Thermoforming Quarterly®

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

FOURTH QUARTER 2014 ■ VOLUME 33 ■ NUMBER 4

Post Conference Edition

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A JOURNAL PUBLISHED EACH CALENDAR QUARTER BY THE THERMOFORMING DIVISION OF THE SOCIETY OF PLASTICS ENGINEERS

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Cover Photo: ***Bowling Pin Organizer by Associated Thermoforming, Inc.***
Photograph by Dallager Photography

Mark Strachan

Moving and Shaking in the Industry - With More Work To Do

The 4th quarter issue of *TQ* allows us an opportunity both to look back the year that was and to look ahead to the New Year. With NPE coming to Orlando in 2015, the thermoforming industry will showcase its latest innovations on the global plastics stage next March. But let's take a minute to reflect on 2014 and consider some noteworthy events.

Consistent with previous years, M&A activity continued apace in our industry. Two machinery heavy-weights from Beaverton, MI are now part of a portfolio of companies assembled by Thermoforming Technology Group, LLC. After being spun off from Sealed Air, Nelipak moved to acquire Flexpak, another thin-gauge medical former. To a lesser degree, the heavy gauge sector saw some consolidation when Speck Plastics agreed to be bought by C&K Plastics. And in Europe, one of the continent's largest thermoforming companies, Faerch Plast, was purchased by a private equity firm. Only time will tell how these investments perform in the long run and it will be very interesting to see if and when the companies are sold, and what investments were made in equipment, processes and people.

Innovation was definitely on display at the 2014 Thermoforming Conference Parts Competition, especially in the heavy-gauge sector. Congratulations to 3-award winner Associated Thermoforming for the Durabin Bowling Pin Assembly (they also won for a pressure-formed medical enclosure!) Years in development, this multi-component part not only displayed ingenuity in overcoming design and production challenges, it also provided significant benefits to the customer in the form of increased productivity and reduced downtime. On the thin-gauge side, Lindar, Innovative Plastech and think4D all walked away with awards for novel parts.

This year's conference also featured the return of several machines. This was particularly beneficial to the student contingent. As in years past, SPE's PlastiVan program educated and entertained young minds. Marjorie Weiner continues to 'drive opportunities in plastics' for middle- and high-school students around the country. Every year we receive multiple letters of thanks from teachers and students who were impressed and inspired by what they learned at our conference.

Readers will know that one of our major themes in this publication is workforce development. In Roger Kipp's SPE Council Report (see page 40), he illustrates just how much work remains to be done in this area. With only 39 applications received for scholarships this year, it is clear that we as an industry must rise to the challenge and engage with young people in our own communities and school districts. Despite the best efforts of the faculty at Penn College, the U.S. is a large country with fragmented apprentice programs and job initiatives. The fact is that no one is going to do it for us; private enterprise must tackle this challenge head-on by truly understanding what it means to invest in people.

It's not too early to make a New Year's resolution. What will yours be?

New Members

Zheng Tian
Bemis Company, Inc.
Neenah, WI

Chris Cooper
Bayer Material Science
East Lyme, CT

AJ Stoneburner
Associated Thermoforming Inc.
Berthoud, CO

Joseph Yu
Saint-Gobain
Federal Way, WA

Antonino Crisafulli
Gallazzi S.p.A.
Tradate (Varese)

Verne Johnson
Verne Johnson & Assoc., Inc.
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Jarid Hirt
Spencer Industries Inc.
Dale, IN

Matt Brunner
Primex Plastics
Richmond, IN

Jamie Carriveau
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Bernadette Chupela
John Martino
Allison Scuderi
Kydex LLC
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Placon Corp.
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Nick Lannes
Doug Thornhill
Inteva Products
Troy, MI

Jeremy Rodenbostel
Mold-Tech Midwest
Carol Stream, IL

Justin Schmader
Houston, TX

David Shelton
Klockner Pentaplast
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Van Kessler
Plastic Components Inc.
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Bryan Kraft
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Triunfo, FOR

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PolyOne
Easton, PA

John McDougall
MAAX Bath Inc.
Lachine QC

Fernanda Munhoz Anderle
Braskem
Porto Alegre, OU

Rober Ward
Thule Inc.
Franklin Park, IL

Kraipop Thongsak
SCG Performance Chemicals
Bangkok, Thailand

Thermoforming in the News

California Thermoformer Expanding into the Midwest

By Jim Johnson, Senior Staff Reporter

Image By: Plastic Package Inc.
Sacramento, Calif.-based Plastic Package Inc. is opening a second thermoforming plant, in La Porte, Ind.

A California-based packaging company is expanding into the Midwest thanks to phenomenal growth in recent years. Plastic Package Inc. expects its second facility to be up in running next month in La Porte, Ind., through a $1.3 million project.
The Sacramento, Calif.-based firm has seen significant business increases in recent years, according to marketing coordinator Catalina Aceves.

"It's very dramatic, the growth that we've experienced and we're really excited about that," she said. "Forty-three percent growth over the last two years. So it's pretty significant."

Plastic Package makes thermoformed packaging for those making bakery goods, confections, cosmetics and electronics. The company also serves school nutrition programs.

The 20,000-square-foot site in La Porte initially will employ about 18 to 20 workers, and the company expects it will take about a year to be running at full capacity with that staff. After that point, Plastic Package will consider further expansion and additional jobs.

"We do have existing clients in that region along with the fact that we did hire a sales representative who is starting to bring on some new accounts," Aceves said. "We were just looking for somewhere that will allow us to continue to serve those clients as well as the potential new clients."

The company is seeing growth due to the type of packaging it offers as well as the markets it serves, Aceves said.
Service to Hispanics, including Hispanic foods as well as Hispanic markets, is one particular area of growth the company sees in its future. Customers also are being drawn more and more to the firm's recycled-content PET packaging.

Plastic Packaging is moving some equipment from Sacramento, where it employs 85, to help start operations in the Midwest. This not only jump-starts the location in Indiana, but also frees up space in the firm's 50,000-square-foot site on the West Coast.

"Our facility in California will continue as a significant factor in our strategic growth," CEO Mike Miller said in a statement. "The addition of the new facility will continue to enhance our ability to support current customers and grow in the Midwest."

Plastic Package dates to 1976 and is owned by father-and-daughter team Jim and Jennifer Kaye.

The company's new Midwest location most recently was a machine shop and before that was used by Whirlpool Corp., Aceves said.

La Porte, in Northern Indiana, is about 70 miles east of Chicago and 27 miles west of South Bend, Ind.

Plastic Package already has started work remodeling the building and expects equipment to be shipped to the site toward the end of October. Production is expected to begin in early-to-mid November, Aceves said.

Ameriform plans $7.5 Million Expansion

By Michael Lauzon, *Plastics News*

Ameriform Inc. has earmarked $7.5 million to expand its thermoforming, extrusion and rotational molding operations in Muskegon, Mich.

The private firm is adding two more vacuum forming lines to meet growth in a range of thermoforming markets, said Ameriform CEO Tom Harris in a phone interview. Also on tap for completion in early 2015 is more sheet extrusion capacity, which Ameriform uses in-house and sells to the marketplace.

"We're trying to get another 10 million pounds of capacity in extrusion," Harris explained.

The next expansion phase will begin in summer 2015 and will add more rotomolding capacity to the firm's two current rotomolding lines.

Ameriform's sales of watercraft such as kayaks and canoes marketed by its Sun Dolphin division are growing to big-box sporting goods outlets. Another key market is portable rest rooms handled by its Five Peaks Technology LLC division. Other large products made by the company range from hunting blinds to dock floats. Most production is for proprietary lines although Ameriform also will custom form or rotomold large components. Expansion should help it diversify into new markets like playground equipment and sleds.

It now employs about 260 but expects to add 60 by early next year as it relocates some production to a leased facility in Muskegon. Harris says the firm now manages about 200,000 square feet of space, including leased space, for manufacturing and other functions. The rotomolding expansion could add another 25 jobs.

Ameriform mainly processes polyethylene but it can also form and mold ABS, polystyrene and polypropylene. Its rotary vacuum formers can handle molds up ten feet wide and 20 feet long with a four-foot draw. Its twin-sheet and pressure forming rotary presses are up to six feet by ten feet. Its extruded sheet production can be as thick as half an inch.

Ameriform was founded in 1988 by Kenneth Harris, father of Tom Harris. Three other Harris siblings also have positions in the company. The family firm did not disclose annual sales.

EFI Acquires Polymeric Imaging's Thermoforming Ink Technology

FREMONT, Calif., Oct. 29, 2014 (GLOBE NEWSWIRE)– EFI™ (Nasdaq:EFII), a world leader in customer-focused digital printing innovation, today announced that it has acquired key intellectual property assets for digital inkjet printing of thermoformed products from Polymeric Imaging, a specialist provider of UV and LED inks for industrial and graphic arts applications.
Based in North Kansas City, Mo., Polymeric Imaging has extensive R&D experience in the development of inkjet inks that address important curing, adhesion, density and durability issues that industrial and graphic arts print professionals encounter when printing on challenging substrates. EFI will use the acquired technology to enhance its customers' inkjet production capabilities for thermoforming and other high-elongation applications requiring exceptional ink durability and flexibility.

Financial terms of the acquisition were not disclosed, but the deal is not expected to be material to EFI's Q4 or full-year 2014 financial results.

"This acquisition continues EFI's momentum in inkjet graphics printing following a highly successful SGIA Expo highlighting our leading portfolio of UV and LED inkjet technologies," said Stephen Emery, vice president of EFI's ink business. "The technology we are acquiring will allow EFI to continue expanding our efficient, high-quality inkjet platforms into new markets."

"As a world leader in UV inkjet manufacturing, EFI has long set a standard for excellence and innovation in digital printing," said Polymeric Imaging founder and owner Don Sloan. "This deal provides significantly greater scale and reach for the development and commercialization of some of the key R&D breakthroughs we have made with inkjet ink."

In addition to buying technology from Polymeric Imaging, EFI has hired key Polymeric Imaging employees responsible for technical and market development of digital ink and coating products.

Those employees are currently assisting EFI's ink operations in the development and testing of new formulations for use in EFI inkjet products.

LINDAR Expands OEM Manufacturing Capabilities

BAXTER, MINN. — LINDAR Corporation, a leading manufacturer of thermoformed OEM parts for equipment, machinery and vehicles of all types and sizes, has expanded its Baxter, Minn., facility and its OEM manufacturing capabilities.

LINDAR recently completed a 33,000-square-foot building expansion, in part to house a new MAAC three station rotary machine that was purchased to advance LINDAR's production efficiencies and product offerings.

"This machine gives us the ability to process higher quality products while improving efficiencies," said Gordy Murphy, LINDAR's operations manager.

Purchased for its speed and accuracy, LINDAR's three station rotary thermoforming machine can handle extra-large sheets of plastic and molds up to eight-feet by six-feet in size.

"The additional capacity this machine provides will accommodate our customers' growth and added capacity requirements," Murphy said. "It's advanced technology with advanced capabilities and it allows us to bring some of the newest product concepts and manufacturing methods to life."
The three station rotary machine allows LINDAR to form larger parts and components while increasing manufacturing speed and reducing energy consumption.

"This is a significant investment in the future of LINDAR," said Dave Fosse, LINDAR's director of marketing. "Our building expansion, the new equipment, and our added thermoforming capabilities are a testament to the overall growth LINDAR is experiencing as a company."

Based in Baxter, Minn., LINDAR specializes in thermoforming large parts for agricultural and lawn care equipment, recreational vehicles, construction and industrial machinery, as well as medical equipment for customers across North America.

The Pull & Push of Global Thermoforming

By Conor Carlin, Editor, *Thermoforming Quarterly*

Editor's note: an earlier version of this article was published in European Plastic Product Manufacturer (EPPM) in May 2014. It has been updated to include some end-of-year comments on the global thermoforming industry. Send all comments and thoughts to cpcarlin@gmail.com.

The thermoforming industry is traditionally defined by its two processing segments: thin-gauge (roll-fed) and heavy-gauge (sheet-fed). This simple definition based on sheet thickness, however, is no longer sufficient to describe a process that is used in a very wide spectrum of applications. Much of thin-gauge thermoforming is bound up in food packaging where consumer demands and the brand equity of global companies pull innovation from package designers, material scientists and equipment suppliers. From North America to Southeast Asia, thin wall packaging is an important driver of growth. In heavy gauge thermoforming, there is a very large variety of materials that must be processed (10-15x more than thin gauge) so machinery must be able to process all material types. While the automotive sector continues to extract innovation from the heavy-gauge thermoforming ecosystem (resin suppliers, material suppliers, converters, OEMs), the medical, building materials and logistics sectors also contribute to the increased adoption of thermoformed solutions.

Several recent market studies suggest year-on-year growth rates of between 2-4% for the industry in aggregate, while deeper analysis shows broad variation in growth rates among discrete market segments[i]. For example, the food packaging sector shows higher rates of growth than retail packaging while the medical sector (both thin-gauge and heavy-gauge) shows higher profit margins than the appliance or marine sectors. Moreover, a newly-released study from BCC Research suggests thermoformed electronics packaging is a fast-growing sub-segment with a CAGR of 4.9% through 2019[ii].

Let's look at thermoforming from two different perspectives: the 'pull' of market demands and the 'push' of industry suppliers, i.e. machinery, tooling and materials.

Thin-Gauge Thermoforming

Because it is widely viewed as the largest market segment by material processed (~7bn lbs in 2012) and by revenues generated ($12.8bn in 2012)[iii], thin-gauge thermoforming for packaging is a good place to start discussing broad trends. And while these numbers are for North America only, similar research suggests that the sector (which includes dairy and beverage) commands the largest slice of the thermoforming pie in both Europe and Asia.

There are several converging elements that create a basis for continued growth and innovation in thin-gauge thermoforming. As food is grown further from its ultimate point of consumption, packaging, and transportation become critical elements in the global supply chain. The change in consumer habits in terms of how and when food is eaten has resulted in package design innovations that incorporate increased shelf life, tamper-evident "intelligent" packaging and high visibility. These factors constitute the pull of the market and have been widely acknowledged and discussed in the industry press. The K-cup is an excellent example of product innovation that led to a mini-boom in thermoformed processing. When viewed in combination with the push of suppliers, however, we can get a more comprehensive view of the industry as a whole.

