Thermoforming Quarterly®

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

FIRST QUARTER 2014 ■ VOLUME 33 ■ NUMBER 1

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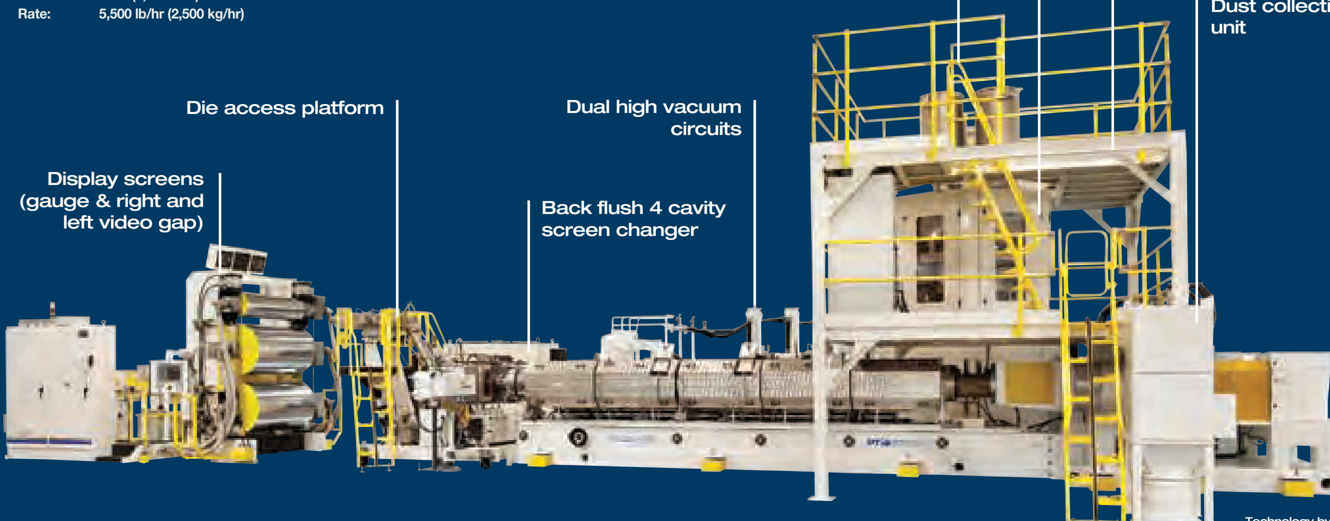

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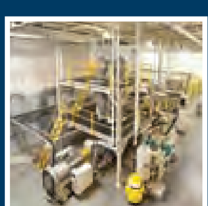
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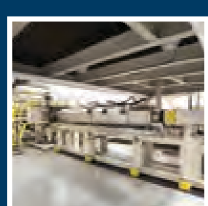
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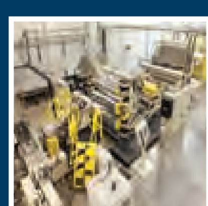
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Mark Strachan

Shape Up to Ship Out!

Here we are, two months into 2014 and we are already looking at a very exciting year for the thermoforming industry. Huge strides in the development of new resin compounds and additives, along with new developments in intelligent machinery operating and monitoring systems, will help make inefficiencies a thing of the past. (Well, greatly reduce them, anyway…)

New, high-tech thermoformed packages that offer exceptional barrier properties along with new developments in oxygen scavenger technologies are now coping with the demands of the food industry (see article on pages 35). Along with new and exciting developments in tamper-evident packages, the thermoforming sector of the packaging industry is doing a tremendous job of keeping products safe on the shelves for longer periods of time while reducing the need for harmful food preservatives.

Decorating of thermoformed packages has also seen incredible advances with in-mold labeling (IML) and pre-printed sheet forming techniques. While plastic continues to be vilified on several fronts, these innovations should be promoted and celebrated.

