



# Thermoforming

## Quarterly®

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

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**Substance**  
*& Style*

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# Thermoforming Quarterly®

*A JOURNAL PUBLISHED EACH  
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OF THE SOCIETY OF  
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# Plant a Seed for Thermoforming Excellence

Because I am so deeply embedded in the business of thermoforming training, I receive multiple calls every week from thermoforming companies looking for skilled workers. This means one of two things: they are adding capacity or they are losing talented people to retirement. There seems to be very little being done by the companies themselves to educate and pass on the torch to the next generation. What is most disconcerting about this predicament is that there is such a small pool from which to tap hard-won knowledge, and this pool shrinks each year. Gone are the days of apprenticeship programs which were essential for the growth, development (and now survival) of manufacturing businesses.

Then occasionally there is a glimmer of hope when stories emerge about individuals such as Joe Peters, CEO of Universal Plastics, who are working collaboratively with local career centers, schools and government agencies to engage young people

in advanced manufacturing in areas such as Western Massachusetts (see page 11 for the article on Workforce Development).

What if more thermoforming and sheet extrusion companies would take up the challenge and give back to the industry which has been our lifeblood for so long? What good is it if we amass a large network of people on our social media sites such as LinkedIn but do not collaborate with each other to achieve a common goal? By networking and collaborating with companies, schools, government agencies and professional societies such as ours, we can educate and engage the next generation to join the exciting industry of thermoforming.

Another exciting success story is the PlastiVan Program run by SPE's Marjorie Weiner, who is educating the younger generation on the exciting world of plastics (see University News section on p. 14).

I know I am not the only one who thinks this way. There are many talented individuals with creative ideas who want to connect and find like-minded partners. For information on how you can get involved, get in touch with one of our board members and join us at one of our events.

"The best time to plant a tree was 20 years ago. The second best time is now." |

A handwritten signature in black ink, appearing to read 'Mark Strachan', with a horizontal line extending to the right.

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## Shirley K's Plastic Products Made with Pride

By Jennifer L. Manfrin | Correspondent  
Zanesville Times Recorder, Zanesville, OH

ZANESVILLE, MARCH 30, 2014 — From staying connected to its roots in Muskingum County to manufacturing products that are American-made, Shirley K's is a local company that is carrying on the traditions of the family plastic thermoforming business with a line of products developed by the business' namesake.

"It's a family legacy, the love of thermoforming and the love of the product," said Carrie Matheney, president of the company. Shirley K's manufactures more than 200 products including storage and organization trays and totes for school, home, medical and industrial needs. The company also makes custom items, pet products and other thermoformed plastic storage products at its new location at 1150 Newark Road.



*Joe Updegrave fills the rotary machine at Shirley K's Storage Totes and Trays. Starting with a flat sheet of polystyrene, the machine then heats the sheet, rotates again, and a vacuum machine sucks the form into a mold which shapes the tray or container.*



*Mike Pulley cleans up the edges of a cutlery tray at Shirley K's Storage Totes and Trays in Zanesville.*  
Chris Crook/Times Recorder

The history of the product line began at the Farbri-Form Co. in New Concord, the family business that was founded in 1943 by Matheney's grandparents, Jack and Shirley Knight.

Matheney and her father, John Knight, CEO of Shirley K's, recently sold the Farbri-Form Co. with the goal of expanding the product line that was created by Shirley Knight. As a chemistry teacher in the 1970s, she realized the need for storage space in the classroom, which inspired her to develop the product line of storage solution products.

"She saw a need to tuck items away when not in use. She worked on the idea of how to organize and store things when students and teachers weren't using them," Matheney said.

Her grandmother took her idea to the family business and introduced the trays in the 1970s. She began selling the product line through catalogs, at trade shows and directly to schools.

"She had a concept and knew about thermoforming plastic. As a teacher, she also understood the storage and organization needs of educators. She could sell the product really well and became a legacy in the industry," Matheney said.

Today, the company that bears Shirley Knight's name manufactures 95 different sizes and 14 colors of durable storage trays that can be stacked or placed in customized cabinetry for creating well-organized spaces. All the products are sold through distributors, direct sales and through several e-commerce websites, including the company's retail store.

In addition to the school products, Shirley K's line also includes material handling products such as industrial storage totes and food handling containers that are FDA approved. Sensory tables for educational play areas for children and even pet beds also are part of the diverse line of products.

"She had an eye for innovation that she passed down to my father to continue the family's passion for making quality products. I find it tremendously sentimental that I'm still selling to folks who bought from my grandmother. It brings a lot of pride to my father, too. It's a neat product and a neat company," Matheney said.

Thermoforming is a plastic manufacturing process that involves heating plastic sheets to 300 to 700 degrees. When the sheets come out hot and pliable, they are placed over molds, several of which are patented, and shaped into the company's signature products. Once cooled, they are hand trimmed and prepared for shipping. The company keeps waste to a minimum by grinding and reselling scrap pieces of plastic for recycling.

In addition to modern machinery, Shirley K's also uses a rotary machine that Matheney's grandfather used when he began



manufacturing in the 1940s.

"It's an honor to still have a machine involved in the manufacturing process that is a part of the legacy of the family business. My father is very proud to use the same equipment that his father used," Matheney said.

Machine operator Joe Updegrave, of Zanesville, operates the rotary machine. "I think it's a unique company that is family-owned and makes a quality, American-made product. It's really interesting to take a sheet of plastic and make the finished product," he said.

Matheney said she plans to continue the legacy that her grandmother started in Muskingum County with plans to expand the company in the community with products made by American manufacturers.

"Our products are manufactured right here with pride by local employees," she said. "We believe in local business and keeping manufacturing in the United States. It means a lot of our family to keep our feet dug in here in Muskingum County and to keep the legacy going." |

## Sportech Adding Machinery to Keep Up With Demand

By Frank Antosiewicz, *Plastics News*

FEBRUARY 26, 2014 — Sportech Inc. is adding machinery and taking steps to add an innovation center to meet growing demand, according to its CEO Chris Carlson.

The Elk River, Minn., company is adding a Maac 3-station rotary thermoforming machine along with another robotic trimmer this year, said Carlson during a telephone interview. He said that work has been steadily increasing and that the company is responding by continually adding new equipment.

Sportech, which has seen its thermoforming sales jump from \$42 million to \$61 million in the past year, supplies cab components, both interior and exterior, to original equipment makers of power sport vehicles like snowmobiles, all-terrain vehicles, motorcycles and other transportation vehicles.

"Working with OEMs [in] power sports, we always try to encourage the customer to visit, so we are creating a space where their engineers and project managers can come to work with our engineers and do some of the development in house," Carlson said.

He said Sportech has been planning an innovation center that will be between 3,000 and 5,000 square feet, including offices and R&D space.

"When we built an addition in 2008, we doubled the size of our mezzanine and by golly, we need to use it now," he said.

The company operates out of two facilities in Elk River that are a few blocks apart. One is 96,000 square feet and the other is 50,000 square feet. It does vacuum forming as well as drape forming.

Carlson said the company has seen solid growth every year. In addition to power sports, the company has customers in the agriculture, transportation and construction sectors. Sportech operates eight machine lines and has 190 employees. The company was listed 28th in *Plastics News*' thermoforming rankings. |

## Gillette pushes new thermoforming technology

By Pat Reynolds, VP Editor, *Packaging World*

APRIL 2, 2014 — A patented approach combines flexo printing and thermoforming in register to produce a tactile quality



that really makes this thermoformed PET blister stand out.

From Procter & Gamble's Boston-based Gillette division comes the well known and well established

Venus line of women's razors—Venus Quench, Venus Embrace, Venus Breeze, Venus & Olay, and others. Now comes Venus snap with Embrace™, a compact and portable version of the longer-handled shaving devices aimed specifically at women on the go.

The packaging is a common enough format: a trapped blister that is thermoformed of PET. But it's no ordinary thermoforming that we're talking about here. This package is one of the first commercial applications of a patent-protected technology from Canada's think4D ([www.think-4d.com](http://www.think-4d.com)). It combines printing and thermoforming in a way that produces a package having an unusually tactile quality. In fact, it's as if the little shaving device itself is perched on top of the plastic thermoform.

According to Gillette's Mike Marcinkowski, Principal Engineer R&D, Global Pack Dev, this package is an extension of some of the work Gillette has done in the past with Gillette Fusion ProGlide packages, where thermoforming is preceded by distortion printing. "But this goes much farther in terms of process and registration," he points out. "The think4D technology takes us to a four-dimensional quality by making the package so tactile."

Early applications of think4D's technology tended to involve shallower thermoforms. In one case, four package-making steps were involved. First was flexo printing of PET sheet. In a second operation, the sheet was thermoformed to a shallow draw and individual thermoforms were die cut from the sheet. Next, a pressure-sensitive release liner was applied to the thermoform.

Finally, the thermoform was pulled manually from its release liner and applied like a label to a conventional folding carton.

When applications like these reached Gillette's radar screen, it caught their attention. But they wanted more.

### Deeper draw

"It was Gillette that challenged us to go beyond a tipped-on label kind of approach and get to a deep-drawn package," says Mike Fehr, President of think4D. Fehr explains that think4D is a division of Friesens Corporation, a Canadian book manufacturer. They've been around for more than 100 years, so printing is in their DNA. It was about five years ago that Friesens came across the intellectual property for the print/thermoform technology now being commercialized by Gillette. "It was mostly a concept," says Fehr. "There wasn't even any equipment in place at the time. But we really liked the idea, so we acquired the intellectual property with an eye toward increasing our print presence in spaces other than book manufacturing. An obvious place to focus on was packaging.

"Thermoforming accurately in register with print was not possible. We believe CPG companies are looking for this kind of tactile packaging as a means of differentiating their offerings. What think4D offers is a combination of printing and thermoforming in register with print at commercially acceptable speeds to produce a tactile package that, compared to something like an embossed carton, is far more impressive. And that's with low draw. With deep draw, the end result is even more remarkable."

The PET thermoforms for this new Gillette package are produced by think4D in two steps. First the rollstock PET sheet is printed. Outside of higher print quality, Fehr says there's "nothing all that special" about the press, but he prefers not to say who supplied it nor does he indicate whether it's flexo, gravure, or offset. He adds that it's also possible to apply additional decorative applications such as foils and tactile inks—all in line.

Once UV-cured printing is done, the material is rewound and, in a second process, is formed and trimmed on what Fehr calls "thermoforming-like equipment that we made ourselves." Coming out of this process are finished, die-cut parts. Depth of draw on the Gillette package is just under 1 1/2 inches. Fehr doesn't want to describe the process in terms of how many units across or how many per cycle. "The pink part mimics the handle on the actual razor," he adds. "The head of the razor and the button are where the thermoform is at its deepest."

Part of the secret sauce is ink, says Fehr. "Several ink suppliers are suitable," he adds. "But we've zeroed in on one that enables us to apply Color Management and whose ink can then be thermoformed."

### All-important FMOT

According to Fehr, it's the unique combination of printing process and forming equipment that makes it possible to thermoform in register this way. From Gillette's point of view, it's all about FMOT—First Moment of Truth.

"That's how we align with them," says Fehr. "They see our technology as being uniquely capable of affecting consumers and producing that all-important FMOT. It draws consumers in from that six-foot distance in the aisle and encourages them to pick up the package, read the trusted brand name, and make their buying decision. That's the connection between us and Gillette. We're able to strengthen their FMOT and provide differentiation among the Venus line-up on shelf."

As for where and how the packaging is done, Marcinkowski prefers not to discuss it. He notes that Venus snap with Embrace started reaching store shelves in January of 2014. It sells for about \$9.50, and it will roll out globally. When asked to talk about the relative cost of a PET thermoform that is produced in two passes, Marcinkowski says all cost targets are being hit. "It helps a lot that the printing and thermoforming are done under one roof," he adds. "That minimizes logistical complications that could drive the price up."

He also says that this package is a perfect example of a platforming strategy he talked about in a recent Q&A with Packaging World (see [pwgo.to/704](http://pwgo.to/704)).

"It's all about looking for something we can do that fits an existing packaging platform yet still gets us some differentiation in the store," says Marcinkowski. "This was all about making the package an extension of the product itself, of extending product awareness into the packaging. The actual product is almost the same size as the printed and thermoformed razor on the package, which, by the way, is peggable or can be displayed standing on its built-in foot." |

## Advances in thick-gauge thermoplastic parts

By Danny English, Online Today's Medical Development ([www.onlinetmd.com](http://www.onlinetmd.com))

APRIL 2014 — Technology is the star in medical devices from MRI and blood analysis machines to CT and PET scan equipment, but they could not function without the custom covers, panels, housings, and enclosures that provide sensitive electronic components structure, protection, and aesthetics.

Custom medical device parts have long been made from thick-gauge thermoformed plastics for cost-effective quality and cosmetics, and recent advancements in thermoforming have increased the advantages of doing so.

Thick-gauge thermoforming



*A one-stop-shop that can make its own tooling, and can trim, route, paint, screen, print, assemble, and ship products has more direct control over the entire process and can complete the job faster at lower cost.*



traditionally involves heating a 1/16" to 5/8" plastic sheet to a pliable temperature, shaping it in a mold, and then finishing it into a usable part. The result is an extremely durable, anti-abrasive, lightweight, part with crisp features and fine surface detail.

With recent advances, medical device designers and manufacturers have a new range of options, starting with the capability of some vendors to create thick-gauge thermoformed parts large enough for even the largest MRI covers.

New choices also include built-in, anti-microbial agents and a twin-sheet thermoforming process that simultaneously thermoforms two sheets of plastic and bonds them together. Screen-printing, hot stamping of logos, and even assembly, fabrication, and fulfillment are also options.

### **Oversize medical parts**

MRI, PET, and CT equipment designed to image an entire human body, or significant parts of it, can be massive. Even X-ray, radiology, mammography, incubator, and diagnostic blood analysis equipment can be large and bulky.

For larger parts, the traditional approach has been molded fiberglass where size, wall thickness, and radii limitations are typically heavier. Oversized thick-gauge thermoformed parts, on the other hand, are lighter and stronger at nearly half the cost.

"Thermoformed plastic is the logical upgrade from fiberglass when large medical parts, panels, housings, or enclosures are needed that must be durable and lightweight, yet aesthetic and affordable," says Wynn Kintz, president of Kintz Plastics, a New York-based thermoformer that has specialized in medical devices for almost 40 years, making products for the industry leaders in biomedical equipment.

Yet creating parts large enough to encompass the entire human body is unique to all but a few thermoformers because it requires large capital investments. Kintz's company, which makes large covers for a majority of the MRI machines in the medical market, can thermoform parts up to 9ft x 13ft with a 60" draw. It achieves this using a piece of equipment called Jumbo, the largest four-station rotary thermoforming machine available in the eastern United States.

### **Built-in anti-microbial protection**

In healthcare, maintaining a hygienic environment is critical. That can be difficult in a clinical setting, even with routine equipment cleaning, because a variety of patients and personnel use medical devices.

"One helpful new option for medical device manufacturers is to add an anti-microbial agent during the manufacturing

process that fights microbes such as bacteria, fungi, mold, and mildew for the life of the product," Kintz says.

When the anti-microbial agent is spread throughout the thermoformed material, its protection is effective both on its surface and in its substrate, and will not wash or wear off.

### **Twin-sheet thermoforming**

Twin-sheet thermoforming, an advanced vacuum-forming technology, is a good choice for some medical device panels and enclosures. These parts will be seen from both sides, needing added strength, or will house insulation, mechanical, or electrical components. The process simultaneously thermoforms two sheets of plastic, then bonds them together to create a durable, lightweight, and economical double-walled structure.

"Since twin-sheet thermoforming replaces two processes with one, it saves time and labor, creates a seamless part and stronger structure, and results in a lighter, more cost-effective component," Kintz explains.