Innovations in materials, tooling and machinery have allowed package designers to benefit from new technology. Multi-layer, barrier and now oxygen-scavenging films are arguably the biggest contributors to thermoforming's growth, especially when you consider that such films cannot be processed via injection molding. Several technical papers have been published on this topic in this publication and in major plastics and packaging industry outlets. The science behind these developments is typically being done at large resin companies or in some cases at university research labs with strong polymer departments.

The application of new inks and printing technologies, as well as thermoformed in-mould labeling (T-IML), mean that thermoforming as a process remains attractive to major global brands such as Yum Brands, Starbucks, McDonalds, Dannone, Mondelez and Nestle for food, dairy and beverage packaging. T-IML allows plastics to displace cans, opening new opportunities for thermoforming converters. The increased adoption of fast-cycling, tilt-mold machinery means that tooling must be precision-engineered to very tight tolerances with servo-driven plug assists for optimal material distribution. Better material distribution leads to lower part weights. Down-gauging is therefore an important resource- and cost-efficient tool for designers and cost accountants.

The use of air-save technology is just one of the new innovations in thermoform tooling. On the topic of air consumption, new high-volume, dual circuit pressure forming valves allow air to flow in and out of the mold cavities for faster cycle speeds leading to a significant reduction in air consumption and, by extension, energy and operating costs.

The importance of retail displays and shelf space are major concerns for these brands, as well as for supermarket inventory managers. Clarity is a key driver. A recent eye-tracking study conducted by Klockner Pentaplast[iv] (featured in TQ4, 2013) used statistical methods to show that consumers fixated for longer periods of time on products packaged in thermoformed clamshells instead of those packaged in paperboard boxes. The data revealed a strong correlation between fixation duration and the ultimate purchase decision.

Beyond the food sector, medical packaging has set a high bar for performance due to the critical nature of this market sector. Regulatory compliance, product safety, package performance, cost and quality are equally important to medical device manufacturers and, by extension, to processors who serve them. Thermoformed trays, therefore, are designed with these concerns in mind. As is the case in other market sectors, low tooling costs and fast turnaround times mean that thermoforming is the logical and cost-effective choice for companies who need to bring new and innovative products to market on a regular basis.

Heavy Gauge Thermoforming

Pressure, vacuum and twin-sheet thermoforming are the 3 process categories typically used by the judges in the SPE Thermoforming Parts Competition when awarding prizes. This year's event (as well as the competition at the European Thermoforming Conference in April) provided some excellent examples of what can be achieved in heavy-gauge forming.

As stated earlier, the wide variety of materials used in this segment means that processors must be able to work with and understand a broad array of customer requirements. From textured instrument panels in the automotive sector to complete assemblies using both plastic and metal parts in medical and other industries, thick-gauge forming provides cost-effective, highly-cosmetic parts. Because these parts are not simply formed, trimmed and packed like items from the roll-fed industry, a tremendous amount of value-add is inherent in how heavy gauge former sell both their products and their process. A few companies such as Ray Products (Ontario, CA) and Productive Plastics (Mt. Laurel, NJ) have published whitepapers and other data explaining how and when the thermoforming process is the optimal solution for companies seeking plastic parts. The specific gravity of thermoplastic versus that of fiberglass, for example, is a major contributor to the lighter weight of a thermoformed part. This leads to significant cost savings both for the actual material used but also for the end-use application (such as transportation) where weight is a critical factor.

In the healthcare sector, developments in anti-microbial agents that can be added to the plastic sheet open up more opportunities for processors targeting this market segment. Large parts such as housings and enclosures are routinely thermoformed thanks to the economics of both the tooling and the processing volumes.

Developing Markets

Data from Euromonitor International show the fastest rates of growth for thermoformed packaging are in China and Southeast Asia[v]. It is important to distinguish among the different countries and regions in Asia as distinct trends can be observed. For example, water cups are the single largest thermoformed item in Southeast Asia, with Indonesia as the standout country. With a population of 246MM and growing, the demand for packaged water is a significant driver of thermoforming activity in this country. Thailand and Vietnam are two other countries where high levels of investment in packaging factories and the required machinery (from Chinese and Korean conglomerates, in many cases) contribute to high rates of growth. The investments in technology required to serve this market are significant: high-speed European machines with precision plug-assisted tooling. Conversely, the requisite training to efficiently operate these sophisticated machines is not yet widely adopted.

SPE CEO Wim de Vos suggests that China is a special case among emerging markets. He sees a wide variety of thermoformers of which a big portion, perhaps half, is supplying the lower-end, lower-demand section of the domestic market. Chinese machinery makers continue to churn out low-end (by Western standards) equipment for their local customers in this market segment. They are also exporting machines in significant volumes to India and other emerging markets. The city of Shantou in eastern Guangdong Province is home to at least 5 thermoforming OEMs, many of which displayed equipment at Chinaplas. While the technology is clearly not up to western standards yet, the presence of Eastern European buyers in the booths of Chinese machinery companies suggests that Chinese equipment is finding acceptance beyond the borders of the Middle Kingdom.

The other portion of the China market consists of larger companies who supply parts to international OEMs and brand owners. They have to fulfill the more demanding specifications of international brands so they are investing in European and US technology for both sheet extrusion and thermoforming. Tilt-mold thermoforming machines appear to be the preferred format among these suppliers.

Turkey has overtaken France and is now on pace to become the 2nd largest plastics converter in Europe[vi], so the moniker of 'developing' market might be dropped in the near future. With 9% growth in the value of thermoformed goods in the domestic market, Turkish OEMs, toolmakers and converters are enjoying robust expansion.[vii] Visitors to K 2013 saw many Dusseldorf S-bahn and U-bahn trains plastered with promotions for the Turkish Pavilion.

In Eastern Europe and Russia, the expansion of major supermarkets brings new stores and distribution centers, increasing the need for thermoformed packaging. As Marek Nikiforov, European Sales Director for GN Plastics has pointed out (see TQ2

Special K-show edition of Turkish Plastics Industrialists' Federation magazine (www.plasfed.org.tr)

2014), Western Europe has many more supermarkets per capita than Eastern Europe, including Russia. OPS continues to be the polymer of choice due to its low cost, but also because the recycling infrastructure that we associate with both North America and Western Europe is not yet developed.

Data Analytics

The advent of big data is a hot topic in many industries for the abundance of information and analytics now available to marketers, engineers and managers. Is it relevant in thermoforming? What sort of data is most important to processors? How does that data get analyzed and by whom in the organization? We are starting to see some emerging trends in the application of information technology to thermoforming. Having the ability to meter and monitor data from various sensors, gauges and scanners can help operators dial-in the process to minimize waste and optimize start-up. Companies like uVu Technologies from the US and Illig from Germany appear to be innovators in this space with more sensors, more data points and new, integrated data analysis designed to perfect a notoriously variable-filled process. There are a few early adopters of this data-driven approach, but it is perhaps too early to tell if thermoformers will embrace (and pay for) greater insight.

Workforce Development

Beyond the markets and technology, thermoformers in both the US and Europe are facing a shortage of skilled labor. This magazine and many others continue to cover this important topic. In fact, Mike Rowe, host of television's "Dirty Jobs", has written a book and started a website (www.profoundlydisconnected.com) dedicated to "challenging the absurd belief that a four-year degree is the only path to success."

In the thermoforming industry, Penn College's Plastics Innovation Resource Center continues to offer programs that benefit both students and prospective employers. Several colleges around the US in Canada routinely graduate young engineers who are recognized by the SPE Thermoforming Division's Scholarship Committee. And yet there is a nagging sense that we are still not doing enough to ensure a steady supply of skilled technicians. In a large, diverse country such as the US, it is unlikely that we will develop a national apprentice system similar to that found among Germany's famed Mittlestand companies. Instead, it is more likely that individual companies will work with local and regional entities (municipal, academic) to create programs and associations designed to develop curricula and skills-based training. In other words, the skills gap is not going to be closed by anyone other than the companies who need to hire talent.

Sustainability: Megatrend or Not?

There is no question that sustainability is more than just a buzz word or a passing trend. In fact, as a business practice, evidence continues to mount that companies who fully embrace sustainability enjoy greater returns than peer companies who do not. A 2009 report[viii] by consulting firm AT Kearney indicated that companies demonstrating a long-term commitment to the health of their business instead of focusing on short-term gains outperformed the industry average in 16 of 18 categories. This 'performance differential' amounts to approximately $650MM in market capitalization per company.

The demand for products that have a lighter carbon footprint has not abated. Continuing R&D in materials science ensures that polymers of the future will perform as well or better than their petroleum-based analogs. Brand owners from food service to automotive design recognize that thermoforming offers a cost-effective solution to many of their engineering challenges. This creates opportunity for both heavy-gauge and thin-gauge processors. For the thermoforming industry, increased recycled content, use of bio-based or biodegradable materials, light-weighting of parts and down-gauging of materials are the major trends we see today, though it should be pointed out that these trends are not universally evident across all regions. The lack of recycling infrastructure and price sensitivity to biopolymers, for example, mean that entrepreneurs and business owners in developing markets will be more likely to focus on short-term economic sustainability.

The ubiquitous K-Cup: miracle of convenience or environmental nightmare? (images.google.com)

That said, there is tangible and measurable momentum among global multinational corporations toward acknowledging that their activities have an impact on the environment. This trend toward sustainable business practices suggests a larger, fundamental shift in the way companies and individuals perceive their actions in relation to the broader environment. In one recent example reported by Plastics in Packaging magazine (issue 157, November 2014), a Canadian division of France-based concrete conglomerate Lafarge recently instituted a K-Cup collection program as part of an alternative fuel initiative. The cups are stored, dried and then shredded before being transported into the large kilns where the energy is recovered in the form of heat. While not exactly closed-loop, this program has the advantage of diverting difficult-to-recycle materials from landfill. The thermoformed, multilayer plastic combined with the coffee grinds mean that K-Cups are not easily recycled, though Keurig Green Mountain has stated that its products will be recyclable by 2020.

There are myriad opportunities for new business development including resource efficiency, carbon accounting/management, LCA strategies, new software development, environmental consulting, bio-based materials development, 'green' chemistry and more. The thermoforming industry has an important role to play now and in the future.

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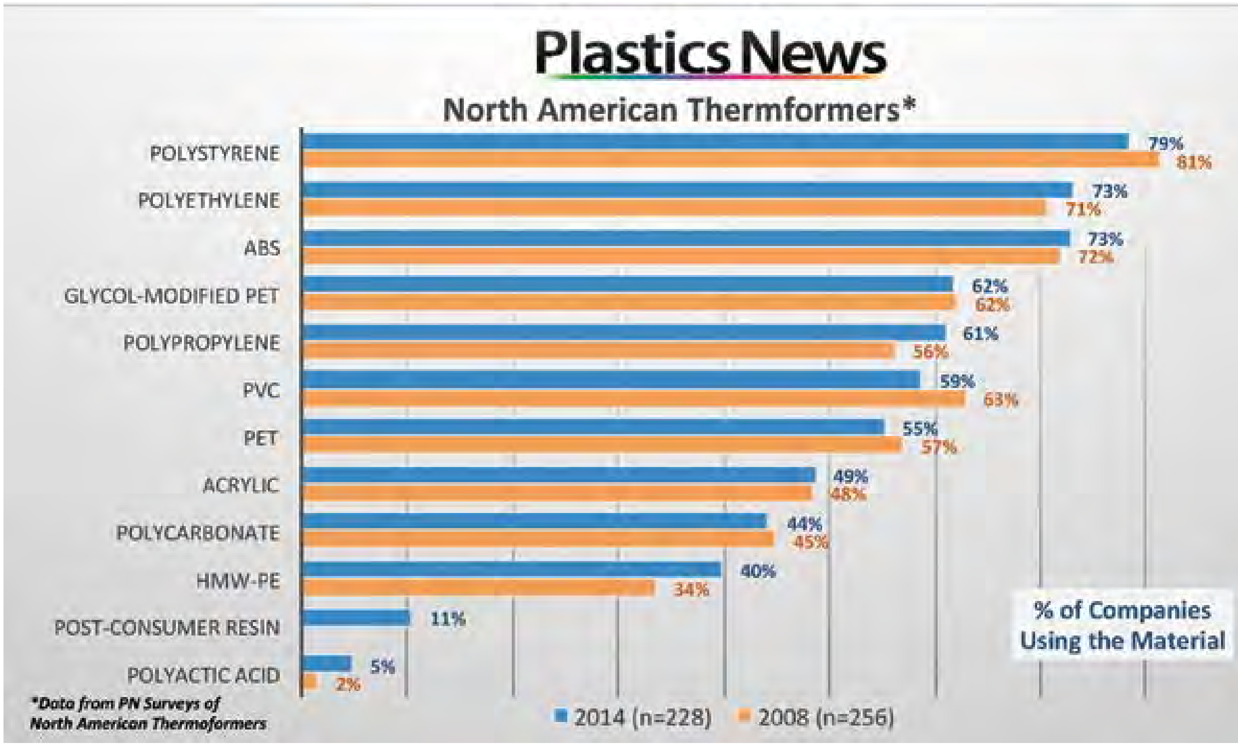
[v] Data from Euromonitor International, "Global Trends in Thin Wall Packaging", presented at AMI Thin Wall Packaging Conference, Wheeling, IL, June 2013

[vi] 3rd GPCA Plastics Summit, "Turkish Plastics Industry: An Overview", 2012

[vii] "Competitive Thermoforming in Turkey", Presentation by SEM Plastik, European Thermoforming Conference, Prague, Czech Republic, April 2014

[viii] AT Kearney, "'Green' Winners, *The performance of sustainability-focused companies during the financial crisis*," 2009



Have an idea for an article?

