of each side of the cup are folded to the other side and average values are taken. A resulting wall thickness distribution of a thermoformed cup using compressed air only, is shown in Figure 2.

Measuring location 1 (ML 1) is located in the middle of the cup base (bottom) and ML 14 near the edge of the opening diameter at the rim. ML 6 and ML 7 are located in the transition area between the bottom and the wall of the cup.

Figure 1: Selected pre-stretch plugs and measuring locations of surface roughness to analyze the influence of different plug surface roughnesses [14, 16, 17].
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Performing the plug processing, the feed of the chisel is set to 0.3 mm. The roughness of this area is with Ra =8 µm. Using the grain size of 2000 it decreases to the half to Ra = 4 µm. Particularly noticeable is the significantly increased roughness of the plugs in the transition location (edge) from the bottom to wall compared to the other measuring areas. The roughness of this area is with Ra = 10 µm very high. The increased roughness might be explained by the more demanding lathing process of larger radii by hand when using syntactic foams.

**Resulting plug surface roughness**

Before thermoforming trails are performed the resulting surface roughness of the pre-stretch plugs is measured to analyze the influence of the different sandpaper grains.

In Figure 3 the resulting roughness of the four produced 4°R3 pre-stretch plugs are shown. These plugs further processed with sandpaper have a different surface roughness depending on the used grain size of the sandpaper. Increasing the grain size of the sandpaper, the surface roughness Ra of the various pre-stretch plugs becomes smaller. A sandpaper with a grain size of 180 results in Rs values of 6.7 µm in the wall location of the plug and up to 8.3 µm in the edge location. When using a sandpaper with a grain size of 2000, the surface roughness decreases as expected. The surface roughness Rs is within the range of 3 to 4.6 µm. The increased roughness in the bottom location of the plugs compared to the wall location can be explained by the different peripheral speeds of the respective plug area during machining.

**Figure 3: Surface roughness of a 4°R3 pre-stretch plug depending on the measuring location and sandpaper grain**

Figure 4 shows the resulting roughness of the 8°R9 pre-stretch plug. As with the grinding of the 4°R3 plug, it can be seen that the surface roughness of the respective measuring location decreases with increasing the grain size of the sandpaper. For example the bottom of the plug using a grain size of 180 has a roughness of Ra =8 µm. Using the grain size of 2000 it decreases to the half to Ra = 4 µm. Particularly noticeable is the significantly increased roughness of the plugs in the transition location (edge) from the bottom to wall compared to the other measuring areas. The roughness of this area is with Ra = 10 µm very high. The increased roughness might be explained by the more demanding lathing process of larger radii by hand when using syntactic foams.

**Resulting wall thickness distributions**

The resulting wall thickness distributions of the molded parts, produced with different surface roughness of the plugs and different sheet temperatures are shown in the following. Figure 5 displays the resulting wall thickness distributions when using a 4°R3 and a sheet temperature of 120 °C.

When comparing Figure 5 with Figure 2, it can be seen that the wall thickness distribution is changed by the plugs compared to pure compressed air forming [14, 16, 17]. Especially the bottom and transition areas (ML 1-ML 7) are stretched...
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less, so that the wall thickness distribution increases by up to 0.35 mm. ML 8 shows the characteristic quench or chill marks (approx. 0.35 mm) that are caused by the sheet being attached shortly to the plugs surface and cooled fast during forming. From ML 8 to ML 14 the stretching of the sheet increases, resulting in thinner wall thicknesses. The part between ML 8/9 and ML 14 represents the sheet section where the material is not in contact with the mold or the plug during the forming process. Due to the reason that no contact with the mold or the plug occurs, the material is freely and more easily to stretch. Volume constancy of the sheet material in combination with a thick bottom area where the material sticks to the plug surface leads to comparatively high stretched material during the forming.