On a recent redesign of enclosures for a medical diagnostic testing instrument, twin-sheet thermoforming reduced the cost of the doors by 30% to 50% compared to a fiber reinforced plastics (FRP) process, according to Kintz.

"Compared to injection molding or blow molding, twin-sheet thermoforming can reduce tooling costs by up to 90% and cut tooling development time in half," Kintz says.

### **Early vendor assistance**

Because every thick-gauge thermoforming application is unique to the medical device, some vendors are willing to send engineering teams to customers to consult during the early stages of development.

Even the largest, most sophisticated biomedical companies can benefit from early vendor involvement. Beckman Coulter, a company that develops, manufactures, and markets biomedical testing products, realized significant improvements in the manufacture of several blood analysis instrument parts after partnering with Kintz Plastics.

"Engineers know the required design outputs, but the product can benefit from expert vendor input," says Sean Peters, a senior procurement analyst with Beckman Coulter's diagnostics division in Chaska, Minn. "When Kintz Plastics helped our engineers with thick-gauge thermoforming material selection and manufacturability on several blood analysis instrument parts, we achieved at least 20% cost savings, 20% time savings, and enhanced quality with a three month ROI on the tooling.

"Any time we can reduce the cost of material, it goes right to our bottom line," Peters adds.

The consultation also enhanced the function and aesthetics of several parts.

"Several vendors had previously refused to even quote us on a



*A thermoformer with full in-house capabilities will be able to take a job all the way through to completion more affordably and quickly.*

part because its shape was unique and difficult to make,” Peters says. “Another part, a sample presentation unit input door, required a clear, high-impact, blemish-free surface for easy viewing. Kintz Plastics worked with us on both these high-tolerance parts to get the precision and aesthetics just right.”

The optimal material for a part is usually based on cost, performance, appearance, and regulatory requirements.

“When my design and engineering team consults with medical device designers or manufacturers, some of the factors considered include necessary part rigidity versus appearance, cost, finish options, conductivity, as well as density and weight,” Kintz explains.

### One-stop shopping

From design engineering to fulfilling and shipping the thick-gauge thermoformed part, the more a vendor outsources any aspect of the work, the greater the potential for delays.

For the best results and turnaround, Kintz recommends working with a vendor with in-house engineering, tooling, and post-forming capabilities. “A thermoformer with its own engineering staff can provide practical, on-site expertise to the design and engineering process,” Kintz says.

“A one-stop-shop that can make its own tooling, and can trim, route, paint, screen print, assemble, and ship products has more direct control over the entire process and can complete the job faster and at lower cost.” |

## 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:

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### Workforce Development: A Massachusetts Success Story

By Pia Kumar, Corporate Development, Universal Plastics, Holyoke MA

Despite historically high unemployment in the US, finding skilled factory workers remains a tremendous challenge. A recent report by Deloitte Consulting LLC for the Manufacturing Institute, entitled 'Boiling Point? The Skills Gap in U.S. Manufacturing', posits that while "the manufacturing industry continues to be widely recognized as an indicator of the health of the U.S. economy", it does not have the requisite skills to compete effectively on a global scale. Based on a survey of manufacturers, the study found that as many as 600,000 jobs are going unfilled despite the high unemployment rate in the U.S. Moreover, manufacturers report that their biggest challenge is filling those highly skilled production jobs which are crucial to their innovation and growth.

Why is manufacturing facing the problem of finding qualified help in a down economy? Three major factors come into play. First, manufacturing has a large image problem, particularly with younger candidates. Old stereotypes of backbreaking labor and grimy working conditions still dominate the minds of the young. Second, the world of viral information exchange has given celebrity status to high technology and cutting edge entrepreneurship, thus making traditionally 'old economy' industries, such as manufacturing, seem comparatively unsexy. Third, the manufacturing companies themselves seem to be relying upon antiquated recruiting and training strategies, which are no longer effective in this ever-competitive and ever-changing economic landscape.

Joe Peters, CEO of Universal Plastics, a 48 year-old custom thermoforming company based in Holyoke, Massachusetts, has been attempting to resolve each of these problems by partnering with local career centers, schools and government agencies to engage young people in advanced manufacturing while helping to reduce high unemployment in Western Massachusetts.

In reality, manufacturing jobs today are much more high tech and more appealing to a younger demographic than most people realize. Workers are now required to be technical experts. They must operate some of the most sophisticated equipment in the world. They can cut steel with lasers, water jets and plasma cutters and can program robots to paint, package and palletize products. Furthermore, the rate of change and innovation in manufacturing is on par with 'new economy' industries so the fear of stagnation is also misplaced.

Peters, along with Universal employee Manny Cruz, has been recently recognized by the state of Massachusetts as a success story for manufacturing training and workforce development. Peters spoke in March 2014 at the State House in Boston about the importance of career centers in Massachusetts and how they

help to both prepare qualified workers for appropriate jobs and connect them to those employers. Peters serves as Chairman of the Board at CareerPoint, which transforms the maze of complex, bureaucratic employment and training programs into one seamless service delivery system for job seeking and employer customers alike. Manny Cruz, a former CareerPoint customer who had been struggling to find employment, also spoke at the State House. As a result of an *On the Job Training Grant* administered by CareerPoint, Manny began working at Universal Plastics where he was trained, mentored and finally hired permanently as a 5-Axis CNC Router Operator, one of those demanding, highly specialized and technical new positions that often go unfilled but are critical to the success of the business. Today in Holyoke, there is one less unemployed young man and one more skilled American factory worker.

Says Peters, "At Universal Plastics, we learned a long time ago that employee training is the only way to get your company to the top of its game. We have taken advantage of several workforce training grants offered by the state to help get us operating as a lean manufacturer and certified under ISO 9000. But that isn't enough. Western Mass, like many areas of the country, has a huge disconnect between the many jobs that are open and the workers qualified to fill them. This skills gap is being reduced successfully by training initiatives funded by the state but designed and administered by our Hampden County Regional Employment Board (REB). Career Point is the one stop center that helps the REB find qualified potential trainees and introduces them to the companies that need those skills in their workforce. Advanced manufacturing represents a huge and growing segment of the job market here. As an advanced manufacturer, the majority of the equipment at Universal Plastics is computer controlled and takes skilled employees to operate."

David M. Cruise, REB President & CEO believes "the availability of a well-trained workforce is the differentiator that will give the precision manufacturing industry the competitive advantage it needs to grow and create wealth opportunities for its employees and investors. Universal Plastics recognizes this and has committed its support for continuous improvement."

In addition to working alongside local career placement centers and the employment board, Joe has also opened the doors to Universal Plastics and conducts ongoing tours for grammar schools, high schools and vocational schools with the goal of exposing youth to advanced manufacturing. "What is always a hit on our tours is when we give the attendees a demonstration on bending Plexiglas and then allowing them to make a picture frame to bring home. We also give them a thermoformed tray full of cookies in a container we make for one of our customers," explains Peters.



Growing a business and helping the local community is nothing new for Joe Peters. An engineering graduate of Holyoke Community College, Peters received the college's 'Alumnus of the Year' award in 2000 and the Holyoke 'Businessman of the Year' award in 2012. He currently serves as a director of the Holyoke Community College Foundation. He is a former Chairman of the Board of the National Society of Plastics Engineers, Thermoforming Division. Peters also served for 5 years as Chairman of the Board of the Regional Employment Board of Hampden County, and is currently serving as Chairman of the Board at CareerPoint Career Center, Co-Chairman of the Workforce Development Committee of the Massachusetts Advanced Manufacturing Collaborative, and is on the Board of Holyoke's Mayor's Industrial Development Advisory Committee and the Holyoke Chamber of Commerce.

"I have always felt that more is required of a businessman than just employing people. Companies must be giving back to the communities in which they operate. Universal has always found ways to be involved from running a golf tournament for the local soup kitchens to sponsoring sports teams. I have found a special love for helping in workforce development. It's obvious to me that a solid workforce is going to help create a solid economy. In the past 20 years of involvement I have seen and helped with many initiatives that have put thousands of people to work in good jobs. But it never seems to end. With the advent of new technology, the type of jobs and the skills required continue to evolve, adding new and different challenges to the equation."

Another recent initiative led by Peters in conjunction with the Holyoke Chamber of Commerce, Boys and Girls Club of Holyoke and Holyoke High School brings in students to the Universal Plastics factory to film a video about local advanced manufacturing. Students will learn about custom thermoforming, see how the machinery works and interview employees and then shoot the video themselves. The goal of this project is, once again, to get local youth excited about local manufacturing so that they will consider coming to work at places like Universal Plastics. Says Jay Kumar, President of Universal Plastics, "If we can get more kids to learn about manufacturing and just how much opportunity there is for skilled, technically advanced operators so that they are making an informed career decision that is a huge win for us. And of course, we hope that some of those decisions lead to careers at Universal Plastics, like in the case of Manny Cruz."

Says Roger Kipp, who spent 45 years in manufacturing, serving in ownership and executive roles covering foundry, tooling and plastics processing: "Students attending the Society of Plastics Engineers 2013 ANTEC Technical Conference Student Luncheon were told that 50% of the plastics industry technical workforce will be retiring over the next 7-10 years. We have an aging manufacturing workforce and plastics are not alone in this challenge. It is time that manufacturers, educators and government got together and focused on relevant applied technology at all levels of education. Manufacturing leadership must reach out to create an alliance by visiting school science labs and by providing exciting presentations on manufacturing as well as opening their doors to parents, teachers and students to tour

today's clean, lean, tech-driven plants. An efficient and effective future workforce begins with a shift in corporate culture focused on people. Joe Peters gets it - manufacturers must develop an alliance with education in order to develop their future. Joe takes a proactive, innovative approach to developing a skilled, enlightened manufacturing team". Kipp currently serves as Chairman of the Boards of the Society of Plastics Engineers Foundation and MANTEC (South Central Pennsylvania Manufacturing Extension Partnership) and is on the Board of the Pennsylvania Industrial Resource Center and the Pennsylvania College of Technology, Plastics Innovation and Resource Center (PIRC).

Apart from educating the youth and building a pipeline for future employees, Universal Plastics is also actively focused on training current employees. Universal employs a safety and training officer who coordinates all training efforts, making sure that employees are current on all of the equipment they operate and the company's operating and safety procedures. The Regional Employment Board offers ongoing training in CNC and other advanced manufacturing which take place during the evenings in local trade schools and the technical community college. Universal Plastics encourages their employees through tuition reimbursements and wage incentives to continue to better themselves and their skills by taking these classes.

Universal Plastics was founded in 1966 by Joe's father, James R. Peters, and is a custom thermoformer of plastic sheet employing over 100 people. Universal is notable for manufacturing a diverse array of products from the bus stop signage in New York City, kayaks made from recycled detergent bottles, the air ducts for the cooling system on space shuttles, the bow and battery compartment of the submarine used by U. S. Navy Seals, and the plastic interior panels of many commercial airliners. Universal Plastics was sold in 2012 to Jay Kumar and continues in its present location. Joe, his brother Mike, and the entire management team has stayed on to continue to grow the business alongside Kumar. Universal has created over 35 new factory jobs in the last two years and in 2013, Kumar purchased Mayfield Plastics, a customer thermoformer based in Sutton, MA with the goal of growing the custom thermoforming business locally through the combined strength and synergies of both companies.

When asked about what's next on his extensive workforce development agency, Joe chuckles and says, in his characteristic self-effacing manner, "Well, the 'Manny and Joe' roadshow continues! I guess they liked what they heard at the State House in Boston and we've been asked to come back and speak again by the Massachusetts Secretary of Workforce Development." But between the lines of Joe's light statement lies an important story, one worth being told and heard by every manufacturer across the United States, about the importance of educating, believing in, training and developing our workforce. Manny Cruz is not just an example of how a young man can improve his future, but also of how collaboration between manufacturers, a government training agency, and today's youth can bridge the chasm between skills and jobs to bolster the future of American manufacturing, an outcome which benefits us all.

Says Peters, "Manufacturing is enjoying a renaissance, as

computer technology and robotics are becoming a way of life. Our hope at Universal Plastics is that we can continue to attract young people to pursue amazing careers that are challenging, rewarding and essential in today's evolving economy." |



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## Have an idea for an article?

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- 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  
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## Need help with your technical school or college expenses?

If you or someone you know is working towards a career in the plastic industry, let the SPE Thermoforming Division help support those education goals.

Here is a partial list of schools and colleges whose students have benefited from the Thermoforming Division Scholarship Program:

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- Pittsburg State
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- University of Wisconsin
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- Ferris State
- Madison Technical College
- Clemson University
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- Penn College

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## Chevron Phillips Lab Day

Vicki Ligon is the Science Coordinator for Creekwood Middle School in Creekwood, Texas. Ron Abbott is the Petrochemicals R&D and Facility Manager at Chevron Phillips' Kingwood Research & Technology Center. In partnership with the SPE PlastiVan Program, these two individuals brought plastics and chemistry to life for a group of middle school students in Creekwood, TX.

The PlastiVan program travels to schools and companies throughout North America, educating people of all ages about plastics chemistry, history, processing, manufacturing, sustainability and applications. The program is easily integrated into school curricula. PlastiVan provides sound science and educational programs which spark scientific curiosity in students while increasing their knowledge of the contribution plastics make to modern life; encouraging them to seek careers in engineering.

For more information about the PlastiVan Program, contact Marjorie Weiner at [mweiner@4spe.org](mailto:mweiner@4spe.org) or +1 978-618-5496. |

Mr. Abbott,

I just wanted to thank you personally for your part in making the PlastiVan presentation possible for our students. Ms. Weiner was amazing and her presentation tied in perfectly with our chemistry unit. It definitely made the material relevant for our students. They loved it!

Thank you so much for thinking about Creekwood. We would love to have her come back again next year.

Sincerely,  
Vicki  
Ligon







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# 9th Annual European Thermoforming Conference

By Conor Carlin, Editor

Over 200 delegates from 27 countries attended the 9th annual European Thermoforming Conference in the glorious Bohemian capital city that is Prague. The theme of the event was billed as "Forming a Sustainable Future" with major topical focus on innovation and competitiveness. Both heavy-gauge and thin-gauge sectors were well-represented in the technical program.

The keynote for the event was delivered by Christian Majgaard, a former top marketing manager at LEGO in Denmark. Mr. Majgaard's speech was titled, "The Quest for Growth" and he enlightened the audience with insightful comments on brands, logos and the importance of communication during periods of change in business. Perhaps central to his talk was the notion that "the idea should be in the middle" of everything a business does. This is opposed to a company-centric view of the world, which can become problematic when the needs of the customer are ignored or forgotten. By keeping the innovation and business idea at the center of your marketing strategy, you will be more successful in the long term.

The Danes were well-represented at this year's event, with additional talks on the future of plastics in design, advances in 3D printing and building a green company at Faerch Plast, one of the largest thermoforming companies in Europe.

### Thin Gauge Panel Discussion

Perhaps one of the more interesting sessions was the thin-gauge panel discussion, featuring experts from six major OEMs: GN, Illig, Kiefel, OMV, TSL and Gabler. The conversation started with a comparison between major global markets, North America and Europe. As has been the case for some years, the difference in machine format (large vs. small) is driven by the needs of the respective markets. Even though "Europe" (as an economic entity) is larger than North America, there is still a great degree of segmentation across nation-states necessitating smaller runs and more frequent tool changeovers.

The difference in platform size also raises interesting points about the economics of thermoforming. For example, faster running machines will generate more scrap which can increase the need for labor. In higher-wage countries in Western Europe, robotic stacking systems and inline grinding are more common than in Eastern Europe (or any developing economy). Larger-bed machines, such as those built by TSL, are frequently used with inline extrusion. The massive output from these systems can

reach 8000lbs per hour (3600kg) with downstream trimming, rim-rolling and automated packaging.