Submission Guidelines

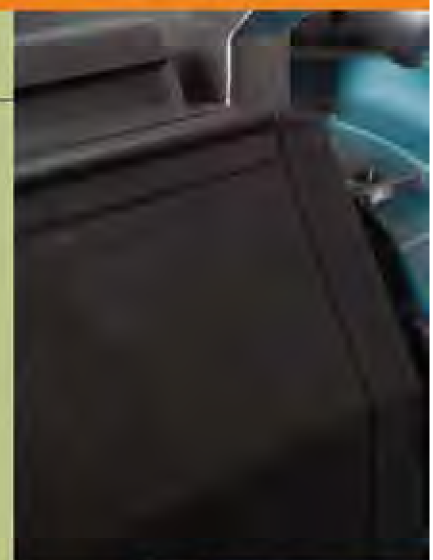
• We are a technical journal. We strive for objective, technical articles that help advance our readers' understanding of thermoforming (process, tooling, machinery, ancillary services); in other words, no commercials.

• Article length:1,000 - 2,000 words. Look to past articles for guidance.

• Format: .doc or .docx

Artwork: hi-res images are encouraged (300 dpi) with appropriate credits.

Send all submissions to Conor Carlin, Editor **cpcarlin@gmail.com**



Thermoforming Technical Problems I Wish I Could Solve

Plug Assist – Speed and Differential Pressure

By Jim Throne, Dunedin, FL

Preamble

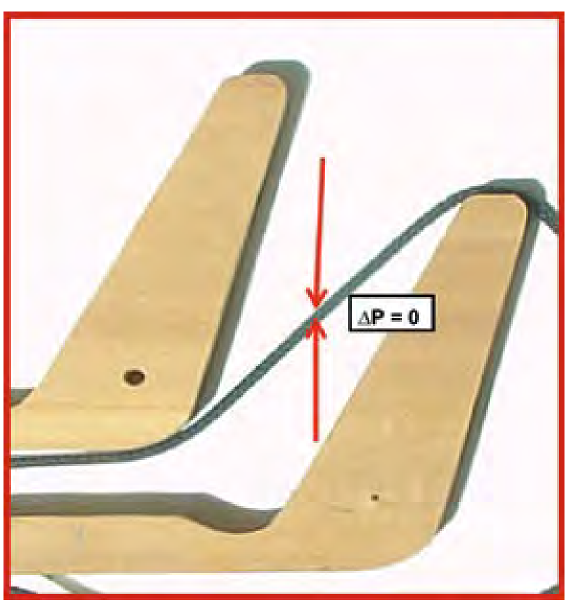
Several years ago, I regaled readers of TFQ with micro-mini-profundities on various technical aspects of the concept we know as thermoforming. Recently, your erstwhile editor invited me to pontificate on these matters. I have accepted the proffered gauntlet. But instead of expounding professorially, I'd like to write in a more conversational tone about problems I haven't solved and may never get around to solving. A caveat: I haven't scoured the literature for specific solutions to many or all of these problems. Please feel free to set me straight if I am preaching to the choir. Another caveat: I will always employ the editorial "we."

Prologue

Plugs are used in nearly every thermoforming process, whether thick-gage or thin. The objective of the plug is to pre-stretch the sheet prior to it contacting a substantial portion of the mold surface. In essence, a plug has an obligation to move the softened plastic sheet from thicker areas to thinner ones. Simple shapes – think drink cups – use simple plugs. Complex shapes require plugs that may be segmented, modular, articulated, and/or sequential.

So, what's the problem?

Technically, we usually envision the plug action as stretching the sheet uniformly in a linear fashion between the bottom of the plug and the side of the mold, as seen here.

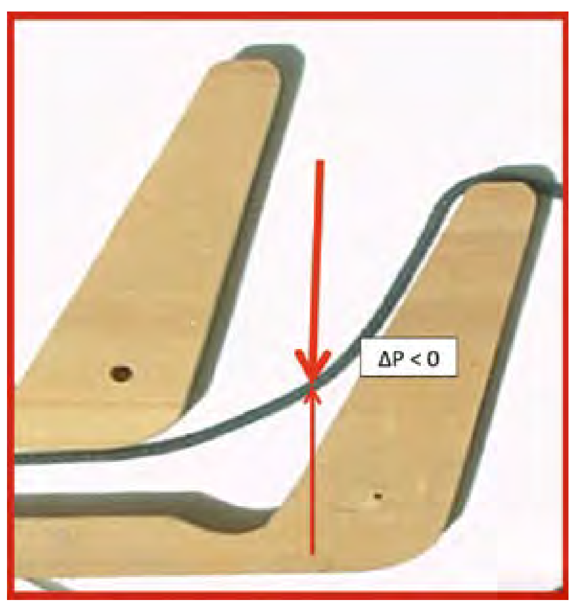


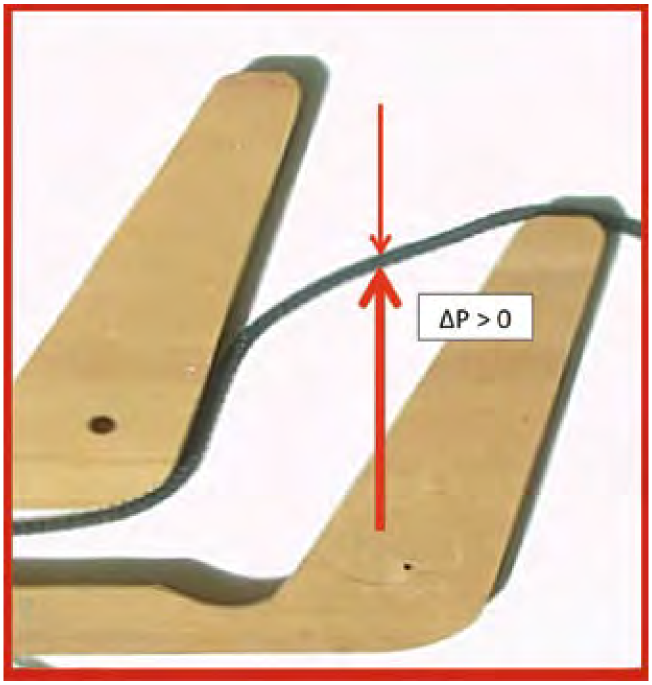
But practitioners in the art will argue that this is not what really happens. Achieving the uniformly ideal part wall thickness in this manner is both impractical and improbable.

So what is wrong with the technology? Consider an alternative to plug assist – pneumatic free blowing. Depending on the thickness and temperature of the sheet, the differential pressure needed to inflate formable thermoplastics is on the order of 0.1 to about 0.4 atm (1.5-6 psi). Typically the thinner the sheet and the higher its temperature, the lower the differential pressure needs to be. How does this relate to plug assist? In the ideal theoretical world envisioned above, the differential pressure across the stretching sheet is zero. Regardless of the speed of the plug or the rate of cavity evacuation or local sheet temperature or whatever. But neither we nor our sheet live in the ideal world.

A Thought Experiment

Let's do a simple thought experiment. Our plug is pre-stretching the sheet into a female or negative cavity. Initially, we assume that the differential pressure across the sheet is zero the instant the plug touches the sheet. Suppose, for whatever reason, the differential pressure across the sheet increases as the plug descends into the cavity. According to what we learned about pneumatic free blowing, we can assume that the sheet will deform. If the pressure above the sheet is greater than that below the sheet (let's call it Positive Differential Pressure or $\Delta P>0$), the sheet will arch downward. If the opposite is true ($\Delta P<0$), it will arch upward. See the pictorials below.





Continue the thought process. Suppose the differential pressure increases to the point where that portion of the sheet nearest a solid surface, viz, plug or mold contacts the solid surface. Unless the sheet slides on the surface (an oft-debated topic to be discussed in a subsequent article), the sheet will stop stretching. Meaning, of course, that only that portion of the sheet still free of the solid surfaces continues to stretch.

So what, "we" say? Hey, if our objective of plug pre-stretching is to achieve uniform distribution of the plastic in the side of the part as the sheet is being stripped from the plug, this is obviated if there is any differential pressure (+ΔP or -ΔP) during pre-stretching. Key word? Any!

So what can cause momentary (accidental or deliberate) differential pressure? How about changing plug speed? Or sheet temperature, sheet temperature uniformity, nonuniform sheet thickness, plug shape, rate of cavity evacuation, and so on. Things that might influence wall thickness in a minor way include plug and mold temperatures, cavity air temperature, plugged vents, phases of the moon, and so on.

Pseudo Plug Experiments

Remember the pre-blow differential pressure mentioned earlier? Well, a while back, I conducted a pseudo-plug assist experiment using my ubiquitous 15 mil natural rubber sheet. Let me summarize my results. The sheet moved from the diagonal toward the plug or mold wall even at differential pressures of a few inches of water column. As expected, increasing plug speed resulted in movement at lower differential pressures.

How do "we" solve the problem?

My experiment was demonstrative but quite crude. A more sophisticated set of experiments should use a transparent mold fitted with proper pressure and vacuum systems and adequate pressure measuring equipment. The mold should be designed to accommodate sheet of known mechanical and thermal characteristics. The system should be designed to advance plugs of various sizes, shapes, and materials into the mold in a controlled manner. The plug rate of advance, the instant differential pressure, and the position of the sheet relative to the mold and plug represent the data base. Local sheet orientation can be obtained by photographing a gridded sheet as it contacts the mold surface.

Second approach? Do a parametric Finite Element Analysis to theoretically calculate the rate of deformation of a theoretical sheet of plastic as a function of the variables described above. Personally, I'd do the hands-on approach first, to rule out minor effects.

I await "our" solutions.

High Melt Strength Polyolefins for Melt Phase Thermoforming and Extrusion Blow Molding Via Electron Beam Modification

By Edward M. Phillips, Principal at Edward M. Phillips, Polyolefins Specialist, Elkton, MD on behalf of E-Beam Services Inc., Dan Yasenchak – Technical & Development Manager at E-BEAM Services Inc., Lebanon, Ohio; and William Crilley – Vice President - Technology and Business Development at E-Beam Services Inc.,Cranbury, NJ

Abstract

Product and Applications Development Engineers continually struggle with the task of meeting challenging performance requirements that balance physical properties and processability within even more challenging economic constraints. In this paper, we update the industry with results that will encourage the use of electron beam modification as a means of utilizing materials with desirable physical properties but historically lack melt processability due to their linear structure. It is a continuation of ongoing work with an emphasis on melt phase thermoforming and extrusion blow molding. By inducing long chain branching through high energy electron beam bombardment, dramatic increases in viscosity at low shear are achieved which increase sag time in thermoforming and hang time in blow molding. At higher shear rates, these long chain branched polyolefins exhibit strain hardening which translates into improved material distribution allowing for down gauging. LCB (long chain branched) LLDPE (linear low density polyethylene) is viewed as new polymer altogether as it has not been used as a stand alone polymer in many applications due to its inherently poor melt strength.

Background

These are not new challenges by any means. LDPE was already broadly used for many applications in the 1950s and 1960s where melt strength was a requirement (extrusion coating, blown film etc.). One major milestone was the extrusion coating of LDPE onto paperboard as a substitute for wax for milk cartons. In the same period the value of the physical properties of PP (polypropylene) were being recognized (higher stiffness, tensile properties, hardness, surface characteristics etc.) particularly for higher service temperature applications. However, conventional PP exhibited poor melt strength due to its linear nature and was not suitable for applications requiring good sag resistance and strain hardening. Even high Mw (low MFR) reactor grade (conventional) PP did not exhibit high enough viscosity at low shear to offer sufficient sag resistance in thermoforming nor hang time in extrusion blow molding. When the mold halves were closed, shear rates increased dramatically and again conventional PP exhibited lack of melt strength resulting in poor material distribution.

In the late 70s and early 80s, Eastman (now Flint Hills), followed by Hercules (now LyondellBasell) offered “alloys” or coupled blends of highly branched LDPE and reactor grade PP plus compatiblizers. These products were offered for extrusion coating (e.g. Profax SD-062, MFR 11-16 g/10 mins. @ 230ºC) and for melt phase thermoforming / extrusion blow molding (e.g. Profax SD-063, MFR 0.2-0.5 g/10 mins @ 230ºC). They offered a significant improvement in melt processability contributed by the long chain branching of the LDPE component (10-30%) plus the physical properties of PP. They filled critical needs in packaging, industrial and automotive segments primarily due to the higher service temperature of the PP component. These blends became known as the first generation of high melt strength (HMS) polypropylenes and enjoyed some commercial success. Even today, it is a common practice to blend LDPE with PP and other polyolefins (e.g. reactor grade LLDPE or HDPE) to reach an optimum balance between However, because they were blends, PP properties, especially heat resistance was compromised by the LDPE component and maximum drawability could not be achieved due to the high concentration of the linear PP component. They were commercially acceptable compromises but not optimal by any means.

In the early 1980s, Hercules established a program within their polypropylene organization known as Controlled Rheology utilizing electron beam induced long chain branching of PP which later became HIMONT’s HMS PP program. HIMONT was awarded a composition of matter patent in 1991 whereby they describe a process of bombarding conventional PP in a modified (reduced O2) environment, breaking the chains, creating free radicals and recombining the chains as side branches in a staged quenching process. They were able to minimize chain scission and maximize long chain branching. The 100% long chain branched PP or HMS PP exhibited a high degree of branching, which was quantified using low angle light scattering techniques. However, from a practical point of view, branching was estimated through changes in rheological properties. Strain hardening could readily be characterized using the Rheotens method which measures melt tension and extensibility simultaneously while increasing strain rate. From these highly branched structures, HIMONT created a family of PP products for processes requiring high melt strength: extrusion coating, melt blown and spun bonded fibers, extrusion blow molding, melt phase thermoforming and extruded low density foam. Each grade was an extruded blend of long chain branched PP with another type of non-irradiated PP that offered the correct balance of fluidity, melt strength and physical properties for a wide range of processes and applications. Because the compounds were 100% PP, there was no sacrifice of properties for processability. Through the 1990s until around the late 2000s, Himont, which became LyondellBasell, built up a business of around 60MM pounds globally of these high performance

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grades from their Varennes, Canada site where they produced polypropylene. Ultimately, the PP reactors at Varennes were shut down followed shortly by the closure of their HMS PP plant in mid-2008.

