



Thermoforming Quarterly®

A JOURNAL OF THE THERMOFORMING DIVISION OF THE SOCIETY OF PLASTICS ENGINEERS

THIRD QUARTER 2014 ■ VOLUME 33 ■ NUMBER 3

Special Extended Conference Edition

Thermoforming Takes The Prize



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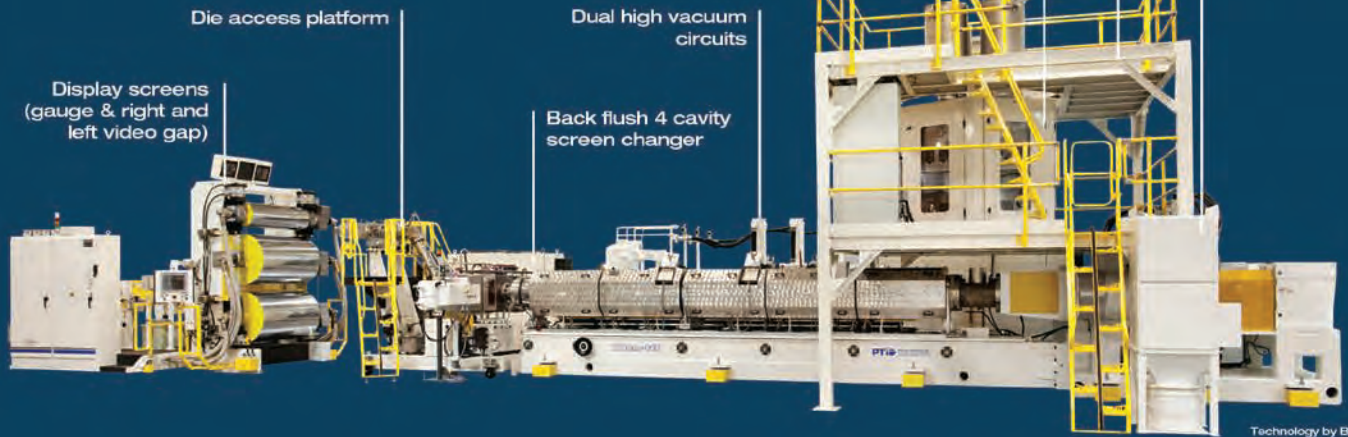
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Thermoforming Quarterly®

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Cover Photo: Renault Twizy rear door assembly by Walter Pack (ESP)
Photographer: David Herranz



Perfect Timing

This issue of *Thermoforming Quarterly* covers some of the most relevant topics currently being discussed in our industry: trends in roll-fed thermoformed packaging, workforce development, the economics of thermoformed transport trays, growth in M&A activity, retort packaging, and techniques that help heavy gauge thermoformers gain more market share in the important automotive sector. Given that we are weeks away from our annual conference, the timing could not be better for us to get together and dive deep into these subjects and the technical underpinnings of our business.

Speaking of timing, the cover of this issue deserves special mention. 2014 saw the inaugural SPE Global Parts Competition at ANTEC Las Vegas. The Renault Twizy rear door assembly (featured in TQ2 vol. 33, no. 2, p.19 as a winner in the European Thermoforming Conference Parts Competition) took home two additional prizes, one

of which was the Grand Prize. Not only is this a wonderful achievement for Walter Pack (Bizkaia, Spain) who created the part, it is also a fabulous acknowledgement for the thermoforming process. The door comprises five ABS-PC and ABS parts and involves three metal inserts. With high quality appearance combined with tight ± 1.5 mm tolerances, the part illustrates how thermoforming combines design aesthetics and safety requirements while incorporating material innovations such as hydrophobic and scratch-resistant nanoparticle polycarbonate lateral glazing.



The Renault Twizy rear door assembly

When you consider the possibilities for processors who seek out innovation further afield from traditional thermoforming, e.g. 3-D printing, new ink technologies, nanotechnology, closed-loop solutions, the world begins to look very attractive. How else can you explain the increasing number of private equity deals in our industry? There are different types of PE investments, of course, but the underlying reason for deploying capital is a belief in profits and a healthy return on investment. And let's not forget about the high rates of growth in emerging markets fueled by increased consumer spending as well as multinational demands for quality improvements.

What will you be talking about when you come to Schaumburg? |

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PendaForm Expanding Bluffton, IN Thermoforming Plant

By Clare Goldsberry, *PlasticsToday.com*
Published: June 6th, 2014

PendaForm Co., formerly Fabri-Form, is expanding its Bluffton, IN, facility that is anticipated to add 50 new jobs and potentially up to \$4 million new investments to the Wells County, IN economy. Work began earlier this year and is expected to be in full production later this year.

PendaForm was formed in the July 2013 merger of Penda Corp., located in Portage, WI, and the Fabri-Form Co. located in New Concord, OH. The company renamed in October of last year. New Concord is the headquarters facility for PendaForm. According to Jack Slinger, president and CEO of PendaForm, Wells County was chosen because of the positive business climate, the ability to expand the building and the hard-working labor force.

The Indiana Economic Development Corporation offered PendaForm up to \$160,000 in conditional tax credits and up to \$35,000 in training grants based on the company's job creation plans. These tax credits are performance-based, meaning until Hoosiers are hired, the company is not eligible to claim incentives, said the Wells County Economic Development office. The City of Bluffton rounded out the incentives through tax abatements, utility upgrades and street improvements.

PendaForm is a leading Tier 1 automotive supplier and the largest industrial heavy-gauge thermoformer in the United States, according to company information. The company's Concord, OH, facility is also a thermoforming facility specializing in material handling, packaging, and engineered components for the automotive, grocery and heavy-duty truck industry. |

C+K Expands with Acquisition of "Friendly" Rival Speck Plastics

By Frank Antosiewicz, *Correspondent, Plastics News*
Published: June 10, 2014 4:44 pm ET

Thermoformer C+K Plastics recently purchased the assets and customer list of a former rival, Speck Plastics Inc. of Nazareth, PA, and it has consolidated Speck's operations into the C+K facility in Metuchen, N.J.

"It's actually been a friendly competition for many years," said Bob Carrier, owner of C+K Plastics, in a phone interview.

The association between the two companies goes back to before he and the owners of Speck were born, Carrier said.

"In 1961, his grandfather and father taught my father the business. They had a shop and back then they built their own machines so my dad went there to learn about the business," Carrier said.

Carrier's late father Emile, who was a salesman for General Tire, joined with another employee, Dan Koch, to form C+K in 1961.

He and Walter Speck III served on a Society of Plastics Engineers' thermoforming board together years ago. When Speck and his sister Suzann decided to sell, they had a familiarity to base the conversation on.

Speck Plastics, which is about 65 miles from C+K's Metuchen's facility, has a long history of thermoforming. It started in 1954 in Port Washington, on Long Island, when Walter Speck Sr. and Walter Speck Jr. joined forces.

Most recently it was owned by the Speck family's third generation — Walt III wanted to pursue a career as a pilot, but Suzann is joining C+K as one of its Mid-Atlantic sales people.

Carrier said three members of Speck's workforce will join C+K. He said the asset purchase included machinery and a customer list. He did not disclose details of the sale.

The Speck operation has been consolidated into the C+K's 80,000-square-foot facility, which has six thermoforming machines including a 3-station Maac. The 8-foot-by-12-foot rotary machine was purchased at the end of 2012. The company also recently added two computer numerically controlled CMS routers.

Carrier said C+K has a diverse market base, making components that range from telecommunications for ships to hospital carts and commercial refrigeration components. Both companies did some work for Lockheed, but Speck has more aerospace and industrial work.

C+K employs about 90, and also has sister company, Valley Extrusions LLC in Allentown, PA. Carrier said that "business is booming" at C+K and noted that sales were 39 percent ahead of last year and that doesn't include new business from the Speck purchase.

C+K is known for its 500 kilowatt solar system that it installed on its roof in 2011, and supplies about half of its energy needs. |

Thermoforming Technology Group Adds Lyle Industries to its Portfolio

By Michael Lauzon, Correspondent, *Plastics News*

Published: July 18, 2014 2:48 pm ET

Updated: July 18, 2014 4:11 pm ET

Thermoforming Technology Group LLC has expanded its thermoforming equipment presence with the acquisition of Lyle Industries Inc.

TTG, which owns thermoforming equipment maker Brown Machine LLC, could help propel Lyle into new market geographies and new products.

Chairman Mike Stein said the acquisition brings “a great thermoforming brand” into TTG.

“Lyle’s high-end [crystalline] PET equipment and bottle trimmers are technology and markets that TTG does not currently participate in,” Stein said in an email to *Plastics News*.

“The acquisition provides a great opportunity to expand Lyle’s global presence through TTG’s existing international network,” Stein said.

Both Brown and Lyle operate as separate companies and maintain their identities, Stein said.

“This acquisition will result in further sharing of best practices and resources that will enhance TTG [companies’] overall value proposition to the thermoforming market,” he said.

Lyle makes roll-fed thermoformers ranging from units geared to limited production to those capable of long runs using high-speed, servo-driven technology. It also supplies on-line steel rule die trim equipment that matches metal-to-metal off-line trimming. It also supplies bottle-trimming equipment.

Lyle, founded in 1965, has customers around the world for its equipment, parts, service and technology. Its major markets are food packaging, horticulture, medical, retail and automotive. Brown Machine is big in roll-fed and cut-sheet thermoformers for new users and customers requiring advanced systems. Brown Machine’s services include process engineering, tooling, productivity enhancing auxiliaries and prototyping laboratory. It claims to be the only thermoforming equipment supplier in the United States offering a full range of products. It has an extensive global presence — its machinery is running in 65 countries. It sells thin-sheet and thick-sheet machinery to diverse markets, among them packaging, automotive, appliance, medical and horticultural. TTG also owns Epco LLC, a machinery remanufacturer and repair company for thermoformers and injection, blow molding and die-casting equipment.

Lyle, Brown Machine, Epco and TTG are all based in Beaverton, Mich. TTG is owned by Spell Capital Partners of Minneapolis and

TTG management.

The deal will enhance and expand Lyle’s product offerings and service capabilities, the company said in a news release. As the thermoforming market grows, Lyle will be able to expand manufacturing capacity and boost research and development. One thermoforming machinery competitor had positive things to say about the deal, including the potential for synergies between Brown and Lyle.

“I believe Mike Stein and the Spell Partners have made a very positive move by acquiring Lyle. The consolidation will add cost savings for engineering, service/install and purchasing,” said Paul Alongi, CEO of Carol Stream, Ill.-based Maac Machinery Corp., in an email to *Plastics News*.

“Brown’s additional technology along with the Spell Partners expertise will catapult Lyle up to the next level. Advancing the Lyle product line while incorporating the savings of consolidation will be better for both firms and for our industry as a whole,” Alongi said.

TTG’s origins date to Spell’s purchase in 2008 of Pacific Production Technologies, which owned Brown Machine and Epco, and hydraulic press maker Pacific Press Technologies. It was Spell’s first investment in machinery manufacturing.

Brown Machine and Epco had been owned by Madison Capital Partners since 1998. Madison had bundled Brown Machine, Epco and Pacific Press into Pacific Production Technologies about a year before it sold PPT to Spell. |

Deal Combines US Packaging Thermoformers

By Gayle S. Putrich, Staff Reportert, *Plastics News*

Published: July 28, 2014 12:42 pm ET

Updated: July 28, 2014 2:28 pm ET

Thermoformed medical packager Nelipak Corp. is expanding its North American holdings and access to the U.S. health care market with the purchase of Phoenix-based custom packager Flexpak Corp.

Cranston, R.I.-based Nelipak announced July 28 that it had closed on the acquisition of Flexpak for an undisclosed amount. The business will be owned by Nelipak and operate under the name Nelipak Healthcare Packaging.

“We are thrilled to expand our global manufacturing footprint and gain greater access to the U.S. and Mexican markets with the acquisition of Flexpak,” said Mike Kelly, president and CEO of Nelipak. “This acquisition enables us to better support our customers, and the Flexpak team and facility complement our current capabilities.”

Founded in 1953 in the southern Netherlands, Nelipak has more than 500 employees worldwide and plants in Cranston, the Netherlands, Ireland, and Costa Rica. From 2005 until late last year the company was a division of Elmwood Park, N.J.-based Sealed Air Corp.'s medical applications business; it was spun off and purchased by private equity firm Mason Wells of Milwaukee purchased in December 2013.

Sealed Air had purchased the business in 2006, and then it added to its medical packaging business a year later when it bought Alga Plastics Co. of Cranston, R.I. Alga began as a family business in 1961.

Flexpak, founded in 1974, is a manufacturer of custom thermoformed trays, clamshells, and blisters with an emphasis on medical markets and some lines designed for the consumer and food markets. In February the company announced new equipment purchases and plans to expand operations in Mexico, where about 40 percent of Flexpak's business was already generated. The merger is expected to continue that growth track.

"This is an incredible growth opportunity for Flexpak's employees and its customers," said Steven Murray, president and CEO of Flexpak, in a news release. "With access to Nelipak's global capabilities, we look forward expanding the Southwest U.S. and Northern Mexican markets and exploring new ways to enhance our value to customers."

Flexpak is No. 81 in *Plastics News'* ranking of North American thermoformers, with sales of \$11 million. Nelipak ranked No. 42 in the listing, with estimated North American sales of \$30 million. |

Tooling Technology Has New Private Equity Owner

By Bill Bregar, Senior Staff Reportert, *Plastics News*
Published: July 25, 2014 11:55 am ET
Updated: July 25, 2014 12:00 pm ET

New York private equity firm GenNx360 Capital Partners has partnered with management to buy Tooling Technology Holdings LLC, a diversified Ohio-based maker of tooling, the fund announced July 23.

Tooling Technology employs about 100 at plants in Fort Loramie and Fremont, Ohio, and an engineering design operation in Grand Rapids, Mich. Terms were not disclosed. GenNx360 officials were not available for comment.

Founded in 1982, Tooling Technology builds thermoforming, blow molding and compression molds for automotive suppliers and customers that make consumer and industrial products — including large molds for hot tubs, kayaks and boat hulls. The company, based in Fort Loramie, does mold design and prototyping, pattern making, CNC machining, casting and finishing.

In 2011 Tooling Technology bought FPM Tooling and Automation, formerly known as Fremont Plastic Molds, to expand into blow mold tooling and automation equipment for trimming, assembly, welding, vision inspection, robotics and packaging systems.

Tooling Technologies also provides quick-change systems for thermoforming, since picking up Edward D. Segen & Co. LLC in 1999. Tooling Technology had been owned by Chicago-based Cognitive Capital Partners LLC.

GenNx360 focuses on middle-market manufacturing firms. Tooling Technology is the third investment for GenNex360 Capital Partners Fund II.

Matt Guenther, the GenNx360 partner who led the transaction, said the private equity owners want to grow the company organically and through add-on acquisitions.

"We strongly believe in the megatrends that drive Tooling Tech's business. Reshoring of industrial manufacturing to the U.S. and strong automotive trends will continue to drive industry growth," Guenther said.

"As we enter our next phase of growth, we are extremely excited to partner with GenNx360," said Tony Seger, Tooling Technology's founder and CEO. "Its significant experience in growing companies, its industry relationships and deep operational expertise will help us immensely in our continued growth efforts." |

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R&D Tax Credits for Thermoformers

By Michael J. Devereux II, CPA
Mueller Prost PC, St. Louis, MO

Enacted in 1981 by the Economic Recovery Tax Act, the Credit for Increasing Research Activities [also known as the Research & Experimentation (R&E) or Research & Development (R&D) tax credit] rewards companies for the development or improvement of its products, processes, techniques, formulas, inventions, or software applications.

As a temporary provision of the Internal Revenue Code, the R&D tax credit enjoys bi-partisan support and is one of the most lobbied tax provisions of the Internal Revenue Code. The credit has expired over a dozen times and is regularly reinstated on a retro-active basis as part of various “tax extenders” packages¹.

The R&D tax credit is a dollar-for-dollar credit against the taxpayer’s federal income tax liability. Taxpayers benefit from the deduction in the year the expenditure is paid or incurred (or subsequent amortization expenditure in the event the taxpayer elects to capitalize its research costs for federal income tax purposes) and by claiming the credit².

Approximately 35 states also have incentives for research and development, based upon the federal definition of qualified research. The various state R&D tax credits range from 1.5% to 40% of the eligible research expenditures, with some states requiring taxable income as a prerequisite for utilizing the credit and others refunding any unused credit to the taxpayer irrespective of the existence of taxable income. Each state has its own requirements, and state credits are only eligible for research conducted within the respective state.

Eligible Research Activities & Applicability to Thermoformers

The R&D tax credit is calculated based upon the expenditures attributed to a taxpayer’s qualified research activities. There are four basic requirements for a qualified research activity. The activities outlined below go beyond the laboratory and R&D departments and demonstrate how companies’ engineering, quality and production departments engage in or directly support qualified research activities. The following overview discusses the requirements and how these activities apply to a typical, custom thermoformer:

1. Development or Improvement of a Business Component

In order for an activity to qualify, thermoformers must be developing a new business component or improving an existing business component that is held for sale, lease, or license, or used by the taxpayer in its trade or business. Business components are defined as products, processes, techniques, formulas, inventions,

or software applications.

Applicability to Thermoformers:

Generally, thermoformers are in the trade or business of manufacturing thermoformed parts to meet their customers’ specifications. In order to do so, they may assist their customers in developing alternative part designs to evaluate or improve manufacturability; develop specialized tooling related to the manufacturing process; develop and test new mold designs; experiment with different methods of production; or invest in advanced machinery to expand upon machining capabilities. Many times, these products or processes qualify as business components and the development and testing of these business components may qualify as a research activity.

2. Eliminating Uncertainty which is Technological in Nature

In order for an activity to qualify, the research must be undertaken for the purpose of eliminating technological uncertainty concerning the development or improvement of a business component.

Uncertainty exists if the information available to the taxpayer does not establish the capability of developing or improving the business component, the methodology of developing or improving the business component, or the appropriate design of the business component.

Taxpayers are not required to be seeking information that exceeds, expands, or refines the common knowledge of skilled professionals in the particular field of science or engineering in which the taxpayer is performing the research. Rather, taxpayers may rely upon existing engineering principles in order to solve the technological uncertainty. Thus, multiple design alternatives may establish the uncertainty required.

Applicability to Thermoformers:

Thermoformers are rarely provided with the information necessary to produce a customer’s part. They are, many times, provided with a part design, and it’s the thermoformer’s responsibility to develop a manufacturing process that will produce a part that meets the customer’s specifications. The development and testing of this process is regularly the focus of many thermoformers’ research activities.

Clearly, the process of experimentation employed by thermoformers relies upon the engineering sciences. Thus, the development of the new processes or improvements to existing processes are technological in nature.