The moderator, past SPE President Ken Braney, posed questions generated by the audience while introducing a few slightly controversial topics. "Do you think the thermoforming industry is advancing as fast as other industries?" More specifically, did the industry 'lose' the margarine tub to injection molding due to lack of innovation? The panel was not so quick to agree with this, although it was pointed out that OEMs and converters need to do a better job of establishing strong links with universities and technical institutes, both to develop the future workforce but also to increase awareness of what is possible with thermoforming. There is "a more common awareness" of injection molding among students. The panel pointed to in-mold labeling and tilt-mold technology as two recent examples of innovation, though they agreed that the rate of innovation could improve. It was also pointed out that thermoforming has a distinct advantage over injection molding when it comes to multilayer sheet and related applications.

Other questions concerned form/fill/seal technologies and whether or not it was receiving enough attention from OEMs and converters. Can FFS be seen as a hedge against injection molding? The role of biopolymers was discussed. The panel suggested that processing biopolymers on existing thermoforming machinery is happening around the world, but the challenges relate to the cost of the materials. There were no representatives from major bioplastics companies available to respond to this, but the growth in biopolymers (see "Thermoforming & Sustainability" on p.32) suggests that there will be more innovation in this sector.

The panel briefly took up the topic of tool interchangeability (having the ability to run different tools on different machines). While some OEMs offer master tooling sets to accommodate molds originally designed for a different machine, the panel suggested that interchangeability can be seen most explicitly when converters run multiple types of machinery in their plants. Competition among suppliers, integration of robotic systems and recent advances in the application of IT to thermoforming (data acquisition and analysis tools) all suggest that the technology is advancing.

### Heavy Gauge Panel Discussion

Representatives from MAAC Machinery (USA), Frimo (Italy) and Illig (Germany) were invited to participate in a heavy gauge panel discussion. The first question addressed the impact of heater selection on energy use and efficiency.

As a rule of thumb, the ratio is 70-90% of energy cost is influenced by heaters. The position of the heater bank and the ability to turn on/off banks during production can also help reduce cost. Certain machines have more heater banks and initial start-up pulls a bigger draw and can set demand charges for the month.



There is more to heating the sheet than the element alone, i.e. radiant energy = square of distance travelled. The proximity of the heating element to the sheet is quite important. Quartz elements allow for changes in temperature during the cycle and these elements can be closer together.

According to the panel, the trends in heating technology seem to be application-specific. The energy retained by ceramic provides an advantage over quartz, though this point might be challenged by manufacturers of quartz panels. Halogen heaters were discussed and the panel identified certain advantages for specific applications but they are not used in as many environments as ceramic or quartz panels. The color of the sheet can influence the efficacy of the halogen heaters. The panel acknowledged that Geiss, a German heavy-gauge machine builder who uses halogen heaters, has been at the forefront of halogen use. Indeed, Andy Eavis, a thermoformer who was among the biggest users of Geiss equipment, spoke up to clarify some of the benefits of halogens: “[During our use] the only downside to halogen was max demand. They get a huge amount of heat into the sheet very quickly. It’s more of an on-demand system – they can be turned off. Fewer electrons are used. The wavelength penetrates the sheet (more like a microwave). Color changes can be mitigated. Overall, much less energy is used in the total picture.”

### Material Developments

When asked about material developments, the panel discussed the automotive industry as a driving force. Many car makers are using TPO foam and generally speaking, there is a very large variety of materials that must be processed on heavy gauge machinery (10-15x more than thin gauge). Machines must be able to process all types. Polyolefins such as TPO and HMW materials are being used more frequently.

SPE CEO Wim de Vos launched a provocative question at the panel when he asked if OEMs have looked at using thermoformed parts on their machines. “BMW and Boeing are replacing functional [metal] parts with plastics. Have you considered the same?” While Illig has one section of a machine made from thermoformed plastic (a water tank), the heat and pressure requirements of pressure forming mean that plastics or composites are simply not compatible. In addition, the economics of switching from steel would be prohibitive. Paul Alongi of MAAC Machinery stated that his company rarely makes two identical machines: “We have eight models and 29 different sizes.” He did, however, also state that electrical enclosures are one section of the machine where plastics might be substituted.

### Economics & Growth

While energy was identified as the largest cost in heavy gauge forming, labor was identified as the second largest factor. Tool changeover time is a big contributor to labor cost, especially on very large machines with heavy tools. While some European machines can be changed over in less than 30 minutes with automated systems, the costs for such systems can be 30-40% of the machine price for larger (MAAC) machines. According to Alongi, “A different ROI analysis is required for changeover systems, but the technology is evolving.”

Cars in developing markets represent higher volume opportunities for thermoformers. The BMW 3-series and the Audi 4-series are relatively mass-produced, but with more models being designed, more tools are required that can be run on the same machine. The economics of heavy-gauge forming are very application-specific and require close financial management. For example, how is cash flow being managed, e.g. inventory of stock sheet vs. inventory of formed part, is instrumental in business decisions. Runs of 150-200 can be quite profitable.

Between Eastern and Western Europe, some differences remain. Supermarkets are more uniform as distribution centers spring up in new hubs. This leads to more similarities in packaging as multi-nationals expand. The number of thermoformers in Western Europe has decreased as production has moved east and labor cost has been the primary reason for this shift. The panel stated that more machines have been sold or moved to Eastern Europe.

### Turkey

Recent data shows that Turkey is now the third largest converting market in Europe, behind only Germany and Italy. The panel suggested that increasing numbers of machinery builders and toolmakers from Turkey represent a price point that is in-between Europe and China/Taiwan. This does represent a new competitive threat to many OEMs, although the North American market has yet to be affected. TSL did announce a new strategic arrangement with a Turkish OEM, though no details were discussed. SEM Plastik, a converter from Turkey, presented some interesting data on plastics and thermoforming in their domestic market: 9% growth in the value of thermoformed goods was probably the most eye-catching stat of the afternoon.

### Sustainable Growth, 3D Printing & the Importance of Design

Innovation was a key theme throughout the conference and the Danes were at the forefront of the conversation again with speakers on both 3D printing and industrial design.

Nille Juul Sorensen of the Danish Design Center posed some awkward questions after sharing some gloomy statistics about resource depletion. What does exponential growth (in technology, primarily) mean for thermoformers? Sorenson gave examples of how companies like Blockbuster, SAS Airlines and Nokia failed rapidly due to major disruptions in their business models. The lesson is that there is no time to change in an exponential world.

On the topic of resource management, Paul Scheers of Pactiv also asked some tough questions: “What if we can’t count on boundless volume growth, extraordinary amounts of cash to invest and cheap raw materials, especially in Europe?” “How do we know where we stand in terms of the economic cycle?” The time and climate in which you operate should influence what it is you actually produce. Pactiv’s growth was fueled by the population expansion of the baby boom generation, a.k.a. an economic supercycle. Scheers outlined seven success factors for packaging converters:

1. Managing raw material inflation
2. Waste reduction
3. Effective capex
4. Operational performance measurement



5. Product and customer profitability management
6. Innovation
7. Global supply chain management

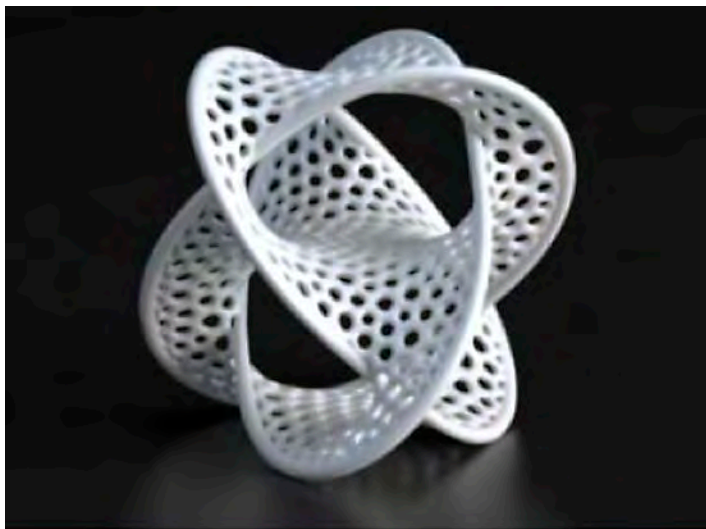
Scheers went further: “The demands of an ageing population are not the same as those of a younger population. Older people already have most of what they need. Supermarket profits have halved in the US since 2006. There was zero growth in the European chemicals sector output in 2013, leaving output for the period 6.4% below the previous year.”

In sum, companies cannot continue to operate the way they have been. In order to change the curve, businesses (and the individuals who run them) must understand where they stand and actually choose a strategy instead of plodding along following outdated models.

### 3D Printing

Is 3D printing hype or a technological revelation? Several speakers and audience members engaged on whether or not the technology is a threat or an opportunity for thermoforming. Speaker David Bue Pedersen of Denmark Technical University (DTU) informed the crowd that “3D Printing” is actually a registered trademark.

Pedersen took the audience through the evolution of the technology from wire-based printers to powder deposition to the resin-based (acrylic, epoxy or polyester) systems of today. Initially used for prototypes, 3D printing technology is now being used for tissue engineering where cells are grafted from a patient, then incubated and put through a 3D printer so the cells are attached to a biodegradable structure. The first functional liver created by 3D printing is expected to be complete this year.



*We're only limited by our imaginations, according to Pedersen.*

Other examples of innovative applications include topology-optimized components, aluminum castings being replaced by 3D prototypes for strengthening and light-weighting, conformal cooling in injection molding that uses numerical simulation for cooling lines that dramatically increase cycle times, e.g. the cycle time of Lego bricks went from 30 seconds to 7.

The economics of 3D printing continue to become more and more attractive. For example, system prices have plummeted from €100,000 to €10,000 in 4 years. Approximately 500,000 machines were sold into the industrial market last year. The primary reason for this increase in sales and decrease in price is the end of patent protection (it was originally filed in the late 1980s): the last one expired seven weeks ago [from the date of the conference]. This “democratization of technology” is fueling the rate of adoption. The entire industry is forecast to grow to \$10.8bn by 2021. And it isn't just businesses that are exploiting this new reality: the Singapore government is investing \$500MM over the next five years.

### Looking to 2016

The event in Prague was deemed to be a great success by both the attendees and the organizers. At the end of the conference, everyone was asked for their thoughts on where the next conference should be held. While it is still early for that decision, memories of Prague will linger pleasantly in the minds of those who traveled from all over the world to this year's event.

For more information on the 2014 conference, readers can visit [www.e-t-d.org](http://www.e-t-d.org). |



*From R to L: K. Braney (moderator), E. Wabnig (Kiefel), J. Romkey (GN), C. Menini (Polytype/OMV), R. Albrecht (Illig), C. Stover (Gabler), D. Irwin (TSL)*



*Sponsors and exhibitors hosted conversations in the tabletop exhibit area.*



*The 5th Parts Competition*

## EUROPEAN THERMOFORMING CONFERENCE – PARTS COMPETITION

The winners of the 5th European Parts Competition were announced on the final day of the conference in Prague. Judges reviewed a wide array of outstanding parts from multiple industries across Europe.

### Thick Gauge Category – Automotive Applications

1st Prize Winner: "Door Assembly for Renault Twizy Electric Car"

Company: Walter Pack, Spain

Jury's remarks:

*High quality cosmetic part respecting tight tolerances set by the highly demanding automotive application.*

The door assembly is manufactured from ABS-PC and ABS. It contains 5 plastic parts, plus 3 metallic inserts, to obtain a part with total tolerances of  $\pm 1.5$  mm.



### Thick Gauge Category – POP/Display

1st Prize Winner: Telia Sign

Company LOGOFORM AB, Sweden

Jury's remarks:

*An innovative tool design enabling undercut parts that are cosmetically perfect, creating new design possibilities for smaller volumes in thermoforming.*

The Telia indoor/outdoor sign is formed from PETG on a positive tool with a split top and a soft hood. It is screen-printed on the back with rounded sides to give the impression that the sign is "hovering" in mid-air.



### Thin Gauge Category – Packaging

1st Prize Winner: "Lo-g" Retail Carry Pack

Company: Protective Packaging Systems Ltd (UK)

Jury's motivation:

*An innovative fragility packaging design incorporating impact-absorbing thermoformed features to protect sensitive electronic parts during storage and transit.*

The Lo-g protective retail carry pack is thermoformed from 1.2mm (0.047") recycled black HDPE and uses a range of thermoformed features such as bellows, springs and buffers to allow for impact absorption. The design criteria for the retail carry pack included the following elements: the package must ensure adequate protection of the product during storage and transportation; it must be stackable; it must improve the customer's opening experience; it must be more sustainable than the current packaging. |





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## Parts Competition Guidelines and Entry Form

September 15-18, 2014

Schaumburg, Illinois

**Submission Deadline:**

**August 15, 2014**

We are excited to welcome all thermoforming businesses to participate in our prestigious global competition. Tool makers and sheet suppliers are also encouraged to participate! The SPE Thermoforming Division is proud to showcase the latest advances and innovations in thermoforming design and applications.

1. All submissions must be final thermoformed components produced from production tooling.  
**Advertising in any form on part submissions is strictly prohibited.**
2. Multiple submissions from one company are accepted; please use one form for each submission.
3. All images and descriptions must be emailed to the Parts Competition Chair two (2) weeks prior to the Conference. Images must be in JPEG format and not exceed 1MB. The part description should follow the criteria as stated on the entry form. The company's name and contact information may only be stated at the bottom of the description.
4. The judging committee reserves the right to re-categorize a product submission and to merge categories that do not have at least five (5) entries.
5. Awards will be presented at the Thermoforming Awards Dinner on Tuesday, September 16, at the Renaissance Hotel.