With the unavailability of HMS PP from LyondellBasell, many converters returned to the technique of blending LDPE with PP on their own. Flint Hills Resources, as a legacy from their Eastman days, continue to offer precompounded blends of PP and LDPE

At E-BEAM Services, we recognize that electron beam induced branching remains to be fully exploited from a technical and business perspective. We are committed to promoting this technology as a useful tool in meeting challenging performance requirements by generating useful data to product and applications development engineers. This paper is a continuation of that effort.

Recognizing an industry trend to blend LDPE with PP and other polyolefins as a means of improving melt strength, we have focused on creating long chain branched LLDPE as a higher performing option. It has been demonstrated by E-BEAM Services Inc. that by bombarding LLDPE with a high energy electron beam, long chain branching can be induced without crosslinking. It has been demonstrated that materials can be produced that exhibit the melt processability of LDPE yet retain the physical properties of LLDPE. This technique is being used by converters making extruded low-density foams from 100% LLDPE, which has not been previously possible and has been the subject of previous papers. This paper focuses on the use of highly branched LLDPE as a melt strength modifier for applications like melt phase thermoforming, extrusion blow molding and extrusion coating. Because of its superior physical properties (tear and puncture resistance) and higher heat resistance, long chain branched (irradiated) LLDPE, VS LDPE is a more desirable material in many applications.

Several commercially available LLDPE grades were selected and irradiated over a range of doses. Melt flow using a common melt indexer and melt tension using the Rheotens method were used to characterize the samples in terms of viscosity, melt strength and extensibility. Selected samples were extrusion blended with un-irradiated LLDPE and high flow PP and characterized again in terms of melt strength to demonstrate its value to converters as an option to LDPE. The results illustrate that as a melt strength modifier, LCB (long chain branched) LLDPE will increase sag time in thermoforming, increase hang time in extrusion blow molding and reduce neck-in and maximize draw rates and draw ratios and delay the onset of melt resonance in extrusion coating.

The approach taken in this project is very practical and reflects the intention to demonstrate the utility of using electron beam processing as a commercially viable means of offering a polyolefin resin that exhibits melt processing behavior comparable to LDPE (low density polyethylene) but has the physical properties of LLDPE (linear low density polyethylene). This objective has been demonstrated and reported in an earlier paper entitled *Creating High Melt Strength Linear Low Density Polyethylene Through The Use Of Electron Beam Modification For Use In Producing Extruded Low Density Non-Crosslinked Foam* – SPE Foams 2011. The work reported here is a continuation of that effort but looking at a broader range of processes.

While several melt processes can be used to demonstrate this improvement, melt phase thermoforming, extrusion blow molding and extrusion coating were selected for the subject of this paper because sag resistance and strain hardening are beneficial.

LDPE has been used on its own for many years as a standard component in improving melt processability. It is polymerized in the presence of a peroxy initiator such as benzoyl peroxide at high pressures (30,000 – 40,000 psi) in an autoclave or jacketed tube at temperatures ranging from 475 to 570ºF (246 to 299ºC). By ASTM standard nomenclature, it will have a density ranging from 0.910 to 0.925 g/cc. The degree of crystallinity ranges from 60 to 70%. The degree of crystallinity and the degree of branching increase as the reaction pressure is increased. LDPE has a good balance of physical properties and exhibits excellent melt processability for many commercial applications such as cast and blown films, blow molded and thermoformed containers, extrusion coatings, tubes and low density foam. All of these processes require or benefit from the “high melt strength” exhibited by the highly branched structure of LDPE. In the melt phase, the long chain branches (LCB) create an intertwining network causing the polymer chains to resist sliding over one another compared to a “linear” polyolefin. A linear polymer can be defined roughly as a continuous chain where the length is at least 1000 times the thickness of the chain. In melt processing of polyolefins, “melt strength” is defined by two key characteristics that can be quantified in practical (process related) terms and in rhelolgical terms. For instance, in extrusion blow molding and melt phase thermoforming, a branched polyolefin of the appropriate molecular weight (Mw) will support the weight of the fully melted sheet or extruded parison. This behavior is referred to as **sag resistance**. Sag resistance is critical as it permits the delivery of the fully heated sheet or parison to the molding stage of the processes.

The other important melt behavior, is the polymer’s ability to resist thinning at high draw rates and high draw ratios or its **extensional viscosity**. When linear polyolefins such as LLDPE (linear low density polyethylene) are extended in the melt phase, because of their lack of long chain branching, the chains align and then tend to slide over one another. There is a momentary point where they begin to exhibit an increase in extensional viscosity that is immediately followed by the onset of shear thinning. The melt will thin out from specific points where the critical draw rate or draw ratio has been exceeded. For instance, in the melt phase thermoforming and extrusion blow molding processes, when the mold halves capture the heated sheet or parison and the forming pressure is applied, shear rates or extensional rates are greatly increased. During the forming stage, the melt from a linear material will thin out in the deeper areas of the mold, in corners and in irregular shapes. A strain hardening material will resist deformation greatly improving material distribution in deep draw areas and corners.

Experimental

The Gottfert Rheotens extension viscometer was utilized in this study to characterize melt tension and extensibility and to illustrate the transition from linear to branched behavior for several commercially available LLDPE feed-stocks. A melt strand is pulled from the orifice of a Gottfert capillary rheometer at increasing draw rates. Melt strength and extensibility are simultaneously measured. Melt tension is reported in cN. These are key rheological properties in predicting processing behavior.

Radiation Processing

The samples were prepared by placing pellets on a tray at a uniform depth. The tray was placed on a conveyor and passed under the scan horn of a 150 kW, 4.5 MeV electron beam accelerator at a controlled rate to obtain an applied dose. The effects of the applied dose were tracked by changes in MI. When LLDPE is exposed to a high-energy electron beam, the polymer chains are broken and free radicals are formed. The broken chains form long side chains at an appropriate dose and then are quenched in air at ambient temperatures creating a stable but highly altered thermoplastic (non-crosslinked) polyolefin. The change VS dose is tracked using MI. As the dose is increased, there is an apparent increase in Mw as indicated by decreasing MI that is a function of branching. Therefore, since MI decreases as branching increases, it is necessary to choose suitable MI feedstock in order to obtain a desired fluidity in the final blend with un-irradiated LLDPE or PP for the extrusion coating process (high MI) or extrusion blow molding / melt phase thermoforming (low MI). A commonly used commercial target range for a melt strength modifier is MI 2 - 3 that is based on commercially available LDPE grades. For the work described in this paper, three specific commercially available grades of LLDPE were selected that will offer a high level of branching over a wider MI range (see Table 1). MI is measured at 190ºC, 2.16kg. and reported as g/10 minutes.

Table 1. LLDPE Feed Stock Selection

Sample	Type	MI	Density
A	Octene	6	0.919
B	metalocene	15	0.910
C	Octene	25	0.917

The LLDPE samples were irradiated at various doses targeting an approximate 80% reduction in MI, which from experience will represent a high degree of long chain branching (see Table 2).

Table 2. Dose Response - MI

	Zero Dose	Dose 1	Dose 2	Dose 3
LLDPE A	6	3	1.0	0.6
LLDPE B	15	5	2.5	1.2
LLDPE C	25	7.2	5.2	3.5

The MI dramatically decreases as the dose is increased. The apparent increase in Mw is presumed to be a result of the transition from a linear to a branched structure. It would be interesting in future work to use low angle light scattering (LALS) to quantify the actual branching index. In the meantime, since melt processability is the focus of this effort; melt tension and extensibility using the Rheotens method was used to characterize the effect of branching. Melt tension and extensibility was measured at 200ºC and reported as cN for its average peak value on all three feed stock samples at all three doses and compared to the LDPE grade (2.3 MI, 0.920 g/cc) commonly used as a melt strength modifier.

Table 3. Dose Response – Melt Tension (cN)

Dose	Zero	Dose 1	Dose 2	Dose 3
LDPE	11	–	–	–
A	0.3	3	7.5	8.5
B	0.1	2	5.5	11
C	0	1.6	3	5

Table 3a. LLDPE Sample B at Higher Dose

Sample B @ dose 4	MI	MT
	0.7	14

All of the un-irradiated (zero dose) LLDPE samples exhibited very poor melt strength but showed marked increase as they were irradiated and, as expected, continued to increase as the dose was increased. Further, the un-irradiated LLDPE samples exhibited melt resonance whereas the melt tension of the irradiated samples increased steadily over the range of the test resisting melt resonance. The behavior is known as strain hardening. Sample B, after being irradiated at Dose 3 exhibited a melt tension value of 11 cN, which is equivalent to the LDPE control. Because of the relatively linear relationship between dose and MI and MT, there is a high degree of confidence that a higher melt tension can be obtained with any of these feed stocks by adjusting and optimizing the dose. In fact, after the initial study was completed, LLDPE Sample B was irradiated at a yet higher dose producing a 0.7 MI with an impressive melt tension value of 14 cN (Table 3a). Based on those results, we adjusted our MI target for future work to a reduction of 85 – 90% lower than the starting MI to maximize branching before the onset of cross-linking. All of the samples discussed here are not crosslinked as indicated by the absence of gels. The dose required to cross-link LLDPE is significantly higher. For example, Sample C offers a greater opportunity to balance MT (target >11 cN) with MI (<2). This data indicates that using materials with a higher MI give greater flexibility in targeting wider MI ranges, higher degrees of branching without creating gels. Further, this data reveals the flexibility of the high-energy electron beam process in targeting specific MI / MT criteria.

Looking at the data in Table 3., we wondered at what point branching is maximized before the on-set of cross-linking. So we too sample B, which exhibited a comparable melt tension to the LDPE control and irradiated it at yet a higher dose. As expected, the MI continued to drop while the melt tension increased to 14 cN. The sample did not appear to be gelled, an indication of cross-linking (see Table 3a.).

Samples A at Dose 3, B at Dose 3 and C at Dose 3 were selected to be extrusion compounded in a blend (20% irradiated LLDPE) with an unirradiated LLDPE matrix (2.3 MI, 0.91 g/cc metalocene LLDPE). The same set of irradiated LLDPE samples were selected to be compounded at the same ratio with a high flow PP (35 MFR, homopolymer) to simulate commercial use in the extrusion coating process. The samples were dry blended and extrusion compounded using a C W Brabender, 28:1 L/D, 0.75" diameter extruder. The screw had a typical 3:1 compression ratio with a four-flight pin mixing section. A 20/80/20 mesh screen pack was used. There were five heating zones set at 330ºF (feed zone), 409ºF, 300ºF, 338ºF and 356ºF (die). A single orifice strand die was used with a water bath, air knife and chopper to produce cold cut pellets. The extruder was run at 100 RPM for all samples. Melt temperature, torque and melt pressure was recorded for all samples.

Table 4. PE Blends - MI

	Control	1	2	3
LDPE	20%	–	–	–
LLDPE A at Dose 3	–	20%	–	–
LLDPE B at Dose 3	–	–	20%	–
LLDPE C at Dose 3	–	–	–	20%
LLDPE B (unirradiated)	80%	80%	80%	80%
MI (g/10 min @190oC)	11	10	11.5	12.8

Table 5. PP Blends - MI

	Control	1	2	3
LDPE	20%	–	–	–
LLDPE A at Dose 3	–	20%	–	–
LLDPE B at Dose 3	–	–	20%	–
LLDPE C at Dose 3	–	–	–	20%
PP Homopolymer	80%	80%	80%	80%
MI (g/10 min@ 230oC)	27	24	26.5	29

The compounded samples were tested for MI (at 190ºC for PE, 230ºC for PP). Melt tension was initially tested at 200ºC and found to be too fluid and sticky because of the higher MIs and difficult to control the pulling function. It was also difficult to maintain a high enough strain rate to permit strain hardening to initiate. Therefore it was decided to re-measure melt tension at 190ºC and at a higher acceleration rate (see Table 6).

Table 6. PE Blends – Melt Tension (cN)

Temperature (oC)	200	190
Acceleration	3X	24X
LDPE / LLDPE Control	0.8	2.0
PE Blend 1	0.8	0.8
PE Blend 2	0.5	0.6
PE Blend 3	0.4	0.4

The industry standard for melt tension for commercially available high flow extrusion coating grades for both PE and PP is between 1 and 3 cN. However, while resin suppliers use the Rheotens method, there are no standardized conditions. Clearly, when the temperature was lowered and the rate increased, the melt tension for the LLDPE / LDPE Control blend entered that range while the irradiated LLDPE / unirradiated LLDPE blends increased only slightly. It is quite possible that even at the higher rate, the critical draw rate / draw ratio was not high enough to exhibit strain hardening.

Table 7. PP Blends – Melt Tension (cN)

Temperature (oC)	200	190
Acceleration	3X	24X
LDPE / PP Control	0.8	1.4
PP Blend 1	0.8	0.7
PP Blend 2	0.5	1.0
PP Blend 3	0.4	0.8

With the PP blends, again, the PP/LDPE control entered into what would be a commercially acceptable range for high-speed extrusion coating. The melt tension of the blends with high flow PP and irradiated LLDPE increased, the onset of strain hardening was not observed.

Sag Resistance and Drawability

To simulate the benefit of long chain branching in terms of sag resistance and drawability, the Brabender extruder was used with a slot die and take away device. First, using a three roll stack, sheet was produced from 100% of the base linear (non-irradiated) components and 20:80, pellet / pellet blends of LLDPE Sample B at dose 4 (see Table 3a) with unirradiated LLDPE used to make Sample B. A 20:80 blend was also made using LLDE Sample B at dose 4 and high flow PP. A pellet / pellet blend was used because it was determined that the extra shear / heat history of pre-compounding did tend to reduce melt tension somewhat presumably by breaking the chains. In commercial use, it is more common that converters do pellet / pellet blending. Also run were controls of 20:80 blends of LDPE with un-irradiated LLDPE and PP (see Table 7 & 8).