3. Qualified Purpose of Research

In order for a research activity to qualify, the research must relate to new or improved functionality, performance, reliability, or quality.

Applicability to Thermoformers:

A thermoformer's research efforts often relate to improved functionality, performance, reliability, or quality. For example, during the development process, a thermoformer may develop numerous hypotheses regarding, but not limited to, the following activities:

- Development of new mold designs
- Development of specialized fixturing or cutting dies
- Development of prototypes or models (including computer-generated models)
- Automation of manufacturing processes
- Development or testing of new concepts or technology, such as in-process monitoring systems
- Implementation of robotics or production logic control (PLC) programming
- Performance of certification testing on new parts

4. Process of Experimentation

In order for an activity to qualify, a taxpayer must eliminate technological uncertainty by engaging in a process of experimentation. Treasury regulations define a process of experimentation as modeling, simulation, or systematic trial and error.

Applicability to Thermoformers:

Frequently, thermoformers rely upon CAD modeling and systematic trial and error, often in the form of prototype (First Article) construction and testing. Moreover, the production, testing, and refining of sample parts typically involves a systematic approach of trial and error. These activities regularly qualify for the R&D tax credit.

In reviewing the four requirements of a qualified research activity, it is apparent that thermoformers regularly engage in qualified research in the course of business operations. Employees across numerous departments may be engaging in or supporting qualified research activities. For instance, the following activities may meet the definition of qualified research activities:

- New mold design using computer aided design (CAD) software
- Prototyping using 3-D printing and/or SLAs
- Experimenting with part-specific PLC programming
- Experimenting with methods of ejection
- Improving manufacturing processes through automation
- Developing or designing new, part-specific tooling
- Performing First Article inspections on new parts

It is important to note that while Congress wished to reward companies for investing in research and development, it did not intend on all activities associated with its research to be credit-eligible activities. Therefore, the Internal Revenue Code and its regulations disallow the following activities:

- Research after the taxpayer has proved the functionality of a new product or process;
- Adaptation of an existing business component to a particular

customer's requirement or need where the research is not aimed at improving the business component's functionality, quality, performance, or reliability;

- Duplication or reverse engineering of an existing business component;
- Surveys, studies, market research, routine data collection, or routine quality control;
- Research conducted outside of the United States;
- Research in the social sciences, arts, or humanities; and
- Research funded by grants, contracts, or otherwise by another person³

New, Thermoformer-friendly Treasury Regulations

On September 5, 2013, the Treasury Department issued proposed regulations clarifying numerous concepts related to research and experimental expenditures. These treasury regulations are applicable for all tax years.

The most notable clarification provides that if expenditures qualify as research or experimental expenditures, it is irrelevant whether a resulting product is ultimately sold or used in the taxpayer's trade or business. This provision may have tremendous impact for thermoformers. For instance, taxpayers may be able to include labor and supplies (materials) used in the construction of a novel, unique, one-of-a-kind pilot model (tooling) if the design is still uncertain at the time of the mold construction.

Documentation is Key

Taxpayers claiming the credit must capture information necessary to prove that qualified research is taking place, while connecting the employees that perform qualified research to the activities themselves. Business documents that many thermoformers already prepare as part of the engineering or reporting systems are the best place to begin. Many times, these documents – including, but not limited to, drawings, iterative designs, sample results, pictures, notes, emails and meeting minutes – create nexus to the employees performing or supporting qualified research.

Conclusion

The R&D tax credit may provide a competitive edge to companies investing significant resources in the development or improvement of its products or processes. Taxpayers that have not claimed the credit in the past should review prior years' tax returns to determine whether amending its U.S. income tax returns is warranted. Taxpayers already claiming the credit should periodically review their credit methodology, documentation supporting the research expenditures, and the underlying activities to ensure they are claiming the proper amount of R&D tax credit. This approach is prudent to ensure that taxpayers are in line with the IRS' documentation requirements, recent court cases, and ever-changing treasury regulations.

A Note about the Author

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Mike Devereux is Mueller Prost PC's Director of Manufacturing

& Distribution Services. Mike's primary focus is on the R&D tax credit and other tax incentives available to manufacturers. He has spoken at the SPE's Annual Thermoforming Conference, ANTEC, Plastics News Executive and Financial Forums, SPI's Business of Plastics, and MAPP's Benchmarking Conference. Mueller Prost's Tax Incentives Group is nationally recognized and has assisted hundreds of companies in the manufacturing sector identify and utilize these incentives.

References

1 The R&D tax credit is currently eligible for research expenditures incurred on or before December 31, 2013. On April 3, 2014, the Senate Finance Committee reported a bill out of committee to extend (retro-actively) the credit for two years, through December 31, 2015. On April 29, 2014, the House Ways & Means Committee reported a bill out of committee that would make the credit permanent.

2 Depending upon whether the taxpayer claims the credit on its originally filed income tax return, the taxpayer may be required to reduce its research expenditures by the amount of the credit.

3 Amounts payable under any agreement that are contingent on the success of the research and thus considered to be paid for the product or result of the research are not treated as fund[ed]. Treasury regulation §1.41-4A(d)(1). |

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THERMOFORMED PACKAGING 2014 – Market Review & Outlook in North America

By *Plastics News Research*

[Editor's Note: *Thermoforming Quarterly* would like to thank *Plastics News* for making excerpts of their in-depth report available to SPE Thermoforming Division members in this issue of TQ. The full report can be purchased online at www.plasticsnews.com/data.]

Thermoformed packaging sector continues to grow in 2014

North American thermoformers continued to operate in the black in 2013 as average sales and employment increased by approximately 2.5 percent from comparable 2012 data, according to *Plastics News* research.

Packaging is a primary end market for thermoformers. Today's packaging designs and materials are constantly being influenced by factors such as changing retail environments, increased need for health and safety precautions, and most important the consumer. The industry has responded through technical evolutions in packaging to meet these needs and continues to provide value to the consumer.

While still a relatively small plastics processing sector, improvements in tooling, machinery and materials are making the thermoforming process a viable alternative in some applications for which it likely wouldn't have been considered in the past.

Additionally, the global market for thermoformed plastic products is expected to increase from a little more than 7 billion pounds in 2013 to 8.5 billion pounds by 2017, a 4 percent compound annual growth rate (CAGR).

There are products that were traditionally injection molded that are now thermoformed. This trend has driven growth in the segment, including among thermoformers serving the packaging end market.

Opportunities

Retailer differentiation and changing consumer trends have resulted in shorter product life-cycles for many packaging designs. As a result the demand for new, creative and innovative thermoformed packaging is stronger than ever.

The United States additionally is benefiting through manufacturing work coming back to the region — primarily from Asia — in a practice that's come to be known as reshoring.

The packaging generally stays close to production, and as work migrates back to North America, it could lead to opportunity for thermoformers.

"There is anecdotal evidence that reshoring is occurring," noted Jeff Mengel, a Chicago-based partner with Plante & Moran PLLC and a longtime plastics industry analyst. "If that is indeed a trend, you will see more packaging returning to support that production."

Wages in China have been rising at an annual rate of 15 percent to 18 percent, and while workers in processing plants still make much less than their counterparts in North America, the advantage of cheap labor in China is ending.

According to Harry Moser, founder of the Kildeer, IL-based Reshoring Initiative, reshoring has added more than 100,000 jobs in the US in the last three years — and the trend shows no signs of slowing down.

Since 2000, unit labor costs in the US have been flat, while those costs have increased rapidly in China. China's costs have increased at a compounded annual rate of 18 percent vs. an increase of 2 percent in the US. The US increase also was matched by a similar increase in productivity.

Even though China's labor costs remain lower than the US, the gap isn't as great anymore, Moser said. China's labor supply also is tightening as a result of 35 years of that country's one-child policy, added Moser, who has more than 40 years of manufacturing experience.

"A lot of good work went offshore, and [US] companies followed each other like lemmings — it was herd behavior," he said. "They improved their margins, but their overhead and shipping got worse."

In fact, Moser added, plastics and rubber is one of several "tipping point" industries, in which by 2015 it will make more economic sense to have products made in the US than in China.

In 2013, 21 percent of large US companies invested in reshoring — double the rate of 2012. According to a 2012 survey, 40 percent of contract manufacturers in the US were doing reshoring work.

Although some arguments against reshoring continue — such as a shortage of skilled labor, experienced management in the US and the cost of making the transition — Moser explained that many US companies now can justify domestic investment in training and automation without sacrificing quality, delivery and time-to-market.

There are rising costs in other areas. Many tax incentives that

China offered to foreign manufacturers are expiring, energy to operate plants is expensive and shipping costs are increasing.

Reshoring has generated 50,000 US manufacturing jobs across all industries in the past three years – 10 percent of new jobs in this sector – and could result in 500,000 new manufacturing jobs by 2015.

Greater productivity, cost reductions and reshoring are expected to increase export activity and add 2.5 million to 5 million US jobs by the end of the decade, according to Boston Consulting Group.

Cost reductions, coupled with comparatively low prices on a global basis for electricity and natural gas, could by 2015 give the US an export cost advantage of 5 percent to 25 percent over Germany, Italy, France and the UK, as well as Japan.

One industry survey estimated that almost 40 percent of firms with annual sales of more than \$1 billion are planning or considering moving production from China to the US, according to Michael Taylor, senior director of international affairs and trade for SPI.

Taylor also cited a recent MIT study that showed that 14 of 108 multinational companies polled were reshoring as well.

Reasons cited for the moves included problems with quality, language, culture, graft and intellectual property protection in China. The US now offers lower energy costs and a relatively weak dollar, Taylor added.

“US manufacturers are becoming more competitive, while Chinese plastic processing is seeing slower growth,” he said. “US businesses also are very innovative, which gives us strong reasons to be very optimistic moving forward.”

Moreover, global packaging sales are projected to grow at an annual rate of 4 percent to \$975 billion by 2018, according to Smithers Pira, a global testing, consulting and information services business.

The growth of global packaging sales is being driven by a number of trends, depending on various geographical regions. Growing urbanization, investment in housing and construction, the development of retail chains, and the burgeoning healthcare and cosmetics sectors are driving packaging demand in China, India, Brazil, Russia, and other emerging economies. An increase in living standards and personal income in the developing regions fuels consumption across a broad range of products, with subsequent growth in demand for the packaging of these goods.

In terms of economically developed markets, several social and market trends have had a major impact on developments in packaging in recent years. These include: the trends towards smaller households and accompanying rise in demand for more, smaller pack sizes, the increasing requirement for convenience among consumers, and the growing number of men interested in health and beauty products.

Medium-term forecasts for food packaging demand indicate a potential growth rate of 3.4 percent on average to 2018, reaching a value of about \$284 billion. Consumption of drinks packaging over the period is projected to increase at a rate of 3.3 percent on average per annum until 2018, reaching a value of \$102 billion.

When it comes to opportunity, P&M’s Mengel said companies that are on the leading edge of logistics innovation can position themselves for increased business.

“In today’s packaging industry, logistics is about the finished product and less about the package itself,” he pointed out. “I really think that companies can help their customers create packaging options that come off the pallets easier and with minimal handling. They will realize increased business opportunities.”

Tamper-evident packaging

A key aspect to thermoformed packaging is product security, keeping the goods inside the container safe from tampering and theft.

Security is a big issue, according to Dr. Joseph Hotchkiss, director of the School of Packaging and Center for Packaging Innovation and Sustainability at Michigan State University.

“We have a program that we collaborate with in the School of Criminal Justice,” he said. “It is an understatement to say that this is a growing worldwide issue. It is driving a lot of innovation, from incorporating identification devices in the packaging as it is being made.”

California-based PWP Industries recently developed a tamper-evident thermoformed package with a pull-open tab.

Previous tamper-resistant packaging methods included shrink wrapping and thermoforming containers with removable tabs.

Sara Lee has adopted the vacuum-formed PET package for various single-serve, “grab and go” foods. In addition, Wal-Mart has approved the tamper-evident system for so-called “Dip-n-Go” packaging.

“Wal-Mart is a leading indicator of what is coming down the pipe with regards to certain packaging practices,” noted Mengel. “If Walmart is starting it, it is something that other companies will emulate and something that thermoformers should be aware of and able to produce.”

Another option is tamper-proof blister packaging, which is ideal for expansive products that require tamper-proof security. These packaging options protect the products in the package until it reaches the customer.

Most tamper-proof packaging is difficult to open without using a knife or scissors. Tamper-proof packaging is an effort by the brand owner to prevent any achievement in tampering or theft of an item.

Fighting the skills gap

A key challenge facing thermoformers, and the plastics industry, is finding qualified workers to fill key technical positions.

The problem is likely to be magnified in coming years as key positions, including machinists, operators, craft workers, distributors and technician positions become depleted by retirements.

According to the US Department of Labor, the percentage of manufacturing workers aged 55 to 64 years and the share of workers older than 65 years both have increased significantly since 2000. Moreover, the Department of Labor reports that the median age of the manufacturing workforce rose from 40.5 years in 2000 to nearly 45 years in 2013, with more than 500,000 employed in rubber and plastics.

Mengel pointed out that the skills gap is less of an issue for processors seeking operators. When it comes to engineers, there is a greater shortage.

“Looking for the right people is the right thing to do,” he added. “Because people are having trouble finding the right people means two things – they are looking to expand and they are looking for the right people. They are having some problems, but that is true of anyone in a technical field right now.”

Strachan said finding skilled workers remains a challenge for thermoformers today.

“I get a call every single day asking me if I know of anyone who can help a company’s thermoforming operation,” he pointed out.

To give back to the industry, Strachan has served in various capacities with SPE’s Thermoforming Division and has been affiliated with Penn College, which is developing a bachelor’s program in thermoforming.

“A lot of companies are sending students to schools so that they have workers for the future,” he said. “There also are companies that are training former military personnel in thermoforming to help fill the void of skilled workers that currently exists.”

According to a study by Deloitte Consulting LLP in Detroit, US manufacturers in general are facing “a serious shortage” of people to fill skilled positions such as engineers and scientists.

Among employers, 52 percent listed inadequate problem-solving skills among job candidates, according to a Deloitte study. That was the most common skill deficiency, followed by lack of basic technical training, identified by 43 percent.

Those conditions factored into 3.6 million job openings being unfilled in the US in 2013, the most recent year for which data is available. The situation can be fixed, according to Deloitte, through integrated management by tying business strategy to attracting, developing and retaining manufacturing workers.

The process includes workforce analytics, which can help in

workforce planning, recruiting, performance management and succession management.

Analytics already are used in many fields, such as insurance, retail, the US armed forces and health care. The process starts with data and basic reporting and ends with predictive analytics.

Perception of workplace skills and job value also are issues. As far as hiring in manufacturing, too many Americans have gone to four-year colleges, resulting in most of them being overqualified for jobs. This especially will be a disconnect between 2014 and 2020, when the highest number of job openings will be for workers with a high school education or less.

According to a survey by the Canadian Council of Chief Executives, on the needs of 100 of the country’s largest companies. It found that 57 percent felt the skills shortage was a “moderate” problem, while 11 percent called it a “big” problem.

Former Canadian federal cabinet minister John Manley told the council skills shortages do have the potential to impact the economy if the Canadian government and industry don’t start working together.

Training to fill gap

At Michigan State, Hotchkiss said enrollment in the School of Packaging has increased by 70 percent in recent years, with 90 percent of students working in a packaging-related position within six months of graduation.

“The skills gap is certainly a problem,” he said. “Fortunately for us, we are seeing an increase in enrollment. It is a challenge, but it is a good problem to have. We also are seeing a high quality among our students.”

Housed on the campus of Pennsylvania College of Technology in Williamsport, PA, the Thermoforming Center of Excellence is an 1,800-square-foot facility that is making waves in the industry.

C. Hank White is director of the Plastics Innovation & Resource Center (PIRC), which operates the center.

White said the center has grown over the last three years to develop projects in research and development.

“We have applied research for companies who probably would not be able to conduct this work on their own, he said.

The center, which debuted in 2010, is funded through a combination of private money, industry contributions and state grants. The facility and classrooms cost an estimated \$400,000. The facility is equipped with an industrial scale Maac thermoformer with heavy- and thin-gauge capabilities.

The thermoforming industry has been battling a skills gap and White said a competency model in which companies effectively screen candidates could result in an improved workforce

Andy Routsis is president of Routsis Training. The Dracut,

Mass.-based company has provided training in the plastic industry for more than 30 years. He said the skills gap poses a threat to companies that may experience difficulties producing quality products on a consistent basis without the human resources necessary to meet growing demands.

“Even though they have the business, their profit margins are shrinking due to the quality that they are expected to maintain,” he said.

Routsis said the skills gap is getting worse by the day.

“As a result, companies need more employees and newer employees do not have the skill sets,” he said. “Worse yet is our industry is not doing a good job recruiting young people into the industry.

To bridge the gap, companies must be willing to conduct constant training programs and training should become a part of their corporate culture.

“Training must be ongoing and not just a one-time or once-a-year event,” Routsis added.

Machinery challenges

According to Mark Strachan, president of uVu Technologies Co. LLC, North American companies also are facing the challenge of older equipment, which can put them at a competitive disadvantage.

As companies come into North America from Europe and South America, they are bringing with them new state-of-the-art machinery.

“Starting from scratch with brand new equipment, they are able to run parts a lot more efficiently,” he said. “Companies like Dart that had a majority of the market may be starting to lose market share.”

As a result, it has led to some strategic consolidation, such as Dart’s acquisition of Solo in 2012.

Today’s thermoforming machines run at higher speeds, achieving 60-65 cycles per minute. Strachan pointed out that is up from about 20 cycles a minute a decade ago.

“The average is probably around 40 cycles per minute,” he said. “The machines are capable of the higher speeds, but companies haven’t fully got a handle on the tooling to enable the machines to maintain that output.”

While companies like Dart have been able to grow through acquisition, that isn’t an option for most thermoformers. Capital investments in new equipment can lead to productivity gains and can prove to be an investment in growth.

With new machinery, thermoformers can increase their productivity with machines that are wider, faster and more efficient than older equipment.

“I have seen some trends indicating there is some retirement

of old presses going on and acquisition of new presses that addresses optimization and productivity issues,” noted Mengel.

Tooling advances

Some of the industry leaders have in recent years opted to outsource their tooling, particularly since their tooling often is large, high-cavitation units. In the same way, matched-metal tooling calls for much more sophistication, and it is frequently farmed out.

Rapid prototyping systems [3-D printers] along with the development of more intelligent and accurate multi-axis machining stations have reduced the time to market.

Wire iridium systems, laser welding and the availability of steel rule knives with softer bodies along with various levels of knife-tip hardness and developments in plug-assist materials [CMT Materials] have increased tooling accuracy and also have opened up previously impossible opportunities for form-and-trim tooling configurations.

Competition heats up north of the border

In 2014, Canadian thermoformers are facing a plastics industry rife with stiff international competition and it may continue to experience challenges in the years ahead.