### Eligible Product Categories:

#### Roll-Fed

- ☐ Industrial
- ☐ Medical
- ☐ Food

#### Heavy Gauge

- ☐ Vacuum Form
- ☐ Pressure Form
- ☐ Twin Sheet
- ☐ TPO

#### Combined

- ☐ Recycled (minimum 40% recycled content)
- ☐ Value Added Assembly
- ☐ Innovative



2013 Parts Competition Winner

**Contact:** Steve Zamprelli  
2014 Parts Competition Chair  
E: [s.zamprelli@formedplastics.com](mailto:s.zamprelli@formedplastics.com)  
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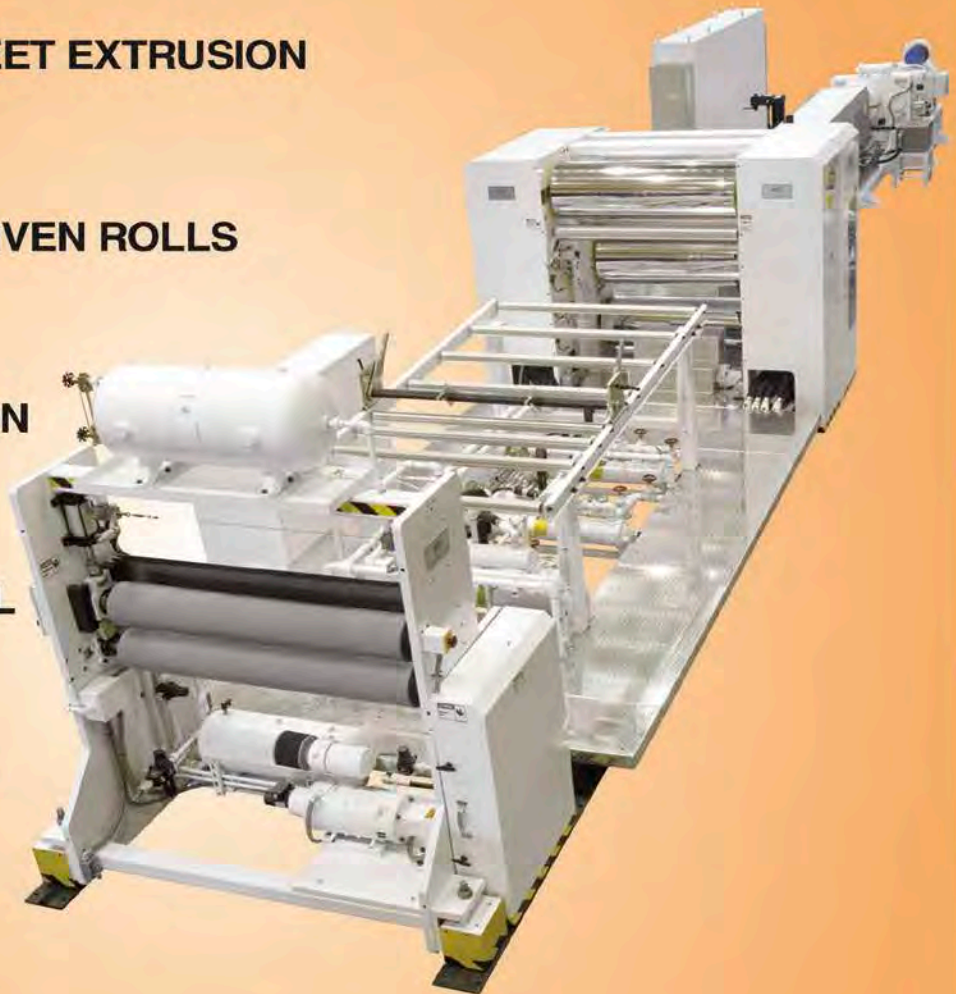
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# Automotive Body and Commercial Vehicle Applications

By Sven Engelmann, written in cooperation with Lukas Schwaighöfer, Senoplast Klepsch & Co. GmbH, Piesendorf, Austria

*[Editor's note: the following article is adapted from Advanced Thermoforming by Sven Engelmann Dipl. -Ing., Director of R&D at EBB Microparts, Crailsheim, Germany. Mr. Engelmann has a distinguished career in polymer science and thermoforming technology. Prior to EBB, Mr. Engelmann was a development engineer for thermoforming technology and polymer materials at Illig and the Director of Polymer Technology at Gerhard Schubert GmbH, a leading designer and manufacturer of innovative form/fill/seal technologies. In addition to his work in the private sector, he is a lecturer at the University of Stuttgart and the Aalen University of Applied Sciences where he teaches "Basics of Thermoforming." He is the author of numerous articles published in both the US and Europe on thermoforming, polymer processing and injection molding. His recent book, published by Wiley, can be purchased on Amazon. He can be contacted via s.engelmann@ebb-microparts.de]*

## 7.1 Applications for Car Bodies—ABS/PMMA

For car body applications including caravans or recreation vehicles, special ABS/PMMA multilayer sheets have been developed. Unlike glass fiber reinforced plastics, these semi-finished products can be formed in a more economic and environmentally-friendly way.

For the recreation vehicle and caravan industry, designers and developers must work out cost-effective manufacturing processes and methods. Certain manufacturing processes that are not current may, in many places, be too costly. In particular, the material technologies used until recently have been too expensive. The elimination of complex and costly paint work, weight reduction by means of a lightweight mode of construction, and the reduction of CO<sub>2</sub> emission values are already the well-defined aims of manufacturers of caravans or recreation vehicles.

A cost-saving consideration is to use ABS/PMMA multilayer sheets. ABS/PMMA multilayer sheets, which are the current trend and for which there are rising demand in the automobile industry this market, were developed by Senoplast Klepsch & Co. GmbH, a company based in Austria. Until the 1990s in the caravan sector, mainly GRP (glass fiber reinforced plastics) composites were used for the front and rear panels. The production of these GRP parts involved huge costs because their production could not be fully automated. To process GRP composites, their specified MAC values (maximum allowable concentration at the workplace) had to be maintained by employing elaborate air ventilation systems with efficient filters. In addition, time-consuming and cost-intensive post-processing

treatments were necessary.

As these vehicles gained popularity in the 1990s, competing design demands increased to attract customers with modern and unusual forms. The original angular form was replaced and the caravan became redesigned. Demand rose for a material that could be used for panels with curves and smaller radii.

Because GRP composites could not meet these needs, manufacturers turned to thermoplastic multilayer sheets in order to manufacture the front and rear panels. These panels were thus thermoformed. During their manufacture, the thermoformed parts were clamped to a frame directly at the manufacturer's site and combined with other materials by means of sealing materials and adhesives. The thermoplastic ABS/PMMA semi-finished parts offered certain advantages compared to thermoset processing:

- Low costs of the formed parts due to the high degree of automation for the thermoforming process
- No painting because the sheets are already pigmented and present an excellent surface quality with outstanding UV properties
- Color variety including standard and metallic colors
- Design freedom due to thermoforming
- Weight reduction
- Good environmental sustainability because parts can be recycled and paint applications are no longer necessary
- High elasticity and thus less sensitivity to outer influences, such as hail

Over the years, pigmented and coextruded multilayer sheets with ABS as the carrier sheet and PMMA as the coating layer became widely accepted. ABS proved to be a good carrier material due to its impact resistance (also in cold weather), breaking strain, and a corresponding stiffness. PMMA (acryl) could meet the high standards for the coating layer (gloss, scratch resistance, and ultraviolet resistance).

In the course of a caravan symposium, organized in 2006 by Senoplast Klepsch & Co. GmbH, a survey concerning customer satisfaction and room for improvement of ABS/PMMA composites was conducted. For this survey, more than 100 participants from international caravan manufacturers and the thermoforming industry were asked the following questions: "Which criteria and product characteristics have the highest priority at the moment? What expectations do you have in the future relating to these composite materials? What characteristics do such materials need to possess?"



- For the majority of interviewed participants, the highest priority items were the improvement of the mechanical properties, the related decrease in scrap for the subsequent processing and an increase in life expectancy.
- In second place came the desire to improve chemical resistance and the compatibility of the thermoplastics regarding adhesives, primers, and sealing materials. This would present the advantage of being able to choose from a broader range of commercially available adhesion and sealing systems. Thus, on the one hand, more cost-effective systems can be applied and, on the other hand, better sealing materials can be used, which were regarded as being chemically aggressive and damaging for the hitherto existing composite materials.
- Third was a request for better surface resistance to the chemicals of detergents, since formed parts have to be extensively cleaned in the manufacturer shops. The development of a multilayer sheet process was started in order to fulfill all these requirements, with a special focus on the caravan industry.
- For the coating layer, a compound based on acryl is used in order to maintain the good surface properties of ABS/PMMA sheets with regard to gloss, scratch resistance, and UV resistance. Compared with the standard acryl types of material available, this acryl blend has more resistance against chemicals and is highly impact resistant.
- For the reverse side of the sheet, a special blend was developed. Priority was given to chemical resistance against adhesives, primers, and sealing materials.

This ABS/PMMA multilayer sheet was already being manufactured for trial productions on industrial lines and it was being thoroughly analyzed in a laboratory. The chemical resistance of the surface and reverse side of the semi-finished product were compared to conventional adhesion and sealing systems. The test was carried out in the style of DIN EN ISO 22088-3. For this test method the sheet is clamped to a bended template having an outer fiber strain of 0.66% in order to simulate inner strain, as can be created within a formed part through wrong processing or assembly. The test medium is applied to the clamped sample. After a residence time of 24 hours, the air is exhausted from around the sample and a tensile test is carried out. The decisive criterion for this is the breaking strain, which drops for a chemical attack. Altogether, 37 media from different manufacturers were tested. Comparisons were also made with conventional ABS/PMMA sheets available on the market.

Interestingly these analyses suggested that the adhesion and sealing systems should not only be tested with regard to their adhesion characteristics but also relating to the chemical influence on the mechanical properties of the component part. Modifications to the system of semi-finished part and adhesive should always be based on compatibility tests.

When the caravan panels are cleaned—subsequent to processing and assembly—stress cracks often appear. This can be due to the use of detergents that are not suitable for plastic materials, but more often the cracks are due to a high inner stress created in the component part in combination with aggressive media. To resolve this problem, a special acryl blend was developed that has significantly lessened the appearance of stress cracks.

The coating layer's resistance to stress cracks was further verified by subjecting it to norm EN 13559. For this test the sheet is clamped to a bended template and a test medium is applied. The test medium chosen was isopropanol, a well-established medium in the caravan industry used for cleaning the final assembly. The time is measured until the first cracks appear.

This test was carried out with a defined outer fiber strain of 0.082% to simulate the internal stress that would be created subsequent to an improper further processing of the formed part. In this test, the surfaces of several commercially available PMMA surfaces and significant improvement were examined. While for standard PMMA sheets, the first cracks appear after a residence time of 0.5 minutes, the special acryl blend can be treated for over 3 minutes without eliciting surface damage. In practice, the cleaning time is under 3 minutes, but when standard PMMA is intensely cleaned, the cracks may appear after 0.5 minutes.

Mechanical tests were another focal point of the evaluation phase. Through product modification, the number of rejects during subsequent processing could be diminished. When big component parts are handled, damage can occur both at the thermoformer's and the manufacturer's site and finally at the very end, the customer's site.

The tests carried out were tensile tests according to EN ISO 527-2, impact strength tests according to Charpy EN ISO 179, and impact penetration tests according to 6603-2.

The utility vehicle industry is continually under pressure to produce exterior and interior component parts that meet the latest design standards. Sheared panel sheets are no longer considered up to date. At the same time, these component parts need to offer increased functionality. The utility vehicle industry prefers prefabricated modules that can easily be integrated. Often systems with clip-in mechanisms are used. Because the market demands a large number of models with the overall quantity remaining the same, methods that lower tooling costs are in great demand. Additionally ever increasing environmental specifications have made painting an expensive proposition.

For all the above-mentioned sectors, ABS and ABS/PMMA sheets offer performance and price advantages. Additionally ABS/PMMA sheets can be strengthened with different materials and technologies to facilitate the production of structural components. Suitable thermoforming machines, forming tools, and materials must be used by utility vehicle parts manufacturers to maintain their competitive advantages regarding design and component parts.

Today well-known European and globally active manufacturers of trucks, tractors, construction vehicles, buses, and special-purpose vehicles count on the competitive advantages of thermoforming for the production of outer panels and interior cover parts. Manufacturers of utility vehicles make the following demands on parts made of co-extruded ABS/PMMA sheets.

- Very good, nearly perfect surface quality, even up to class-A



surface quality

- Elimination of the painting process
- Color matching with the painted component parts
- Excellent UV property
- Corresponding impact resistance and breaking strain
- Simple adhesion respectively availability of flexible adhesion techniques
- Reinforcement techniques, particularly for structural components

The semi-finished products for the thermoforming process must be subject to color shade management so that the thermoformed parts come up to the high quality demands of the utility vehicle industry. So it is important that the producer of semi-finished products has a good color laboratory and is able to create colors according to customer demand. In this way, laboratory colors are developed in cooperation with all concerned parties. Some producers of semi-finished products have a color spectrum of up to 5000 colors.

Most manufacturers do not want to paint thermoformed parts for cost-related reasons, so the semi-finished sheets are often pigmented and manufactured in desired matching colors based on customer demands. Competent handling of color shade is what ensures color success. Compliance with customer-specific color shade tolerances between color type and the recurring production of sheets is necessary. Additionally the pigmented sheets must withstand exposure to changing environmental conditions and keep their color for years, and mainly the stress caused by constant exposure to ultraviolet rays.<sup>1</sup>

### 7.3 Cover for Head Lamp

*In cooperation with Thorsten Eymael and Nina Schick, SE Kunststoffverarbeitung GmbH & Co. KG*

Another example for an application in the sector of commercial vehicles is the cover of head lamps on a delivery truck. Covers for head lamps are developed in limited editions. These are thermoformed parts that are formed from PC and subsequently lacquered on the rear side. A high depth of sharpness must be attained with the transparent material despite the different radii of the tool contour/outline at the front side of the part. Thus a high degree of design freedom is achieved and the thermoformed part captivates with its optic refinement. |



*Product brochure senosan® utility vehicles, Senoplast Klepsch Co. GmbH, Piesendorf, Austria 2007.*



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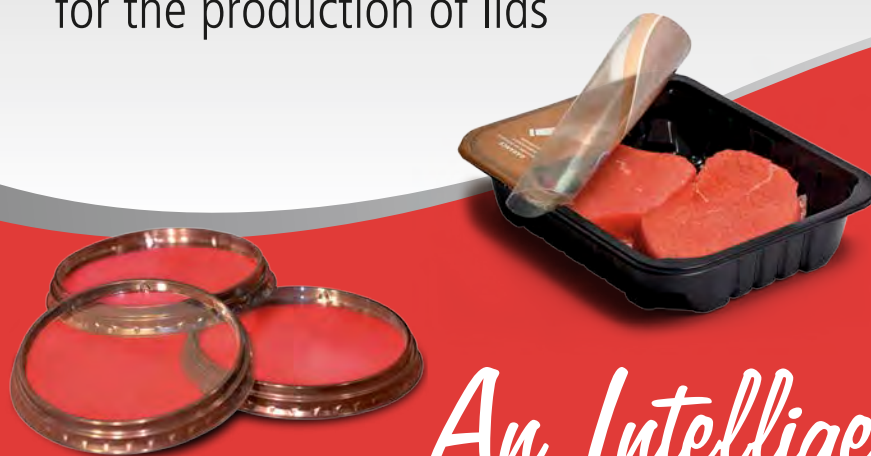


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# Thermoformability Analysis of APET Sheets Using Novel Test Equipment

By Amit Dharia, Transmit Technology Group, LLC, Irving, TX

## Abstract

The quality of thermoforming depends on knowing and controlling several material and process variables, the most important being the quality and uniformity of sheet stock. The extruded sheet can vary in resin microstructure, contamination, amount of regrind, sheet thickness, thermal history, crystallinity, and residual stresses. Effects of such variations manifest during production, resulting in frequent process set-ups, high scrap rate due to non-uniform heating, wall thinning, tearing, haze, pin holes, shape distortion, and difficult demolding. In production, variations mean cost.

In this paper, we will illustrate the use of Technoform – Thermoformability Analysis Test equipment – in detecting differences between APET multi-layer sheets and optimizing process conditions.

## Introduction

Thermoforming is a process of shaping a plastic sheet heated above the softening point (Tg) and below the melting point (Tm) of a polymer, and stretching the heated sheet over or inside a mold cavity by rapid application of force. It is widely used in thin wall parts with large surface area (1).

The ability of thermoplastic to thermoform primarily depends on its softening point, crystallinity percentage, melt strength, and melt elasticity at thermoforming temperature and speed. The sheet extrusion history itself introduces a wide range of variables of which the processor may not be aware. Most often, the source of variation is due to resin micro-structure, amount of regrind, heat history, contamination, inadequate or excessive drying, incompatible additives, poor extrusion process, uneven roll temperatures and roll speeds or roll nip gap causing uneven thickness across the width of the sheet or webbing along the length of the sheet. Unfortunately, the thermoformer learns of any such anomaly only during actual production.

At present there are no standard incoming QA or QC tests other than the supplier's specification sheet. Attempt to correlate melt flow rate, melt tension, melt strength, sag resistance, hot tensile strength, or low shear steady state Rheology to actual thermoforming often fail because such tests are performed on polymer melt at much lower speeds under isothermal conditions – none of which applies to the commercial thermoforming process. Commercial thermoforming involves very high speed 3D stretching of a 2D sheet well below its melting point and under non-isothermal conditions (2).