In the bottom area the thickness increases by approx. 0.1 mm from 0.4 mm to 0.5 mm. If more material remains in the bottom area the material has to be thinned more in other areas, as can be seen in ML 10 to ML 14. In this area the wall thickness decreases from approx. 0.16 mm to 0.1 mm. Nevertheless, the wall thickness distribution only changes in the respective characteristics as also shown in [14, 16, 17]. The trend does not change fundamentally even if different plug roughness are applied.

In Figure 7 and 8 the resulting wall thickness distributions of the 8°R9 plugs are shown as a function of the different roughness respectively sandpaper grain size and sheet temperatures. The wall thickness distributions differ from those shown in Figures 5 and 6, because the influence of the different roughness more pronounced.

The resulting wall thickness distribution is within the range of (0.3 mm). Only the higher roughness of the plugs further processed with sandpaper of a grain size of 180 tends to show a slightly thicker bottom (0.41 mm). However, the influence is minimal and different surface roughness do not have an influence on the formation of quench marks

In Figure 6, the sheet temperature was increased from 120 °C to 130 °C. The wall thickness distributions differ at the varied sheet temperatures because of different stretching resistances of the sheet.

**Figure 5: Resulting wall thickness distribution when using a 4°R3 plug with different roughness and a sheet temperature of 120 °C**

**Figure 7: Resulting wall thickness distribution when using an 8°R9 plug with different roughness and a sheet temperature of 120 °C**
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The distributions at 130 °C sheet temperature are shown in Figure 8 and also display a high influence of the different surface roughness. Increasing the sheet temperature from 120 °C to 130 °C the resulting wall thickness distribution does not change drastically.

![Figure 8: Resulting wall thickness distribution when using an 8°R9 plug with different roughness and a sheet temperature of 130 °C](image)

Especially the bottom area varies between 0.25 mm and 0.4 mm, which corresponds to a doubling of the wall thickness. The quench marks, on the other hand, decrease by up to 0.1 mm. Due to volume constancy during stretching of the sheet the material has to be thinned out more when the bottom and wall areas are thicker. The wall area from ML to the rim (ML 14) described above also has a thickness of up to 0.4 mm, as at a sheet temperature of 120 °C.

**Discussion**

As expected, the resulting surface roughness of the plugs decreases as the grain size increases. Higher grain sizes make the surfaces smoother. Differences between the different measuring areas on the plug are based on the different rotation speeds of the plug during mechanical processing as well as during further processing with sandpaper. This leads to higher surface roughness in the bottom areas (Ra = 4.6 - 7.4 µm) due to the peripheral speed decreasing towards the center. In the wall area (Ra = 3.0 - 6.7 µm) of the plugs, where the surface roughness is reduced, the peripheral speeds are higher. The material is better removed by the sandpaper in these areas. With one exception, the roughness values of the transition area of the 4°R3 punch lie between those of the side wall and base area. This changes with the 8°R9 punch used, as the surface roughness of the transition area (Ra = 10 - 13 µm) is significantly higher than in the other areas. A possible reason for the change might be that manufacturing the larger radius during machining by the chisel produces greater surface roughness. These surface roughness can therefore no longer be reduced by using different sandpapers. It can be assumed that with greater surface roughness the material adheres more strongly to the plug due to increased static and sliding friction. Thus, the material will be stretched less in the contact area. With smoother surfaces, the material can slide off more easily, so that the area is stretched more in this case. It is also possible that with an even smoother surface, the material begins to stick more strongly to the plug due to adhesion.