According to the Mississauga, Ontario-based Canadian Plastics Industry Association (CPIA), the Canadian plastics industry includes more than 2,400 companies employing an estimated 76,500 workers. Canada’s \$17.6 billion plastics industry is a sophisticated, multifaceted sector encompassing plastic products manufacturing, machinery, molds and resins. Overall, Canada’s manufacturing sector contributes 13 percent to the gross domestic product and employs close to 1.8 million Canadians, more than 95 percent of whom are in full-time jobs.

In Canada, Ontario is at the epicenter of plastic processing activity. The province is home to 1,200 plastic companies employing more than 36,000 and producing \$8 billion in shipments annually. It is the third-largest North American plastics manufacturing jurisdiction behind California and Ohio.

Packaging makes up 39 percent of the Canadian plastics industry, according to CPIA.

According to CPIA, the plastics industry is vital to Canada’s global competitiveness as, increasingly, plastic packaging and products are being used in a wide array of consumer goods, as well as in advanced applications including telecommunications, electronics, aviation and aerospace, medicine and life sciences, building materials, automotive and renewable energy.

According to Carol Hochu, CPIA president and CEO, challenges facing Canadian thermoformed packaging processors today include volatile materials costs, utility costs. Moreover, access to skilled labor in some regions of the country is a challenge.

Hochu points out that the North American economy continues its slow rebound, though that recovery remains somewhat sluggish.

Bill Empey, who has researched the plastics industry as managing partner with Toronto-based Prism Economics and Analysis, said the recession had a serve impact on the Canadian plastics industry.

“The industry has regained half of what it lost over the past few years, and that retrenchment seems likely to continue,” he said.

Another source for optimism, Empey continued, can be found in new opportunities for plastics processors in sustainable product markets, with a continued increasing demand for bio-plastics, high performance composites, and additive manufacturing.

Empey added that the biggest threats to Canadian processors are factors that would hamper gains already made.

A longer-term barrier has been high value of the Canadian dollar and this factor may remain as an issue if commodity prices remain high.

Mexico offers opportunity in North America

Mexico remains a region full of opportunity for North American thermoformers, with retail packaging manufacturers doing more than \$13 billion in business in 2013, continuing growth trends of the previous two years, according to the sector’s national trade association, Asociación Mexicana de Envase y Embalaje AC (AMEE).

The extent of thermoformed packaging’s contribution to that growth is unclear, according to officials.

According to Enrique Guzmán Sánchez, director of machinery manufacturers trade body PMMI’s Latin America office, located in Mexico City, Mexico is Latin America’s biggest and the world’s 11th largest exporter of packaging.

Mexican manufacturers are the second-largest importers of US packaging and processing machinery, according to the US Census Bureau’s Quarterly Import/Export Statistics for September 2013. The report notes changes of 15.79 percent (increasing to \$48 million) for processing equipment and 10.43 percent for packaging machinery (increasing to \$115 million) since the same period in 2012.

“By the end of 2013, Mexico was second only to Canada in imports of US packaging and processing machinery,” Guzman noted.

Going South

North American companies have been investing in Mexico, and packaging opportunities are bound to follow.

Nestlé recently announced plans to build an infant nutrition plant in Ocotlán, Jalisco, and a pet food plant in Silao, Guanajuato, “a striking example of the company’s commitment to Mexico.”

PepsiCo has a history in Mexico, which is considered one of the most attractive — and fastest-moving — markets in Latin America.

“Mexico’s middle class is expanding,” Guzman said. “And its economy is forecast to grow at 3.4 percent in 2014, making it the fastest-growing among the largest economies in North and South America.”

In addition, Cisco Systems Inc. has announced a \$1.3 billion investment in Mexico in 2014 — generating more than 900 jobs. PepsiCo’s plan is expected to generate 4,000 new jobs, and Nestlé anticipates 700 direct jobs as a result of their new Mexican plants.

In December 2013, custom thermoformer and contract packaging firm Flexpak completed an exclusive sales and distribution agreement with the warehousing and supply chain management firm TriMedEx LLC of Tijuana, Mexico, enabling Flexpak to expand its Mexico presence in the Tijuana medical device market.

About 40 percent of Flexpak’s current business is generated in the Mexico markets for Hermosillo, Reynosa and Nogales.

Moreover, Mexico’s competitiveness for manufacturing and exporting to the US is improving versus China.

A number of US companies are now turning their attention to source products from Mexico and, to a lesser extent, from China.

Companies in Mexico spent \$535 million on packaging machinery imports in 2012 — about 85 percent of their total packaging machinery expenditure — making their nation the world’s seventh-largest importer of packaging machinery. The data does not detail how much of that machinery was thermoforming equipment.

Guzman said industry experts predict 6 percent to 8 percent overall growth in Mexico’s packaging machinery market in 2014.

Bioplastics could make inroads in thermoforming

With green products a key concern for customers, thermoformed packaging processors are searching for materials options that are renewable and recyclable.

They are looking toward bioplastics and biocomposites as options to create green products that meet sustainability goals of their customers.

To that end, three universities are joining forces to establish the Center for Bioplastics and Biocomposites to combine academic and private resources to study technical issues surrounding renewably sourced materials. The participating schools are University of Massachusetts Lowell, Iowa State University, and Washington State University.

According to Meg Sobkowicz Kline, a faculty member at the University of Massachusetts Lowell, the focus on the center is to conduct pre-competitive research that would benefit many companies.

David Grewell at Iowa State is director of the Center for Bioplastics and Biocomposites, which will combine academic

and private resources to study technical issues surrounding renewably sourced materials.

According to Grewell, the center will “cover all aspects, including feedstock logistics, pretreatment, synthesis and compounding, manufacturing, economics, and end of life treatment.”

The center will conduct research that promotes industry-wide acceptance of biobased plastics and composites and increases the use of sustainable materials. Projects will look at all aspects in the development of biobased plastics including feedstock logistics; synthesis and compounding of materials; and economic and environmental analysis of new products.

“By bringing together our expertise, we will be able to successfully transfer our ideas, results and technology to the US plastics industry,” said Grewell, who also is chairman of the Iowa State team and an associate professor of agricultural and biosystems engineering.

Companies participating in the center will be able to use results of the research on a royalty-free basis. Research projects will be determined by the members.

When it comes to bioplastics and biocomposites reshaping the plastics industry, Grewell said he does not see major changes to the industry as many of the renewable plastics are a 1-to-1 drop in for traditional plastics.

“While some of the biobased plastic are degradable, the larger market are durable plastics,” he said.

The thermoformed packaging segment can realize some benefits from the center’s expertise.

“We have experts in packaging as well as films and the results will give the industry the knowledge and expertise to quickly and economically use sustainable plastics,” Grewell said.

Grewell added that thermoformers can make use of these materials today.

“Companies such as Ford and Coca-Cola already use these materials, and many of the materials can be thermoformed,” he said. “In addition, some, not all, of these material have a one-to-one cost compared to traditional plastics.”

The proposed center, if approved by the National Science Foundation and the Board of Regents of the state of Iowa, should be fully functional by the end of 2014 with projects running for one to two years on a continuous basis.

“We have 21 member companies that cover the industry from materials suppliers to end-users and we expect more industry members to join,” Grewell added. The cost to join is \$30,000 for companies with more than 500 employees and \$15,000 for companies with fewer than 500.

Administrative costs are being underwritten by the NSF under a

program to encourage collaborative research.

Companies on board include 3M, Branson Ultrasonics, Aspen Research, Creative Composites Ltd, Dukane Ultrasonics, Laurel Biocomposites LLC, M-Base, Minnesota Corn Research & Promotion Council, RheTech, Siegwark USA, SuGanit Systems Inc., Bioplastics Magazine, Powder Coating Research Group, Rubbermaid, USDA-ARS-NCAUR, Dixie Chemical Co., Taylor Technologies, Inland Labels, EcoProducts, Berry Plastics Corp., and ADM.

Grewell concluded that the center will be judged a success “when bioplastics are the mainstream plastics used by industry.”

Executive Spotlight - Dr. Joseph Hotchkiss, Director, School of Packaging and Center for Packaging Innovation and Sustainability at Michigan State University

Dr. Joseph Hotchkiss is director of the School of Packaging and Center for Packaging Innovation and Sustainability at Michigan State University. He has been at Michigan State University since 2009. Prior to that, he was director of the Cornell Institute of Food Science at Cornell University. He also spent 20 years with the Food and Drug Administration and started his career as a supervisory research chemist with Adolph Coors Co.

Q: The skills gap is a key issue for the plastics industry today. The shortage of qualified workers also is a challenge for thermoformers. At Michigan State, you are at Ground Zero in training the next generation. How has enrollment trended in the program?

A: We have had an explosion in students. We’ve seen an increase of about 70 percent in our undergraduate students. We’ve had a little bit of trouble dealing with it, to be honest. Not only in terms of numbers, but the quality of student coming into our program has increased in recent years.

If you wait six months after graduation, you will find that 90 percent of our students have employment in a packaging-related position. We don’t count students that wear paper hats and we don’t count students who are going on to further their education. The average salary is \$60,000. Our students are doing very well.

Q: What kinds of jobs are they filling? Are they becoming engineers or filling jobs in other areas of the packaging segment?

A: The short answer is yes! One of the major growth areas is technical sales and a lot of our students are focused in that area. A majority, probably 65 percent, go to the brand owners.

A lot of brand owners are doing packaging development on their own. A lot of the students will do all sorts of aspects of packaging design.

Among our students, the single most common initial career path is something related to packaging engineering. Often, our students start out in some sort of project role. They can end up being the interface between the brand owner and the converters and the materials industries.

Our students also go to the converter industries and the basic material industries. It has been a change in recent years that the brand owners are picking up most of them.

Q: There are a lot of trends today in thermoformed packaging that are impacting growth and innovation. From your perspective, what are some of the current trends, including packaging applications? How are these trends driving growth and innovation?

A: The biggest trend from our perspective, and it is a large-picture trend, is the power of the tools that have been brought to packaging design, including graphics and so forth.

What used to take tens of thousands of hours and weeks to complete in terms of prototyping for packaging and evaluating that prototype is now reduced to a matter of days.

What this means all across the industry is that the speed of which packaging changes, not just in terms of its presentation but in terms of its materials, is just going to accelerate. I think that everyone has to be responsive to that change.

The other change that we see is that more and more the world of packaging is being driven in some form by the brand owners. They are really driving the packaging value chain.

The greatest example of driving the packaging value chain is Coca-Cola and its plant bottle. They own that bottle all the way back to the production of the resin. That is an example of a brand owner getting into the other segments of the industry. That is going to affect everyone in the industry.

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- Article length: 1,000 - 2,000 words. Look to past articles for guidance.
- Format: .doc or .docx

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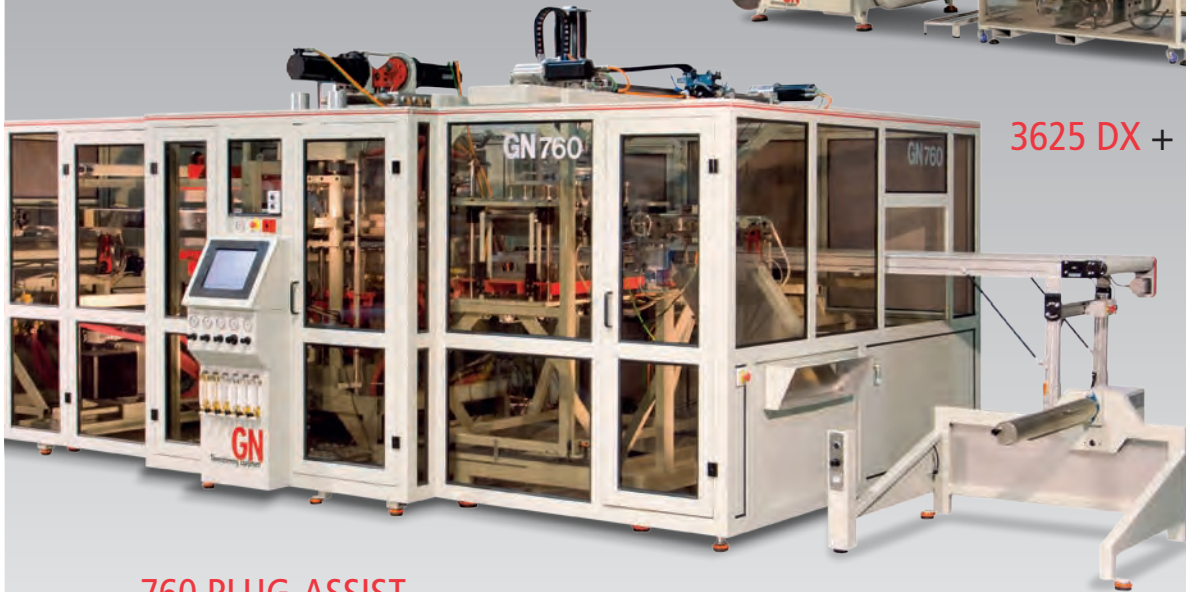
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Thermoformers Must Prioritize Talent Acquisition and Retention

By Zach Ernest, KLA Industries, Cincinnati, OH

In this extremely competitive, high volume, low margin manufacturing industry, the companies with the best people will rise to the top. After all, what else separates one company from the next? Everyone is using similar machines, tooling, and resins to produce their products. New innovations in product lines are great, but they are also quickly copied. From the new hires to the senior leaders, people are the difference: a company's greatest asset is its employees.

At the time of this article, the US unemployment rate is approximately 6%, far below the 10% unemployment rate that America faced in 2009 in the heart of the recession. For people with the right skills, experience and degrees, the unemployment rate in the thermoforming industry seems quite a bit lower. Despite consolidations and recent facility closures by several of the nation's largest thermoforming companies, the demand for engineers and other technical professionals remains high. Fueling this demand is the growth of the industry as a whole and increasing production capacity at many successful organizations. The rising number of baby boomers who are expected to retire in the next few years means companies are scrambling to replace these highly skilled employees. According to Forbes, 75 million boomers are expected to retire within five years and 68% of HR professionals say that boomers retiring will have a major impact on the workforce.

One of the biggest problems companies will have is succession planning. Training of Gen X and Gen Y will be crucial or companies will be in major trouble. This will also mean that an increasing number of opportunities will be created for these individuals to advance their careers.

With this being said, companies must develop a plan for how they will attract these skilled workers while retaining their most valuable people.

Manufacturers that want to attract top talent must be prepared to sell themselves when interviewing passive candidates. While companies must stay competitive when it comes to salary, bonuses and benefits, they must also focus on being a place where people want to come to work. A recent study by CareerBuilder shows that nearly 3 in 4 (68 percent) candidates say they will accept less than their lowest target salary for a company with a favorable brand. This proves that having a positive reputation is becoming much more essential from a professional standpoint.

In order for companies to retain their top people long-term, they must highlight how they appreciate their employees and what sets them apart from others in our industry. Employees need to be challenged and feel that their work has an effect on the company as a whole. Everyone wants to work where they feel valued, appreciated, and where they can make an impact.

Once your company has implemented a positive branding strategy, shown how they offer stability and career growth opportunities, retention of their most valued employees will come shortly thereafter. Continue to develop these employees and provide them with the ability to take on more responsibility over time so they can mentor those who will backfill their position as they advance.

As Richard Branson said, "Train people well enough so they can leave, treat them well enough so they don't want to."

Zach Ernest, CPC leads the Thermoforming Division of KLA Industries, Inc., an executive search firm specializing in the polymer and plastics industry. |

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Paint Replacement in Automotive Applications

Written in cooperation with Thomas Höfels and Walter Körmer, Senoplast Klepsch & Co. GmbH, Austria, & Thorsten Eymael and Nina Schick, SE Kunststoffverarbeitung GmbH & Co. KG, Germany

[Editor's Note: the following article is the second to be adapted from Advanced Thermoforming by Sven Engelmann Dipl. -Ing., Director of R&D at EBB Microparts, Crailsheim, Germany. His recent book, published by Wiley, can be purchased on Amazon. He can be contacted via s.engelmann@ebb-microparts.de]

9.1 Paint Replacement

Paint is always a cost driver in car manufacturing. In a modern car plant paint lines consume approximately 50% of the available surface and approximately 50% of the investment. In addition there are environmental regulations that make the construction of paint lines increasingly difficult in Western Europe.

With film technology, colored plastic films are reinforced with other plastic materials. The result is an entire car component made of plastic. Thus the component requires no painting, weight is reduced, and before or during reinforcement various elements like antennas, connection screws, and hinges can be integrated. For all these reasons the automotive industry is adopting thermoforming as a process for high-quality polymer films and sheets.

One of the first thermoforming applications using colored sheets that were thermoformed was exterior body parts of driving-license-free vehicles. The manufacturers of these vehicles have high standards regarding metallic color effects and color consistency. These standards are very similar to those of the automotive industry. Also when it comes to surface quality, the standards are as high. Although driving-license-free vehicles cannot be compared to regular cars, the learning experience was great in the early stages of paint replacement in thermoforming applications.¹

9.2 Reasons for Replacement of Paint in Automotive Applications

There are many reasons why OEMs would like to eliminate the painting processes:

- High investment cost for paint lines
- High operating costs of paint lines
- Expensive pre-painting part preparation
- High scrap rates
- Environmental regulations
- Capacity dictates price
- Danger of stranded investments

¹Wilhelm Klepsch, Kompetenz in Kunststoff, Page 47, Esperanza Holding, Piesendorf, Austria, 2008.



License-free cars are paint-free cars. License-free cars are a specific market segment in some European countries. These cars have body parts that are completely made from thermoformed, inline colored coextruded plastic sheets. Most parts are made from single-shell, thermoformed plastic sheets that easily can be fastened to an aluminium frame by adhesive systems or mechanical systems like bolts, screws, or rivets. For some parts a two-shell construction consisting of an outer shell with a high-gloss colored surface glued to an inner shell of an embossed material is used. The result is a very stiff reinforced body part. Robots are used to mount the thermoformed body panels onto the aluminium frames. Such vehicles are very lightweight, with a total maximum weight of 350 kg (770lbs).

Due to the lightweight construction these vehicles are ideally suited to be equipped alternatively to the traditional diesel engine with an electric “zero emission” engine. As may be expected, such vehicles will have a great potential for inner city transport.

9.3 Layer Construction of Coextruded, Inline Colored Plastic Sheets

For license-free cars typically a coextruded ABS/PMMA sheet, which is colored to customer specification inline.

Sheet suppliers combine selected PMMA and ABS Polymers in a five-layer sheet. Each polymer plays its particular role, supported by a sophisticated formulation with functional additives, like colors and UV stabilizers, and elaborated layer distribution in coextrusion. The result is a unique combination of properties, tailor-made to meet demand specifications.