This lack of knowledge prior to production about the quality

of the sheet results into expensive trials, and loss of time and material. More specifically when the supplier and processor have a dispute, there is no finite test method to resolve it.

Technoform is fully automated equipment developed for rapid evaluation of thermoformability under conditions similar to the actual commercial thermoforming process. The operation of the machine, test method, and its applications are reported in prior publications (3,4,5,6).

Due to its OPS-like clarity, PVC-like toughness, chemical and stain resistance, and recyclability, APET (PETG and CPET) is widely used in food and consumer packaging applications. However, variations in PET sheets are a major concern for productivity (7). The source of variation could be due to intrinsic properties of the resin, drying of the resin prior to extrusion, pre-crystallization, or variations in the sheet extrusion process.

PET is unique in its crystallization. It crystallizes slowly from melt but rapidly when heated just above its Tg. Besides temperature and time, stress is an important factor affecting crystallization of PET. Depending on the processing conditions and thermal treatment; APET can be completely amorphous or semi-crystalline with resulting glass transition temperature varying from 67 °C (152.6 °F) for an amorphous PET to 80 °C (176 °F) for highly crystalline PET (8). APET with co-monomer crystallizes at a slower rate and has higher Tc allowing it to be thermoformed better than amorphous PET made by quenching (CPET). All PET materials are hygroscopic. Unless dried properly (moisture level < 0.05%) residual moisture will lead to cleavage of polymer and degradation. This will further change flow properties which in turn will affect wall thickness and crystallinity.

Sheet producers and thermoformers often remix regrind with virgin PET. Regrind is not as crystalline as virgin PET. Mixing poorly-dried or crystallized PET regrind can affect overall properties of sheet. Multilayer extrusion with tie layers can further introduce process and material variables.

Thus, unless made under controlled conditions, PET films/ sheets produced from same virgin PET will vary. Understanding such variations prior to production will increase efficiency.

The objective of this paper is to present the results of thermoformability investigation of two multi-layer PET sheets using Technoform.

## Experimental

**Material:** Two different lots, PET1 and PET2, of clear multi-

layered sheets made apparently from the same grade of APET are assessed. Both lots had very similar thickness distribution and average thickness of 0.30 mm. One lot thermoformed well and the other did not.

**Tests:** The following tests were performed.

- (1) Fourier Transform Infrared Spectroscopy (FTIR) test was performed on sheets as received to see any major differences in materials used or any changes in microstructure after extrusion process.
- (2) DSC test was performed at 10 °C/ minute (50 °F) heating rate from 40 °C to 300 °C (104-572 °F) to determine glass transition temperature and onset of secondary crystallization upon reheating. The decrease in T<sub>g</sub> indicates loss of molecular weight of PET.
- (3) TGA test was performed (30 - 75 °C (86 - 138 °F) at 20 °C/ minute (68 °F) in air) to determine presence of any monomers, water, or products of degradation etc.
- (4) Thermoforming was tested using Technoform at various pre-heat temperatures, plug speeds, and plug temperatures to determine differences in forming characteristics and to identify suitable process temperature range.

## Results and Discussion

An FTIR test was performed on films as received. The IR spectrum contains information about the microstructure which can reveal differences in both chemical and physical properties (crystallinity). PET chains have either hydroxyl or carboxyl ends or ester linkages. Degradation of PET occurs via a breaking of the chain at ester linkages via hydrolysis. Such degradation can cause a decrease in molecular weight, branching and cross linking. This changes the shape and position of bands at 1700-1730 (C=O Ester), 815 1/cm, 1015 1/cm, 1338 1/cm, 1455 1/cm (In plane C-H). The FTIR scans show differences in 1670 -1730 1/cm. Lot PET2 exhibited some degradation during processing.

### Differential Scanning Calorimeter (DSC)

The glass transition temperature for properly dried PET varies from 69 °C (156 °F) for amorphous to 81 °C (178 °F) for crystalline PET. It varies mostly with molecular weight (IV), amount of plasticizer, and thermal history. DSC testing was performed by first heating the sample at 10 °C/ minute rate from 30 °C to 290 °C, holding at 290 °C for one minute, quickly quenching to room temperature and then reheating at 10 °C/ minute rate to 280 °C. Figures 2 and 3 show the 1st and 2nd

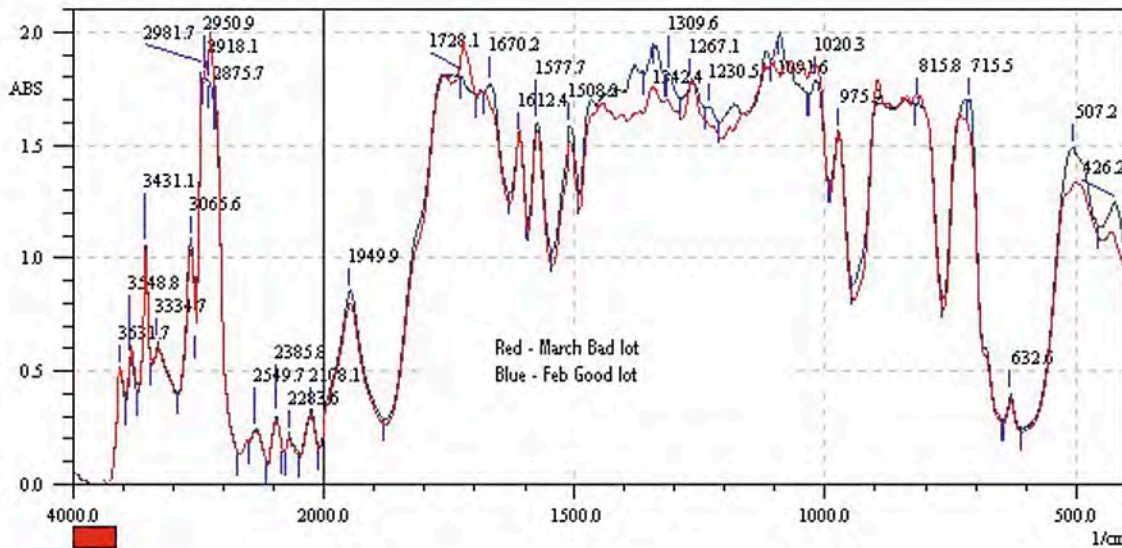


Figure 1: Comparison of FTIR scans

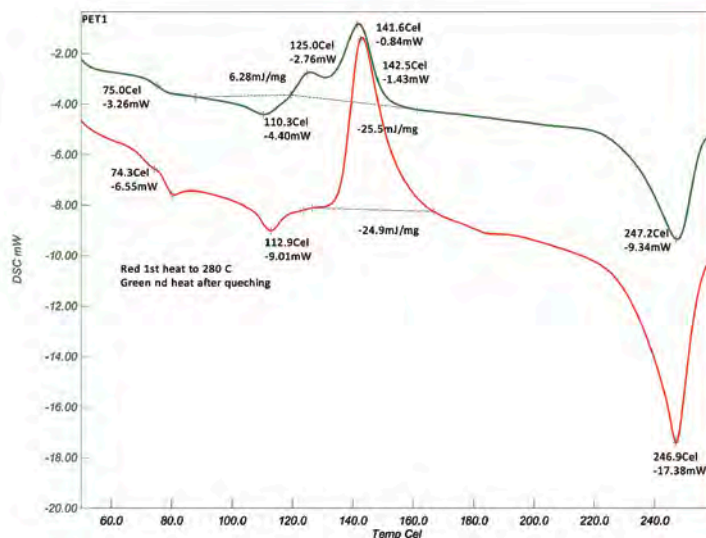


FIGURE 2: 1st and heat scans for PET1 (DSC 10 °C/minute heat rate)

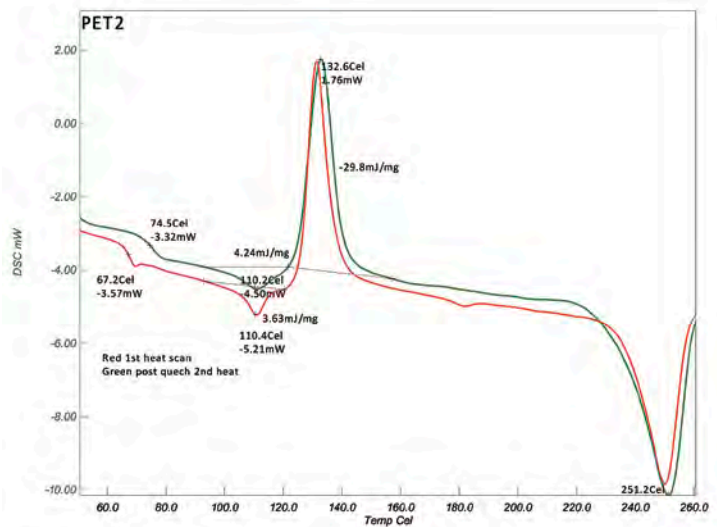


FIGURE 3: 1st heat scan of PET2 (10 °C/minute rate)

heat scans for two PET lots. In the first heat scan, the glass transition temperature for PET2 was lower PET1: 74.6 °C (169 °F) for PET1 as compared to 69.2 °C (143 °F) for PET2. The secondary crystallization occurred at 131 °C (268 °F) for PET2 and at 142 °C (273 °F) for PET1. The change in the secondary crystallization peak in the second heat cycle and lower melting point indicates PET1 has some co-monomer. The enthalpy of the secondary crystallization is also greater for PET2. The decrease in Mw tends to increase free volume and molecular mobility which would enhance the crystallization rate. When preheated to 160 °C (320 °F), the weight increased by nearly 10% for PET2 while it remained the same for PET1. PET2 also showed white streaks, perhaps due to poor heat sealing due to higher crystallinity of PET.

### Thermo Gravimetric Analysis (TGA)

TGA test was performed to determine presence of the water, solvents or plasticizers. Figures 4 and 5 shows TGA scans for two lots of materials. There were little or no volatiles detected between 30 °C and 160 °C (86 - 320 °F). Nearly 3.7% higher weight loss for PET1 and 6 °C (42.8 °F) lower decomposition temperature than PET2 indicates PET1 to have co-monomer.

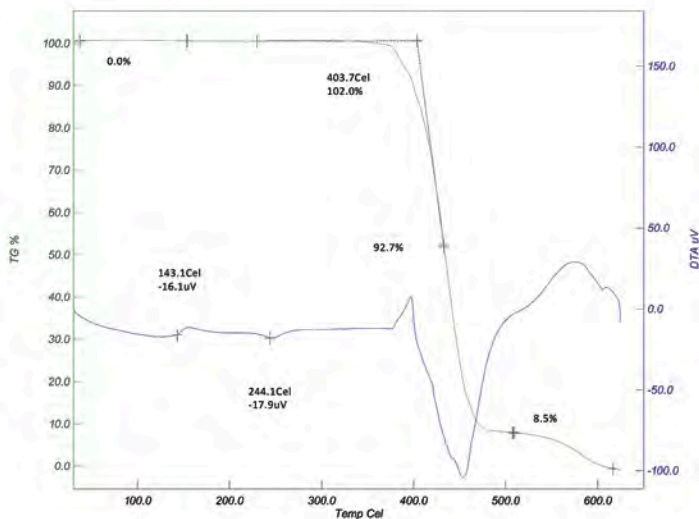


FIGURE 4: TGA scan for PET1 (20 C/minute in air)

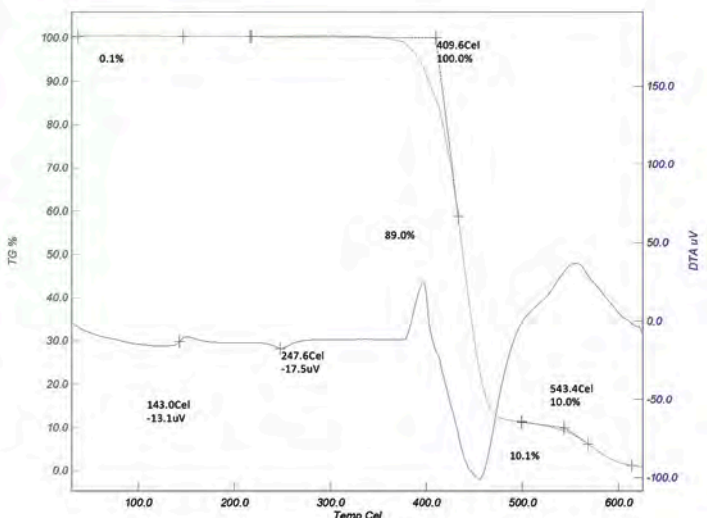


FIGURE 5: TGA scan for PET2 (20 C/minute heating rate)

### Thermoforming Experiments

Thermoforming ability was tested using fully computer controlled thermoforming test equipment.



FIGURE 6: Technoform – Thermoformability Analysis Equipment (US 7,059,108)

Two lots of PET were tested at pre-heat temperatures of 140 °C /150 °C /160 °C (284/302/320 °F), plug speeds of 60 -90mm/ second, and plug temperatures of 30 °C (86 °F) and 60 °C (140 °F). The draw depth was kept constant at 50 mm (1.96”).

127mm x 127mm (5” x 5”) samples cut from extruded sheets (with curled portion up) were firmly held between two steel plates having 50mm and 70mm (1.96” and 2.75”) diameter openings. The sample is uniformly but rapidly heated from top and bottom to the desired temperature using two adjustable ceramic heaters preheated to 650 °C (1202 °F). Actual surface temperature of sheet was continuously monitored by non-contact IR probe and recorded. When both surfaces attained desired temperature, the sample tray was moved rapidly to be formed by a plug at pre-programmed speeds. The plug used in this study was a round bottom cone shape polished aluminum plug with 1.75” top and 1.40” bottom diameter with overall 50mm height. The plug was equipped with heater to allow controlled heating the surface.

The force to form was measured using a precision load cell (0.5%) and recorded as a function of draw depth and time. After forming, the plug remained inside the part for a specified time for cooling. A second non-contact IR temperature probe continuously measured the surface temperature of the part during forming and cooling. Due to the time lapse in moving the sample tray, the actual surface temperature during forming is lower than the set temperature.

By changing the diameter of the sample window opening, the original area and hence the area draw ratio were changed.

In general, force vs. depth plots show four distinct regions:

1. Negligible force - material is hot with a very small portion in contact with plug;
2. Linear increase in force - hot but elastic material,
3. Stretching without force - material is in rubbery state, and



4. Rapid increase in force - material is cooling below forming temperature and walls are thinning unevenly.

The width of each zone will vary with test temperature, plug shape, and speed. Under similar test conditions, force vs. depth plots for given material should be the same within the experimental error.

The results of tests are tabulated in Table 1. Samples are labeled as PET-LOT (1 or 2) pre-heat temperature / plug speed / draw depth / dwell time / plug temperature. i.e. PET1L15060503030 means PET1 was formed using a tray with a larger opening with a sample pre-heated to 150 °C, at 60 mm/second, plug speed to a 50mm depth, with a cooling time of 30 seconds by a plug at 30 °C.

Figure 7 and Figure 8 show the forming force as a function of draw depth for lots PET1 and PET2 respectively. Figures 9 and Figure 10 shows the surface temperature as function of draw depth.

For uniform wall thickness, the sample sheet must retain heat and stay above T<sub>g</sub> and below secondary crystallization temperature during plug travel. If the material loses heat or crystallizes at any point during forming it will lose melt elasticity; the part will not form and the plug will retract.

Formability is considered good if the sample can be stretched to full depth with a smooth surface and good clarity without tearing, and using lower force over wide processing speeds and temperatures. As can be seen from Figure 7, PET1 was thermoformed over a wider range of temperatures and plug speeds. PET2 had limited forming ability above 135 °C (275 °F) even when a heated plug and higher plug speeds were used. At lower pre-heat temperatures (140 °C / 284 °F which resulted in forming temperature of 128-135 °C / 262-275 °F) PET2 also formed to full 50 mm draw depth parts with clear and smooth walls. Under equivalent conditions and draw depths, PET2 required much lower force to form. This perhaps is due to lower melt strength.