The resulting wall thickness distributions show that the influence of the roughness depends on the used pre-stretch plug geometry and the sheet temperature. The different wall thickness distributions can be explained by analyzing the different stretching resistances and the plug/sheet interaction at different sheet temperatures. With 4°R3 and 8°R9 plugs, the freely stretchable areas of the sheet have different sizes resulting in locally different stretching degrees. As shown in Figures 5 and 6, the material thins out to a thickness of 0.1 mm in the range from ML 10 to ML 14. It is more difficult to draw the material around the edge radius of 3 mm compared to the radius of the other plug with a radius of 9 mm. Since the deflection of the material from the plug requires more force for smaller than for larger radii, the stretching resistance of the sheet is not sufficient to thin the material from the contact area. During the dynamic process the contact area is increased because the plug is pushed into the sheet and the material covers the edge areas and parts of the side wall of the plug. Thus, even higher forces are needed to pull the material of the plug because more material is in contact with the plug and greater frictional forces have to be overcome. Therefore, the bottom area is stretched less and remains relatively thick at approx. 0.4 to 0.5 mm at the two selected sheet temperatures.

The plug surface roughness has no influence on the resulting wall thickness distribution (Fig. 5 and Fig. 6). The comparatively large contact area of the sheet with the plug leads to the necessity that high forces are required to stretch the contact area. The influence of the surface roughness is less important in this case. The induced force that pulls the material around the plug edge is therefore so great that the different friction and adhesions effects are overcome.

The influence of the roughness changes using an 8°R9 plug as shown in Figs. 7 and 8. In general the material is easier
to pull around the radius of 9 mm. Because of the greater pull off and thus stretching of the material from the plug the bottom has a thickness of 0.3 mm (ML 1). Since the bottom area is now thinner than before, less material is drawn from the cup rim due to volume constancy. The area from ML 10 to 15 is comparatively thick.

However, when using plugs with a wall angle of 8° and an edge radius of 9 mm, the surface roughness of the plugs has an influence on the wall thickness distribution. Especially in the bottom area it can be seen that rougher surfaces lead to more material in the bottom of the cup. Due to the increased friction of the material on the plug, the removal of the sheet is more difficult and the material is less stretched. For example, the wall thicknesses at both sheet temperatures and high roughness (sandpaper grain size 180) show a thickness of 0.4 mm, while it decreases to as little as 0.25 mm for a smooth plug with low roughness (grain size 2000). In addition, the tendency can be seen that the increase in sheet temperature leads to stronger adhesion of the material to the plug, as described in [15]. The average surface roughness produced with a grain size of 400 and 1000 (Ra: plug edge 11 and 13 µm; plug bottom 5 and 6 µm) leads to a slightly thicker wall thickness of the bottom using a higher sheet temperature. In addition to the stronger adhesion of the material to the plug, the stretching resistance of the sheet decreases at higher sheet temperatures. The lower stretching resistance leads to a tendency, that less material is pulled off the plug and therefore the bottom is stretched less.

At this point, it cannot be explained why the wall thicknesses in the bottom of the cup on ML 1 are 0.4 mm for a rough plug and 0.25 mm for a smooth plug at both sheet temperatures. The different sheet temperatures lead to the expect that different wall thickness distribution should occur due to the changed adhesion and stretching resistances of the sheet. However, it is possible that the adhesion and stretching resistances at this test setting are balanced which results in the assumption that the effects cancel each other. Further tests have to be carried out to analyze this more in detail.

Furthermore, it is questionable to what extent the wall thickness distributions are influenced, if the roughness at the plug edges is significantly increased when using a 4°R3 plug. The roughness differ significantly from those of the 8°R9 plugs. It must be questioned whether a Ra of approx. 13 µm at an edge radius of 3 mm will have an equally high influence on the wall thickness distribution.

Conclusions

Various pre-stretch plugs were produced which differ in geometry and surface roughness. Based on the analysis of the surface roughness it can be shown, that the post-processing with sandpaper results in different roughness on the plugs depending on the grain size of the sandpaper and on the measured plug location. The plug bottom and the transition area (edge) are comparatively rough compared to the side wall of the plug.