Customers request a perfect surface finish, free from any defects, with high gloss and a “deep” 3D color effect. Mechanical properties, like impact strength, must be high and must not change over time. And finally, the processing by thermoforming

must be easy and reliable with short cycle times.

Perfect flow of material allows high draw ratios and ensures the best gauge distribution in the finished part. This is important to support the physical properties in the finished parts of a difficult design. For example, Senoplast of Austria introduced Easyglide® for thermoforming to improve flow and reduce cycle time. Easyglide® is an additional layer of ABS designed for the backside of the sheets.

9.4 Color Management during Product Development and Production

9.4.1 Color Formulation Process

Colors, including metallic colors and colors with special effects that exactly match the customer's specification need to be consistent from delivery to delivery. The colors must not stain over time or fade. Appearance simply should not change during the whole lifetime of a vehicle.

The process introduced to meet these color requirements follows several steps and confirms color match, reproducibility during the extrusion process, and durability (e.g., UV stability, general weatherability). These steps include first careful selection and formulation of colors. Durability is confirmed by 310 hours MEGASUN quick test, 1500 hours XENON weathering (EN ISO 4892), and oneyear Florida weathering (ASTM D 1435-2005, ASTM G147-2009) of sheet and thermoformed parts. Finally samples are assessed according to DIN EN ISO 3668.

9.4.2 Color Approval by Customer

Once a color is formulated, limits of color deviation need to be established in consultation with the customer. During the first production run an internal specification is set as the maximum tolerance. This tolerance could be, for example, a Delta E_{CMC} value <1.5 (DIN 5033).

Within this tolerance variations may be seen along three axes: light–dark, red–green, and blue–yellow. In effect color variations can occur in a three-dimensional color space, as a “color bubble.” The input from the customer is crucial for the first production runs, as only the customer can decide what is an acceptable color.

This input could be that the color should be lighter or darker than a certain reference, more or less green, more or less red, and so forth. This narrows the “color bubble” and reduces it to a “color cone.” It also allows an internal specification to be set for the first production run.

After the first production run an internal analysis on statistics of color deviations are made. The customer is asked to inspect the parts for color deviations and provide feedback. Finally an agreement on a color specification will be signed by both parties, which sets the quality standards for all subsequent production runs. Many difficulties can arise in color matching. Two common ones are known as “metamerism” and the “flip effect.” For each color formulated to match a given sample, the spectrum of light by which the samples are compared needs to be defined. A number of standardized light sources (DIN 6173) are available,

known as, for example, D 65 (“Daylight,” 6500 K), TL 84 (4100 K) or CWF (“Cool White Fluorescence,” 4150 K).

Colors that match under one light source with a given spectral distribution may look quite different when viewed under another light source. This effect is known as “illuminant metamerism failure.” The reason for this disparity is that different pigments absorb wavelengths at different rates. This is a typical problem when trying to match painted metal and colored plastic. Another typical situation is when trying to match colors used in exterior and interior applications.

“Metamerism” is the effect, when colors match under all light conditions (e.g., under light of different spectral distribution). Metameric color matches can be achieved in near-neutral grays, white colors, and dark colors. Metameric color matches are problematic, however, when intense colors or colors with special effects are used.

“Flip effects,” also called “geometric metamerism effects,” are present when samples match when viewed from one angle but fail to match when viewed from another angle. The reasons for this could be related to the alignment of color pigments during the extrusion process. The effect can be quite pronounced in metallic colors and special effect colors. It is important to consider this effect when mounting several plates of plastic sheet next to each other. Plates always should be placed in the same direction of extrusion.

9.4.3 Quality Assurance of Colors During Production

During regular production, inline camera systems and offline color readings are used to continuously measure, compare, and record color values. This is complemented by visual comparison to a master sample. Pigmentation is adjusted inline if deviation from the limits is noticed.

The key to consistent coloring is careful pre-production preparation and communication between the color laboratory and production team. Color masterbatches could be compounded to ensure consistent results during production.

9.5 Requirements from the Automotive Industry on Surface Quality

The glossiness of coextruded PMMA surfaces is determined by the raw material. Extrusion or thermoforming equipment has a small influence. Once in use, the glossiness of coextruded, inline colored surfaces is relevant to the surfaces' scratch resistance.

PMMA is the material of choice for surface layers of coextruded film and sheet. A coextruded PMMA surface layer exhibits the same scratch resistance as a standard PMMA, like it is used in injection molding for a variety of exterior automotive parts. Although PMMA is known to be somewhat brittle, coextruded sheets and films have excellent mechanical properties.

Selection of PMMA grades that are particularly suitable for co-extrusion and maintaining an optimum layer thickness of the PMMA is key. Today, for a number of reasons, there is no alternative to PMMA when it comes to co-extrusion with ABS or

PC/ABS:

- PMMA has very good adhesion to ABS and ABS/PC.
- PMMA easily can be polished.
- PMMA can be colored in many different ways.
- PMMA is UV stable.
- PMMA has very good chemical resistance.

PMMA also has demonstrated good scratch resistance. In the automotive industry scratch resistance is always tested against a wash brush test, known as “Amtec- Kistler wash brush test” (DIN 55665), that pushes PMMA to its limits. The test setup consists of a sample plate treated several times by a wash brush and water in which a certain percentage of quartz sand is dispersed. Gloss before and after treatment is measured and residual gloss or loss of gloss (percentage) is the main criterion.

Under these test conditions coextruded PMMA surfaces show a brittle scratch behavior. The only polymer, however, that shows better test results, is a special PC copolymer. The PC copolymer develops scratches of the same length and depth, but of a more ductile behavior compared to PMMA. Therefore residual gloss is a little better, too. However, the PC copolymer has a number of disadvantages, like limited coloring possibilities and inferior chemical resistance.

The Amtec-Kistler test results of paint or the new paint-film technology are clearly superior to coextruded surfaces with PMMA or the PC-copolymer top layers. While residual gloss of paint-film is around 78 gloss units after the Amtec-Kistler test, the PC copolymer is at 30 gloss units and PMMA at 15 gloss units. Automotive requirements are typically at around 75 to 85 gloss units. To compensate for this gap, extrusion companies are developing various options to improve scratch resistance.

To add a layer of “hard-coat” is one option to improve scratch resistance. The surface is lacquered and hardened (UV-cured). Hard-coated PC or PMMA surfaces show excellent scratch resistance but cannot be thermoformed anymore. Unfortunately, all coatings known so far that can be thermoformed after cure do not show any better scratch resistance than a coextruded, uncoated PMMA layer. As an alternative to coating, inline polishing may improve scratch resistance. Another alternative may be found by turning to nanotechnology, but there is no commercial product available at the moment and much more research is still needed.

9.6 Requirements from the Automotive Industry on Color Match

There are several technical limits when it comes to matching automotive paint with coextruded inline colored sheets or films:

- Orientation of the pigments in extrusion direction, as already discussed above.
- Limits to the concentration of pigments in the polymer matrix. Concentrations that are too high can cause delamination.
- Limited choice of color pigments for extrusion due to lack of temperature resistance of pigments.
- Effect pigments may lose their brilliance during the extrusion process.

- Difficulties due to different layer thickness of paint and co-extrusion layer: thicker PMMA layers with lower pigment concentration have to match with thin paint layers with high pigment concentration.

In addition there are commercial limits when it comes to matching automotive paints with coextruded inline colored sheets or films. For example, we analyzed the color portfolio of a typical OEM. Typically 12 standard colors are in use. From these 12 colors, 7 colors require less than 7 tons of plastic sheet each per year, based on an annual production of 200,000 vehicles. To match colors and to produce colored sheet for quantities of less than 7 tons per year usually cannot be done economically.

Sometimes cars also show clearly visible color deviations on spray-painted plastic and metal parts (see Section 9.4 for discussion of metamerism and illuminant or geometric metamerism failure). It may be helpful to show such examples to OEMs to illustrate the limits of color matching.

9.7 Automotive Industry and Orange Peel

Solvent-based automotive paints are sprayed onto steel.

Variations in the spray process cause variations in the paint layer or variations in the paint/solvent mixture. After drying, these small variations result in a surface waviness, referred to as “orange peel.” Coextruded surfaces, however, show no or very little surface waviness.

When extrusion processes are well controlled, surfaces become mirror-like. An orange-peel surface can be achieved using a thermoforming mold with a slightly structured surface.

This technique is used to hide defects from the extrusion or the forming process or to better match surface structures of thermoformed and painted surfaces.

9.8 Examples of Paint Replacement in Automotive Applications

9.8.1 Use of Color Contrasts

Because color matching of automotive paint is challenging, early applications of coextruded inline colored sheets and films were in contrasting colors. Some examples are:

- The roof module of a car: the contrast color being “high gloss black” which forms a perfect unit with the dark tinted glass of the sunroof.
- The front grill of the MAN trucks: the chrome logo of MAN contrasting the high-gloss black surface, also in contrast to the color of the truck (see cover of TQ 2, vol.33 no.2).
- Tuning parts: many are made from coextruded inline colored sheets in a contrasting color.

9.8.2 Approved Color Match-Thermoformed Pickup Covers

Some car manufactures produce pickup covers, typically consisting of an inner and an outer thermoformed coextruded sheet, a honeycomb core, and polyester adhesive layers. The outer coextruded sheet has to match several standard colors used for body paint. In this particular case, four metallic colors and three uni-colors were matched. The typical angle of view between the thermoformed part and the surface of body paint on metal is tilted by 90°. Therefore metamerism effects appear to be

less critical, and the large surface areas of different materials next to each other can be matched very well.

9.9 Paint-Film Technology—Painting Prior to Thermoforming

In the case of the new paint-film technology a coextruded film is painted prior to thermoforming and parts manufacturing. The current series applications of paint-film technology are for the roof modules of different car types. Today's, paint-film technology can meet all automotive requirements regarding color match, scratch resistance, chemical resistance, and so forth.

The first commercial high-volume thermoforming application for large-area exterior automobile parts was established for a customer of Senoplast in Germany, coextruding an ABS-PC compound with PC on the top. The conversion process at the customer premises includes painting and drying under cleanroom conditions, thermoforming of the part, and UV curing of the paint. The last steps are inserting the glass fiber and the PU back-foaming of the thermoformed part, and finally trimming and inspection.

The highlights of the results of this application are:

- Use in 250,000 car roofs per year.
- Very short cycle time for thermoforming, UV curing, foaming, and trimming.
- Fully automated production, with two operators manning the entire line.

The latest technology of thermoforming includes the following features:

- Thermoforming under cleanroom conditions.
- Thermoforming tools mounted on a rotating table with tool change done between thermoforming cycles.
- Automated loading, unloading and UV curing with robots.

The latest technology of PU foaming includes the following features:

- Use of rotating foaming tools.
- Random production of partial roof modules, antenna covers and partial roof covers.

9.9.1 Outlook

Thermoforming of coextruded colored sheets and films has the potential to replace paint in automotive applications. Weight reduction drives the use of plastic parts in automotive applications.

- Class A surfaces can be achieved with thermoforming; solutions for high scratch resistance are available.
- While injection-molding is now standard in the automotive industry, the full potential of thermoforming has yet to be realized when it comes to high volume exterior applications.
- Paint-film technology is the first to apply thermoforming in a high-volume exterior application; other technologies and applications are sure to follow.
- New areas of interest are body panels for trucks, utility vehicles, and niche vehicles such as battery powered "zero-emission" city cars (E-mobility), in particular to reduce the vehicle's weight.

- The automotive industry is looking for partners that can provide thermoformed parts in high quantity and quality.

9.9.2 Chrome Optics

Parts with the optic appearance of chrome can be produced by thermoforming. For semi-finished products with metallic décor surfaces, the carrier layers are typically ABS cast with a special lacquer film. Many different surfaces can be simulated such as:

- Chrome
- Stainless steel
- Aluminium
- Metallic
- Brushed metal optic
- Silver

These surfaces are also UV and scratch resistant. Postsurface treatment is not necessary. Low mold costs promote faster face lift cycles, especially in the automotive branch. Large parts are put into practice. Applications extend to metallic decoration found on the interiors as well as exteriors of automobiles. |

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Factors Affecting Thermoformed Trays During Retort

By Rabeh H. Elleithy, Printpack, Williamsburg, VA, USA

Abstract

The performance of thermoformed trays during retort is affected by different factors. However, these factors could be grouped into three main sources: material, design, and processing method/conditions. Understanding the individual and cooperative effects of these sources on the performance of the trays during retort is the topic of this article. Optimizing these three sources is key to a successful tray for retort application. Nonetheless, a clever engineer could compensate for a shortcoming of the material by superior design and balanced processing conditions. Similarly, un-optimized processing conditions could be compensated for by choosing a better material coupled with more robust design.

Introduction

A thermoforming engineer should pay close attention to the processability of different grades of the same resins as it could vary considerably. The processability of high impact polystyrene, HIPS, was evaluated using viscoelastic techniques [1]. There was a good correlation between the melt viscosity at 170°C and the sagging behavior of 3 different HIPS. As the melt viscosity increases, the sagging resistance increased as well [1]. Lee et. al. [2] reported that Acrylonitrile – Butadiene – Styrene, ABS, copolymers with larger contents of hard rubber particles exhibited more melt elasticity and had a better thermoforming performance than other ABS tested. Lau et. al. [3] indicated that the sagging resistance of PP was improved by blending conventional PP with PP that has low MFR. Walton et. al. [4] reported that the branched PP they examined showed improved melt strength but low melt extensibility. Hylton et. al. [5] showed that the important property is the 30 second recovery during their rheological test. They demonstrated that the higher the recovery; the more difficult it is for polypropylene to conform to the mold during thermoforming. This previous research demonstrated that the choice of the resin has a fundamental effect on the thermoforming process, which in turn affects the performance of the final product.

The performance of the thermoformed product is not only affected by the chosen resin, but is also affected by the processing method. Harron and co-workers [6] showed that the line speed and the chill roll temperature influence the tensile properties. Whereas, MFI affects the sag of the sheet, the melt temperature controls the shrinkage in the machine direction of the extruded sheet. Chan and Lee [7] analyzed some factors that affect the residual stresses of extruded sheets. They reported that the overall orientation stress increased as the draw ratio increased and as the melt temperature decreased. They remarked that the core orientation stress was almost unaffected by the cooling. Whereas, faster cooling rates and lower die

temperatures increased the surface orientation stresses. At low draw ratios, the flow-induced molecular orientation inside the die contributed significantly to the sheet overall residual stresses. Harron et. al. [8] showed that shrinkage of the thermoformed part is controlled mainly by the temperature of the cooling water. They noticed that lower shrinkage occurred at lower temperatures of the cooling water.

The retort process presents a special challenge to plastic containers. This challenge is partially attributed to the pressure difference between the retort chamber and the inside of container. This pressure difference induces stresses at the container walls. Keep in mind that the containers' temperature is about 121°C during retort. The stiffness of the container could be as low as 10% of its stiffness at room temperature. The containers should resist the retort-induced stresses at the retort conditions without any permanent damage.

In this paper we discuss the influence of individual and cooperative effects of material, tray design, and thermoforming factors on the performance of single-serving trays during retort.

Material and Experimental

Four different trays were analyzed in this study; #2, #2b, #5, and #8. All trays have the same generic sheet structure; PP / Tie / Barrier / Tie / PP. Trays #2 and #2-b are identically the same except their design is different as seen in Figure (1). Trays #2, #5, and #8 have flat base as seen in Figure (1-a). Whereas, tray #2b has a concave base, Figure (1-b). Finite element analysis, FEA, was used to compare the induced displacements and stresses as a function of internal pressure for both a normal flat-base tray, Figure (1-a), and a concave-base tray, Figure (1-b). Trend stress analysis was performed using linear elastic stress analysis. We used material properties at retort temperature of 121°C.

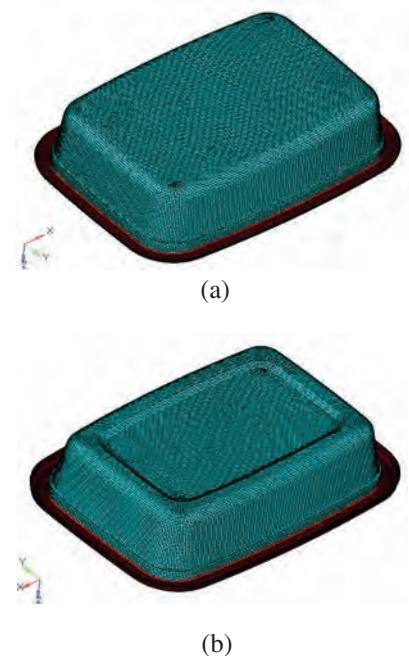
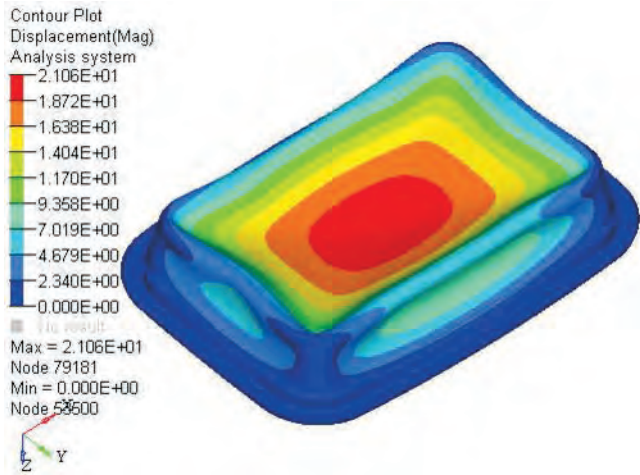
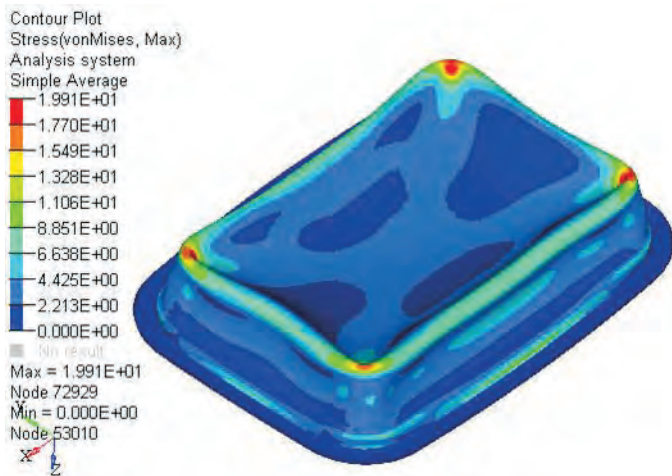


FIGURE (1): Solid model of the trays analyzed in this study.



(a)



(b)

FIGURE (2): FEA analysis of the induced displacement, mm, and stresses, MPa, during retort for tray #2.