These advances are exciting, but processors must continue to make capital investments and to develop their human resources if they want to stay relevant and profitable. With an increasing array of machinery configurations and innovative, complex tooling capabilities available to us today, thermoformers have every opportunity to keep pace with increasing demands for quality and speed.

Many of these technologies will be showcased at one or more of the exciting conferences planned for 2014. To name a few:

- SPE European Thermoforming conference (Prague, Czech Republic – April 3-4)
- AMI Thin Wall Packaging Conference (Chicago, IL – May 20-21)
- ANTEC (Las Vegas, NV – May 28-30)
- PIR National Hands-On Thermoforming Workshops (Williamsport, PA – June 10-12 and 24-26)
- SPE Thermoforming Conference (Schaumburg, IL – Sep 15-18)
- Pack Expo (Las Vegas, NV – Sept 23-25th)
- Pack Expo (Chicago, IL – Nov 2-5th)

As I mentioned in my last address, *Thermoforming Quarterly* is now available in digital format for worldwide distribution. All sponsors can now include hyperlinks to their company websites. We continue to seek out new industry practice and technical articles, so send us your ideas. Help us to give back to the industry by promoting knowledge and preparing the next generation of thermoforming practitioners.

Send me your comments and feedback. I look forward to hearing from you.

Thermoforming in the News

North Carolina Thermoformer Diversifies into Aerospace

By PlasticsToday Staff

JANUARY 22, 2014 — AS9100C aerospace certification is enabling a thermoforming processor in Belmont, North Caroline, to diversify into this demanding sector. Wilbert Plastic Services will this year start processing heavy gauge plastic thermoformed parts for this specialized industry, increasing its client base in the Carolinas and across North America.

The announcement was made by company president and CEO Greg Botner. AS9100 was instituted by the Society of Automotive Engineers (SAE) in 1999. AS9100C, the third revision of an international quality management standard for the aerospace industry, is a certification under the ISO9001 series that demonstrates a manufacturers' ability to meet various regulatory requirements, including legal and safety standards. The certification improves customer trust and satisfaction while ensuring reliability per the manufacture of aerospace components.

North Carolina-based Wilbert Plastic Services already serves the automotive, leisure craft, and industrial sectors.

"The AS9100C expands our manufacturing capabilities within the plastics industry," said Botner. "It also offers aerospace customers a new option, one with more than 50 years of plastics experience, to choose when considering plastic products. We're ready to explore these avenues in the year ahead and move into this industry."

Wilbert plastic services acquired the AS9100C for aerospace in the fall of 2013. The certification was specifically awarded to the Belmont location. Added Botner, "This facility allows for the high-quality production of aerospace components or products and is strategically located to offer a wide variety of thermoform products to the industry. We're eager to demonstrate our capabilities."

The manufacturer also holds the ISO9001 certification in addition to ISO14001 and TS16949.

Thermoformer Flexpak Adds Equipment, Eyes Growth in Mexico

By Roger Renstrom, plasticsnews.com

FEBRUARY 13, 2014 — Custom thermoformer and contract packaging firm Flexpak Corp. of Phoenix added two Keyence Corp. model 5120 laser markers in December and plans, during 2014, to seek certification under the ISO 13485 medical standard.

Flexpak will use the device for secondary operations to print kit surgical instructions, part numbers or a logo or brand identification on a tray, Steven Murray, Flexpak president and CEO, said Feb. 11 in an interview at the Medical Design & Manufacturing West trade show in Anaheim, CA.

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

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

Tom Flannery, TriMedEx founder and president, said the agreement is a possible first step toward a full-scale Flexpak medical device thermoforming operation in Tijuana.

Flexpak employs about 60, occupies 82,000 square feet including a controlled environment of 13,000 square feet and projects 2014 sales of $11 million.

The fully integrated manufacturing facility is registered under ISO 9001:2008.

Have an idea for an article?