The trials show, that the influence of the surface roughness on the resulting wall thickness of the molded parts depends on the used plug geometry and the sheet temperature. For plugs with a small edge radius and a larger contact area with the sheet, the surface roughness has a small influence. It can be stated, that the material must be pulled around the edge radius. If the force is large enough to pull the material from the plug, all frictional forces are overcome. Thus, no differences in the wall thickness distributions can be recognized. This changes when using a plug with a larger wall angle and a larger edge radius. The material is easier to pull off the plug. Then the friction effects have a greater influence. Rough plugs result in less stretching of the material because less material is pulled off the plug. Smooth plugs enable an easier material pull off, so the bottom of the molded cup becomes thinner.

In further investigations it has to be analysed to which estate a higher roughness of a 4°R3 plug or lower roughness of an 8°R9 plug in the edge area influence the wall thickness distribution. This will enable to analyze the different determined effects when using the other plug geometry and vice versa. In addition, the roughness should be adjusted over the entire plug that the same roughness is set in each location. Furthermore, the influences of additional plug geometries, lower roughness and additional sheet temperatures should be analyzed.

Acknowledgement

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April 2021 - All around the globe, we observe a strong food packaging trend towards increased post-consumer recycled (PCR) content. Many brand owners committed to increasing PCR content in water and carbonated soft drink segments. These developments have driven demand and prices up for clear post-consumer recycled PET bottle flakes. Starlinger viscotec’s solution to tackle this challenge is to prepare PET tray flakes for the recycling loop!

PET-Tray flakes are currently still underutilized. In the US only around 15% of PET thermoformed materials, such as clamshells, cups, trays, or boxes are recovered from the recycling stream. According to NAPCOR, the US currently uses 139 Million pounds of rPET back into thermoform food packaging. The state of California alone disposes of 250 Million pounds of PET thermoform material annually! “In the North American market post-consumer thermoforms are generally not captured in the PET recycling stream.”, confirms Jeff Cornell, Vice President of Sales at Starlinger-Sahm, Inc. “This is changing with new legislation and improved technologies to sort out this valuable material.”

With more developed reprocessing routes, PET trays can be expected to be collected and recycled at a similar rate to overall plastic packaging. This means, that in the near future, this material will enter the PET recycling loop, and recyclers are now preparing their recycling lines for processing it. Yes, post-consumer PET thermoform is good and usable material, and suitable for upcycling. However, it has lower intrinsic viscosity (IV) and it is amorphous – therefore, the material needs pre-treatment first.

Upcycling PET with deCON IV+

For tray to tray recycling, it is required to keep the intrinsic viscosity of the sheet and the final thermoformed packaging at an optimal level. In 2019, Starlinger viscotec has presented the turnkey solution to close the tray recycling loop with deCON IV+. As expected, the response to the solution has been fabulous and it underlines the potential that customers see in tray to tray recycling. “With viscotec’s experience, we are poised to meet the demand for true Tray to Tray circular economy requirements with the deCON IV+: offering crystallization, super cleaning decontamination and iv increase all in one compact unit.”, emphasizes Cornell.

North American and European customers invest in deCON IV+

Starlinger customers in Europe and the US have purchased the new decontamination dryer. Clients from the US, Great Britain, Poland, Japan, Germany and Italy, are convinced by its functions for the PET thermoform application. The deCON IV+ is designed for the production of dry, IV increased, crystallized, de-dusted post-consumer flakes. The unit processes thermoform flakes, bottle flakes, or in-house skeleton waste and is installed directly in front of a production extruder.

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The deCON IV+ unit recovers the loss of intrinsic viscosity during extrusion

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Lacerta Group, Inc., producer of thermoforming and packaging solutions, runs a deCON iV+ decontamination dryer at their venue in Mansfield, Massachusetts.

Jeff Cornell, Vice President of Sales at Starlinger-Sahm, Inc.