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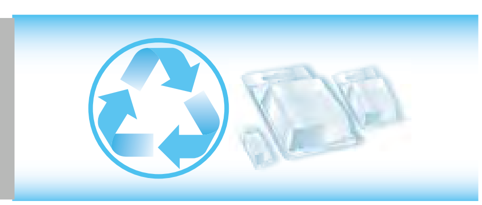

As the melt was pulled from the die onto the chill roll at a controlled rate, the control samples, 100% un-irradiated LLDPE and high flow PP, exhibited high neck-in as reported in Tables 7 and 8 in total inches. They also exhibited melt resonance, a thick-thinning effect that occurs when the maximum draw rate / ratio is exceeded resulting in high edge weave and non-uniform material distribution. As expected, neck-in was reduced with the addition of 20% LDPE. With the addition of 20% LCB LLDPE (sample B at dose 4) there was an even more significant reduction in neck-in.

Table 7. LLDPE Blends w/ Sample B at Dose 4–Neck-In (inches

Un-irradiated Sample B	3 – 3.5*
80% Un-irradiated Sample B + 20% LDPE	2.9
80% Un-irradiated Sample B + 20% Sample B irradiated at Dose 4	2

* Edge weave due to melt resonance

Table 8. PP Blends w/ Sample B at Dose 4–Neck-In (inches)

High Flow PP	3.25
80% High Flow PP + 20% LDPE	2.5
80% High Flow PP + 20% Sample B irradiated at Dose 4	1.75

In the next phase of this work, sheet made from the blends will be suspended in hot air ovens set at 180oC and the time for the sheet sample to sag to 3” will be recorded. It is accepted that sag of greater than 3” would not be sufficient for commercial application. This comparative sag data can also be used to predict hang time in extrusion blow molding. Based on the Rheotens data and the drawability data in Tables 7 and 8, similar improvement in sag resistance can be expected compared to the controls and addition of 20% LDPE.

Conclusions

The results of this work demonstrates the value and versatility of using radiation processing as a tool in meeting specific sets of application performance requirements demanding the physical properties of polyolefins inherently having poor melt processability due to their linear structure. The data generated here will serve as a road map for the product and applications development engineer in expanding the portfolio of resins available to him or her. The dose response data on the 100% long chain branched LLDPE reveals the dramatic improvement in melt strength resulting from radiation processing. The work with PP and PE blends shows promise in the use of LCB LLDPE as a melt strength modifier. The scope of work with blends was very narrow but clearly shows that higher doses on higher MI LLDPE feedstock exceeded the performance of LDPE as a melt strength modifier while offering improved properties and higher heat resistance.

Commercial Implications

When modifying commercially available LLDPE grades or other thermoplastics using high-energy electron beam radiation, there are no volume restrictions limiting the tailoring of a specific polyolefin feed stock and essentially creating new products. Modifications at the polymerization level require very large volume opportunities due to the large transition volumes. Consequently, product development at the reactor level is very costly and requires a large up front opportunity for the resin suppliers. Of course down stream / secondary operations like radiation processing add cost to the reactor feed stocks but can also bring high value in terms of processability, down-gauging and creating unique products new properties offering sustainable competitive advantage. E-BEAM Services Inc. does not market radiation modified polymers. We are a radiation services provider. We work in confidence with each of our customers in developing new products that meet their specific application performance requirements. The resulting formulations belong to the customer.

Accurate Color Matching: A Best Practice Guide

By Blake Johnson, Technical Director, Lanier Color Co., Gainesville, GA

When working with a color house to develop new products, there are a number of factors to take into consideration. While it may seem simple enough to just tell the color house to provide a color match, color is a combination of science and art.

A color match is only as good as the information provided. The end application's requirements determine the quality and performance of the color. Always keep in mind that when it comes to information, the color house would rather "have it and not need it" than "need it and not have it". In short, there's no such thing as too much information.

Some of the necessary information imperative to a good color match can include the following:

- color target
- end application
- primary light source
- specific base resin
- processing parameters
- color tolerance
- visual or instrument evaluation
- expected life of the part
- functional additives needed (UVIs, antimicrobials, anti-stat, etc.)
- expected thickness
- regulatory requirements (FDA, etc.)

Color Selection

The process of providing color starts with the color selection. Perhaps you are matching existing colors in the field. Maybe a marketing department somewhere has decided to revamp an image and has concept colors mind. Either way, you must begin by selecting then matching a color. Generally, the color house will be provided with a color target. This target may be cloth, paint, plastic, or the ever-popular PMS (Pantone Matching System) number. In the case of existing colors, the color house would ideally like to see the desired color in the polymer system in which it is to be used. This will aid in the pigment compatibility selection for the resin system. Not all colorants perform suitably in all plastics. If a plastic part is not available, then another color representation may be submitted for matching. If the latter is the case, a full understanding of the requirements plays an even larger role.

Before the color house starts to work on the match, they will need to know what the end application is. This is very important when it comes to designing the formula. The pigment system used in an indoor part could be very different than that of an outdoor part. Colorants are not created equal and they have a wide variation in their characteristics. This includes weatherability, regulatory status and performance in various polymers. Knowing what the end part will be gives guidance to the color house to formulate accordingly.

Metamerism

One of the bigger challenges that plastic/color processors face is metamerism. Metamerism is a visual phenomenon where two colors appear the same in one light source, but not in another. We've all put on our black pants and black socks, only to walk outside into the daylight to find we're actually wearing navy blue socks. This is metamerism. It occurs when a different pigment system is used in one part versus another. For an example, if a color house is asked to match a pantone number, the color target would be an ink system. Colorants used in ink are likely not suitable for the environment within a polymer, therefore a different pigment or dye system may be required. Below you can see the difference in color from one light source to another.

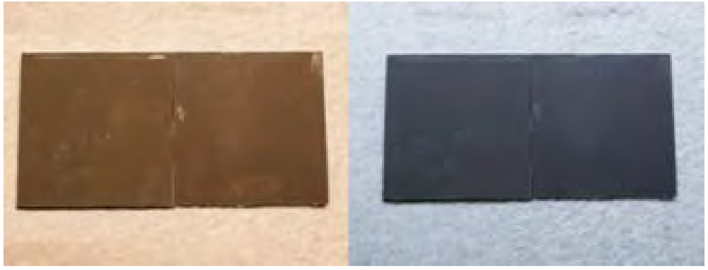

Figure 1: Difference in color between light sources. Courtesy of Lanier Color Co.

This is where the primary light source comes into play. In order to get the best available match, the color house will need to know the light source in which the end part will be viewed. During color development, the color house should be evaluating the color in the same light source as the customer. For example, if the color house is matching a painted target for outdoor lighting, the customer should also be evaluating in outdoor/daylight (D-65). In some cases it proves difficult to achieve a non-metameric match in plastic to a paint pigment system. Again, the colorants used in paint may not be suitable for use in plastics. A light-booth is a great tool to evaluate color in controlled light sources and review metamerism. Also, a spectral curve from a spectrophotometer can prove a great method for reviewing metamerism. A non-metameric match will result in perfectly aligned curves, while the curves curves will not line up when metamerism is present. See below example of a metameric color curve:

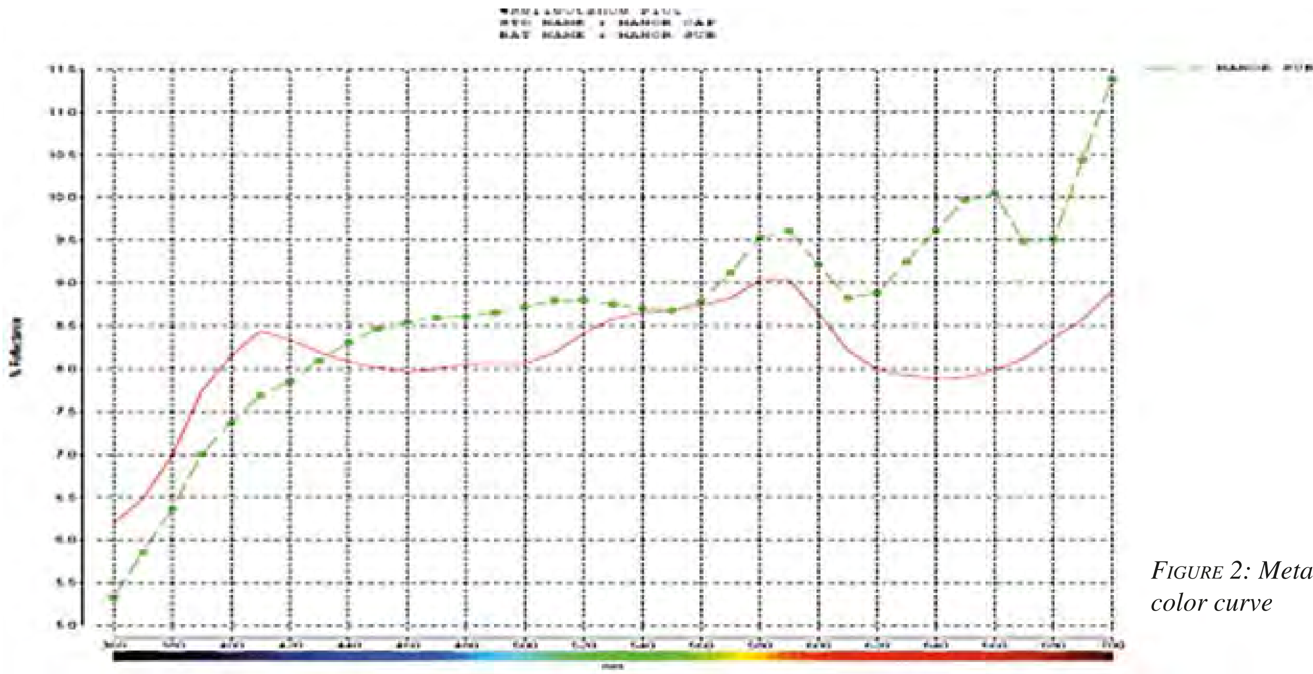

FIGURE 2: Metameric color curve

Base Resins

Along with light source, the actual base resin is extremely important to achieving an accurate color match. Take ABS for example. There are seemingly endless grades of ABS in the plastics industry. ABS grades vary widely in both the amount and the type of rubber content. This, together with the method of production, can dramatically change the yellowness index and its effect on the final color of a product. Instructing a color supplier to use their "house" ABS for a color match and then evaluating the sample in yet another type of ABS will likely yield a different color. In other words, the color chips may look fine, but when processing the color in a different resin, the result could be off-color parts, wasting both time and money.

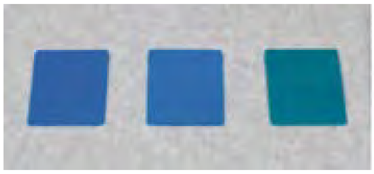

FIGURE 3: Example of one concentrate at 2% in three grades of ABS

FIGURE 4: Example of two different ABS grades

In order to avoid unacceptable color shift during processing, let the color house know your preferred processing parameters. Again, not all pigments are created equal therefore not all pigments will hold up in all processes. A pigment that works well in FPVC at 315º F (157º C) may burn out of Polycarbonate at 550º F (288º C). Colorants can vary greatly in their ability to withstand heat and shear and a few degrees can make the difference between an on-color part and a failure. Below is a picture of one color concentrate let down in one PMMA compound. The chip on the left was molded at 470º F (243º C) while the one on the right was run at 420º F (215º C).

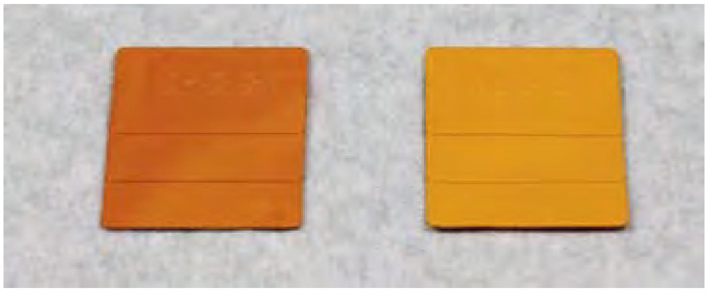

FIGURE 5: Two different results from one color concentrate molded at two different temperatures.

Color Tolerances

It will also be important for the color house to understand the color tolerance. What are the end user's color difference requirements? Do they use an instrument to evaluate color, or is it done on a strictly visual basis? It is important to know how to interpret the spectral data. Take CIE LAB for example. Generally we receive delta difference feedback on the L*, a*, b*, where +L light, -L = dark, +a=red, -a=green, +b=yellow and –b=blue. When dealing with multi-layer sheet products, most often the cap color tolerance is significantly more critical than the substrate for the same product. To some extent it depends on the visibility of the substrate in the final application.

Some types of colorants lend themselves to instrumental evaluation much more easily than others. For example, metallic, pearls, and fluorescents can prove very difficult to measure accurately. A spectrophotometer measures color by shooting light onto a surface, while an electronic "eye" (or observer) reads the reflection and absorption of light waves at certain points. The computer then translates those readings into a numerical value. Metallic colors by their very nature offer "reflection" of light to give them their appearance. That same reflection makes it difficult for the color eye to accurately read the color, especially on the L* value. The same principle applies to pearlescent colors.

Fluorescent colors absorb UV energy and re-emit that energy in the visual spectrum (400-700 nanometers). The same function that gives them the very bright, vibrant appearance also makes it difficult for a computer to properly translate these colors into readings. These special effect-type colors should only be read as a reference and as a check for gross errors in color. Here again, keep metamerism in mind. If the color house is matching a metallic paint, the plastic specimen will need to be evaluated in its primary light source as the pigment system in the painted piece may be different than the selection in the plastic specimen.

Understanding the Final Part

What is the expected life of the final part? As mentioned earlier, some pigments are better suited for certain applications. If the part is only designed to withstand indoor lighting for a year or two, these pigments may be very different than what would be used in an outdoor part designed to withstand 3 years of sunlight. In general, the color's longevity is only as good as the pigment selection. While there are light-stabilizing additives available for use in plastics, they tend to protect the polymer, not the colorants.