Differential Scanning Calorimetry, DSC, was used to study the melting and crystallization behavior of the trays. A small piece of the tray flange, about 5 mg, was heated / cooled / heated at 10°C/min in an open aluminium pan at atmospheric conditions. The melting and crystallization behavior of the material was recorded as a function of temperature.

Plate-plate rheometer was used to compare the flow properties of the tray materials. The plate diameter was 25 mm and the plate-plate gap was 0.5 mm. The testing isothermal temperature was 205°C, and the frequency sweep was from 0.02 to 500 rad/sec. The complex viscosity, η^* , was plotted as a function of angular frequency, ω .

More over, torsional Dynamic Mechanical Analysis, DMA, was performed at 1 rad/sec from 40°C up to 160°C. The complex modulus, G^* , was recorded as a function of temperature.

Results and Discussion

During the retort cycle, trays are exposed to both positive and negative pressure. The positive internal pressure will cause the tray to expand and “bulge out”. Whereas, the negative internal pressure will create a vacuum and cause the tray walls and base to buckle inwards. This “buckling” is simulated by FEA in Figure (2). The maximum “buckling” occurred at the middle of the base of the tray. For tray #2, the maximum “buckling” displacement was about 21 mm. This “buckling” was reduced to only 16.6 mm when the concave-base, Figure (2-b) was used.

By the same token, the induced stress during the simulated retort process was reduced from about 20 MPa for tray #2 to 13 MPa for tray #2-b. Thus, appropriate design could (and did) reduce the tray deformation during retort, which is translated to better performance of the trays during retort.

The crystallization and 2nd melting behavior of trays #2, #5, and #8, Figure (3), showed that the resins used in making these trays were different from each other because they have different melting and crystallization peaks.

All trays used Ethylene Vinyl Alcohol copolymer, EVOH, as a barrier. That was discerned from the melting peak, T_m , at 188°C, Figure (4).

However, tray #8 has a bigger and sharper EVOH melting peak than those of the other two trays. This indicates that tray #8 has more EVOH than trays #2, and #5. More EVOH is typically used to improve the tray performance after retorting.

Tray #8 has a major melting peak at 165°C that is attributed to the melting of Polypropylene, PP. Tray #8 also has a minor melting peak at 120°C which could be attributed to Polyethylene, PE. PE blends with PP are sometimes used to improve the melt strength of the extrudate. On the other hand, trays #2 and #5 only had one major peak at 164°C and 168°C respectively. The high melting temperature for PP of tray #8 would imply that this PP has larger size crystals as compared to trays #2 or #8.

Similarly, the crystallization process of tray #8 showed two distinct peaks that were attributed to PP and PE. The

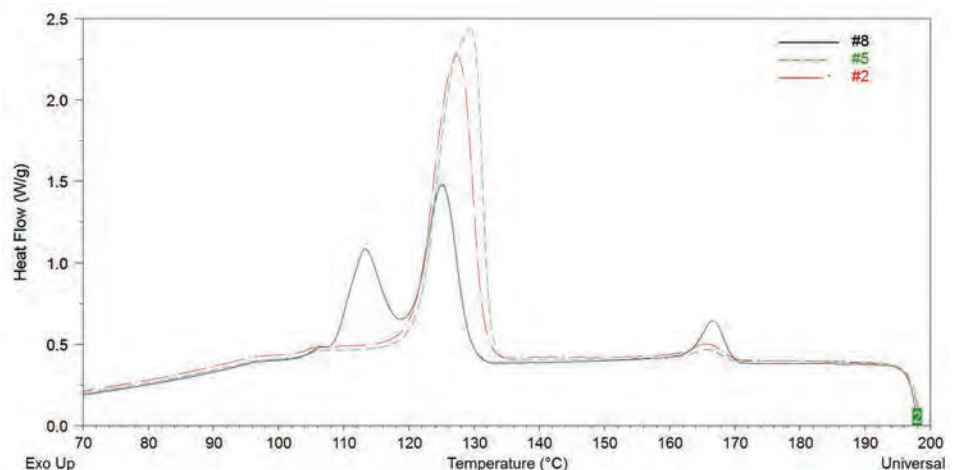


FIGURE (3): DSC depicting the crystallization behavior of trays #2, #5, and #8.

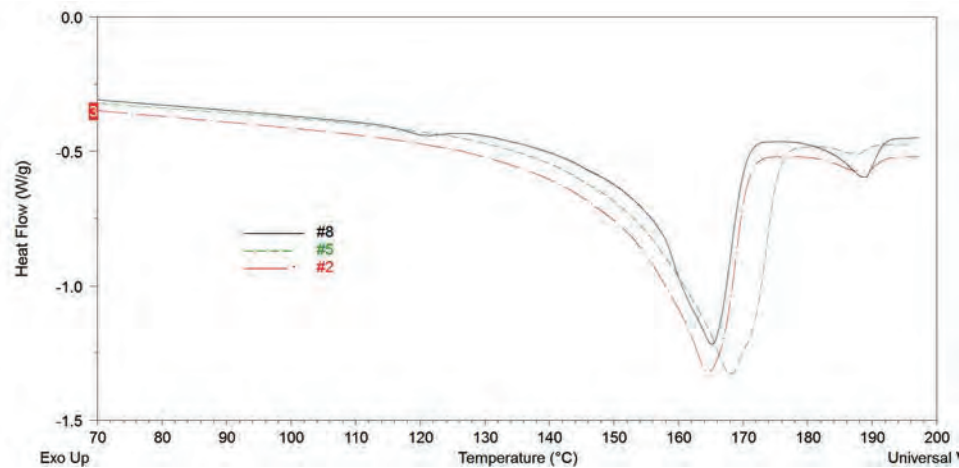


FIGURE (4): DSC depicting the melting behavior, second heat, of trays #2, #5, and #8.

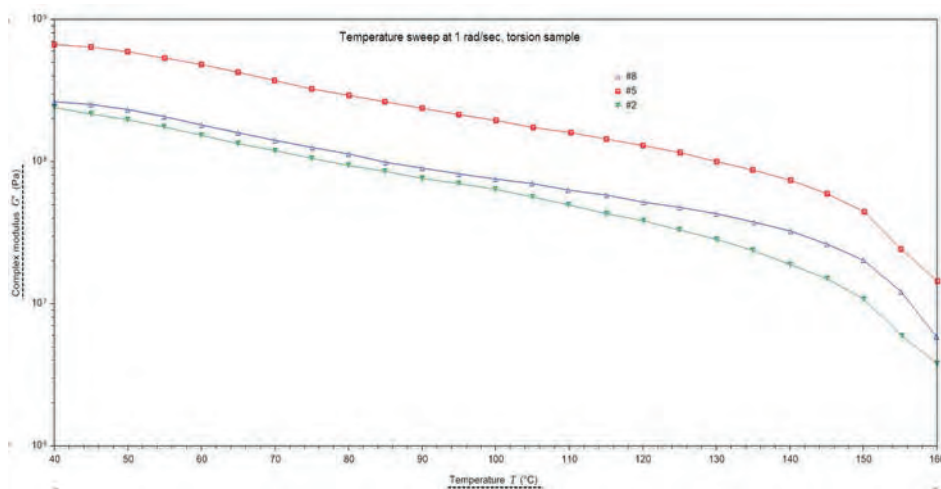


FIGURE (5): Torsional complex modulus, G^* , as a function of temperature at 1 rad/sec for trays #2, #5, and #8.

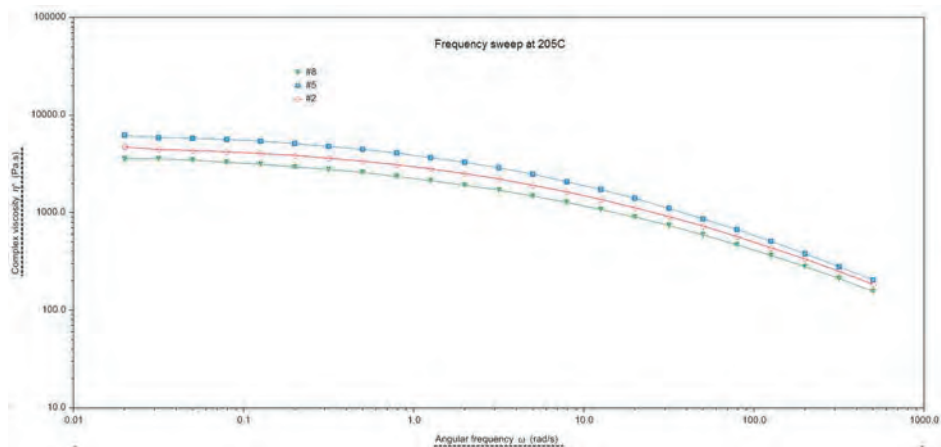


FIGURE (6): Complex melt viscosity, η^* , as a function of angular frequency, ω , for trays #2, #5, and #8 at 205KC.

crystallization behavior of trays #2 and #5 suggested that this PP will be more crystalline than that of tray #8.

The relationship between the torsional complex modulus, G^* , and temperature for trays #2, #5, and #8 at 1 rad/sec is depicted in Figure (5). As the temperature increased, the modulus decreased at a slow initial rate until the temperature reached 144°C for tray #2, 147°C for tray #5, and 150°C for tray #8. Above these transition temperatures, the modulus decreased at higher rate than the initial rate.

The initial modulus at 40°C for tray #5 was about 250% higher than either tray #2 or #8. It stayed higher than that of tray #2 and #5 for the rest of the experiment until 160°C. For example, at 120°C the modulus of trays #5, #8, and #2 was 120, 50, and 40 MPa respectively. That would suggest that the stiffness of tray #5 could be 300% that of tray #2 providing that all other influential factors are kept the same. In other words, the wall thickness of tray #5 could be thinner than that of either tray #2 or #8 and still all trays would have the same apparent stiffness at 120°C.

The melt rheological behavior of the resins of trays #2, #5, and #8 at 205KC is depicted in Figure (6). Tray #5 had higher complex viscosity, η^* , than that of trays #2 or #8. The high values of η^* would suggest that the sheet extrusion of tray #5 should occur at higher temperature to match the viscosities of trays #2 or #8. This higher viscosity of tray #5 could result from a high molecular weight or high molecular entanglements of that resin. This high molecular weight and high crystallinity, seen in Figure (3), act as anchors that would hinder the molecular mobility which could explain the high stiffness of tray #5 as compared to the other trays, as shown in Figure (5). As discussed before, this high stiffness could be advantageous during the retort process.

Conclusions

The design of the trays contributes significantly to the induced stresses during retort. It was shown that the correct tray design reduced the induced stresses by about 35% and the induced deformation by about 20%. Using resins with high crystallinity and high molecular weight



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would increase the tray stiffness by hindering the molecular mobility.

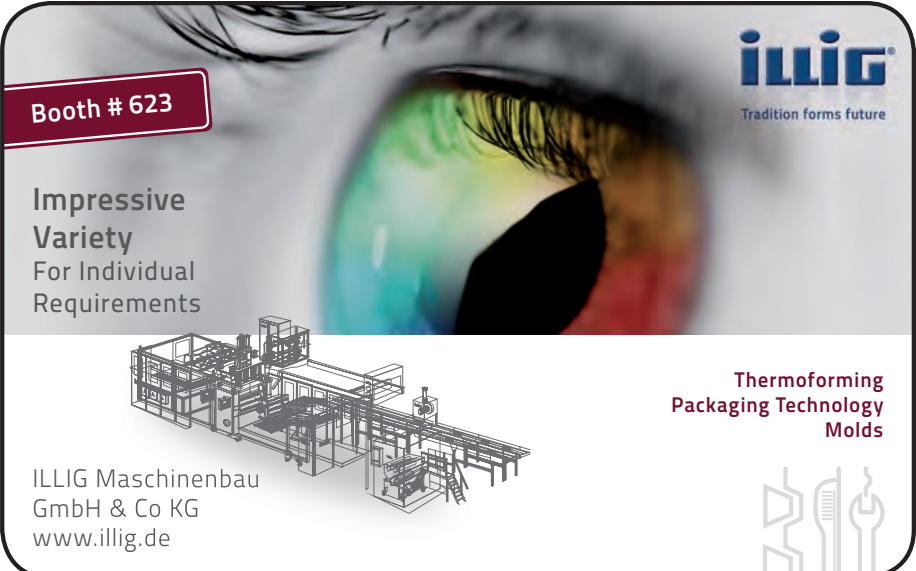
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Mold and Vacuum

By Mauro Faé, Director of Engineering, Self Group, Rivignano, Italy

In addition to thermal distribution within the thermoform mold, air evacuation by vacuum is critical to maximize final product quality, energy consumption and cycle time.

It is easy to understand that the quantity and position of vacuum holes is a very important balance to strike when the goal is to obtain optimal performance of the vacuum system and consequently to achieve final product definition. The quantity and position of holes, however, are not the only variables to be considered. In fact, to achieve good evacuation for the air trapped between the sheet and the mold surface, it is necessary to consider the tool surface roughness obtained during the mold finishing phase.

An extremely high gloss finish, i.e. mirror polished surface, needs a large amount of very small vacuum holes distributed over the entire mold surface in order to evacuate the air in a short amount of time. Lack of rapid air evacuation creates high risk of air stagnation between the sheet and the mold surface and, as a consequence, the potential generation of unacceptable non-aesthetic spots, dots or waves on the final product surface. Air evacuation is usually even more sensitive in case of glossy materials. By contrast, a high degree of roughness on the mold surface, e.g. a sandblasted mold surface, together with vacuum holes of relatively large diameter will improve the performance of the mold in terms of rapid air evacuation while allowing the forming of sharp details. That said, it will also increase the risk that final product will have undesirable orange-peel surface defects. So it is very important to make the correct choice in terms of the numbers of holes, the diameter of the holes and the surface roughness related to the geometry, e.g. flat vs. round surfaces, sharp vs. negative corners, male vs. female mold shape, etc., of the part to be produced. To choose the correct mold surface finish and vacuum hole dimensions/distribution, it is particularly important for professional mold maker to know the following details: the thermoformed material data sheet and starting thickness; the desired final part thicknesses; and the actual application of the product and desired level of cosmetics.

Nowadays, in an aluminum mold, it is possible to machine vacuum holes from 2mm (0.0787") (#47) diameter, or higher, down to 0.3mm (0.0118") (#80) diameter. The difference in cost between a mold drilled with 0.3mm diameter holes compared to the same mold drilled with 0.6mm (0.0236") or with 0.8mm (0.0315") diameter holes can be quite high due to the complexity required to drill such small holes. This technical choice then influences the ROI of the tool investment. The wrong choice,

however, will almost certainly create higher quality and final customer satisfaction costs.

Minimizing the time necessary to evacuate the air is a challenging target not only from the perspective of reducing the cycle time but also from the perspective of achieving the correct aesthetic result of the final product. In fact, if the air is evacuated too slowly, it is possible the heated plastic sheet will cool down before forming to the complete mold surface and not form properly. To design a tool adequately for an efficient vacuum system, it is important to remember that air is a fluid and that the vacuum holes can be modelled physically and mathematically as a tube. The following simplified formula (Equation 1) and drawing (Figure 1) explain what physically happens:

$$\Delta P = r \left(\frac{v}{d} \right)^2 \cdot l$$

EQUATION 1

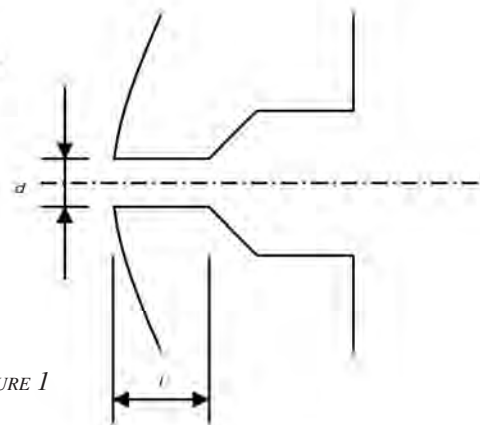


FIGURE 1

ΔP represents the pressure drop and can be used to measure the vacuum efficiency. f is a function of the speed (v) and of the hole diameter (d) while l is the length of the holes. There are two ways to reduce the ΔP value: by increasing the diameter d or by reducing the length of the tube. Unfortunately, for the aforementioned aesthetic/cosmetic reasons, the diameter cannot be increased too much since it might cause visible marks on the plastic part. In that case it is possible to work on the other variable, the length l , which can be shortened by back drilling the hole d with a bigger drill in the inner (rear) part of the mold itself. For instance, assuming ΔP and d as constant, halving the length l , the speed v will theoretically double. We say it will “theoretically” double because air is a compressible fluid with his own roles.

Understanding Air Volume

Let us move our attention from the components of the molds to the macro systems, and in particular from the vacuum holes to the total amount of air that must be evacuated prior to the plastic material making complete contact with the outer mold surface.

In an effective mold design it becomes very important to answer the following question: what is the minimum amount of air necessary to form a part? And then, how can the total air volume be reduced?

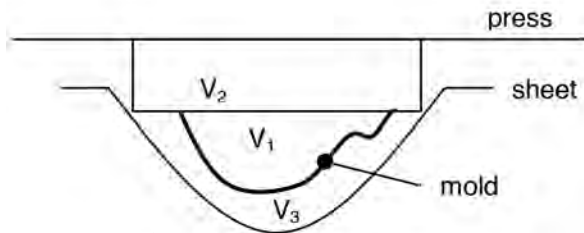


FIGURE 2

In both configurations the air volume named V_3 between sheet and outer surface of the mold is the only one not influenced by the tool design but only by the geometry of the part.

Referring to the other two air volumes, called V_1 & V_2 (the air behind the mold geometry and in the vacuum box), an effective design of the tool can greatly reduce the volume or reduce it to almost zero with, as a logical consequence, a reduction in energy consumption used to generate the vacuum.

When considering male molds, volume V_1 is zero when the mold is made by aluminium billet after machining (if the rear part of the mold is not milled) while if the mould is made by a thick skin casting of aluminium, V_1 is not zero. In some cases, based on the geometry of the part to be produced, if V_1 is big, it is possible to fill the cavity with some material. In this way the real V_1 is reduced and the air to be evacuated is much less than without the filling material. Of course the material inside the mold must have some specific characteristics (e.g. polypropylene balls) to be effective and last the lifetime of the mold. It should not collapse under heat and vacuum pressure and it should not generate dust that will damage the vacuum pump circuit or mark the part during de-molding when inflating air through the vacuum holes of the mold.

In picture 1 we see an example of how to reduce V_2 on a male mold by using a specially designed metal frame, allowing a reduction of the volume V_2 to zero. In this solution, a total air reduction of more than 50% can be achieved.



PICTURE 1

Other possible solutions are shown in pictures 2 and 3.

In picture 5 it is visible how, in a female mold, all cooling manifolds are moved out from the vacuum box. This eliminates the air volume taken up for manifolds with V_1 reduced by 90%.