During preheating, PET1 absorbed heat slowly (3.5 °C/ minute) and took a little longer compared to PET2 (3.75 °C/ minute). Material which absorbs heat slowly also retains it for a longer time. Figures 8 and 9 show the surface temperature during forming as a function of draw depth under various forming conditions for PET1 and PET2 respectively. For uniform wall thermoforming, it is essential that materials retain heat during the forming process and stretch at a uniform rate. Crystalline material begins to cool faster. PET1 retains heat for a longer period of time without undergoing crystallization while PET2 lost heat quickly due to rapid crystallization.

### Conclusion

The thermoforming test method presented here is simple, rapid, repeatable, and it reflects actual thermoforming process more closely than previously used test methods. Force required to form material to a specific draw depth is used as a quantitative tool to compare the thermoformability of PET sheets.

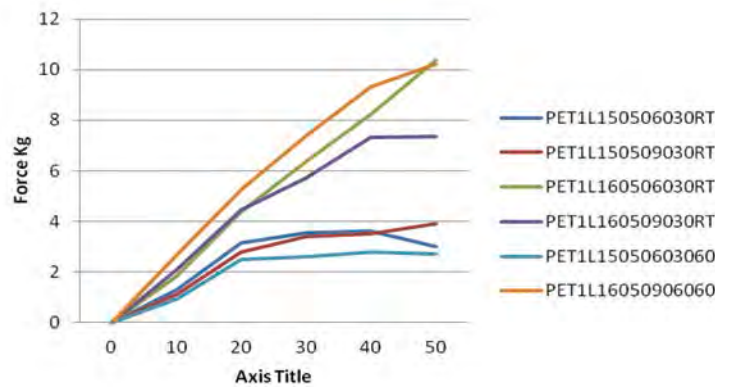


FIGURE 7: Forming force vs. Draw depth for PET1

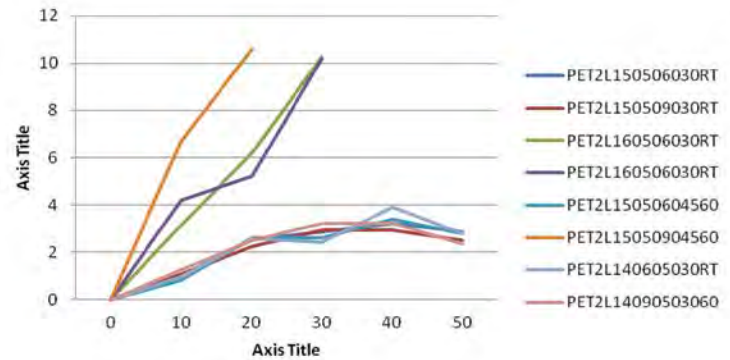


FIGURE 8: Forming Force vs. draw depth for PET1

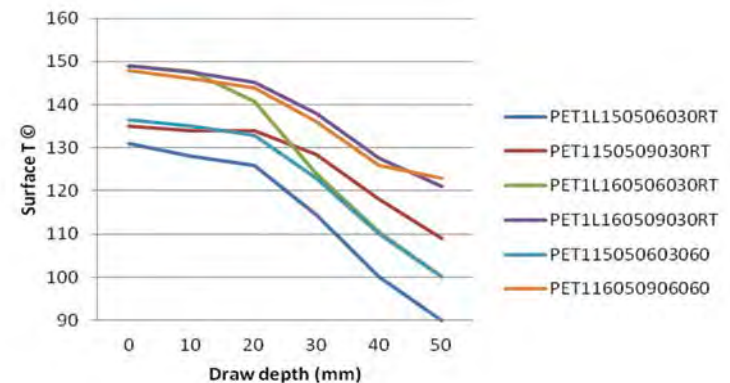


FIGURE 9: Surface temperature during forming vs. draw depth for PET1

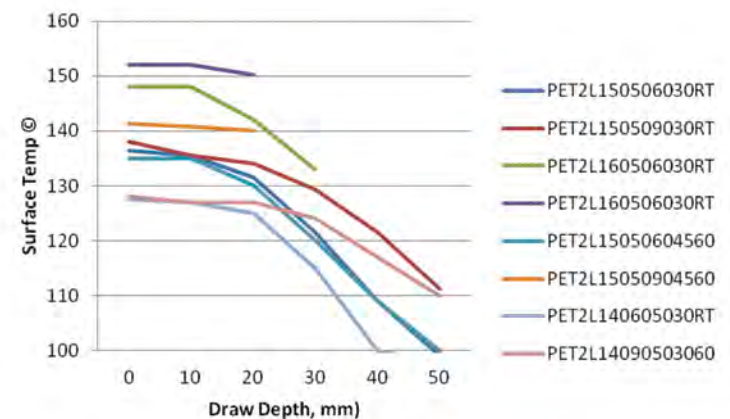


FIGURE 10: Surface temperature during forming vs. draw depth for PET1



FIGURE 11: Thermoformed parts PET1 under various forming conditions.

- |                     |                     |
|---------------------|---------------------|
| 1. P060503030ET1L15 | 5. PET1L15060503060 |
| 2. PET1L15090503030 | 6. PET1L16090506060 |
| 3. PET1L16060503030 | 7. PET1S15060403030 |
| 4. PET1L16090503030 | 8. PET1S15090403060 |

The lot which thermoformed well over a wide range of process conditions seemed to be APET with some co-monomer while the lot which failed to form has higher  $T_m$  and lower  $T_c$  indicating it to be cold quenched CPET. It also has lower  $T_g$  perhaps due to degradation caused by hydrolysis, mixing of regrind or different thermal history. This resulted in earlier and faster secondary crystallization. Lower pre-heat temperature, a heated plug, and faster plug speed produced acceptable parts.

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- (2) D. Hylton and C. Chem, SPE ANTEC (1988)



FIGURE 12: Thermoformed parts from PET2 under various conditions.

- |                     |                     |
|---------------------|---------------------|
| 1. PET2L150506030RT | 5. PET2L15050604560 |
| 2. PET2L150509030RT | 6. PET2L15050904560 |
| 3. PET2L160506030RT | 7. PET2L140605030RT |
| 4. PET2L160506030RT | 8. PET2L14090503060 |

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In addition to the technical data, up-to-date market figures are provided. Many diagrams are included and available for download, including those on production capacities, regional distribution, monetary market shares, or fields of application for various bioplastics. Also available are detailed comparative data of individual groups of material, their fields of application, regions, feedstock and land use efficiencies as well as current markets and market trends over a five-year period, etc.

To allow easy navigation and quick access to the data, the main menu is arranged by categories such as feedstock and land use, biopolymer output, process routes, and wide-ranged market figures on production capacities. Also included are sub-menus with information on individual aspects. <sup>1</sup>

For complete information, visit [www.downloads.ifbb-hannover.de](http://www.downloads.ifbb-hannover.de)

Sample data presented below:

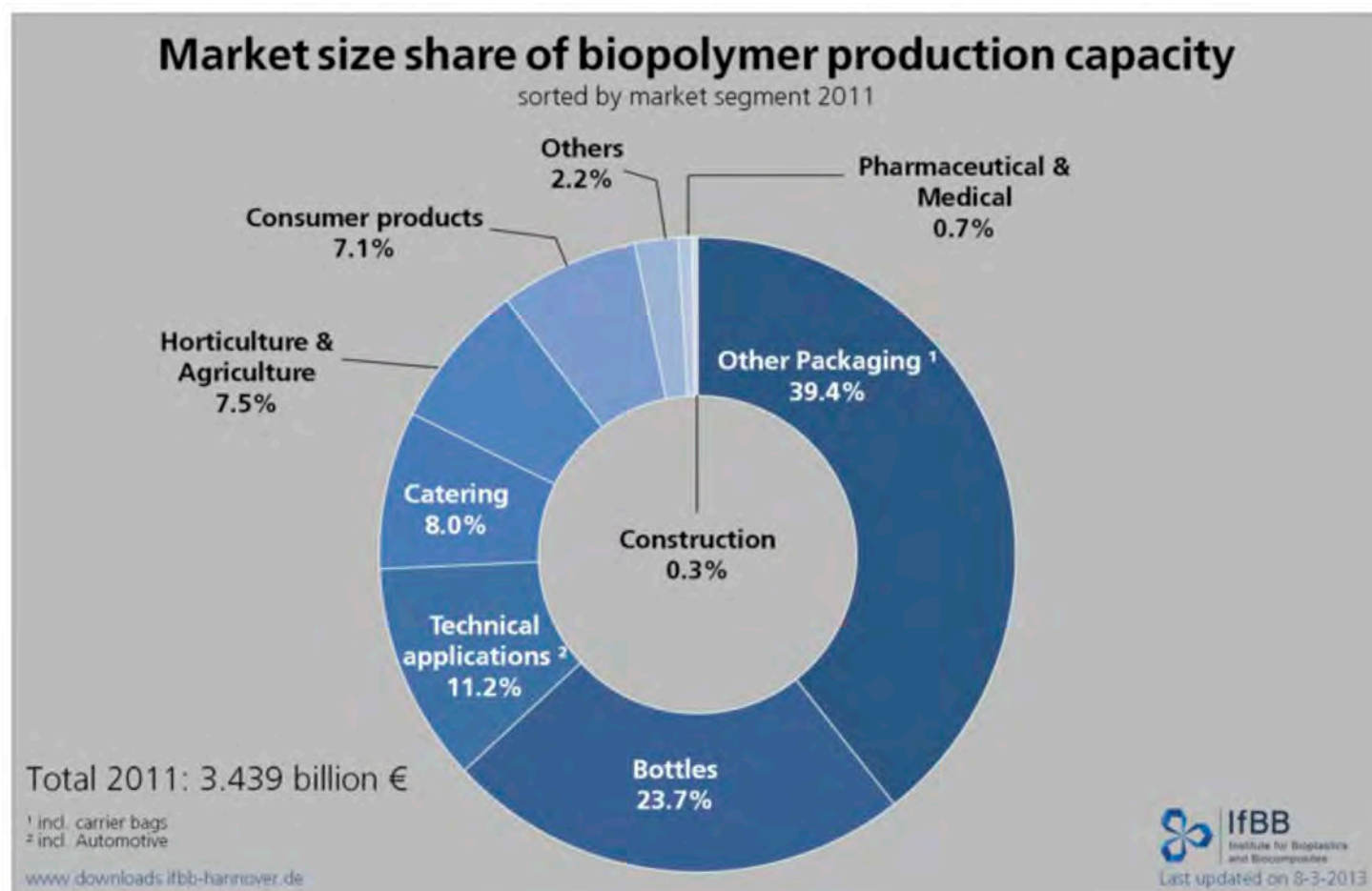


Fig. 1



## Market size of biopolymer production capacity

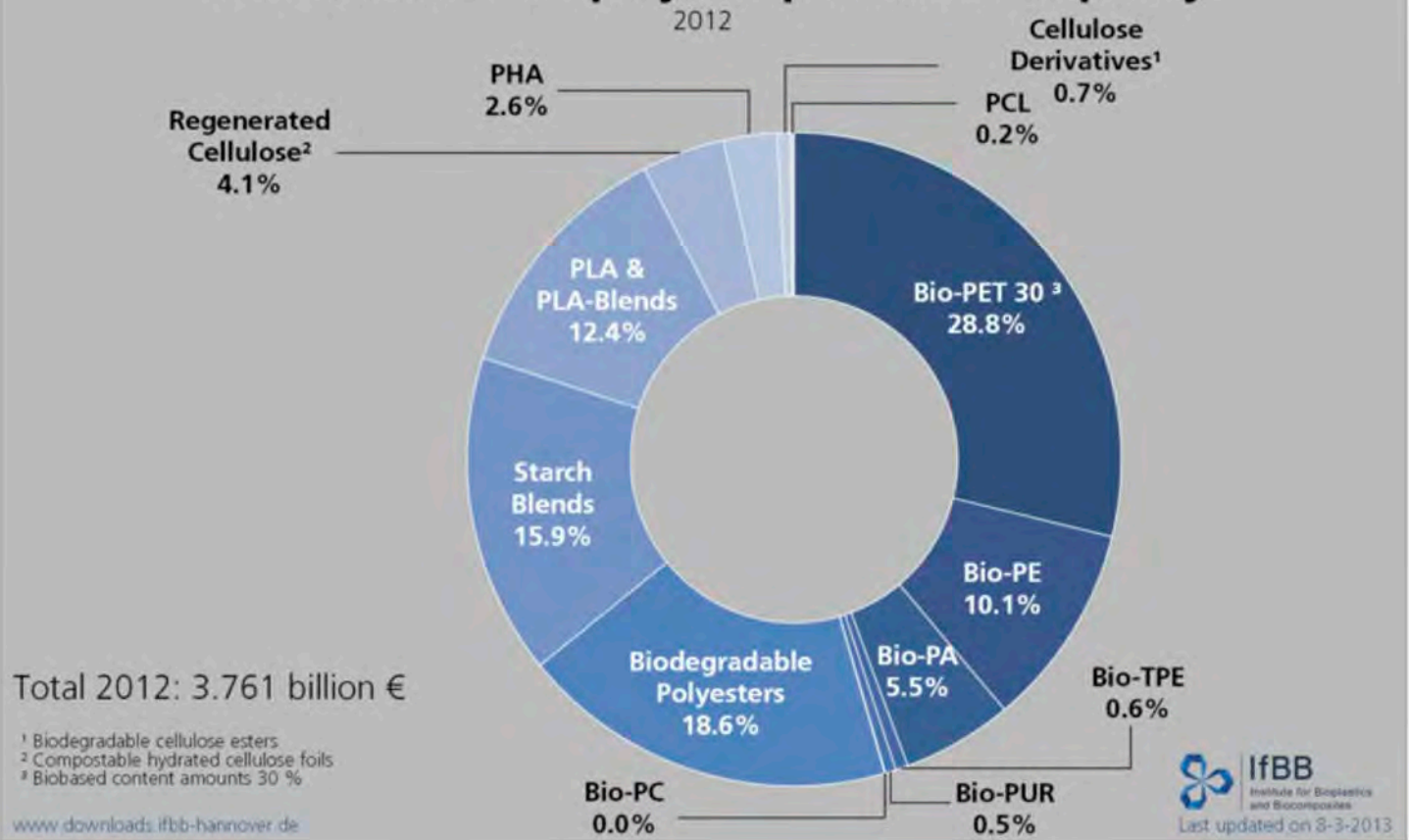


Fig. 2

## Market size share of biopolymer production capacity

sorted by region 2012

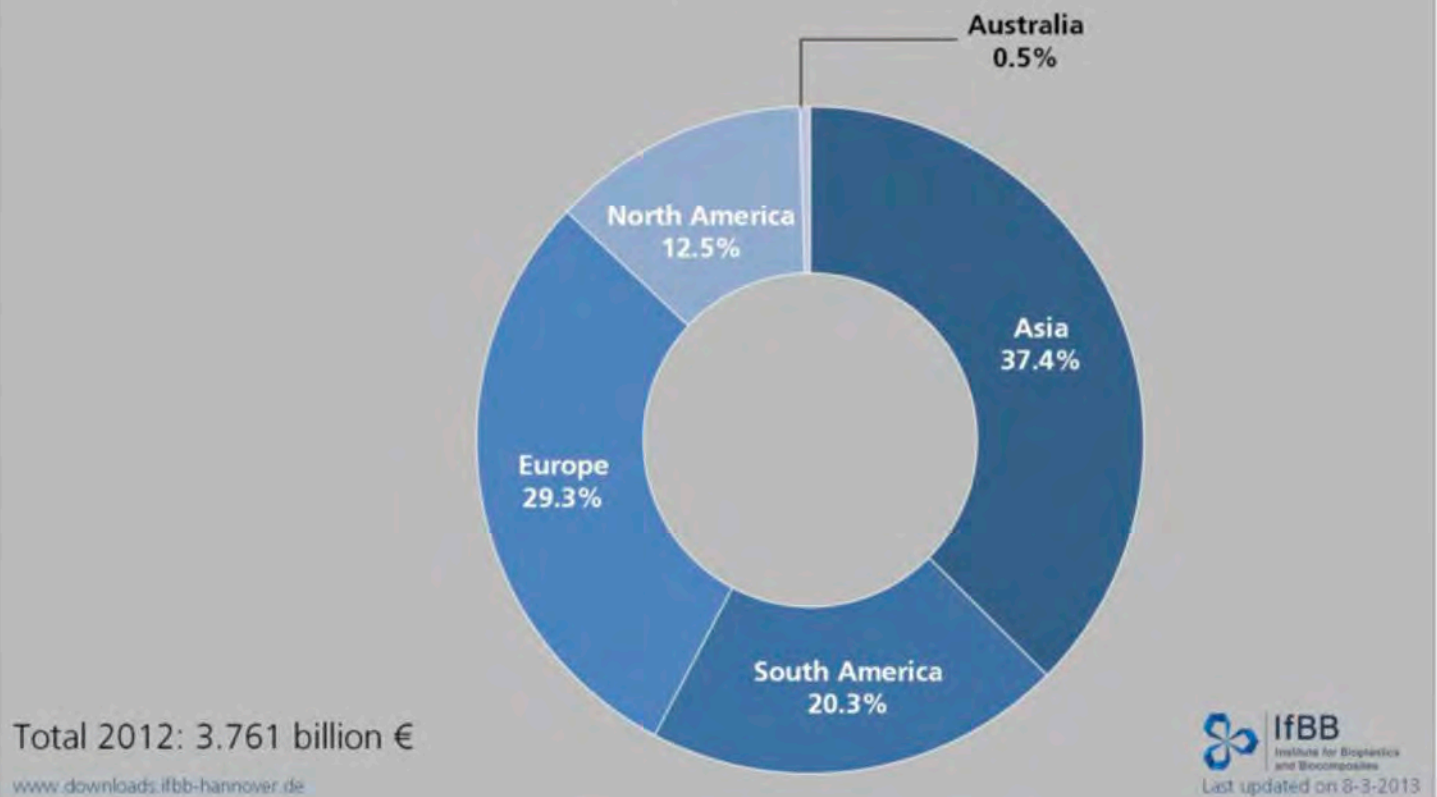
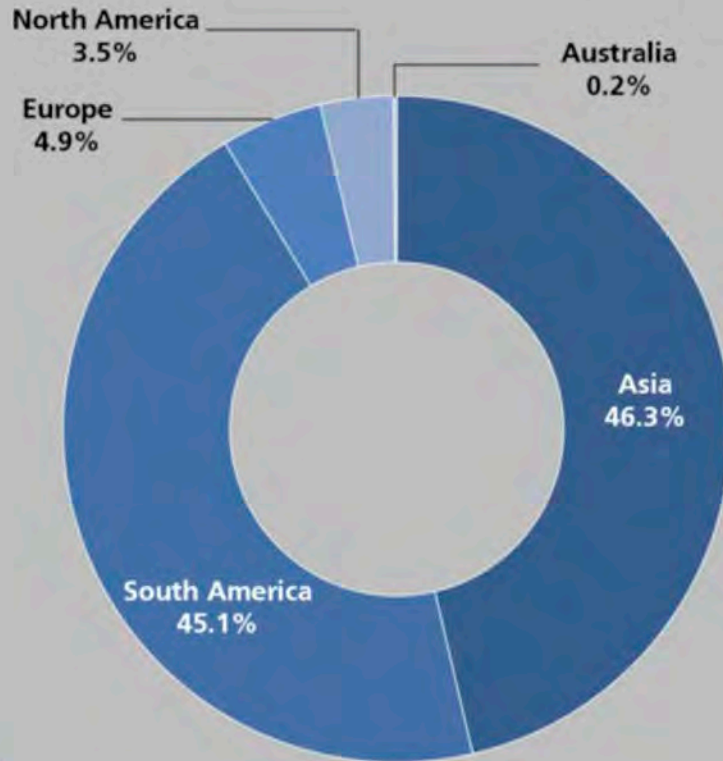


Fig. 3

## Material share of biopolymer production capacity

sorted by region 2016



Total 2016: 5.778 Mt

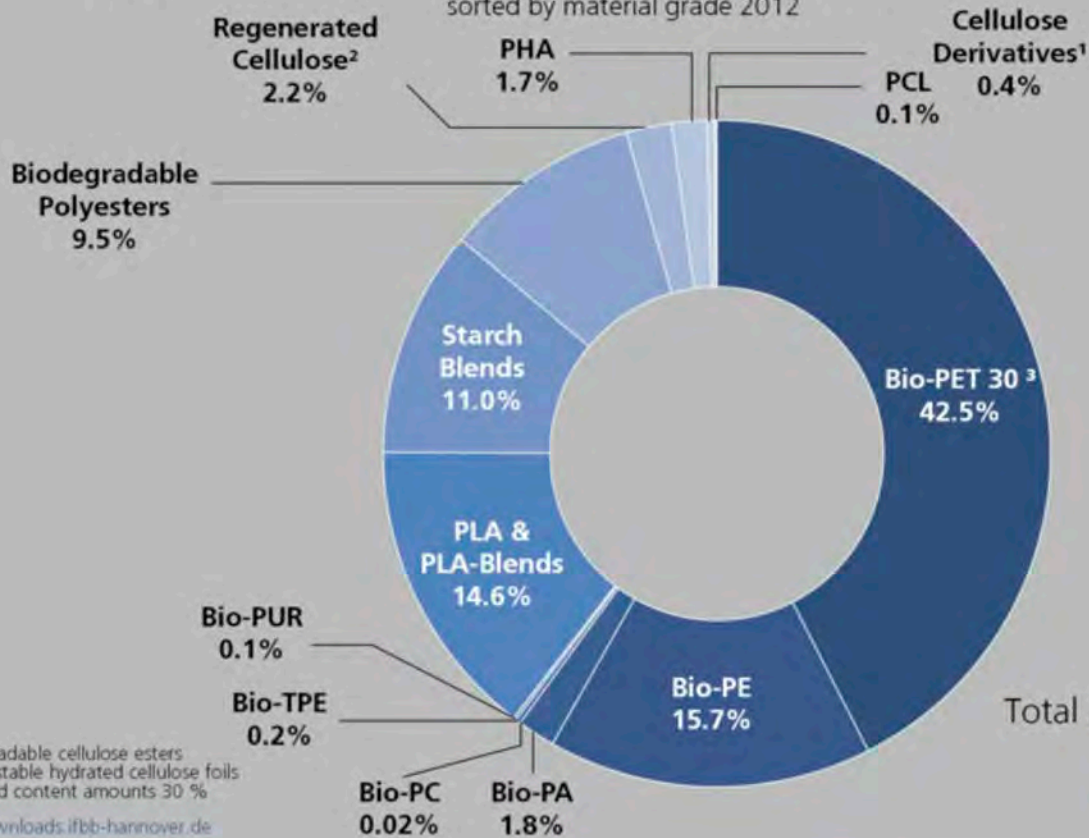
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Fig. 4

## Material share of biopolymer production capacity

sorted by material grade 2012



Total 2012: 1.274 Mt

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<sup>1</sup> Biodegradable cellulose esters  
<sup>2</sup> Compostable hydrated cellulose foils  
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Fig. 5

## Material share of biopolymer production capacity

sorted by material grade 2016

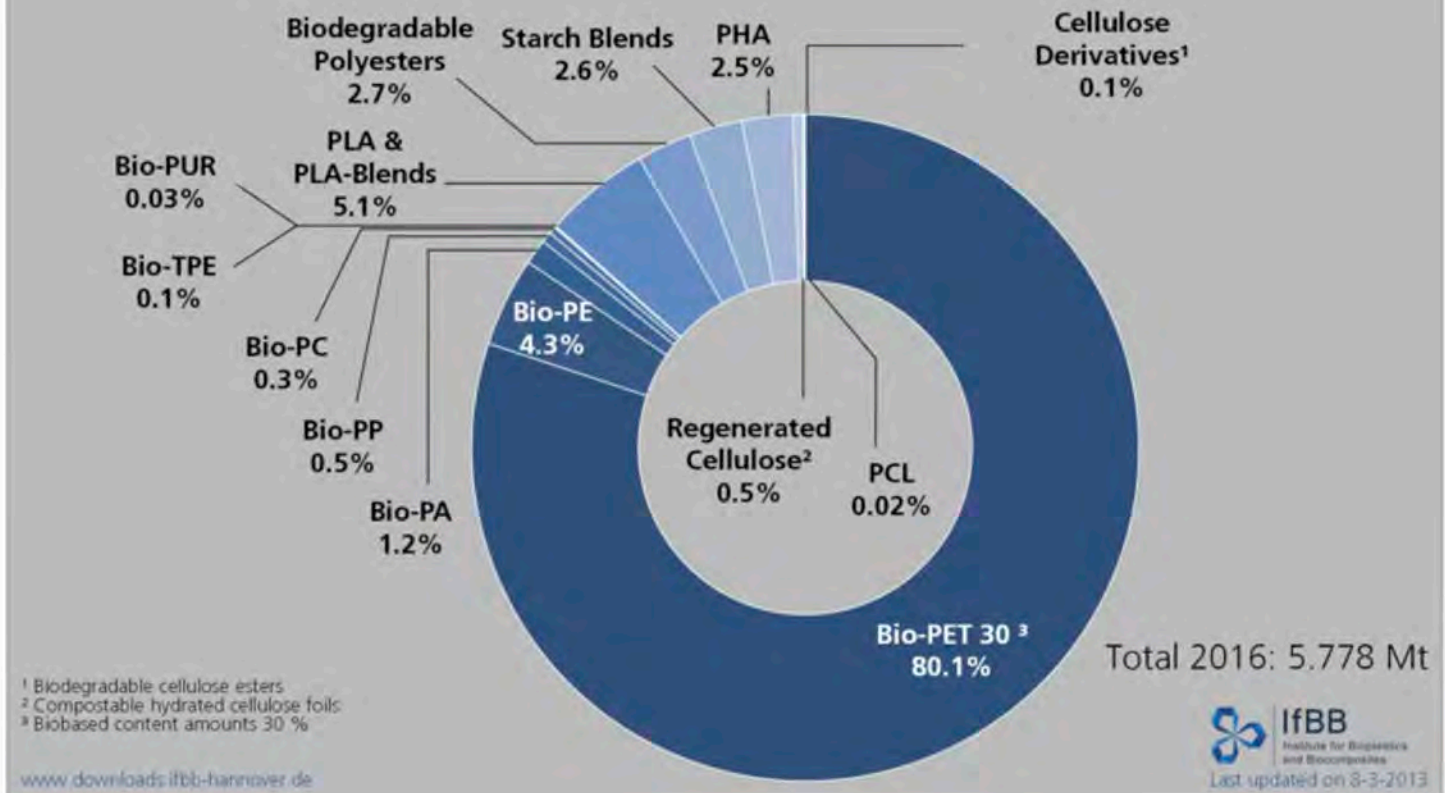


Fig. 6

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# Interview with Marek Nikiforov, GN Plastics

By Conor Carlin, Editor

*Marek Nikiforov is the European Sales Director for GN Plastics. This year, he was the Chairman of the European Thermoforming Conference, held in his native Prague. Multilingual, hospitable and knowledgeable, Marek's experience of thermoforming in Central and Eastern Europe make him a very valuable asset both to his employer and to our industry as a whole. TQ caught up with him just after the conference.*

**Conor Carlin:** Tell us a little bit about your position at GN and your history with the company.

**Marek Nikiforov:** I started my relationship with GN in 1998 as a student. The company where I worked was the agent for GN in Central Europe. In 2004, the GN headquarters (in Halifax, Nova Scotia) set up GN Europe officially and asked me to run the company. I am now the European sales director for continental Europe, Russia and the Middle East.

**Carlin:** Looking at the thermoforming industry in Europe, what general trends are you seeing today?

**Nikiforov:** Generally speaking about broad trends, I don't see that much that is similar to North America. There is some M&A activity (examples include Coveris' purchase of Paccar, Guillin's acquisition of Sharp Interpack) but not to the extent or scale that you see in the US with financial buyers. I really think the small-to medium-sized companies still have a chance to compete and bring products to market. The converters have weathered the financial crisis fairly well but there is some remaining evidence of the credit crunch. Post-2008, customers have to show leasing companies or banks more evidence of contracts in order to get funding. Also, it is more difficult to plan. In the past, we could forecast machinery sales in Eastern Europe, but now we have "surprise" sales in Italy or Spain for example, while what we thought would come through in the Eastern countries does not. In terms of material trends, transparent food packaging continues to move to PET. Post-consumer waste regulations are being driven mainly by the UK market. Prices of virgin PET are declining while PS and other polymers are increasing. Recycled materials are limited to PET but this gives price stability to customers for longer term contracts.

In terms of machinery, most OEMs now provide larger tonnage presses to allow for increased linear cutting. This aligns with the increased use of PET.

"Europe" as an entity is not homogenous. Different countries use different polymers. In Germany, for example, PP is still used for thin packages such as biscuit or chocolate trays whereas you

would see OPS or PET used in France and Belgium. This is driven by recycling mandates (Grunpunkt) and recycling taxes. In the meat tray segment, there is a move from EPS into PP or PET/PE. Sealability is an important consideration. The weight of PP meat trays is lower due to the lower density of PP which means that converters can reduce the relative amount of taxes. Generally, EPS is declining across Europe.

**Carlin:** Can you comment on Central & Eastern Europe in terms of thermoforming technology and market development? Is the region still distinct from Western Europe?

**Nikiforov:** To be clear, we are talking mainly about thermoforming for food packaging. The food segment can be divided into trays (e.g. meat) and cups / margarine containers, usually higher volume products. The main development of the private sector in Central and Eastern Europe started in the 1990s and grew out of the centrally planned economies. For example, in Belarus, there was one company producing cups and trays for the entire Soviet Union – with no competition! At that time, GN machines, being compact and relatively inexpensive, were well-suited to the needs of processors in the region. Tooling was cheap for short-run projects as the needs of those local markets were smaller and different than larger, western countries.

German, Italian and some US machines were still mainly used in Western Europe because of the needs for higher volume runs with more expensive, more complicated tools.

We are seeing more inquiries for water cups (from the Middle East, in particular). Supermarkets are large drivers of packaging requirements. The density of supermarkets per capita has been higher in Western Europe than in Eastern Europe for many years, but now with increasing wealth in the region (especially in Russia), more and more packaging is being designed and brought to market.

**Carlin:** Is the topic of sustainability prevalent in the markets where you are active? Why or why not?

**Nikiforov:** In Western Europe, sustainability is almost like a magic word. When RPET first arrived, the primary driver for adoption was cost. It wasn't initially perceived as having high value when compared to virgin resins. In Eastern Europe, sustainability is correlated with the best price! It's more a question of being economically sustainable. In other words, profits mean sustainability.

If PLA was the same price as PS or PP, it would be accepted

more quickly, I think, in these countries. OPS is still very common for cake domes, meat trays, deli trays, etc. It is a perfect material because of price and transparency. Unlike in Western markets, there is no RPET sheet available to compete with OPS on cost and there are very few recycling programs. Many OPS thermoformers don't have extrusion lines and the scrap commands a high price. The demand for PET scrap, and therefore the price, is much lower. All of this plays into the economics of thermoforming in the region.