Is there a requirement for "functional" additives? These are additives that perform a function, like anti-static, ultraviolet inhibitors and antimicrobials. Anti-static agents migrate to the surface and dissipate static electricity from a plastic part. Depending on what the part is designed to do, varying levels and different chemistries are available. If the plastic processor is merely trying to keep sheets from sticking, there would be a certain level and chemistry needed to meet that need. If, on the other hand, the end part will house flammable liquids, then a greater level of a longer lasting additive may be required.

Ultra Violet Inhibitors, or UVIs, tend to be broken down into two categories: UVA-ultra violet absorbers and HALS-Hindered Amine Light Stabilizers.

Ultra Violet Absorbers do just that; absorb UV energy, thus protecting the polymer from radiation. These additives take the brunt of the UV as opposed to the plastic. While UVAs can aid in color retention, pigment selection plays a far greater role in colorant longevity.

HALS act as free radical scavengers. As weather, rain and sun light beat down on a plastic part, free radicals form and begin to attack the polymer chain. HALS can be added to protect the polymer from early degradation as a result of exposure to outdoor elements. In many cases, UVAs and HALS can be added together to synergistically protect the plastic.

Antimicrobials are additives designed to hinder the growth of certain bacteria. Again, the end application dictates the level and chemistry needed. One possible application for antimicrobial might be bath and shower stalls, where killing certain bacteria might be deemed necessary.

When designing a color for thermoforming, the colorant supplier will need to know the designed part thickness, ideally pre- and post-forming. Part thickness can somewhat dictate the amount of functional additives in the formulation. A thinner section may require more additive that its thicker counterpart. Also, opacity must be taken into consideration. Sheet thickness has a lot to do with opacity. Knowing on what thickness to evaluate the color's opacity can save the colorant supplier from over- or under-engineering the formulation.

One major piece of information that the colorant supplier might need to know is whether or not there are any regulatory requirements surrounding the end part. REACH, Proposition 65, FDA and other regulations need to be considered. Will the final part come into contact with food? Does the final application require FDA-sanctioned materials? Is it a one-time use item? Knowing this at the outset of the project will allow the color house to formulate around the needs of the final customer.

Conclusion

In summary, the match going out is only as good as the info coming in. While there are other variables which affect the quality of a color match, inaccurate or missing information is one of the primary reasons for inaccurate matches. Most colorant suppliers provide color matches and samples free of charge, but there are costs involved. In order to keep resubmissions minimal and approvals plentiful, it is imperative that proper, complete information be conveyed to the color house. Providing information such as that outlined above can certainly increase the chances of having an acceptable color match submission the first time. |

THERMOFORMER OF THE YEAR 2015

The Awards Committee is now accepting nominations for the next THERMOFORMER OF THE YEAR. Please help us by identifying worthy candidates. This prestigious honor will be awarded to a member of the industry who has made a significant contribution to the thermoforming industry in a technical, educational, or managerial aspect of thermoforming.

Nominees will be evaluated and voted on by the Thermoforming Board of Directors at the Winter Board Meeting. **The deadline for submitting nominations is December 15, 2014.**

Questions? Please contact:
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Download the nomination form at: tinyurl.com/TotY2015Form

SPE Thermo Forming Division

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
- Endowments

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.

ATI Strikes Gold with Bowling Pin Setter Production

By Bill Bregar, Senior Staff Reporter

SCHAUMBURG, IL. — Heavy-duty equipment used to arrange and re-set bowling pins netted three awards for Associated Thermoforming Inc. in the parts competition at the Society of Plastics Engineers Thermoforming Conference.

ATI, which is based in Berthoud, CO also won in the pressure formed category, for a cover for a medical smoke removal system.

Stephen Zamprelli, parts competition chairman, said 25 parts were entered, even one from India. “We had some great products out there,” said Zamprelli, vice president of product development for Formed Plastics Inc. in Carle Place, NY. Judges were Roger Kipp of Roger C. Kipp Sr. & Associates, and Ian Strachan of ToolVu.

ATI molds the thermoformed bowling pin resetter parts for QubicaAMF, the bowling products supplier — to replace metal with plastic. According to A.J. Stoneburner, estimator and sales engineer at Associated Thermoforming, ATI and the customer worked together for seven years to develop the pin elevator, which collects pins and orients them before depositing them on the other thermoformed part with cavities to hold the pins — called the Durabin.

Development of the Durabin took one year, he said. Each one of the 10 cavities for the pins has a different wall thickness in unique areas, since the pin-setting device deposits each pin into place at a different angle and specific impact zone. ATI used computer-aided design, with detailed information from the customer, to design the part and individual plug assists.

By using a PVC track for the chain drive that moves the pins up through the elevator apparatus, QubicaAMF has improved the working lifetime of the chain, said Paul Gleason, PTI process engineer. Stoneburner said the new mechanism also enabled a better-looking, space-saving design in plastic. “The big thing by moving to that chain drive: They were able to make an oblong shape instead of a circle,” he said.

The bowling pin equipment won the heavy-gauge vacuum forming award, the twin-sheet award, and the People’s Choice Award, voted on by conference attendees.

Award winners were honored at a dinner on Sept. 16 at the conference in Schaumburg. For the second year, the SPE Thermoforming Division held a student awards competition. First prize, and a $1,000 award, went to Jerrold Ancheta of San Jose State University for a vacuum formed trans-radial prosthesis. Madeline Freding of the University of Wisconsin Stout picked up the $500 second place price for her product, called Re-Form. Here is a recap of the 2014 winners:

Roll-fed: Food Grade
Image By: SPE Thermoforming Division Lindar Corp.'s tamper-obvious cake package.

Lindar Corp. of Baxter, MN, won for its two-piece cake package with a tamper-obvious closure. The package has two performance innovations to allow the vendor to thaw and sell frozen treats: A perimeter ventilation to allow the package to breath. A slightly domed top area disperses condensation to the perimeter area of the dome. Each package is designed to allow retailers to stack them. The cake package is formed from recycled-content PET on a six-cavity aluminum tool. According to Lindar, it was a challenge to do proper trim registration and consistent perforations.

Roll-fed industrial: Gold
Think4D Inc. of Altona, Manitoba, won the gold award for the roll-fed industrial category, for a blister package for the Gillette Venus Snap Razor. The pre-printed PET dome is formed in precise registration with the razor, enticing customers to pick up and feel the package, according to Think4D.

The package uses 73 percent less plastic that previous Venus packaging, and is 27 percent lighter. A smaller package, with a 53 percent reduction in packaging materials, means the product can be packed more densely for distribution. Making the package smaller, the razor was placed in a reusable travel pod. Think4D pressure formed the package on aluminum tooling with six cavities per index, from roll-fed sheet.

Roll-fed industrial: Silver
The silver award went to Innovative Plastech Inc. of Batavia, IL, for a set of interlocking trays to hold and display products in retail refrigerators. Innovative Plastech thermoforms the three trays from black recycled PRET. The black color helps to draw more attention to the product, not the tray.
The modular trays are snapped together, using a single rail snap for easier closure, instead of competing trays that use several smaller snaps. The positive portion of the snap is machined in pieces so it can't be confused with the negative snap. Also, to drain off water in a wet-spray refrigerator, Plastech designed an extended S-curved shape, for stability, instead of the standard straight drainage channels or holes punched all over the tray.

Pressure-formed: Gold
ATI officials stayed on the podium to grab the pressure-formed gold with a housing used in a smoke evacuator in medical electro-surgical procedures. The part demands a very severe draw ratio to get the plastic all way down to the bottom. ATI does that in a negative mold with many undercuts, especially a very deep one in the rear of the part. The key is automated lifter core pulls around the perimeter. Also, the back section of the mold has a core-pull. ATI also uses a pneumatically articulated plug assist to get the needed uniform wall thickness into the rear section. The sheet is fire-retardant Kydex-T.

Pressure-formed: Silver
Silver in the pressure-formed category went to Saint-Gobain PPL in Puyallup, WA, for a nine-part package that create an enclosure for a robot being developed by Adept Technology in California for laboratories and SC wafer fabrication, in clean rooms.
The parts must fit with very tight and even parting lines, according to Saint-Gobain. That required all but two of the parts having deep draws and undercuts. Tooling is CNC-machined from an aluminum billet that is gun drilled with water cooling lines. One part has a silk screened Adept logo.

Twin-sheet: Silver
Profile Plastics Inc. of Lake Bluff, IL, won the silver award for a twin-sheet, pressure formed spine board used to transport victims for medical treatment. Molded from ABS sheet, the board has molded-in straps. Profile uses two textured, machined aluminum, water-cooled pressure form tools to create a single hollow shape with 22 pinch regions. It has a slip-resistant surface.

Combined Category: Roll-fed or Heavy-gauge
The award went to Universal Protective Packaging Inc. of Mechanicsburg, PA, for a patented Geospring thermoformed recycled HDPE end-cap packaging for the hard disk drive industry. Universal forms the parts on a Sencorp 2500 thermoforming machine using roll-fed black sheet.

Because of the size of the mold, maintaining optimal mold temperature and ensuring adequate material distribution over the mold presented challenges. The mold's temperature was controlled by using bubbler baffles, and material distribution was overcome by using HYTAC B1X plug assist.

The end cap gives maximum protection during transportation with its spring system, which uses harmonic bellows that form a flexible ridge for shock and vibration absorption. When dropped from a height, the rapid deceleration caused by the impact engages the spring system and efficiently dissipates the shock and vibration. Also, the end caps are compact, lightweight and nestable, reducing box size and warehouse space requirements.

Combined Category: Innovative Part
Philadelphia-based CW Thomas LLC won for an airline seat pocket assembly using three thermoformed components and value-added fabrication. Two of the parts are pressure formed and one is vacuum formed. All three molds are single cavity tools, CNC machined aluminum. There is an aluminum brace in this unit also. CW Thomas forms the parts using custom-colored, aircraft-grade acrylic-PVC. All parts are trimmed, and the hole positions for assembly are routed. CW Thomas officials said the plastic seat pocket saves weight, and reduces costs, from the traditional metal assemblies.

Combined Category: Combined Value-Added Assembly
Specialty Manufacturing Inc. of San Diego won for an assembly for a large medical device, made from pressure-forming, including some twin-sheet parts. The material is custom-colored acrylic/PVC, made on textured tools, machined from block aluminum. Specialty Manufacturing assembles the glass to the upper housing, to reduce assembly time for the customer.

SPE 2014 Thermoforming Conference Review

By Nancy Lamontagne, Freelance Writer

The SPE Thermoforming Division 23rd Annual Conference got off to a great start on Tuesday with an inspiring and informative keynote presentation "Pathways to Growth–Better Pick the Ones That Work!" from Christian Majgaard of Majgaard Brand & Business Development. Majgaard, a former top global manager with the toymaker LEGO®, talked about the importance of companies taking paths that increase their likelihood of doing well and decrease the risk of negative scenarios. He emphasized making sure that an idea or product is liked by the customer and not only by the company. It is key to understand the customer, what the company is uniquely offering them, and how it will be accomplished. He pointed to LEGO's strategic decision to view children, not product distributors, as its customers. This decision led the company to stratify products to specific age ranges. He also described how the company partnered with MIT when they first identified robotics as a direction for new products and discussed the expansion of LEGOLAND Parks as a way to maintain direct contact with customers.

During the roll fed technical presentations Tim Wilson from Strainoptics, Inc. overviewed how to diagnose stress-related problems in thermoforming. He introduced the topic by summarizing causes of residual stresses, some of which are desirable or intentional such as those that produce orientation of molecular structure in bi-axially oriented films. Measuring stresses is important for optimizing processes, improving product quality, and preventing failures. He then outlined how to analyze stresses using ASTM D4093 standard test methods such as qualitative color pattern observation and quantitative devices such as polarimeters.

For the joint technical session, Dave Morgese from The FoxMor Group Inc. and Bill Gerlach from Brabazon Pump, Compressor & Vacuum teamed up for a creative presentation that compared using individual vacuum pumps or a central vacuum system for thermoforming. They aimed to overcome fear of the unknown, which they cited as one of the main factors keeping companies from converting to a central vacuum pump system. The presenters created the fictional ACME Thermoforming Company based on conservative realistic assumptions and showed that ACME would save around $46,000 each year on electricity and vacuum pump maintenance by using a central vacuum.

Ryan Hunt of ALGIX, LLC presented a cut sheet presentation on life cycle assessments, which quantify and interpret the flows to and from the environment for a product. Environmental impacts can include air emissions, water effluents, solid waste, energy, and resource usage over the life cycle of a product or process. He pointed out that brand owners and top tier companies such as Walmart, Apple, and ExxonMobil are very interested in life cycle assessments analyses because they care about how customers view their environmental impact. Hunt walked through the steps required for a life cycle assessment and presented comparative analyses for his company's algae-based plastics. He showed that an algae blended masterbatch of half polystyrene and half algae dramatically reduced most of the environmental impacts and that combining algae with PLA bioresin can make PLA even more environmentally friendly and thus even more competitive.

The cut sheet technical presentations included Blake Johnson from Lanier Color Company, who gave practical advice regarding the information needed to produce accurate color matches. He noted that to save time and money, it is very important to have up front communication and to work in collaboration with your color partner. For the best possible match and a quality part, he noted that the color house needs a firm agreed-upon color target and must know the final application for the product, the light source where it will be reviewed (ideally the same as where the customer will view the part), and the exact grade of base resin. Other key information includes the processing parameters, the color tolerances for the part, how the color will be evaluated (visually or by use of a spectrophotometer), the expected life span of the part, any need for functional additives, the part thickness, and any known regulatory requirements.

In addition to networking with colleagues during lunch, SPE Thermoforming Division treasurer James A. Alongi gave a financial summary for the fiscal year ending June 30. He was followed by Councilor Roger Kipp who noted that SPE is the leading resource relating to plastic and science in the world and that events like the annual conference are one of the top member values. He said that SPE is working to better deliver and communicate about the value of these events and has created the Next Generation Advisory Board (NGAB) to help by providing input from young people. He also pointed out the technical library that is now on the SPE web site and the soft launch of "The Chain," which will open globally at ANTEC.