Closing the loop in PET thermoform recycling

Post-consumer PET Tray flakes and rPET Tray

Follow the SPE Thermoforming Division on Twitter @SPEThermo
A Data Visualization Tool Identifying Opportunities to Recapture Plastic in the US & Canada

Closed Loop Partners

Editor’s Note: During one of many Zoom meetings during the pandemic, I watched with great interest as Jon Powell of Closed Loop Partners (CLP) demonstrated the power of data visualization tools applied to the thorny problem of plastics recycling. CLP is a NY-based investment firm seeking to catalyze private funding for global plastics recycling infrastructure. The group has recently developed an online tool to help industry identify opportunities to reclaim and recycle plastics. The excerpts below are taken from the company’s website. The link will take readers directly to the interactive map.


Demand for recycled content is growing rapidly, with more than 250 brands and retailers in the U.S. committing to increase their use of recycled content in products and packaging. While 90% of plastic waste ends up in a landfill, incinerator, or worse, in our oceans and the environment, the current supply of recycled plastics meets just 6% of demand for the most common plastics in the US and Canada because of technical or market barriers. This highlights the significant gap between where we are and where we need to be.

Using plastic packaging as a starting point, this tool guides investors, brands, entrepreneurs and policymakers to make data-driven decisions that drive toward a circular future. The map brings to light the diversity of plastic waste, breaking down the volumes of plastics by type and the flows by country, state and province. In doing so, it highlights the critical opportunities to recapture valuable plastics and re-incorporate them into manufacturing supply chains. Enhancing the transparency of supply chains and better understanding the current flow of materials are essential first steps to improve plastics recovery.

And as we collectively move forward on our journey toward circularity, we need to go beyond packaging and capture the full range of plastics flowing through supply chains, including plastic-based healthcare products or textiles, among others. We call upon industries to join us, and share critical data on their plastic waste streams to shed light on opportunities to keep all kinds of plastics in play.
If you are an educator, student or advisor in a college or university with a plastics program, we want to hear from you! The SPE Thermoforming Division has a long and rich tradition of working with academic partners. From scholarships and grants to workforce development programs, the division seeks to promote a stronger bond between industry and academia.

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Moving Toward ‘Widely Recycled’

By Steve Navedo, Navedo Management Group

Editor’s Note: We are grateful to Dan Leif, editor of Resource Recycling, for making this article available to SPE Thermoforming Division members. This article originally ran in the Spring 2021 edition of Plastics Recycling Update magazine. Find more from Plastics Recycling Update at resource-recycling.com/plastics. We invite interested members to attend the publication’s Plastics Recycling Conference March 7-9, 2022 outside Washington, D.C. All the conference details are at plasticsrecycling.com.

Consumer guidance from the recycling industry often goes something like this: “If you are not sure if something is recyclable, don’t put it in the recycling bin – because it’s better to not recycle than to attempt to recycle a contaminant.”

That advice is critically important for protecting the materials that have well-developed and cost-effective routes of flowing through the recycling stream. But it also raises a dilemma when trying to bolster recycling of a material such as the PET thermoform, which holds great opportunity for development in the recycling marketplace but which needs more clarity about its acceptance in local programs.

This article will explore the fundamental issues that have led to barriers in terms of bringing more thermoforms into the plastics recycling system. It will also offer advice for addressing these problems.

Technical Considerations

There are technical-level recycling differences between a clear plastic bottle and a clear plastic clamshell, and this is the first hurdle in growing thermoform recycling in the U.S.

First is the inconsistency of plastic resins used in manufacturing thermoforms – this is one of the biggest reasons thermoforms are not universally recycled. Although PET is the recycling industry’s preferred resin, the percentage of thermoforms made from OPS (oriented polystyrene) is still significant. In addition, some thermoform manufacturers use other PET look-alikes, such as PLA, PVC and PETG.

Labels and glue stand out as another critical technical issue. There is little uniformity in the labels used on thermoformed plastic containers, and this variation in label choices includes the continued use of recycling- unfavorable paper labels. For the purposes of PET recycling, the most advantageous label substrates are polyolefin-based, most commonly polypropylene. This is because the PP will float in water, whereas PET will sink, facilitating separation during wash in the reclam- ation phase.