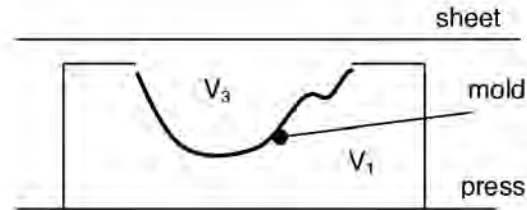
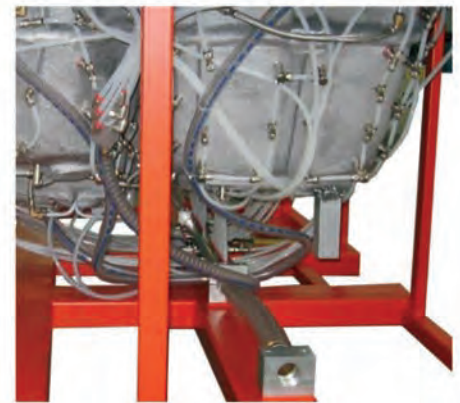


FIGURE 3

When the required amount of vacuum holes is not so high (this can be accomplished by direct vacuum) it is convenient to connect every single hole to a main manifold (picture 6). In this way the V_1 air volume is reduced by 97%. Moreover the mold lifetime is extended because there is no pressure working on the mold surface.



PICTURE 2



PICTURE 3

To summarize, the following parameters are used to design the mold vacuum when taking into consideration the effects they have on final product quality, energy consumption to produce vacuum and unitary product cycle time:

- vacuum holes diameter, distribution (quantity and position)
- mold surface roughness
- length of the vacuum holes
- quantity of air to evacuate

Correct mold design with specifically studied design for vacuum can minimize the impact on costs and on the ultimate ROI. Other aspects of tool design are related to process set-up, mold handling, mold maintenance and other downstream tasks after the vacuum forming process. These must also be carefully and duly considered by engineers. This is why mold design should always mix technical issues with criteria and concepts including total quality. To have a high-performing tool, one must be able to manage several technical fields while possessing know-how on many engineering skills with the part designer, the process specialist and the toolmaker communicating through detailed mold specifications. The highly-experienced tool maker evaluates your specifications and provides recommendations based on practical experience which is often a step ahead of your expectations. A diversity of perspectives coupled with industry knowledge creates an environment where success can thrive. |



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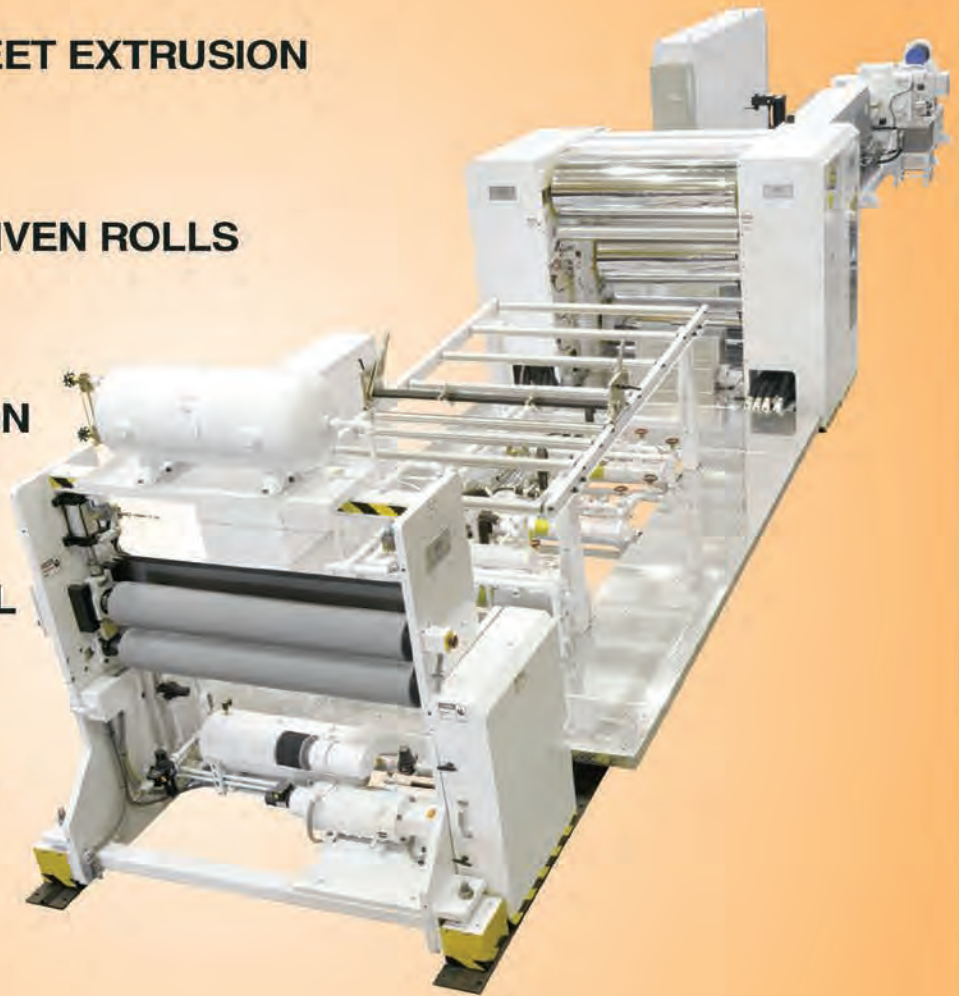
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Minimizing Color Processing Costs

By Paul Uphaus, Commercial Development Manager, Primex Plastics

“As I hurtled through space, one thought kept crossing my mind — every part of this rocket was supplied by the lowest bidder.”
John Glenn

If this was the case, why were the results sufficient to guarantee a successful mission? There are two main reasons: 1) though the customer was buying based on the “low bidder price,” they received the right final product and acceptable reliability through knowledgeable design and 2) more importantly, the specifications were communicated accurately. It is true that the price dictated the performance of the end product, but both the supplier and the customer understood the specifications and the limitations of the design.

The same principle holds true when it comes to obtaining sufficient information for a color match for extrusion, thermoforming, or other thermoplastic processes. Specifically, there can NEVER be too much information. The more information that can be obtained during origination regarding the end use including any regulatory requirements, the more accurate you will be in presenting a cost-effective and correctly-performing product. This is a critical discussion point when asking customers for detailed end use information as they want fast and accurate results. In general, it is perceived that the industry average for approvals and orders obtained after a custom color match is approximately 20-30% as color approval is driven in some cases by customer preference or other subjective criteria. It is imperative that we improve this factor beyond this ratio by providing enough starting information to formulate efficiently for the end product use. This will help assure customer satisfaction and growth in our industry.

Let’s look at the most fundamental pieces of information required. Of course, adequate information must be requested at the beginning of a project. This includes, but is not limited to, the following primary questions:

- What is the end product and use?
- What is the exact resin to be used in the match? (Including all layers such as cap and substrate.)
- Requirements such as FDA, CONEG, NSF, light fastness and / or weather fastness
- Expected life-time or service-life in the end application
- Sheet gauge before and after forming (depth of draw)
- What is the light source used to view the final color match?
 1. Daylight D65, C
 2. Incandescent light A
 3. Florescent light F2, F11
- Is this a visual match or will an instrument such as a

spectrophotometer be used?

- What is the target to be matched?

The best color target medium is an actual piece of plastic of the color that you want in the resin type to be used in the application. This is not always possible, however, as targets are most often in the form of:

- Painted metal parts
- Cloth or printed paper
- Pantone numbers (most common)
- These should be considered as “concept colors” as it is most likely not possible to match that exact color in plastic.

When Pantone numbers are supplied they must have a letter (C, M, or U) after the number. It is not an option to match Red 185 since the C stands for “Coated” and the U stands for “Uncoated”. They can look completely different. Pantones are ink on paper and not all pigments used in ink can be used for plastics. The age (color fade due to storage) and print differences between editions causes many Pantone matches to be rejected.



Pantone color chart

When applicable, you should also discuss the limitations of fluorescents and high Chroma colors when used outdoors. The brighter the color, the less stable it can be. Make sure to review processing limitations such as extruding a co-ex custom color over black or another field of color. Also consider the possible addition of regrind and the resin stability at the desired thickness. Determine at what light source the color will be viewed. Is it Daylight D65, C cool white fluorescent, Incandescent Light A or

Fluorescent Light F2-F11? Is it critical to understand if the end user will be making a visual approval or if they will be using a spectrophotometer? This is also where the light source comes in. Most color spectrophotometers are set for the Daylight D65 or C scale. Some colors such as yellow are very susceptible to the light source and may give different results. If one person views it in Daylight while another views it in Fluorescent Lighting, a failure can occur. The way color is viewed is a subject in itself and will be covered in future articles.



Standard spectrophotometer

Another important consideration is that some colors such as metallic, fluorescents, or many transparent colors, cannot accurately be measured on a spectrophotometer. Texture can also distort the readings so an override is often used to visually assess the sample. A trained color technician can be as good as or better than the computer in determining the acceptability of the match. Let's take a look at a real-world example. The customer is designing a part for an outdoor playground and they are ready to request pricing.

Upfront Discussion

What is the actual color target? Are there multiple matching parts? Is it a Pantone, a part they currently make, a color chip, a customer defined printed target or a market idea? Is durability testing of concern or required? Most importantly, what is the service life or point at which they would replace parts due to

defect or wear? UV performance equals higher costs. Discuss the limitations of Fluorescent and High Chroma colors, if applicable. The brighter the color, the less stability is exhibited.

Next, consider the internal processing limitations, e.g. is co-ex over black or field of color required? What is the effect of the addition of regrind into the substrate and the resin stability at the desired thickness? Not only can these factors affect the quality of the color but they can drastically influence the cost structure.



Brightly colored HMWPE playground equipment

Control the Standards

This is perhaps one of the most critical subjects in color matching and one that can cause a customer to lose faith in a supplier's ability, especially with computer-controlled standards. It is imperative to store and record the date for future reference. If or when there is a color problem, this is the first place to start the investigation. Always ask what standard chip was stored and then verify that both parties have the same standard. Be sure not to use a lot-chip or a re-created chip, unless all parties have agreed and both have stored that new standard. Storage of the visual standard chips should be in controlled envelopes in cool dark cabinets and dated. Be careful when cleaning handling standards. Do not use cleaners which may have optical brightener or bleaching chemicals.

With good information as the key to developing the right product, we can all participate in minimizing cost and color processing issues while maximizing results. |

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An Interview with SPE 2014 Thermoforming Conference Keynote Speaker: Christian Majgaard, Majgaard Brand & Business Development

By Lesley Kyle, OpenMindWorks, Inc.

Christian Majgaard will present his keynote address on Tuesday, September 16, during the SPE Thermoforming Conference in Schaumburg, Illinois. Drawing on his global experience with LEGO® as a market researcher, where shifting managerial assignments – including some years outside with PA Consulting - took him to global top management, heading up marketing, business development, innovation and brand management in the 1980s and 1990s.

Following are some of Mr. Majgaard's thoughts on how branding will evolve and impact the thermoforming industry in the future.

Lesley Kyle: In an uncertain world, how should companies plan for future growth?

Mr. Majgaard: It depends: the world is uncertain. As a general rule, in uncertain times, strategies and plans should be shorter and perhaps expressed more as intentions as opposed to rigid plans. Speed of execution has always been relevant, but in times of uncertainty, speed means even more, because windows of opportunity are shorter. Reassessment of plans and strategies must also be more frequent because the “map” we look at keeps changing. We have all found ourselves in situations where our GPS wasn't recently updated.

The nature of the business means a lot to this rule of thumb. An enduring purpose like wanting to be excellent in a particular category may still prevail and even help a corporation to avoid losing sight of its ultimate mission. Uncertain times are not the same as bad times. A company wanting to move ahead and out of its traditional industry position has a greater chance of doing that if times are unstable. It takes more courage than normal.

Kyle: How often and when should companies evaluate their brand?

Majgaard: The first thing any company should do is to seek clarity on what they mean by the fluffy buzzword, “brand.” Brand means reputation, i.e. how much customers and stakeholders know and how they regard the company, including its products, services and people. And this has very little to do with logos, slogans or letterhead: the latter being expressions and the former being impressions.

Brands only exist in the minds of customers and stakeholders and can and should be measured via interviews. The classic



measurements are on awareness, image and satisfaction. A strong brand scores high on all three metrics and provides its owner with much greater top line growth, healthier margins and more forgiveness in case of failure. And more qualified people wanting to work for it.

The best road to brand building is often to do the things well that really matter to customers combined with fair prices and service. All of this adds a relevant degree of innovation: i.e. to be able to offer something others can't. Wild advertising budgets don't fit into a technology-oriented B2B market like thermoforming. Brand evaluation, in terms of awareness and image in B2B companies, should be measured every third year or so. Customer satisfaction should be evaluated more often than that and preferably so that issues can be correlated to concrete parameters.

Kyle: What is unique about Majgaard Brand & Business Development? Who are your clients?

Majgaard: We are not a normal strategy house since we only consult on strategies related to a core idea, market and brand.

Whilst we advise on branding, we don't offer advertising or communication solutions. The way we deliver is not only through consulting, but also through speaking and workshops. Our staff is small and all are very experienced professionals. We work across industries and borders. We have serviced global corporations like Heineken, Motorola, Fujitsu, Siemens, ABB and LEGO, but we have worked with regional and local companies as well.

Kyle: What areas of opportunity do you see for companies looking to connect with their customers on a higher level?

Majgaard: strategic alliances and shared ownership are all part of the structured high-level ways of connecting. In more practical terms, I believe it adds value to apply wider customer contacts to a company beyond the most narrow and dangerous model: seller to buyer. Top to top, IT to IT, R&D to R&D, etc., is a very good model, but is mostly valid where there is a fair balance of size and business involved. Placing employees at the customer's office is also a valuable approach. Wal-Mart's head office is full of people from various suppliers. Indirectly, this also impacts how the top to top works.

Kyle: Have corporate mission statements become irrelevant?

Majgaard: Yes and no.

Fifty percent of mission statements are just polished, "could be anybody's call" missives and have no value. The acid test includes two criteria:

- Is the mission expressing the real essence and meaning of why the company should be preferred by its core target customers?
- Is the mission – written or conceptual – elegant or not - shared by the employees to the extent that we can call it a "shared commitment?"

Warning: Companies that address their profits in their mission statement make less money than those that speak about their customers' needs. If you work with global corporations, you should be aware that Europeans have a different interpretation of the meaning of mission and vision. "Vision" is the ultimate end goal and aligns well with phrases beginning with "someday, we shall be the most/ best..." whereas mission statements more

often answer the question, "Why should customers prefer to work with us?"

Kyle: Which trends – good or bad – are you seeing in today's business landscape?

Majgaard:

- *Globalization:* The world is getting smaller. You should not only think about where in the world your company should be competing. You should also think about WHO in the world will come closer to your doorstep and YOUR customers, even if you don't move.

- *Concentration:* Most industries move towards concentration. You must consider whether you want to eat or be eaten.

- *Speed of Technology:* You must consider technology platforms that can create harmony with both where you came from and where you are going. You must think of new ways of owning production or machine capacity. Nowadays, businesses in the travel industry don't always own their airplanes and hotels or own their buildings.

- *Environment:* Plastic is not as nice as apples and carrots. Clever recycling and biodegradability is here to stay and will become the norm.

- *Emerging Markets:* Basic industries keep moving away from Europe and the USA - or at least have much higher growth in emerging markets.

- *Time to Market:* New technologies arrive at a higher rate of speed. Therefore, you need to deliver – and faster.

Kyle: What will SPE Thermoforming Conference attendees learn from your presentation?

Majgaard: They will get inspiration for building their business and their brand. I will not speak as an industry expert because that's not who I am. But I will apply interesting real life examples that hold meaning to your industry. I promise I will make the attendees laugh as well! |

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Conference Highlights:

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Technical Sessions

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Workshop: Optimization of Flat Sheet Extrusion

Monday, September 15, 2014

8 a.m. – 4 p.m.

Presented by Tim Womer, TWWomer & Associates, LLC

8:00 a.m. – 8:15 a.m.	Introductions
8:15 a.m. – 9:00 a.m.	Rheology 101
9:00 a.m. – 9:45 a.m.	What Your Screw Designer Never Told You about Screws
9:45 a.m. – 10:00 a.m.	Break
10:00 a.m. – 10:45 a.m.	Mixing for Single Screw Extruders
10:45 a.m. – 11:30 a.m.	How to Choose the Right Screen Changer
11:30 a.m. – 12:00p.m.	Review of morning topics
12:00 p.m. – 1:00 p.m.	Lunch Break
1:00 p.m. – 1:45 p.m.	How Melt Pumps Can Help Your Process
1:45 p.m. – 2:30 p.m.	Basic Review of Chill Roll Technology
2:30 p.m. – 2:45 p.m.	Break
2:45 p.m. – 3:30 p.m.	Optimizing Sheet Extrusion Conditions to Minimize Internal Stresses in Thermoformed Sheet
3:30 p.m. – 4:00 p.m.	Open Discussion: Q&A Session and Troubleshooting!

McConnell Thermoforming Workshop Outline

Monday, September 15, 2014

8 a.m. – 4:30 p.m.

Robert Browning and Don Hylton of the McConnell Company will be presenting the following topics at the upcoming SPE Thermoforming Conference, in Schaumburg, Illinois.

Thermoforming: “Ten Steps to Becoming A More Efficient Thermoformer”

Robert Browning, McConnell Company

“Staying Prepared to Stay Ahead of the Competition”

The “Ten Steps to Becoming a More Efficient Thermoformer” in a competitive world of thermoforming, and how problems faced today are easily solved by getting back to the basics of our knowledge and experience.

Bridging the Gap - From Sheet to Thermoforming

Don Hylton, McConnell Company

Thermoformers use a lot of time, material, and money tweaking the process to solve problems which are primarily related to the material. This session will discuss the properties of sheet material and how they influence thermoforming. Specific tests to measure these properties will be discussed. Examples will be given that illustrate how test results and knowledge of the material can be used to solve problems and assure consistent thermoforming quality. The outcome will be suggestions on establishing proper sheet specifications for high quality and cost-effective thermoforming.

- I. Key material properties that influence thermoforming
- II. What properties should be measured and why
- III. Key tests and how to conduct them
- IV. Using test results and material attributes to troubleshoot and solve problems
- V. Suggestions on establishing proper sheet specifications

Thermoforming: “The Limitless Possibilities”

Robert Browning, McConnell Company

“There exist limitless opportunities in every industry. Where there is an open mind, there will always be a frontier”

—Charles Kettering

Today, we have almost unlimited possibilities with thermoforming, from the very simple, to extreme complex parts.

With the quality and tolerances achievable today, the acceptance of thermoforming as a high quality manufacturing and forming process is at levels never seen before.