Submission Guidelines

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

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

• Format: .doc or .docx

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

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(as of February 18, 2014)

1. Forming HDPE on Tooling Board Mold

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Thermoformed Trays: How Plug Assists Play a Crucial Role in Package Design, Material Distribution and Product Safety

By Noel Tessier, Senior Materials Engineer, CMT Materials, Inc.
Attleboro, MA

When it comes to medical plastic packaging, device manufacturers rarely have the option to rank safety, compliance, performance, cost and quality in order of importance. For most device manufacturers and their suppliers, each of these elements is equally important. Whether you are working with rigid thermoformed trays, form/fill/seal trays or flexible pouches, the same rules apply. In this article, we will focus on thermoformed trays and how plug assists play a crucial role in package design, material distribution and product safety.

Plug assist technology allows plastics processors to reduce starting gauge, reduce cycle times and improve material distribution. There are different types of plug assist material, each with their own benefits (see Table 1).

Syntactic foam plug assists are purpose-engineered for thermoforming and provide unique properties that result in superior packaging.

There are several key pre-requisites for any thermoformed tray in medical device packaging including rigidity and clarity. Features such as impact resistance and ease of de-nesting (the ability to stack, or 'nest', one tray on top of another without sticking) are also considered. Material selection therefore is of primary importance. Certified, medical grade films made from HDPE, PP, PS and PETG are the most commonly used materials in thermoformed medical packaging. Each material type has its own characteristics and sheet suppliers generally provide the appropriate documentation outlining specific properties including specific gravity, tensile strength and, perhaps most importantly, thermoforming temperature.

Heating and Cooling the Sheet

Best practice suggests that the temperature of the plastic sheet should be measured to ensure the optimal forming window. New data-driven technologies are being integrated with thermoforming systems that allow processors to dial in very specific measurements. Generally speaking, the goal is to keep the heat in the sheet right up to the point where the plastic enters the tooling cavity. This is where the plug assist becomes part of the equation.

Category	Material	Pros	Cons
Historical/Traditional	• Wood • Felt • Foam/Felt covered forms	• Good insulator • Ease in machining • Low cost	• Durability/dimensional stability • Mark-off/Part repeatability • Temp resistance
	• Aluminum	• Temp/process control • Durability • Surface characteristics	• Temp/process control • Increased cycle time • Process cost
Traditional Solid Polymers	• Delrin® • Nylon • Urethane	• Cost & availability • Ease in machining/ toughness • Surface characteristics	• Poor durability/dimentional stability • Poor insulators • Temp resistance
High Performance Solid Polymers	• Polysulfone • PEI	• Improved temp resistance • Toughness/strength • Surface characteristics	• Poor durability/microcracking/ Crazing • Poor insulators • High cost
Engineered Plug Assist	• Syntactic foam	• Excellent insulator • Ease in machining • Surface finish choices • Durable	• Learning curve for use • Initial cost • Many choices

Table 1: Categories of plug assist materials with comparative benefits

The plug is designed to pre-stretch the material into the right place at the right time. Doing so adds a level of predictability to a process that is notoriously filled with variables. Let's look at two such variables as they relate to the plug: thermal conductivity and the coefficient of thermal expansion.

Thermal Conductivity

Thermal conductivity refers to the quantity of heat that passes in a unit of time through a unit of area when its opposite faces differ by a unit of temperature (BTU/hr-ft-°F). In this case, we are talking about BTUs as the quantity of heat that passes in an hour in a foot for every degree of temperature difference between the plug and the sheet. A high number either means the plug will quickly freeze the sheet or that it must be heated/cooled with an outside means to match the sheet temperature. This is logical, but it adds cost and complexity while increasing the cycle time.

It is also the case that air flow and ambient conditions can vary, which reduces consistency. Most processors choose a plug with very low thermal conductivity simply because it does not remove heat or chill the sheet under any conditions. The lower the conductivity number, the less impact it has on the sheet.