The conference's theme of "Ideas Worth Forming" was apparent during the afternoon Innovation Briefs. Nate Bachman from Arkema presented the first brief on the company's SolarKote T Acrylic Capstock System and Elium liquid thermoplastic composite resin. SolarKote T bonds SolarKote to a TPO substrate using a Tacryl 1080 tie layer. Solarkote T fills in some of the characteristics not available from TPO. It achieves good scratch and mar resistance, and SolarKote blocks UV, protecting substrates underneath it. Bachman then discussed the Elium liquid thermoplastic resin, which can replace polyester, vinyl ester, and epoxy in fiber reinforced applications. It is recyclable, styrene free, weldable, thermoformable, and designed for aesthetic parts as well as structural mechanical parts. Kent Johansson from WM Wrapping Machinery S.A. and Steven Blazey from A. Schulman Inc. also presented insightful briefs on Tuesday.

The SPE Thermoforming Awards Dinner recognized many of the great leaders who have helped make the industry what it is today and also looked to thermoforming's future by awarding scholarships.

Bill Kent of Brown Machine was named 2014 Thermoformer of the Year. He has been in thermoforming for more than 50 years, starting work at Brown Machine in 1961 where he worked with Gaylord Brown. Bill began as a technician and was soon traveling the world as a sales engineer. In 1985, he was named Vice President of Advanced Technology and remained in management at Brown Machine until he retired in 2012. Bill was a founding member of the SPE Thermoforming Board in the early 1980s and was re-elected to the Board of Directors in 1998, where he served until 2011. He attended almost every NPE show from 1966 to 2012 and every SPE Thermoforming Conference from its inception in 1988 to 2011.

This year's scholarship winners included Drake Stephens from Pittsburg State University, who was awarded the Segen Griep Memorial Scholarship; Paul Woodson from Kettering University, who received the Thermoforming Divisions Memorial Scholarship; and Anna Macherkevich of Kettering University who received the Bill Benjamin Memorial Scholarship. The Awards Ceremony also included the much-anticipated Parts Competition Winners. Before everyone headed to Casino Night, the formal program ended with an invitation to the SPE 2015 Thermoforming Conference, which will be held Aug. 31-Sept. 3 in Atlanta.

Wednesday morning began with an engaging and inspiring keynote presentation from Tony Bridwell, Chief People Officer of Brinker International, the parent company of Chili's and Maggiano's restaurants. His talk, "Culture is No Longer the Softer Side of Business," emphasized the importance of accountability, which is part of an organization's culture, not skills. At Brinker, they go by the premise that only when you assume full accountability for your thoughts, feelings, actions, and results can you direct your own destiny; otherwise someone or something else will. Clearly communicating desired results are key to accountability, and every employee must know what the desired results are and how they contribute to them. When developing the desired results, companies need to be sure they are memorable, measurable, and meaningful. Bridwell also talked about how experiences form beliefs, and beliefs heavily influence actions, which in turn lead to results. Without addressing experiences and beliefs it is difficult to sustain actions that lead to the desired results. He detailed the differences between "the blame game" and accountability, the latter of which leads to results and involves phrases like see it, own it, solve it, do it.

John Davidson of Distortion Arts, LLC presented a Cut Sheet Technical Presentation on the exciting opportunities and advancements in distortion forming. For many years distortion forming was based largely on trial and error, but now it is becoming digital. A computerized approach can be used to gather the data needed for repeatable distortion forming, and this is better, faster, and cheaper because it eliminates the trial and error. State-of-the-art technology is allowing high resolution digital printing to be combined with very complex geometries, and Davidson showed several examples of impressive distortion formed products such as life-size gaming figures, backlit vending machines, large products for 3D billboards, and complex 3D signs. He noted that it is best to marry the printing and the 3D specifications from the beginning. Information that is important for this include specifications for the application, printable substrate, print process, and formable inks. He also demonstrated 3D PDFs as a way to design or offer a digital proof for approval.

The Roll Fed Technical Presentations on Wednesday included one from Dino Caparco of Yushin America, Inc. on the advantages of using robotic stacking for thermoformed parts. He noted that robotic system installations often show payback times of 1 year. One automation method is known as tracking, which is typically used when parts remain in the web intact and are freed as the material passes over the roller. In this setup, the robot tracks the servo motion of the thermoformer using an encoder, and speeds typically range from 15 to 20 cycles per minute. The non-tracking method is usually used when parts are extracted from the up-stacker. The robot picks from up-stacker and stacks the parts on conveyer and runs parallel to the sheet. This setup can be used to pick up one part at a time or a stack of parts. For both tracking and non-tracking robotic systems operator training is key as is picking the right robotic stacking tooling when installing a system.

During the afternoon Joint Session, Jonathan Kirschner and Rachel Benyola of AIIR Consulting, LLC led an interactive workshop on succession planning. The presenters introduced the topic by explaining the importance of succession planning when making smooth transitions in leadership and keeping the company profitable during such important changes. A pipeline of future leaders is important so that they can be mentored and groomed before assuming leadership positions. AIIR's succession planning model includes identifying top talent in the company and figuring out who in this group has the right leadership skills for the leadership position. Once the person is selected, he or she is integrated through mentorship and the new leader integrates his or her vision for the company. A strategic development plan is needed to further develop the leader, who can be coached individually based on this plan. The presenters noted the importance of off-boarding the previous leader so that this person doesn't continue to exert influence based on the old vision. The main drivers for succession planning are business continuity, which enables the business to run based on strategy, not who's coming and going; managing risk by having a pipeline of leaders; and retaining top talent by rewarding them. When these three things are happening, the company will likely see business growth.

2014 THERMOFORMING CONFERENCE REVIEW

Brisk traffic at the PMC booth.

Attendees at a joint technical session on vacuum systems.

Division Chairman Mark Strachan surveys production on the GN machine.

Roll-fed workshop participants discuss part design and forming processes.

Chairman Jim Arnet cuts the ribbon as the Thermoforming Board of Directors welcome attendees to the 23rd annual conference.

Andrea Varisco of Italian toolmaker Termostampi inspects a deep draw part.

Marjorie Weiner of SPE's PlastiVan program enlightens young minds with the wonders of plastics.

HEAVY GAUGE VACUUM FORMED

1st Place

Durabin Pin Setting System
Associated Thermoforming, Inc.
Berthoud, CO

HEAVY GAUGE VACUUM FORMED

2nd Place

Robot Enclosure
Saint-Gobain PPL
Puyallup, WA

HEAVY GAUGE PRESSURE FORMED

1st Place

Medical Enclosure
Associated Thermoforming, Inc.
Berthoud, CO

HEAVY GAUGE TWIN SHEET

1st Place

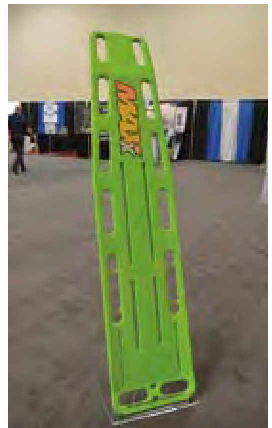
Bowling Pin Organizer
Associated Thermoforming, Inc.
Berthoud, CO

All photos courtesy of Dallager Photography

AND PARTS COMPETITION

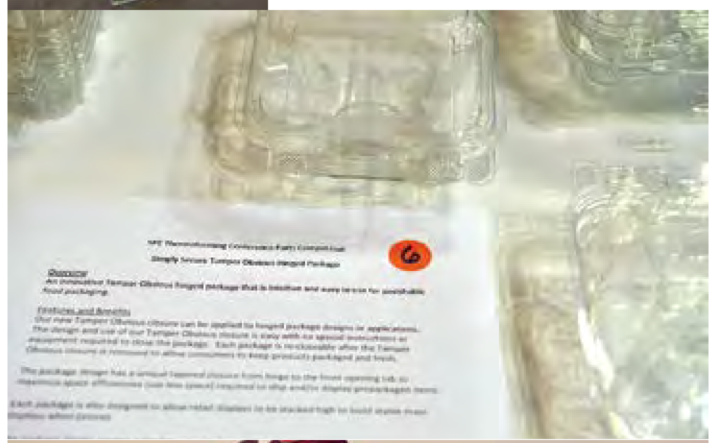
HEAVY GAUGE
TWIN SHEET
2nd Place

Rescue Backboard
Profile Plastics
Lake Bluff, IL



ROLL-FED
FOOD
1st PLACE

Tamper Obvious Package
Lindar Corp.
Baxter, MN



ROLL-FED
INDUSTRIAL
1st Place

Gillette Venus Snap Trap Blister
think4D
Altona, MB Canada

ROLL-FED
INDUSTRIAL
2nd Place

Grocery Refrigerator Tray
Innovative Plastech
Batavia, IL

COMBINED RECYCLED

1st Place

Geospring Protective End Cap
Universal Protective Packaging
Mechanicsburg, PA

COMBINED VALUE ADDED

1st Place

Large Medical Device Assembly
Specialty Manufacturing Inc.
San Diego, CA

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Ceramicx and Weco Achieve Energy-Saving Breakthrough for In-line Thermoformers

By Dr. Cathal Wilson, Director, Ceramicx Ireland

Ceramicx, a leading producer of IR heating systems for the thermoforming industry, together with a US-based inline thermoforming company, has just confirmed 40% energy savings for an infrared heating system when compared to a conventional calrod heating system on an identical thermoforming machine. The figures are obtained from an independent study conducted by Dr. Robin Kent of Tangram Technology Ltd – Consulting Engineers for Plastics Products. Dr. Kent measured the detailed differences between the two plastic thermoforming systems. Direct comparisons between two thermoforming lines were undertaken using identical tools, products and cycle times. The measuring equipment used for all electrical testing was the Elcomponent SPC Pro. This is a data logging device that measures all three-phases of the complete incoming supply to the thermoforming machine. It uses a single phase supply (phase to neutral) as a reference voltage for the calculations.

The Ceramicx based heating systems showed a decrease in the average power drawn from 56.16 kW to 32.85 kW, representing a 41.6% reduction. Figures were also taken that showed a direct comparison between the two oven systems. With the machine base loads removed, the Ceramicx system then showed a measured energy saving of 45.8%. Additional study work undertaken showed that yet further improvements and energy savings would be available using the new Ceramicx-based system.

Both machines were directly comparable and both are part of two in-line and fast cycling systems, loaded with the same tools both making the same polystyrene-based products for the Fast Moving Consumer Goods (FMCG) and food service markets.

The Ceramicx IR-based oven platen and control system was designed and built at the company's manufacturing facility in West Cork, Ireland before being shipped directly to the end user's manufacturing facility. The Ceramicx oven has a total of eight temperature sensors built into the system. These can be selected individually or grouped for control purposes. Additionally the heaters can be subdivided into as many as 132 separate zones, thus giving a wide range of control options.

The Ceramicx oven system features upper and lower heating platens together with power control systems, enclosures, switchgear, and PLC control.

A total of 420 world class-rated[1] Ceramicx IR elements were deployed in this particular oven system. Each of these Ceramicx-made elements has its own unique and traceable heating fingerprint, the performance of which is documented and verifiable online.

Figure 1: Ceramicx Oven and Control System

Calrod Oven							
	Current 1 (amps)	Current (amps)	Current 3 (amps)	Power Factor	Voltage (volts)	Energy (kWh)	Power (kW)
Avg	84.5	82.0	90.3	0.9	235.4	0.02	56.2
Max	151.3	149.4	160.7	1.0	238.6	0.03	100.8
Min	29.0	19.7	30.0	0.5	230.9	0.01	19.1

Table 1: energy data for calrod oven

Ceramicx Oven							
	Current 1 (amps)	Current 2 (amps)	Current 3 (amps)	Power Factor	Voltage (volts)	Energy (kWh)	Power (kW)
Avg	53.8	53.2	63.3	0.8	240.5	0.010	32.8
Max	116.8	109.9	105.5	1.0	242.4	0.020	59.9
Min	20.6	20.9	21.8	0.4	237.8	0.003	10.1

Table 2: energy data for Ceramicx oven

The oven assembly itself is fitted with pneumatic cylinders which are operated manually via two solenoid valves. The lower platen is used as a counterweight, using steel rope and pulleys. The control systems offer the processor a choice of both open and closed loop control, together with cost-saving procedures in start-up and fault monitoring in addition to inline process energy control.

Ceramicx founder and Managing Director Frank Wilson says, "We are very pleased indeed to confirm through data and measurement that Ceramicx-built IR heat solutions provide immediate savings for fast-cycling thermoformers."

Brett Wehner, CEO of Ceramicx's USA distributor, Weco

International, says, "What's exciting about this work is that it shows how fast-cycling thermoformers can realize immediate savings on energy in addition to producing quality parts. Not only that, they can legitimately state that the packaging is 40% greener, with a de facto 40% reduced carbon footprint. It really is a win-win for the thermoformer."

Ceramicx has been building IR heat solutions for thermoformers for over 20 years. Since 2011, Ceramicx has been rated as a world class manufacturer and supplier of IR based heating solutions including components, ovens and platens for the global thermoforming industry. During the past 4 years Ceramicx has developed unrivalled expertise for cost-saving in-line thermoforming heat solutions and IR-based retrofits.

Weco/Ceramicx will be adding to and developing these energy saving messages in the coming months and as part of their joint preparations for the USA's triennial plastics exhibition, NPE March 23-27, Orlando, Florida.

"The Weco/Ceramicx NPE 2015 booth will lay out these energy saving messages and benefits in full," says Wehner. "We will provide full production details on just how these numbers are achieved." |

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1 "World Class Manufacturing" determined as part of the Benchmarking Competitiveness Initiative across companies globally, administered by Enterprise Ireland in Ireland. "World Class" refers to being in the 90th percentile of companies of a similar size and industry focus.