Russia uses a lot of OPS because it is cheaper than PET. There is no collection of PET bottles in Russia, so the recycling infrastructure is not yet developed the way it is in Western Europe. Private companies are not yet willing to invest in PET and without government support it is unlikely they will take the risk themselves. Western European governments have supported recycling programs for many years now. I think OPS will still be the material of choice for the foreseeable future.

**Carlin:** What do you see as the main driver of innovation in the areas you cover?

**Nikiforov:** The main driver of innovation at GN is our customers. We try to listen to them and learn from them. Our customers are driven by supermarkets and distribution centers. Those drivers are cost and aesthetics. How can you create new, attractive packages that differentiate you from the competition? Elements like tamper-evident designs are a big driver of innovation in thin-gauge thermoforming. Smarter designs and lower weight packages can command a premium. We see segmentation in terms of packaging, such as 'economy' and 'premium'. For example, high clarity and design elements (ribs, tabs, undercuts) can lead to premium pricing for thermoformed containers. The price differential can be +/- 10%.

**Carlin:** At the K Fair last year, machinery manufacturers from Turkey were well-represented. What can you tell us about the impact of the Turkish market on thermoforming in Europe?

**Nikiforov:** This is a tricky question because the situation is still in flux. The overall market in Turkey is growing very quickly so the machinery companies are serving both their domestic market and export markets. Statistics show that Turkey is now the 3rd largest converting market in Europe so it is something that we are watching closely.

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**Carlin:** You've been a busy man over the past few months getting ready for the 9th European Thermoforming Conference. What do you plan to do with yourself now that it's over?

**Nikiforov:** Well, I am still recovering from our open house event in addition to the conference. We were fortunate that Easter arrived after the conference so I had a few days off, but I have been traveling quite a bit again to Romania, Italy and other European countries. There will be a flurry of activity between now and the summer so more "ABC" for me and my team.

**Carlin:** You mean, "Always Be Closing," the famous phrase from Alec Baldwin's character in the movie "Glengarry Glen Ross?"

**Nikiforov:** Yes, that's the one. We still borrow a few things from you guys in the States! |

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# Multitouch: The New Way to Perfect Thermoforming Sheet

By Peter Rieg, Regional Sales Manager, Battenfeld Cincinnati,  
Bad Oeynhausen, Germany

## The Motivation for a New Roll-Stack

A reconsideration of the roll-stack reflects the need for higher efficiency and improved quality of thermoformed sheet. The primary material focus of this development was polypropylene (PP) where increasing worldwide demand was asking for efficient solutions. With the introduction of high-speed extruder technology in 2004, higher outputs were achieved. However, this also created a challenge to increase cooling capacity. It was well known that wider or larger diameter cooling rolls have a negative impact on sheet quality, especially on semi-crystalline materials like PP. Therefore, the objective has been to develop a cooling system that runs single web only, maintaining or even improving quality. Higher throughputs must be covered with higher line speeds.

## First Steps and Design Principles

A first approach with multiple cooling rolls resulted in no significant line-speed improvements. Analysis had shown that with increased line-speed the heat transfer coefficient between the sheet and the rolls decreased. A quite simple explanation and solution was found: by increasing the line-speed, more air is dragged between the cooling roll and the sheet, creating a very thin but good heat insulation layer. By nipping the rolls, any air entrapment is avoided [picture 1]. The heat transfer coefficient is immediately increased by a factor of 4, independent of the line-speed. Consequently, with the Multitouch all rolls are nipped hydraulically and are independently servo driven [picture 2]. In the sheet forming area, the polishing rolls have a high PLI and each nip is adjusted according to the final thickness. The gap distance of each nip is displayed in the control system and can be adjusted from there.



PICTURE 1 - Air entrapment avoided by nipping the rolls.



PICTURE 2 - Multi-nip section in open and closed position.

The first two rolls (which have to withstand the highest line pressure) are larger in diameter than others in order to provide the necessary low deflection for the first calibration of the sheet thickness. All following rolls are made with smaller diameters. An important design detail is that the circumferential length of the sheet on an individual roll is equal to that of other rolls [picture 3]. Therefore, an individual roll temperature setting is not necessary and all rolls can be supplied from one water source.



PICTURE 3 - If the contact length is equal, at higher line speeds the cooling behavior can be compared to a simulated steel belt.

The effect of the multi-nips is finished when the sheet temperature is below the crystallization temperature. Therefore bigger, simple post-cooling rolls can be used to cool the sheet further down to winding temperatures [picture 4]. In cases where the Multitouch is intended to run in-line with a thermoformer, a haul-off unit is installed instead of the post-cooling rolls.

## The Results

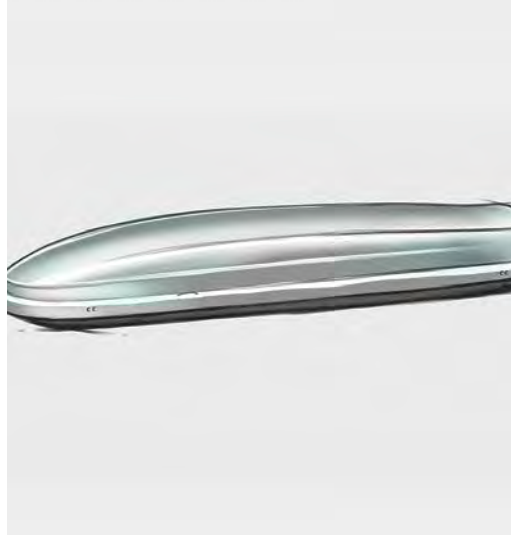
In different test-runs and in a one-year period of field-test the Multitouch has immediately proven its capability to run the desired output. In addition to the easy-to-adjust narrow die, the fully automated process control and short change-over times make it possible to provide a higher uptime than usual. The typical sheet thickness range is between 12-60 mil (in PP) running up to 210 ft/min, with the output mostly restricted by the winding speed.

By installing an indefinitely small melt-bank between all rolls, a smooth surface can be achieved even when the internal heat in the sheet creates surface distortion like heat pockets or "orange skins."

With the first prototype and the first systems in production, other improvements in sheet quality were found in addition to higher line-speeds:

- Due to faster cooling, the size and the amount of the crystals in PP is reduced and the amorphous areas are increased. With homo-PP this leads to much better





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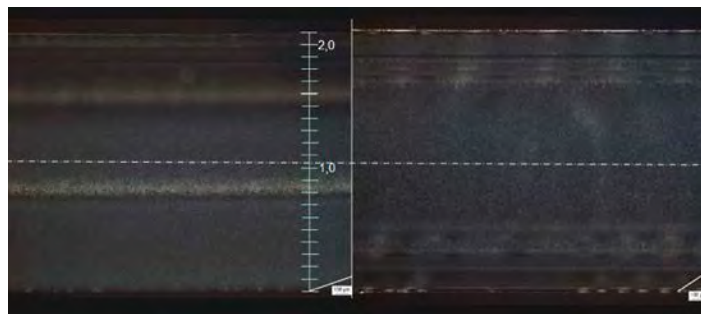
PICTURE 4 - Out-of-line execution of a Multitouch with post-cooling rolls. Polymer flow direction from right to left.

transparency and a wider thermoforming window in general [picture 5].

- From the design principle, the cooling length for the upper and lower side of the sheet is kept equal. With small rolls running at high-speeds, the sheet sees something like a steel-belt with equal cooling from the top and bottom. For this reason, the formation of internal tensions is avoided and the sheet shows improved flatness compared to standard cooling processes [picture 6].
- Running the sheet through multiple nips as long as it is in a soft state leads to an improvement in the thickness distribution. Tests with 60 mil sheet, one produced in a conventional fashion, the other on the Multitouch, showed an improvement in the crosswise tolerance to 25% of the standard value. For the thermoformed article, a reduction in weight distribution over the whole cavity from 0,29g down to 0,08g was observed [picture 7].

### Summary and Outlook

The introduction of this new roll-stack system, the Multitouch, is a further step for higher production efficiency. For certain products it is even possible to produce them first-time, worry-free. Further developments include winders that allow higher winding speed, enabling the Multitouch to perform even better. With higher speeds, lower sheet gages and double-sided polishing should be possible. This surely will impact the market for plastics and packaging, allowing for the creation of better or new products. |



PICTURE 5 - Microscopic comparison of a mono-layer PP sheet produced on a conventional roll-stack (left) and the Multitouch (right): More uniform distributed amorphous areas with the new technology.



PICTURE 6 - Left image: sheet made from identical PP, standard on the right, Multitouch on the left. Right image: Conventional sheet after unwinding with internal stresses, Multitouch sheet in the middle without noteworthy internal stress.

conventional transparent						
	1	2	3	4	5	6
1	6,05				6,03	
2		6,17		6,22		6,04
3	6,17		6,23		6,16	
4		6,08		6,14		6,05
5	6,02				6,03	
6		6,04		6,06		6,04
7	6,03		6,08		6,03	
8		6,05		6,08		6,03
9	5,97		6,01		5,94	

Heaviest cup: 6,23 g  
Lightest cup: 5,94 g

delta 0,29 g

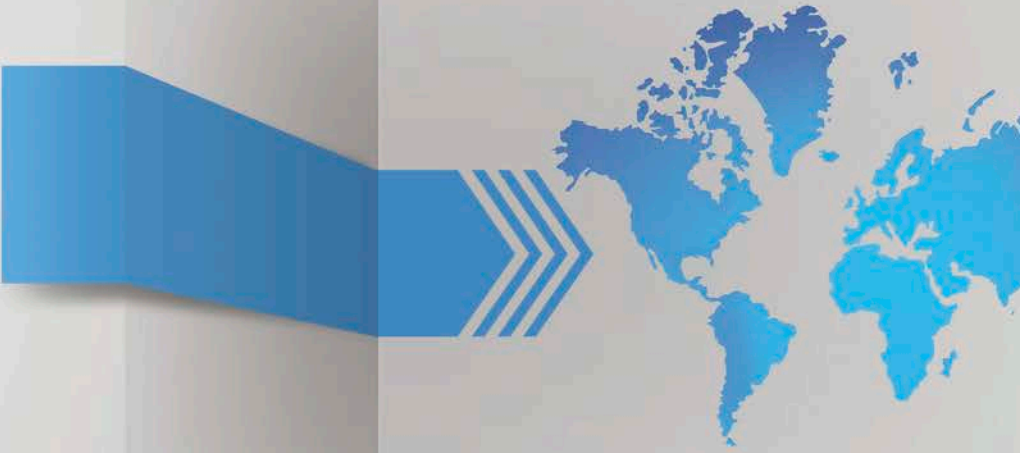
multitouch transparent						
	1	2	3	4	5	6
1	6,00		6,03		6,00	
2		5,99		6,01		5,99
3	6,00		6,03		5,99	
4		6,03		6,04		6,03
5	6,00				6,00	
6		6,01		6,02		6,01
7	6,02		6,05		6,01	
8		6,05		6,07		6,03
9	6,04		6,06		6,02	

Heaviest cup: 6,07 g  
Lightest cup: 5,99 g

delta 0,08 g

PICTURE 7 - Comparison between standard sheet (left) and Multitouch (right). Shown is the cup weight distribution over the cavities.

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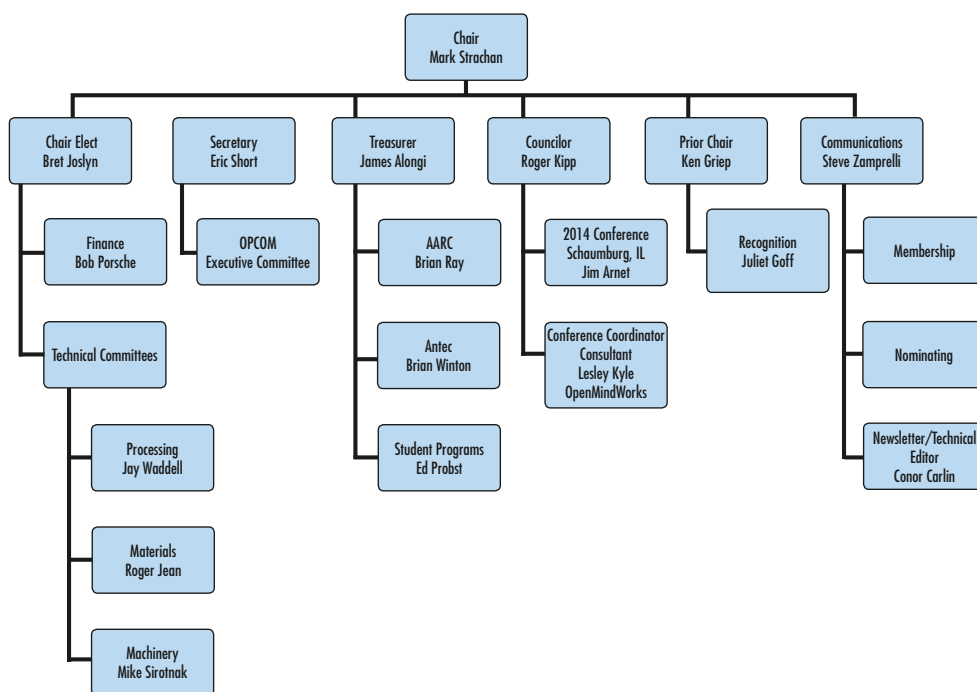
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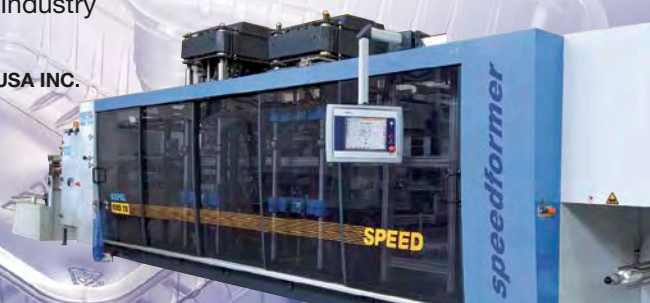
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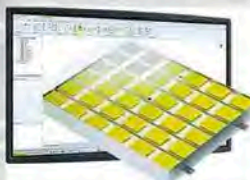
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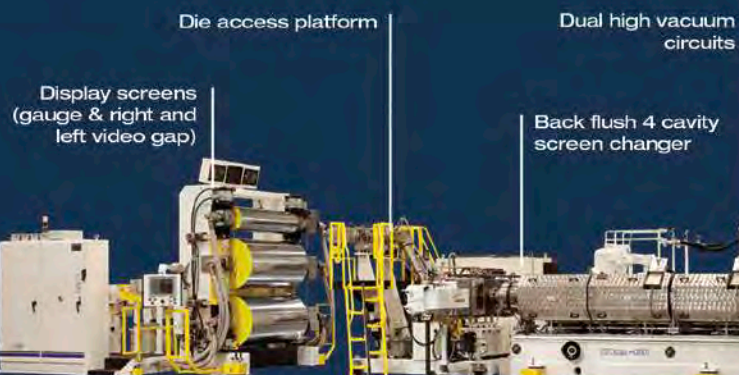


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### World's Largest Inline Dryer-less PET Sheet Extrusion System

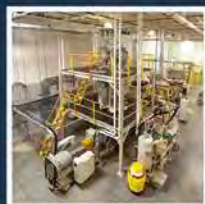
HVTSE™ Model 170mm/420 Twin Screw  
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Width: 54 in (1,370 mm)  
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Technology by Bandera

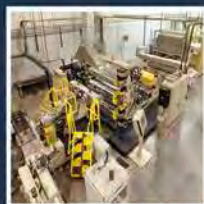
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