Coefficient of Thermal Expansion

The coefficient of thermal expansion (CTE) is the amount of expansion (or contraction) per unit length of a material resulting from a one degree change in temperature. In simplest and most practical terms for the thermoformer, it can be thought of as how much a material will grow when its temperature increases. In English units it is typically expressed in length/length/per degree Fahrenheit (in/in/°F). In metric, it is m/m/°C.

Syntactic foams are filled with hollow glass spheres, so even though they are polymeric in nature, the stable fillers mean that the CTE is relatively low, around 20-30 x 10[superscript starts]-6[superscript ends] in/in/°F. When you couple this with the fact that syntactics are excellent insulators and therefore take less heat from the sheet and run at much lower operating temperatures, you have a material that maintains a much higher dimensional stability than other plug material types. By way of comparison, Delrin has a CTE of 59 x 10-6 in/in/°F. Nylon can range from 40-60 x 10[superscript starts]-6[superscript ends] in/in/°F. This means they grow and change greatly during the process as they absorb heat from the sheet during contact. With more stable materials, the thermoforming process itself becomes much more stable, providing for a greater degree of consistency and repeatability.

Plug Geometry, Plug Material and Package Design

When it comes to package design, form and function must be balanced. Design engineers use state-of-the-art software to create innovative and eye-catching packages while still maintaining the fundamental goal of protecting and displaying the product inside. Syntactic foam plug assists aid in the design process by pre-stretching the sheet into position without removing heat or affecting its formability. This is critical because the design work is based on material specifications which are based on specific, optimal sheet forming temperatures. Overheating a sheet is often the cause of loss of plastic orientation, lower strength, loss of clarity, sheet stick to the plug and a wide range of uncontrolled issues, all due to compensation for a plug that chilled the sheet on contact.

It is important to understand the interplay of the plug material, plug geometry, tool design and sheet temperature, and not just to look at each element in isolation. Surface friction, roughness and temperature are all in play. To control the interaction between plug and sheet requires the ability to modulate release. Doing so reduces variability and increases repeatability.

Testing and Validation of Specific Plug Materials

CMT Materials of Attleboro, Massachusetts, USA, and RPC Cobelplast of Lokeren, Belgium, performed tests to develop optimal plug materials for multilayer barrier films that would be used in both rigid thermoformed trays and form/fill/seal (FFS) applications.

RPC Cobelplast is a leader in coextruded, multilayer, high barrier plastic films for the European and international thermoforming market. RPC has a custom-made laboratory thermoforming machine to aid in the development of improved multilayer films for thermoforming. This machine was used to evaluate a range of plug materials in forming multilayer packages from a PE/EVOH/PS coextruded sheet.

Two series of different plug materials were evaluated: PTFE, POM, HYTAC-W, HYTAC-B1X, HYTAC-WFT and HYTAC-FLX. Initial trials showed HYTAC-WFT and -FLX to have the best potential for medical thermoforming applications. Based on these results, CMT went back to the laboratory and developed HYTAC-FLXT to combine the best performance properties of the two materials. A third set of trials showed HYTAC-FLXT to have the best forming and release characteristics of all the plug materials in multilayer applications with EVOH.

A final series of trials compared RPC's standard PTFE plug material to HYTAC-FLXT using a starting sheet of 1.4 mm thickness of PE/EVOH/PS. The team looked at optimised plug geometry for PTFE as well as several process variables developed for the PTFE plugs and compared them to three different plug geometries for HYTAC-FLXT and process changes to determine the best conditions for HYTAC-FLXT.