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Roger Kipp
Councilor

SPE Member Value - Building Our Future Workforce

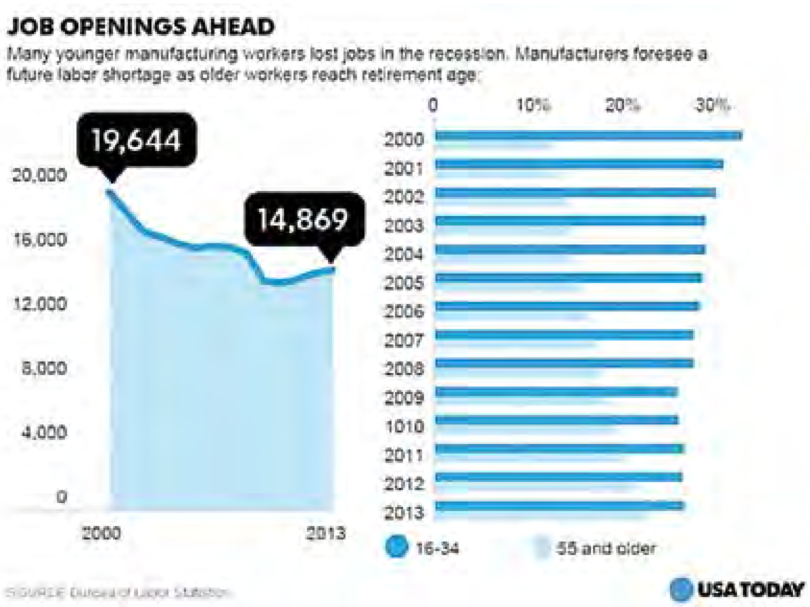
Despite high unemployment since the recession, manufacturers still struggle to fill hundreds of thousands of job openings. Since bottoming out in February 2010, employment at U.S. factories has risen by 700,000 to 12.1 million, recouping about 30% of the jobs the industry lost in the downturn.

Plastics manufacturers are increasingly looking to high schools, community colleges and universities to fill current staffing needs and gear up for a wave of Baby Boomer retirements. Educators and others are trying to dispel student misconceptions about industry and spark their interest in manufacturing before they choose other jobs or head to college for a costly liberal arts degree that yields disappointing results for many graduates.

Manufacturing is dogged by an outdated image that it's "very physical, labor-intensive, you're working with your hands, you're getting dirty and there's no career path," says Gardner Carrick, vice president of the Manufacturing Institute, the industry's training arm. Actually, "you're working with computers and robots that are doing what you used to do by hand. That requires a skill set in science, technology, engineering and math (STEM) above what was required a generation ago."

This quote and the graph are from a recent USA Today article covering all manufacturing. However, this is also a primary concern of plastics industry leader. Filling those technical jobs within our industry covering positions from research chemists to programing and process technicians will require a significant turn in thinking regarding manufacturing and manufacturing careers.

While manufacturers should take the lead with an education outreach program, I see SPE as part of the solution. The SPE members who work within our Foundation, Divisions, Sections and special interest groups (SIGs) can be an important conduit between manufacturing and education.



At the SPE Foundation we continue to have an impact through scholarship development and awards, with grants for plastics related education, and with the PlastiVan™ Program.

Scholarships primarily provide financial support for four-year college degree students. There has been some movement, however, by the Foundation and by Foundation donors to offer scholarships directed at technical associate degrees and even in certificate programs in applied technical sciences. This direction is driven by the realization that technical jobs in plastics manufacturing have potential for high paying, satisfying employment that is free of high student debt load. Manufacturers aligning with colleges and technical schools providing internships and apprenticeships provide further encouragement for young students to pursue that technical degree.

Yet with all of this effort including 1800 emails to student advisors across the nation, only 39 applications for scholarship were received by the Foundation this year. We are talking about free money and very few takers. The Foundation needs your support to by taking advantage of this valuable member resource to communicate this scholarship opportunity to your local organizations and communities.

The SPE Foundation manages the PlastiVan™ Program. No, it is not a physical van, but the outreach instructors travel across the country to present this program full of information and fun experiments to students about plastic science and technology and to show them how plastic products are a part of everyday life. The students have a good time and they learn molecular and earth science during the presentations. The instructors also tell them about many of the fun, high-paying, high-tech jobs that are out there in plastics manufacturing. The time taken with these students means we are going to have better plastics-educated teachers, students and parents. Direct observation and interaction leave a lasting impression with students.

The PlastiVan's™ "Driving Opportunities in Plastics" science experiments will also help to explain the importance of the reuse and the recycling of all types of products. As an industry, we are aware of the environmental importance of recycling and we have spent considerable money and effort looking for ways to recycle more types of plastic in more places.

The PlastiVan™ Program is available throughout the nation to share the resources of the Society of Plastics Engineers by making presentations to middle and high school students, teachers and the general public. As SPE members we are fortunate to be part of playing a role in improving the educational opportunities that can lead to further career interest in our industry.

What are groups doing within SPE to support the future plastics professionals' requirements? One new group that I mentioned in my last report is the Next Generation Advisory Board. The NGAB is a group with total focus on providing relevant impact to our industry now, while

supporting development of a future plastics workforce. Their "Action and Resources" slide below will give you a quick overview of how they're going about it.

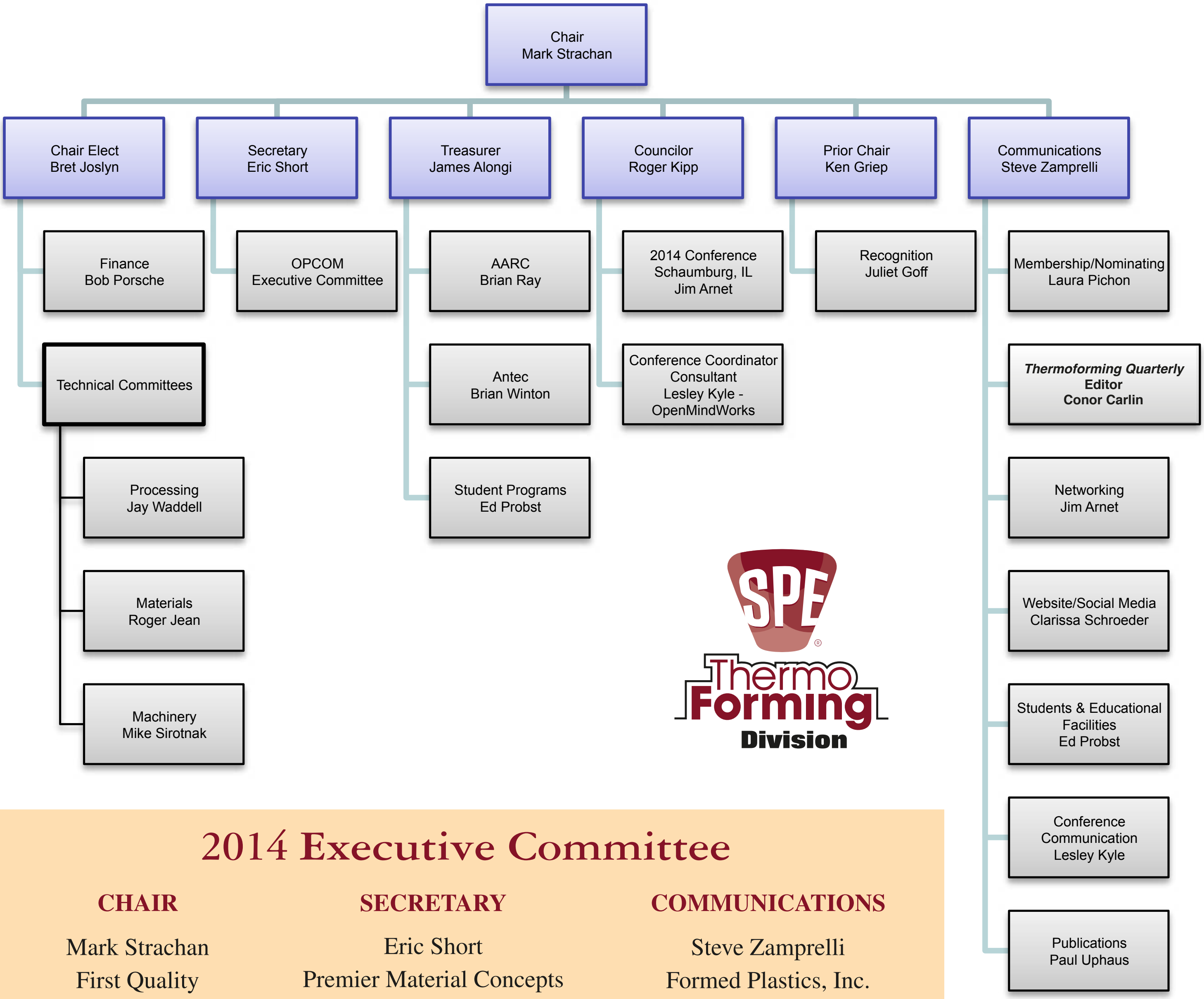
The NGAB is another example of your SPE membership supporting and further developing the future of our industry.

The value of membership can truly be realized when we are aware of what our membership is doing and then we "get on board" to find a place where we can help.

I encourage you to contact me for further information on how to amplify your membership value. Please connect with me soon srkipp@msn.com

Membership in SPE is a membership in the future of the Plastics Industry!

2014 THERMOFORMING DIVISION ORGANIZATIONAL CHART



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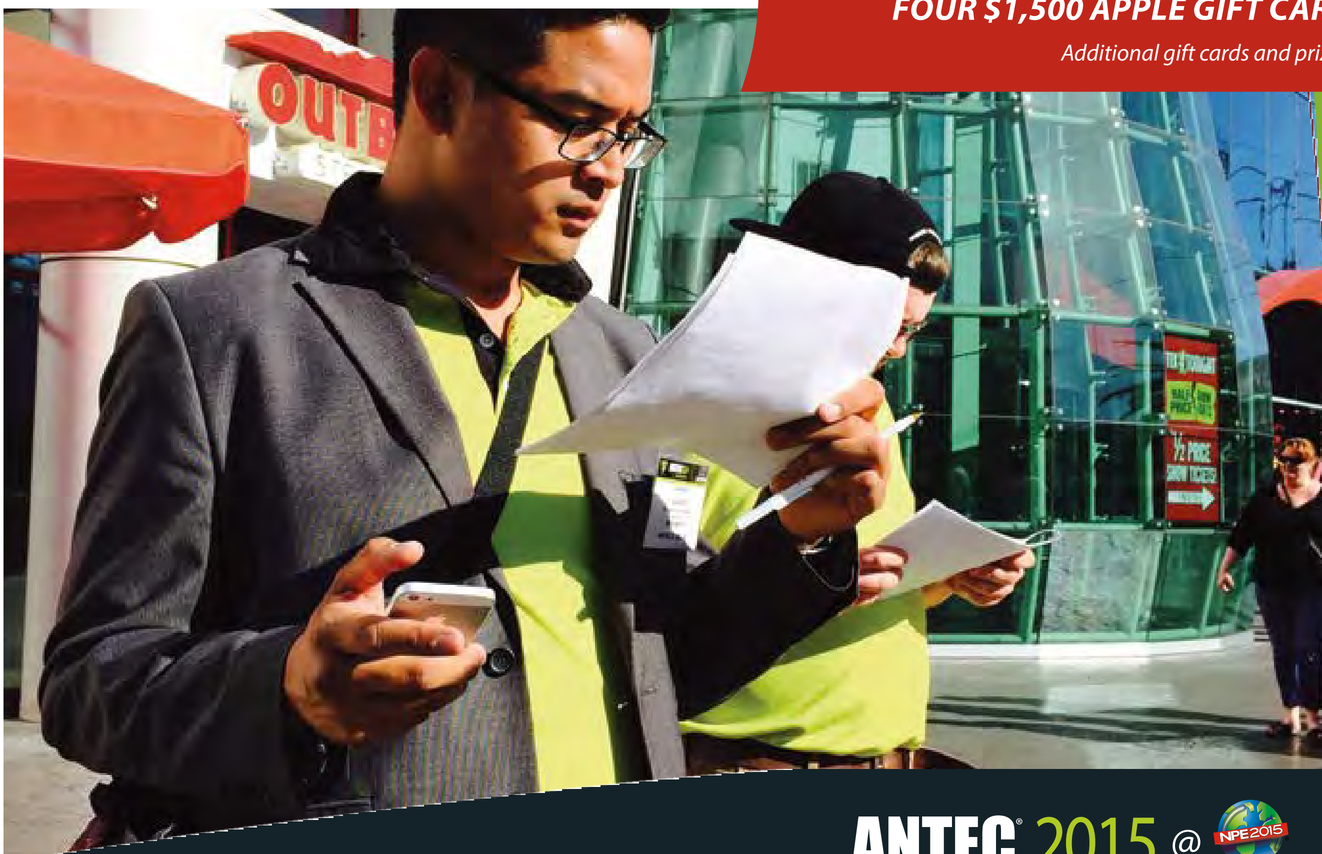

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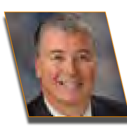

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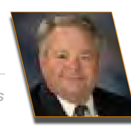

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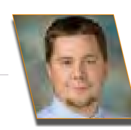

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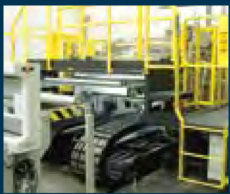
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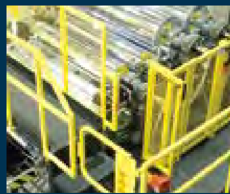
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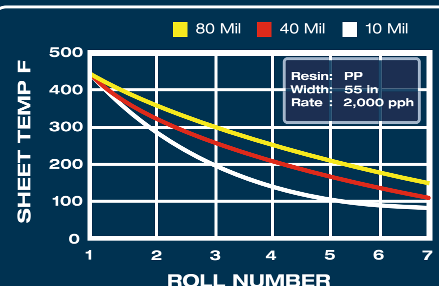

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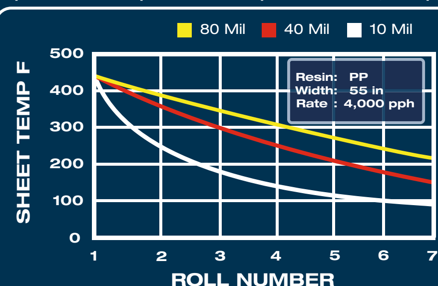

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