Additionally, the glue used on thermoforms is much more aggressive than glue used on bottle labels. In many cases, the glue extends to every square inch of the label, making it more difficult to remove from the PET container (or the PET flake once ground). The residue from adhesives also has a tendency to taint the water solution used in washing the PET flake.

The third area of technical concern is intrinsic viscosity. The IV, a measure of a plastic’s tensile strength or elasticity, for PET thermoforms is generally low compared to that of PET bottles, creating challenges when bottles and clamshells are processed together. However, the IV of the post-consumer thermoform regrind can be increased after washing – by solid-stating in the decontamination and upgrading stage – to accommodate end use applications, such as PET bottles, that require a higher IV than the IV of the sheet used to manufacture the thermoforms.

Finally, the thinness of thermoform containers causes a “bulk density” concern in the reclam- ation process (this issue is also seen when processing single-serve water bottles). Plastic bottles and containers are ground into flake form prior to washing, and if the flakes are too light, they have problems flowing readily through the wash process.

Reclaimers can mix and blend the lighter regrind with the thicker bottle flake to raise the overall bulk density. In this step, the blending needs to be vigorous to create a homoge- neous mix to prevent slugs of varying bulk densities going through the system. Alternatively, reclaimers can modify their wash lines to compensate for higher percentages of lighter regrind.

Learning From the Bottle Sector

The beverage industry has used a “triple bottom line” ap- proach to the plastic packaging debate for much longer than the “non-bottle rigid” community. In the process, beverage container stakeholders have invested time and money, both pushing back societal attacks, as well as actively collaborat- ing with the recycling industry. A clear market for recycled material also developed: thanks to direct food contact ap- proval, label testing, light-weighting and bottle bills, plastic beverage bottles catalyzed post-consumer plastics’ entry into direct-contact food packaging.
In short, the plastic beverage bottle industry set a standard for post-consumer plastic recycling. In the late 1990s The American Plastics Council (today, the Plastics Division of the American Chemistry Council) created the All Bottles Program. Since 95% of all plastic bottles were made of recycling friendly PET or HDPE at the time, a simple public message to recycle all plastic bottles was employed. Unfortunately, this strategy worked to the detriment of communicating recyclability for all other plastic packaging, including PET thermoforms.

Today, virtually every recycling program accepts PET and HDPE bottles for reclamation. This development should serve as a template for other non-bottle plastic rigidics. Specifically, thermoformed PET plastic packages must achieve social acceptance as “recycling friendly,” comparable to the technically compatible single-serve plastic water bottle. In partnership with relevant stakeholders, PET thermoforms should, at a minimum, move beyond How2Recycle’s “check locally” classification to the “widely recycled” status held by plastic beverage bottles.

In developing a plan for progress, it’s smart to ask the following question: How did plastic beverage bottles become the preferred recycling package? As noted, the beverage industry collaborated with the plastics recycling industry. For instance, both Coke and Pepsi were long-standing members of the Association of Plastic Recyclers (APR) Technical Committee. The beverage giants discussed, negotiated, and came to terms with the technical hurdles that challenged the recycling industry.

A number of examples underscore the work done to ensure bottle recyclability. Bottle makers eliminated the big black HDPE base cup that served as the pedestal of highly popular 2-liter containers. Aluminum caps gave way to PET recycling-friendly PP caps. Paper labels vanished, replaced by PP labels, which eventually became smaller and more transparent. The practice of using heaps of glue was replaced with a couple of strategic dots of adhesive.

This type of recycling-oriented product modification, on a collaborative stakeholder level, is the paradigm shift needed for the thermoform industry to overcome pushback from the recycling community.