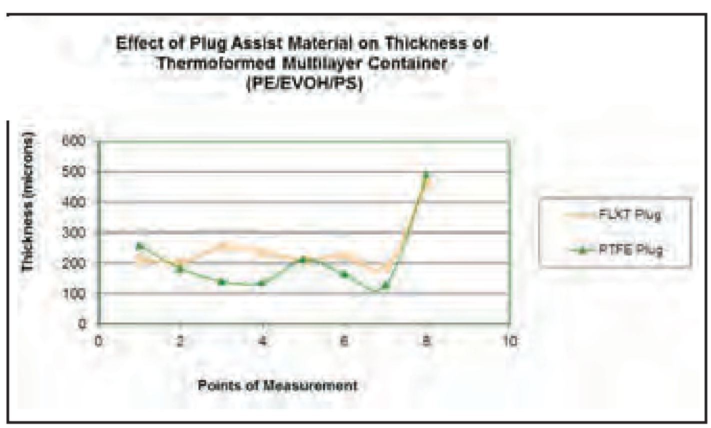


Figure 1: compares the thicknesses for the multilayer with EVOH

Sustainability and the Bottom Line(s)

Reducing the starting gauge of the plastic sheet is a well-known reason to use plug assists, but the benefits extend beyond the package. Using less material through down-gauging (or light-weighting) has important environmental benefits. When considered in the context of millions of packages produced each year, the numbers can drive change at the top levels of major device manufacturers, especially those public companies with prominent commitments to sustainability. Whether it's due to ESG reporting (environmental, social and governance) or CSR requirements (corporate social responsibility), business are seeing how innovations in packaging not only result in a lighter environmental footprint, but also in tangible cost savings.

The judicious use of plug materials and of plug assist techniques have proven to reduce material thickness without compromising the quality and integrity of the package. That's a double-bottom line worthy of notice from the design lab to the C-suite.

Acknowledgements: RPC/CMT study (2009)

About the Author

Mr. Tessier is a materials engineer with over 35 years of experience in the Research and Development of composite materials and syntactic foams. He is one of the three founding directors of CMT Materials, Inc (1998), the first company to be dedicated to thermoform tooling materials. Author and co-author of five patents and numerous articles and presentations, Mr. Tessier's impact on thin-gauge thermoforming can be measured both by the increasing volumes of plastic packaging around the world and more specifically by the adoption and growth of third axis plug-assist forming. He is currently responsible for the development of new and innovative materials at the company.