This workshop will explore the products and possibilities of today's thermoforming; and how scientific troubleshooting is used to achieve the necessary goals for the future.

Afternoon Panel Discussion: Thermoforming Questions and Answers

Bring your questions and problems and get free help from a panel of experts, representing all areas of thermoforming.

In the past years, the open panel discussions and questions have produced some very intense and diverse conversations in all areas of thermoforming.

Attendees are encouraged to bring their questions, sample parts, etc., for help and discussions. |

SPE 2014 Thermoforming Conference® Keynote Speakers

Tuesday, September 16
8:30 a.m. – 9:30 a.m.

Pathways to Growth – Better Pick the Ones That Work!

Tales from reality on business innovation and branding

Christian Majgaard

Majgaard Brand & Business Development



Christian Majgaard, former top global manager with toymaker LEGO® and world acclaimed speaker and consultant, offers inspiration and personal experiences from his work with business innovation and branding. He is famous for turning complex issues into straightforward messages, blended with great humor.

Here are some quotes from his presentation:

“If you want a new mission, I shall write one for you now, but how will you make people change?”

“Companies having the word ‘profit’ in their vision statement make less money than those with the word ‘customer.’”

“The original meaning of ‘marketing’ was the two-way exchange of information and value between company and customer – on equal terms. Many companies forgot that and turned marketing into a one-way communication machine.”

“The core discipline in ‘branding’ is to impress customers with things they find important. Smart words and flashy logos don’t belong on that list.”

Wednesday, September 17
8:30 a.m. – 9:30 a.m.

Culture is No Longer the Softer Side of Business

Tony Bridwell, Brinker International



Brinker International, parent company to Chili’s Grill & Bar and Maggiano’s Little Italy, is one of the world’s leading casual dining restaurant companies with over 1,500 restaurants in 33 countries and two territories.

“Life is Short. Work Happy.” That motto describes the culture at Brinker and culture is the number one reason BrinkerHeads state why they love coming to work! BrinkerHeads are hungry to work hard and play hard. In 2013, Brinker was ranked third on the *Dallas Business Journal’s* “Large Companies Best Places to Work.”

Tony Bridwell, Chief People Officer with Brinker International, will discuss how creating a culture of accountability led to breakthrough results. Below is what’s on the menu:

- The role of accountability inside your culture
- Why focus on culture and accountability?
- What drives culture?
- How to drive results with your culture |

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Plant Tour A - TEQ

Thursday, September 18, 2014

8:15 a.m. – 2:15 p.m.

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Busses will depart the Renaissance Hotel

Tour One: 8:15 a.m. – 11:15 a.m.

Tour Two: 11:15 a.m. – 2:15 p.m.

At TEQ, we deliver innovative and sustainable design, engineering and manufacturing solutions to the medical and commercial markets for thermoformed packages and specialty products.

TEQ, a subsidiary of ESCO Technologies, is a custom thermoformer located in Huntley, Illinois, dedicated to providing high-quality thermoformed plastic packaging and products to medical, electronic and commercial markets.

The tour of TEQ's device facility will include the manufacture process of lens filters used on IR thermometers for medical professionals and the consumer market. The tour will focus on the manufacturing process (including ToolVu) that is incorporated on both thermoforming lines to monitor process repeatability. It will also include an overview of the quality practices used for measurement of the finished products and sampling plan. The site is built around the concept of a modular clean room that could be incorporated as a remote manufacturing site to be able to produce products closer to the customer point of use. |



Other Conference Highlights:

- Technical Sessions
- Exhibitions
- Networking Events
- Parts Competition

Plant Tour B - PTi

Thursday, September 18, 2014

11 a.m. – 3 p.m. (bus transportation and lunch provided)

Busses will depart the Renaissance Hotel at

11:15 a.m. and return by 3 p.m.

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For more information on PTi products and services contact PTi sales at www.ptiextruders.com |

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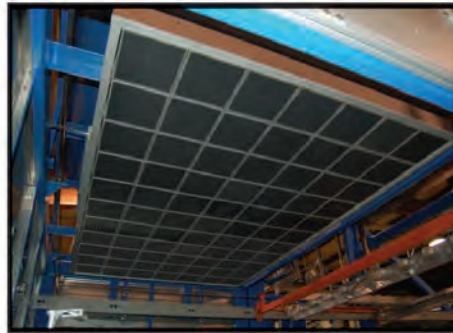
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BILL KENT, Brown Machine



Following a stint at Western Michigan University, Bill began working for Brown Machine at Gaylord Brown's side in 1961. He began as a technician, assembling machinery on the shop floor and traveling to customer facilities for machine installation and service needs. By 1965, Bill had worked his way up to the position of sales engineer and for the next 46 years, he worked in customer and technical related roles. Bill was promoted to Vice President of Advanced Technology in 1985 and held a management role until his retirement in May 2012. Bill retired at the apex of his 50-year career at Brown Machine.

As the market segments for thermoformed products continued to expand, Bill was well-versed in the products, machinery (roll-fed and sheet-fed) and the requirements for end-use markets such as food packaging, disposable containers, point-

of-purchase, medical, horticulture, agriculture, construction, RV, recreational, dunnage, appliance and automotive. Bill worked through the evolution of new materials from the early beginnings of polystyrene through APET, PP, TPO and bio-resins. Bill also participated in the development of thermoforming equipment and tooling in forming and post-trimming processes, direct inline forming with extrusion, hot-sheet direct-coupled extrusion, forming and cutting with steel rule/forged high die, single station and rotary thermoforming equipment for vacuum, pressure and twin sheet applications and countless special machines and applications across the globe.

Technology continued to evolve and Bill participated in this progression from primarily mechanically-actuated equipment to electrical- and servo-actuated equipment; from cal-rod heaters to quartz and panel heaters; from pneumatic to electric single station and rotary equipment; from flywheel to servo trim presses; from single screw to multiple screw lip rollers; from limit switches and push buttons to sophisticated computerized control systems. Bill was the messenger from the market to the design engineers. He traveled everywhere to deliver the "What's new?" message to a hungry market. During his career, Bill logged over six million flight miles as he traveled around the world, expanding Brown's footprint and promoting the thermoforming industry.

Bill was one of the founding members of the SPE Thermoforming Division Board in the early 1980s and was re-elected to the Board of Directors in 1998 where he served through 2011. During his tenure on the Board, Bill was active in the Machinery Committee and worked on the technical programs of many successful SPE Thermoforming Conferences. Throughout his career, Bill delivered countless technical presentations, participated in panel discussions and moderated many sessions at the conference. Bill attended virtually every NPE show from 1966 through 2012 and every SPE Thermoforming Conference from inception in 1988 through 2011. He educated customers and audiences about materials, processes, equipment and tooling to help them achieve their goals. |

SPE THERMOFORMING DIVISION 2014 SCHOLARSHIP WINNERS

The Segen Griep Memorial Scholarship

Drake Stephens, Pittsburg State University

Drake Stephens is a senior at Pittsburg State University. He is planning to graduate in May 2015 with a bachelor's degree in Plastics Engineering Technology with an emphasis on both design and manufacturing and a minor in chemistry.

Drake is from Kincaid, a small town in southeast Kansas. He attended Crest High School and received an Associates of Science degree from Allen Community College. During the summer of 2013, Drake held an internship at Charloma Inc., a custom plastics production company with multiple thermoforming machines in Cherryville, Kansas. During the summer of 2014, he is participating in an Internship with ORBIS, an injection molding company located in Osage City, Kansas.

The Thermoforming Division Memorial Scholarship

Paul Woodson, Kettering University

Paul Woodson, from Sterling Heights, Michigan, is currently a senior mechanical engineering student at Kettering University. He is also pursuing the recently developed plastics engineering minor, which includes classes in polymer science, mold design and plastics processing. Because of his interest in plastics, Paul found a co-op job with Magna Exteriors where he could put his passion for the industry to work on a daily basis.

Paul is very involved on campus. He is the current president of the Kettering University SPE Student Section, which encompasses both A and B sections. Paul frequently helps Professor Richardson in the Polymer Processing Lab with outreach programs for middle and high school students and with managing the processes for needed parts and materials. Paul is also involved with "Innovation to Entrepreneurship," and runs the weekly "Innovation Quest" held on campus, which involves engineering challenges for teams of students.

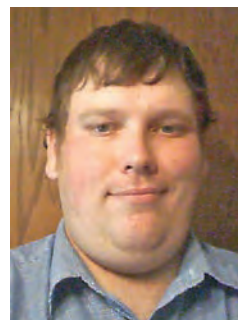
Paul will graduate in 2014 and hopes to accept a full-time job

with Magna Exteriors to continue his work in the automotive industry and to utilize his knowledge of plastics. He wants to continue his education by earning an MBA or a Master's Degree in plastics engineering.

The Bill Benjamin Memorial Scholarship

Anna Macherkevich, Kettering University

Anna Macherkevich grew up in Grand Blanc, Michigan. She is currently an undergraduate Mechanical Engineering student at Kettering University in Flint, Michigan. Anna holds the position of Vice President for the school's newly formed Plastics Engineering Club. Anna's cooperative educational experience is with Chrysler Group LLC. She has been employed by the company since October of 2012 and has rotated around the Supplier Quality organization. She is currently on the interior team for Ram Trucks and deals with hard-trim components. She is completing a thesis on developing strategies to control gloss levels on interior hard-trim Polypropylenes and TPOs. |



Drake Stephens



Paul Woodson



Anna Macherkevich

Thermoformed Protective Packaging: Engineered Cost Savings

By Jeff Pitt, Founder, Protective Packaging Solutions (UK) Ltd.

Thanks to innovations in mobile technology, consumers now search, compare and purchase goods from the comfort of an armchair or while mid-air in a wi-fi-enabled 747. Convenience coupled with transparent pricing has led to a phenomenal increase in online shopping, a trend that shows no signs of abating as more and more people worldwide are connecting to the internet. Indeed, Forrester Research shows a 9% CAGR for US online retail shopping for the period 2012-2017.

The combination of shorter product life cycles and quicker time to market for next generation goods reveals that packaging technology has not expanded at the same rate as consumer behavior. With the advent of on-line purchases, the critical process of protecting fragile goods during transportation and storage has become much more demanding. Inevitably, the result is that fragile goods are packaged in over-engineered solutions using excessively robust and bulky traditional materials such as carton board origami, EPS foams or even inflatable systems requiring special equipment.

Whether they are driven by sustainability commitments or simply by cost-cutting measures, many companies are in a continual process of reducing, reusing and recycling packaging rather than using a mix of different materials that complicates end-of-life efforts and recycling streams.

Engineered Thermoformed Packaging

The global packaging industry is large and dynamic, driven by shifting consumer demands and the exigencies of worldwide logistics. A good example of an innovative packaging system that considers both sustainability efforts and product protection is the 'Lo-g' concept developed by Protective Packaging Systems Ltd. of the UK.

'Lo-g' is a modular plastic thermoformed packaging system that is tailored specifically to a product or groups of products. The concept evolved during PPS's involvement in developing an advanced continuous fibre composites bumper beam system for a luxury brand of cars. The same principle of protecting precious cargo while sacrificing the impact-absorbing features within the car has now been applied by PPS to the problems associated with protecting the fragile contents held within a 'Lo-g' pack.

There are three core elements that are always incorporated into the package design to optimise performance:

1. Springs: strategically positioned to absorb impact, the springs are incorporated into the internal face of the package. This allows the product to be seated on a layer of air. The spring design is flexible and its geometry is optimised in line with the product complexity and other

packaging performance requirements.

2. Bellows: an array of interlocking features is positioned at the ends of the pack that function like a concertina on impact. Two opposing sides incorporate an innovative feature that transverse the pitch of the bellows enabling all four sides to interlock for total closure.
3. Buffers: the buffers are impact-absorbing features that appear below the cut line of the packaging. They are generally designed to incorporate a positive / negative feature which enables the 'Lo-g' packs to interlock during stacking, storage and internal transportation. However, the main advantage of the buffer is that these features will engage against the internal wall of the secondary packaging forming a layer of air between the outer packaging and the 'Lo-g' unit.

Due to the superior performance of the 'Lo-g' pack, the outer (usually cardboard) packaging can be downgraded considerably with lighter-weight cartons, sleeves or mail-bags replacing bulkier outer cartons.

PPS encourages clients to consider recycled materials and select polyolefins that generally demonstrate the durability and pliability that is advantageous to the package's functionality.

One of the major benefits of this complete wrap packaging solution compared to other systems is the ability to design specific geometry into each face that, when folded up through 90 degrees, enables an 'undercut mentality' promoting real pack design innovation. This three dimensional approach enables both the product and accessories to be securely held in bespoke cavities. The need for bags and inner cartons for these accessories is eliminated.

Improved Logistics, Reduced Costs

'Lo-g' packs nest readily offering the customer excellent density of packaging. It can be a single piece wrap with integrated locking mechanisms. This reduces the need for tapes and straps while ensuring the pack assembly is a rapid process that can be achieved with a minimum of effort.

There are numerous other important operational and logistical benefits associated with this packaging system, which not only enhance its environmental performance, but also offer serious savings opportunities along the supply chain, including:

- Reduced packaging bill of material (BOM)
- Simplified transport, logistics management and supply chain
- Smaller warehouse & storage requirements

- Reduction in the number of pallets
- Reduced transportation which in turn reduces carbon footprint
- Mitigation of dirt and dust contamination
- Less packaging waste
- Reduced cost of quality, better packaging performance, fewer breakages and returns

Case Study Example

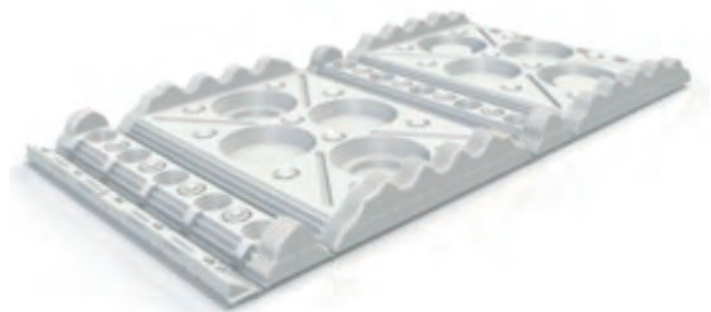
The following example is based on a project where laptops were being packed with either pulp multi-trays or foam end-caps. Based on a run of 10,000 laptops and using a 10 ton trailer as the basis for logistics calculations, the existing package of 0.0329m³ (1.161ft³) required 7 vehicles per day to transport 1428 units. The new Lo-g package was 0.025m³ (0.882 ft³) and required only 5.32 vehicles per day to transport 1880 units.

The reduction in volume has broader implications for incoming goods, i.e. the delivery of packaging materials to the warehouse. Due to the interlocking design of the Lo-g package, an incoming pallet of 500 empty packs in two stacks is more efficient than a bulk pack of foam rubber end caps stuffed into a large, pallet-sized polythene bag that was previously used. 59 pallets per day of foam end caps were required to support production. On an annual basis (300 days), vehicle movements would be 804 vehicles. Using a conservative assumption that local transport is the basis for supply costs, at \$650 per journey, we arrive at a total of \$522,600 for incoming goods. When the Lo-g pack is substituted, only 20 pallets (each containing 500 packs) are required to support production. Using the same conservative assumption for local transport costs, we arrive at 273 vehicles per year at \$650 per journey, which totals \$177,450 for a reduction of 66%.

The reduction in outbound (finished goods) vehicle movements also translates into significant savings. Assuming 6 days per week and 50 trading weeks per year, there would be 504 fewer

vehicle movements per year using the Lo-g design. With an estimated cost of \$1300 per journey, the annual savings would be approximately \$655,000 per year. In sum, by switching to the Lo-g package design, the customer can realize savings of over 30% when both packaging materials and associated logistics costs are factored in.

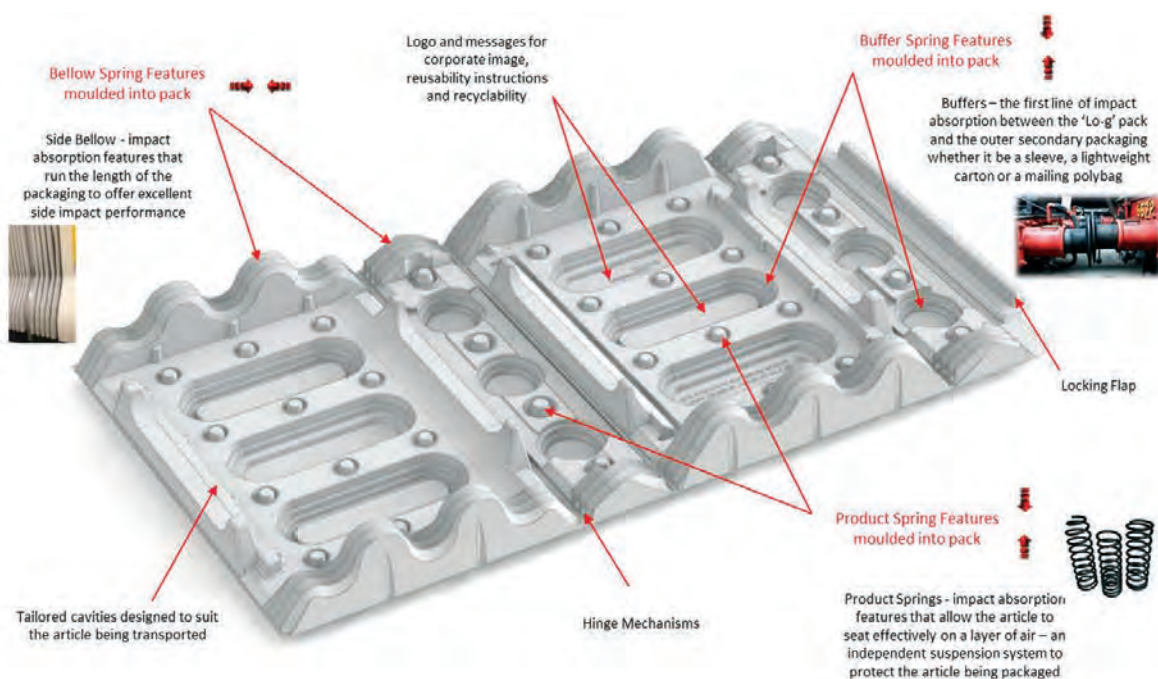
The Lo-g packaging system represents a unique and technical thermoformed solution for a wide range of consumer electronics, medical and industrial products. |



Empty Lo-g pack prior to packing



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Interview with Chris Gagliano

Program and Technical Service Manager for the Thermoforming Center of Excellence,
Plastics Innovation & Resource Center, Pennsylvania College of Technology

TQ caught up with Chris at the recent National Hands-On Thin-Gauge Thermoforming Seminar in Williamsport, PA.

Conor Carlin: Tell us a little bit about your background and how you arrived at this position.