A Growing Need for Material

Although the recycling industry demand for post-consumer thermoforms remains murky due to technical challenges, the demand for recycled PET (rPET) is crystal clear. Brand company commitment for increased post-consumer content in packaging has never been higher. Many consumer-goods companies and retailers have committed to increase recycled content in their packaging to an average of 25% by 2025, compared to the current global average of 2%, according to the Ellen MacArthur Foundation.

As the most recycled plastic globally, PET is the key to increasing recycled plastic content in packaging, particularly in food packaging. Regrettably, the U.S. recycling rate for PET plastic bottles remains stagnant, under 30%, which is not nearly enough to satisfy the CPG demand for recycled content. Today, over 1 billion pounds of PET is used annually to manufacture sheet and film – this supplemental volume of available post-consumer plastic can no longer be ignored.

The plastics industry and its partnering stakeholders must venture their recycling efforts beyond just plastic bottles, and step up their accountability for responsible after-use management of plastic packaging. Failing to do so invites extended producer responsibility mandates for packaging. PET thermoforms are “low hanging fruit” for plastic recycling, with the potential to add hundreds of millions of quality pounds back into the global rPET supply stream.

Recovering the thermoform material will require a collaborative stakeholder value chain.

Ultimately, each stakeholder compromise will promote the greater good of higher plastic packaging recycling rates. In addition, the intrinsic cost for recycled content should be proportional to the commercial benefits earned from post-consumer recycling’s halo effect.

Time for Coordinated Outreach

Below is a look at the six key stakeholder groups in thermoform recycling and what each category requires for greater engagement:

Consumer: Consumers are the ones who choose whether or not to move material into the recycling system to start with, and they need an education campaign that explains PET thermoforms are recyclable and collected in their community for recycling. This education could be complemented by a widespread “Buy Recycled” marketing blitz (the Foundation for Plastic Recycling has in fact already began a “Buy Recycled” effort.)

Materials Recovery Facility: Outreach to MRFs must stress that there is a viable domestic market for collected thermoforms, either in segregated bales or contained at a designated percentage in post-consumer PET bales. At the same time, increased grant opportunities from government and industry could encourage additional investments to accommodate an increased PET thermoform collection stream.
Reclaimer: At the reclaimer level, operators require assurances that increased PET thermoform volumes will lead to ROI that justifies upgrades made to existing PET recycling operations, including the addition of thermoform-dedicated recycling systems. Reclaimers all need to be confident that incoming material supply will fulfill benchmarked quality specifications.

Converter/Thermoformer: Sustainability awareness and technical collaboration with packaging design engineers is necessary to create more recycling-compatible package designs. Also necessary is outreach encouraging converters to incorporate more post-consumer content in their packaging, with favorable awareness of post-consumer resins’ distinguishing quality specifications and pricing structure. It is important to mention that post-consumer resin is not a traditional “commodity” because product quality and specifications are source dependent. Post-consumer resin is more akin to a value-added “specialty resin” than it is to an ordinary commodity.

Brand company: Brands also need outreach to push them to incorporate more post-consumer content in their packaging, with a favorable understanding of post-consumer content specifications and pricing structure.

Retailers: Retail stakeholders need to require vendors who want to sell in their stores to use rPET or PET with recycling friendly labels in their thermoformed packaging. It’s also worth noting that employees working in supermarkets are often the direct recipients of consumer complaints over plastic packaging. At a minimum, they should be able to reply that their packages are recyclable in their own community.

Unfortunately, consumers are at a disadvantage in their understanding of “what is” and “what is not” recyclable. Many do not know that PET thermoforms are 100% recyclable. Ultimately, the public is restricted to those postconsumer materials their local recycling programs are willing to pick up.

The beverage industry’s current “Every Bottle Back” campaign reflects a commercially preemptive prototype that should put them in good stead as legislative mandates are developed. The thermoform industry, as such, has never organized a national eco-centric promotion. It is not practical to deliver a national recycling message for thermoforms while they fall under that mixed bag of recyclables accepted or rejected for collection at the local level.