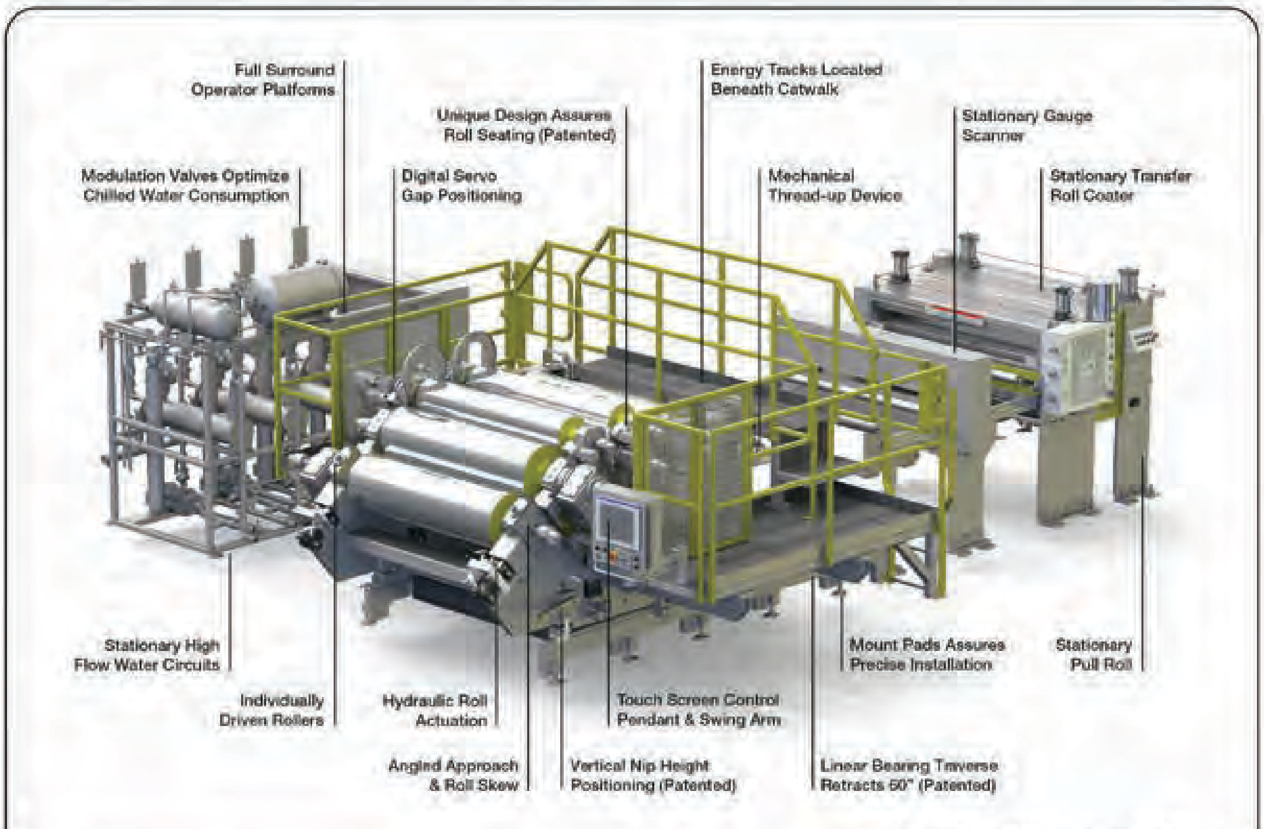
Super G Multi-Nip™ Roll Stand from PTi

PTi is the leading manufacturer of highly engineered sheet extrusion systems. This article illustrates and describes the benefits of PTi's newly introduced all-nipping roll stand for cooling and polishing sheet. The major benefits of this design are as follows:

- Multi-patented technology assures all rolls are properly nipped for optimal performance
- High capacity thermal ability provides uniform core temperature ideal for Form, Fill & Seal applications
- Multi-roll arrangement yields ultra-low sheet orientation (i.e.; stress-free production)
- Compact configuration minimizes system footprint
- High quality sheet aesthetics result from the all-nipping rolls

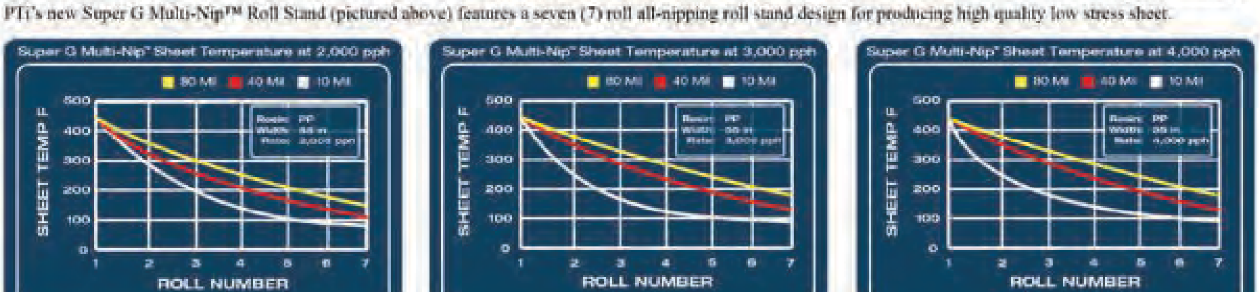
The charts listed below show the average sheet temperature as the sheet passes through the unique roll stand. The analyses examined 80, 40 and 10 mil sheet thicknesses at production rates of 2,000, 3,000 and 4,000 lbs/hr for unfilled PP resin at 55 inch sheet widths. In each case the data reveals the achievement of a rapid cooling rate while maintaining balanced average web temperatures. This results in the production of a high quality 'stress free' sheet ideal for many demanding sheet applications including Form, Fill & Seal. Comparative analyses were performed using much larger roll stand configurations as a benchmark. In each case the Super G Multi-Nip™ out performed these benchmark cases.