Chris Gagliano: I began my career in the thermoforming industry in 1987 with Bo-Mer Plastics in Auburn, New York. I was hired as a floor inspector to inspect all the thermoformed parts and to record data points associated with final part quality. After a short while, there was an opening within the company to work on the forming machinery. Knowing what a good part looked like from a QC perspective, now I had the challenge of how to actually make that quality part! Keep in mind, this was before the Internet and there was quite a bit of trial and error, some hard-won experience with analog gauges and dials, and a fair bit of extrapolation.

Eventually, I moved to Auburn Vacuum Forming Co. (another heavy-gauge processor) where I worked as the lead set-up technician. My eventual supervisor and mentor approached me after two years with an opportunity to move into estimating/inside sales. This allowed me to work directly with customers and understand their discrete needs and concerns. In 2002, I was promoted to sales manager and stayed in that role until 2005, when I joined F.M. Howell and Co. in Elmira, NY, as sales manager for its heavy-gauge business. I also played a role in the thin-gauge packaging business, as Howell was enjoying some growth at that time and was expanding its plant.

In September 2008, I was offered a wonderful opportunity to be sales and operations manager at a small company called CCM Inc. Thermoforming was only a small portion of the business, as the company was primarily a plastics fabrication operation using acrylic and polycarbonate materials, but we slowly built up sales to the point where thermoforming was responsible for a third of the business.

Then at the end of 2011, I was introduced to Roger Kipp of McClarin Plastics, who suggested that I speak to Hank White at Pennsylvania College of Technology regarding a position in its newly created Thermoforming Center of Excellence. I think it was a case of good alignment between the program's needs and my skill set, and I started in February 2012.

Carlin: What are some of the fundamentals of the thermoforming program?

Gagliano: Well, let me make sure you understand how the PIRC works. There is an academic component, but that is separate from the PIRC. We are essentially a business unit. My focus is on industry projects and training. Projects can vary from material development and mold trials to process development and troubleshooting. We provide customized training in addition to our national thin- and heavy-gauge workshops. For example, during our workshops, we have both classroom sessions with subject matter experts, as well as hands-on experiences in the labs. Since understanding extruded sheet is critical to thermoforming, we include sessions in our extrusion lab, where participants can run the extruder, examine the die, measure data points and observe how changes in operating parameters impact the sheet. Of course, those involved in extrusion perform these in their own plants, but for thermoformers who don't extrude in-house, it is very valuable. We also make sure folks understand some of the key testing equipment and associated ASTM methods used in thermoforming to measure tensile, impact and flexural properties of the polymers.

Carlin: What is industry's role in the development of the program at PIRC?

Gagliano: Firstly, we are self-sustaining so we work on a cost-recovery basis. We "sell" machine and service time to industry for thermoforming projects, material testing, etc. We also participate in customized polymer development improving on available plastics. Secondly, we have the advantage of employing students to do some of this work on the equipment, which allows them to receive hands-on training while providing a service to a company. You can see from our wall of sponsors that private industry does play a big role through donations, matching grants, equipment and materials. The SPE Thermoforming Division has been a major supporter of ours.

Carlin: This is a very hands-on program with extrusion, thermoforming and testing equipment. What sorts of roles do graduates get when they are hired?

Gagliano: We offer two- and four-year degrees. The majority of two-year graduates tend to take positions such as process technician, set-up technician, machine operator, etc. Typically, those who graduate from the four-year program [the degree is a Bachelor of Science] are hired as process engineers or quality engineers. Some of them go straight into supervisory roles, where they can command impressive starting salaries due in large

part to the hands-on nature of the skill sets they acquired. Annual salaries of \$50,000 to \$80,000 are not unusual for our graduates.

Carlin: Broadly speaking, how has the thermoforming industry responded to the need for workforce development?

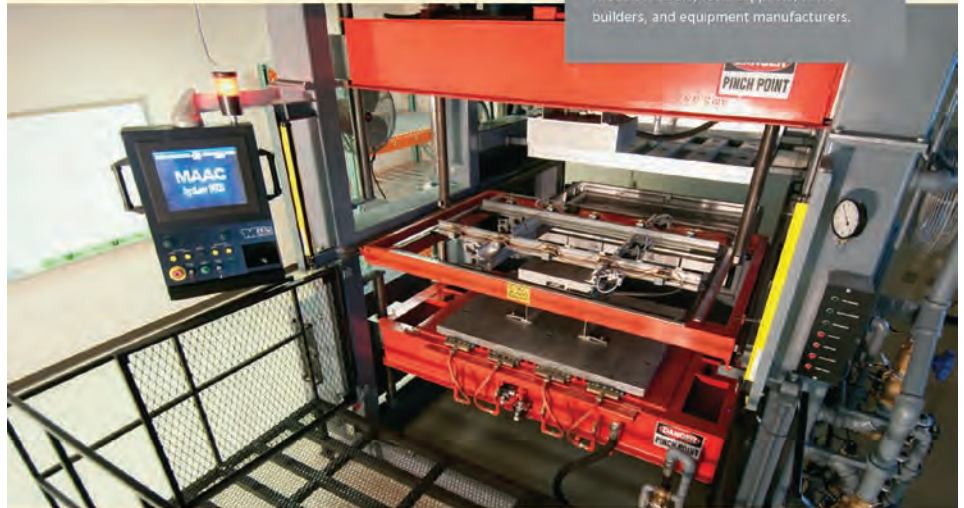
Gagliano: In a word, tremendously. We can gauge this by increased attendance at our workshops. This year, we had to cut off the number of attendees because we can only accommodate so many people in our labs safely. Companies with limited financial resources are sending multiple employees, year after year, for training. This is incredibly encouraging for the industry and U.S. manufacturing as a whole. There is a huge concern that institutional knowledge isn't being captured effectively, as the older generation of operators, technicians and designers moves into retirement. We seek to actively address this industry skill gap.

Carlin: What trends do you see in terms of skill sets, hiring practices for the thermoforming industry?

Gagliano: The students in the Plastics and Polymer Engineering Technology majors are sought after from a variety of industries due to the unique type of programming offered here at Penn College. The students have a good balance of theory and applied technology experience which makes them very attractive to employers. Graduates are recruited into various positions in manufacturing operations, process technology, R&D, product design and project management. The students also develop excellent analytical skills used to diagnose and troubleshoot problems (or avoid them in the first place!), and they are prepared to work hard and efficiently with minimal additional training upon graduation. Their classroom and lab experiences are complemented by the real-world projects they are exposed to through their work with the Plastics Innovation Research Center (PIRC) at the college. |



Dr. James Throne of Sherwood Technologies, Kaitlyn Lewis of Performance Validation, and Mark Strachan of uVu Technologies at the Thin Gauge Thermoforming Workshop in June.



Thermoforming Center of Excellence

PIRC's Thermoforming Center of Excellence (an 1,800 square foot facility) is dedicated to serving the needs of thermoformers, sheet extruders, resin suppliers, mold builders, and equipment manufacturers.

Training services

Plastics industry employees need to understand the latest technology advances. The Center offers credit and noncredit courses to prepare new workers entering the workforce or to advance the knowledge and skills of current workers. Workshops are held at the Center; training also can be delivered on site upon request.

Project services

Industrial scale, state-of-the-art process equipment supports member- and client-driven research and development. Services focus on opportunities and issues related to the development, manufacture, and improvement of thermoformed sheet products (*rigid sheet and film forming*). Programs advance manufacturing technology, develop products and processes, and lower costs.

Potential projects include:

- Reduced material use through tooling design advancements and processing control
- Advanced theory development of mold temperature control and its effects
- Optimization of vacuum/air for faster forming, better part definition, and faster cycles
- Documentation and evaluation of the impact of recycling material properties
- Optimizing material recycling capability
- Bio materials development research

Materials testing and analysis

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- Materials identification and deformation

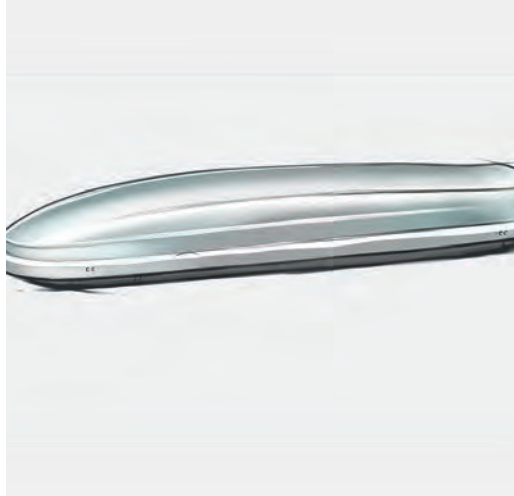
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Roger Kipp
Councilor

COUNCIL SUMMARY



Keeping Pace in a Growing Industry

SPE is the leading resource for technological and scientific information for the global plastics industry, a sector that is forecasted to continue to grow at a 4-5% annual rate. Yet membership is stalled at 14,000, with 74% of members in North America. As membership outside North America continues to grow, maintaining support for global SPE activity is paramount.

Global relationships continue to expand within the Society at large and in the Thermoforming Division. This was evident in the broad support for the European Thermoforming Division this April at the 9th Biannual European Conference in Prague, Czech Republic, where 19 of our division members were in attendance, exhibiting and speaking. Further afield, ANTEC Mumbai 2014 is scheduled for December 10-11, 2014 while the European Additives and Color Conference will be held in February 2015. These worldwide programs provide a diversity of knowledge that is not possible through any other plastics industry organization.

While the goal of SPE has been to increase member value, the reality is that the value is not clear and is perceived to be low. The value proposition of SPE is difficult to define. With this challenge it appears that the continued expansion and success of the Society's journals and even more prominently the success of ANTEC and other conferences (TopCons,

MiniTechs, and Training Work Shops) globally accent what appear to be the primary benefits of the society: technical data communication and verification. Delivery of this technical information continues to be refined and updated for today's plastics engineers. SPE is making changes that are relevant to the lifestyle needs of current and future members.

Some highly visual changes are already in place which enhance the technical image of SPE with a focus on the website and other branding activities. The \$120,000 investment in the new site resulted in the hugely improved and exciting www.4spe.org that is now live. I invite all of you to visit and search for technical papers through the new search engine function. Additionally, there is a current project within our division to incorporate technical articles from past *Thermoforming Quarterly* magazines into this new format.

Our SPE leadership has put together a strategy to improve membership communications and access to technical experts in a wide range of specialties. This includes a unique application called "The Chain" that will go live this fall with the demo planned for September 14th. The benefits will include:

- A social media network to help engage members any time, any place. Higher Logic is the planned vendor (www.higherlogic.com)
- Members will be able to create subgroups (communities) for special interests, send invitations through chat system communications and still use LinkedIn with a pull into the SPE social site. Profiles can be automatically populated from the existing SPE profile.
- The group network access can be

"member only" and further refined with restriction flexibility.

Headquarters will increase their visits to Sections, Divisions and the members' companies to strengthen the SPE brand. Many successful Divisions and Sections have "gone their own way" in recent years creating a duplication of efforts with the accompanying waste.

The sustainability of SPE as a global society requires the leadership to support and promote:

- Unified efforts and elimination of duplication
- Robust communications
- An overhaul of Governance with a smaller elected Board for governance decisions and a new active role for Council
- Developing a brand that attracts younger members with programs like the **Next Generation Advisory Board** that has been in place for one year and is doing great things appealing to young members
- Continuing investment in **Information Communications Technology** such as the new Plastics APP (Plastics Guide) currently in development, SPE Mobile, SPE Events, SPE Magazine, SPE Membercentric (The Chain)

Implementation of these actions and your support through application of the new tools will allow SPE to reinforce its position as the leading resource for technological and scientific information in the plastics industry.

I invite you to email me (srkipp@msn.com) to share your thoughts and suggestions as Council continues to be proactive in addressing future growth opportunities for your SPE. |

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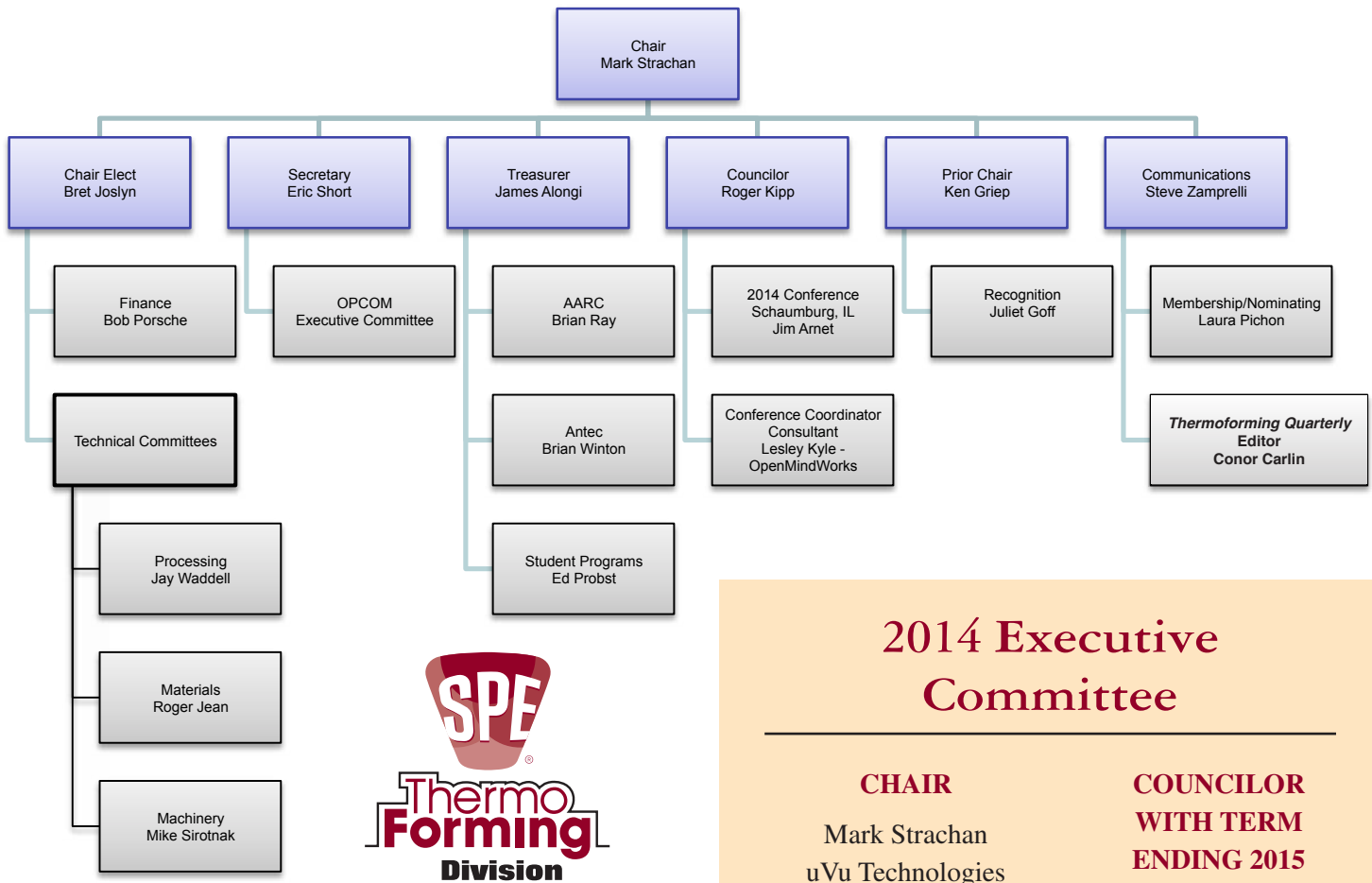


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From the Editor

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.

Thermoforming Quarterly is proud to publish news and stories related to the science and business of thermoforming:

- New materials development
- New applications
- Innovative technologies
- Industry partnerships
- New or expanding laboratory facilities
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We are also interested in hearing from our members and colleagues around the world. If your school or institution has an international partner, please invite them to submit relevant content. We publish press releases, student essays, photos and technical papers. If you would like to arrange an interview, please contact Conor Carlin, Editor, at cpcarlin@gmail.com or 617-771-3321.

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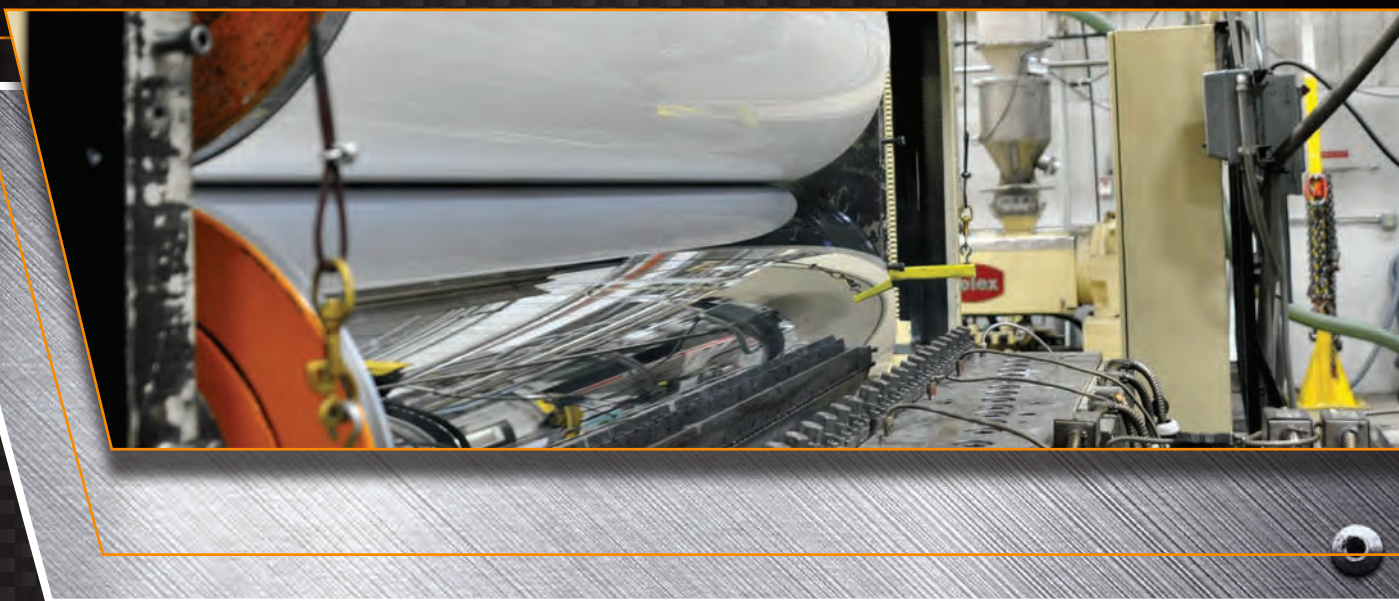
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