Unfortunately, thermoforms do not benefit from a centralized deep pocket benefactor group, as the beverage industry’s endorsement of plastic bottles. However, thermoform packaging can benefit from the collaborative stakeholder strategy described above. This value chain is robust enough to effectively increase post-consumer plastic packaging recycling rates and divert millions of pounds of scrap plastic waste from our lands and waterways.

Unleash the Arsenal

If extended producer responsibility policies take hold in the U.S., as is expected, and corporate stakeholders are held responsible for the after-use management of their packaging, it behooves them to take the lead on this effort and administer programs that are effective and sustainable for the consumer, the environment and their businesses.

Client stakeholders must demand sustainable goods and services from their suppliers and service providers. It is critical for corporate stakeholders to exhibit responsible service and product stewardship while remaining actively engaged in the regulatory process.

It’s also worth noting that a national bottle bill would increase the recycling rate and cure the supply shortage for the recycling industry, but concurrently such a system would remove reclaimer incentive to accommodate thermoforms into the recycling stream. Further, beverage industry resistance to a national deposit proposal would suck up significant resources, money and time better spent in helpful collaboration than in steadfast opposition. Moreover, the post-consumer thermoform waste problem would still exist.

Voluntarily increasing thermoform package recycling is one key step to address the plastic waste problem, and it is in the best interest of the plastics, food, CPG and recycling industries to make this happen now.

A common saying in the recycling industry is that “there is no silver bullet” to fix the post-consumer plastics problem. This rings true for the issue of increasing thermoform recycling: any effort should incorporate a full arsenal of environmentally sound, economically practical and socially sustainable strategies. Hopefully, deployment of a variety of complementary efforts will culminate with an unconditional “Widely Recycled” label on every clear plastic PET thermoform.

Steve Navedo is a corporate sustainability veteran who has dedicated over 30 years to plastics reclamation, sustainable packaging and promoting the growth of the nation’s recycling infrastructure. Currently an independent consultant, he is president of the Navedo Management Group and can be contacted at steve@navedogroup.com.
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ALL GENESIS SYSTEMS FEATURE 3 MONTH EXPEDITED DELIVERIES!

Complete Genesis systems are available to meet your exact processing needs. Individual lines sized by process, sheet specifications and output are immediately available and summarized below:

<table>
<thead>
<tr>
<th>Process</th>
<th>Resins</th>
<th>Gauge</th>
<th>Structure</th>
<th>Rates</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COMPACT INLINE THERMOFORMING</strong></td>
<td><strong>Sheet Extrusion/Thermoforming</strong></td>
<td>9 – 90 MILS</td>
<td>Mono- and/or Co-extrusion</td>
<td>1000+ pph, 2000+ pph, 3000+ pph, 4000+ pph</td>
<td>36 – 68 inch sheet widths</td>
</tr>
<tr>
<td><strong>ROTARY THERMOFORMING</strong></td>
<td><strong>Inline Rotary Sheet Extrusion / Thermoforming</strong></td>
<td>9 – 25 MILS</td>
<td>Mono- and/or Co-extrusion</td>
<td>1000+ pph, 2000+ pph, 3000+ pph, 4000+ pph</td>
<td>up to 55 inch sheet widths</td>
</tr>
<tr>
<td><strong>ROLL STOCK</strong></td>
<td><strong>Sheet Extrusion</strong></td>
<td>9 – 60 MILS</td>
<td>Mono- and/or Co-extrusion</td>
<td>1000+ pph, 2000+ pph, 3000+ pph, 4000+ pph</td>
<td>36 - 68 inch sheet widths</td>
</tr>
<tr>
<td><strong>RECYCLING</strong></td>
<td><strong>Extrusion Pelletizing</strong></td>
<td></td>
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</tr>
</tbody>
</table>

Complete Systems built and shipped in as little as 3 months!*

*Contact PTi to determine whether your project qualifies for a Genesis Program Expedited Delivery!