For more information on PTi's products and services go to www.ptiextruders.com or contact sales at (630) 585-5800.



Featured in PTi's Demo Center July 2014.

PTi's new Super G Multi-Nip™ Roll Stand (pictured above) features a seven (7) roll all-nipping roll stand design for producing high quality low stress sheet.



Thermal analyses results (pictured above) reveal sheet temperature versus roll position cooling performance at production rates of 2,000 pph, 3,000 pph and 4,000 pph for sheet thicknesses of 80, 40 and 10 mil running unfilled polypropylene (PP) at 55 inch sheet widths.

An Inside Look at ISO Certification

By Heidi Lake, Red House Media and Dave Fosse, LINDAR Corporation

"ISO certified." We've all probably heard about this internationally acclaimed form of quality management, but is it really worth all the hype? LINDAR Corporation thinks so.

Founded in 1993 in Baxter, MN, LINDAR specializes in three different thermoforming segments: paint supplies, food packaging and custom industrial plastic components. The company spent the last three years adjusting their processes to meet the International Organization for Standardization's (ISO's) intense requirements and recently became 9001:2008 certified for quality management systems.

A leading manufacturer of paint trays, paint tray liners and wallpaper water trays, LINDAR creates custom products for some of the world's most well-known paint supply companies. The company is committed to using reliable, recyclable materials and a manufacturing process that is not only fast, but efficient and cost effective.

What does it mean to be ISO certified?

ISO is the world's largest developer of voluntary international standards, providing top-of-the-line specifications for products, services and good practices in thousands of industries around the world, from food safety and computers to agriculture and healthcare.

"We use ISO's standard for quality management to continuously improve our service, operation and manufacturing processes to exceed our customer's expectations," said Dave Fosse, LINDAR's director of marketing and key account development.

With more than 18,000 standards for technology and business in 163 countries, ISO standards are created to make the world a safer, cleaner, more efficient place to live, work and play.

Standards are available in many categories, including food safety management (ISO 22000), information security (ISO 27001), and quality management (ISO 9000). The ISO 9000 category addresses various aspects of quality management providing guidance and tools for companies who want to ensure their products and services meet their customer's requirements and that quality is consistent.

There are many standards within the ISO 9000 family that are associated with a company's quality management. LINDAR is ISO 9001:2008 certified, meaning they follow ISO's manufacturing and ordering processes, ensuring consistent cost, quality and on-time delivery of both products and services.

"At LINDAR, we use our ISO certification as further proof that we are accountable, efficient and we care about our performance," Fosse said. "Our customer base includes all of North America, and we want even our most faraway customers to know they can count on consistent, high quality products from us."

Benefits of ISO Certification

After nearly six months of being ISO 9001:2008 certified, LINDAR is already seeing the benefits. With monthly internal audits and annual external audits to review quality management processes, LINDAR is accountable for not only their products, but their manufacturing processes as well.

"We always want to improve and we have set incredibly high goals for ourselves," Fosse said. "ISO is a great tool that helped us get the systems we needed in place to accomplish our goals."

As a plastic thermoforming manufacturer, LINDAR falls under ISO's rubber and plastics company category. Fosse said because there's an elite group of American companies within that category, the ISO certification makes LINDAR stand out among their competition.

"Becoming ISO certified was not easy, but it was well worth our efforts. It reinforces our 'can-do' culture in both management and our processes," Fosse said. "It allows us to hold ourselves accountable while assuring our customers that our products are safe and high quality."

Becoming ISO Certified

While LINDAR is certified to ISO's 9001:2008 category for quality management, there are thousands of classifications to meet virtually any industry, including manufacturing, distribution, mechanical engineering, quality management and services. ISO develops the international standards, but certification is performed by a third party, accredited, certification firm. For example, LINDAR is certified by TUV SUD America, Inc.

The cost for certification varies greatly — reportedly anywhere from $2,000 to $50,000 per year — depending on many factors, including the maturity of the existing management systems, the size and complexity of the organization and the implementation of a formal management system.

For LINDAR, the extensive three-year certification process cost tens of thousands of dollars, and required them to thoroughly document the safety, culture, quality and processes needed to manufacture thermoformed plastic parts. In the end, TUV SUD America, Inc., named LINDAR one of a select group of plastic product facilities in the United States to achieve the ISO 9001:2008 certification, with three "best in class" rankings.

"It took a lot of work and dedication to reach this extremely high level of quality management, but we are proud to say we did it," Fosse said.

Composite Material Properties in Laminations

By Robert M. Stack and Francis Lai
University of Massachusetts Lowell

ABSTRACT
The criteria for successful laminations were investigated through research into the development of thermoformed composite structures. A review of several ASTM and ISO standards was performed for testing and evaluating these materials in terms of strength, impact resistance, flexural properties, and adhesive strength in various modes of failure for the components to the final products. Further, it was determined that the T-peel test (ASTM Standard D1876-08) was the most useful to quantify the quality of adhesion of the laminates produced.

Introduction
Composite materials are found in thousands of applications across many industries from aerospace and automotive to recreation and packaging. What began as a means of producing relatively light-weight, large-scale plastic products has grown to include combinations of many materials to take advantage of their own particular properties. Nielsen [1] listed many advantages of composite materials including, strength and modulus, impact resistance, corrosion resistance, chemical resistance, improved mechanical damping and increased heat distortion temperature. In this research, critical-to-quality features regarding composite mechanical properties are identified and the synergies of coupling of materials in composite laminations are demonstrated. Several laminations produced by the thermoforming process are investigated for strength, flexibility, impact resistance versus their component materials. The primary objective was to develop an understanding of the significant factors that allow or prevent a material's use. A second objective was to evaluate test methods and quantify the quality of the composite structure. This required investigation into the basic theories of cohesion and adhesion and their measurement factors including solubility, cohesive energy density, polarity and surface energy. Currently, there are over 100 ASTM standards related to the testing and characterizing of composite materials. Several of the most commonly utilized standards are discussed in regard to their application to twelve thermoformed laminations produced for evaluation of this production process. These laminations are evaluated for the core mechanical properties, and then tested as unitized materials for shear strength and peel resistance.

Adhesion, Cohesion and Developing Laminated Materials
In order to develop practical laminated materials with properties more desirable than the sum of their parts, it was necessary to investigate both adhesion and cohesion. Dupre [2] investigated and described the nature of the energy of adhesion, W_a as a function of surface energies as:

$$W_a = \gamma_1 + \gamma_2 - \gamma_{12} \qquad (1)$$

where γ_1 and γ_2 are the surface energies of the two surfaces in contact, and γ_{12} is the energy of the interfacial tension. According to Buehler, "the energy of adhesion represents the work necessary to separate the two surfaces from their adhesive contact. If the two surfaces that are brought into contact are identical, they will coalesce to form a homogenous body. Then, the decrease in free energy is the work of cohesion, W_e, which is the reversible work necessary to create two new surfaces as"[3]

$$W_e = 2\gamma_1 \text{ or } W_e = 2\gamma_2 \qquad (2)$$

Often, the adhesive strength of the system is greater than the cohesive forces within any of its components. With sufficient adhesive or cohesive energy composite materials can be tailored to create any number of desirable properties.

Characterizing the Strength of a Laminated Composite
Compatibility of polymers became a significant concern with the advent of modern techniques of over-molding, insert molding and multi-material injection molding. One early compatibility chart, shown in Figure 1 and still in use today in industry was developed by Eckardt *et al.* [4].

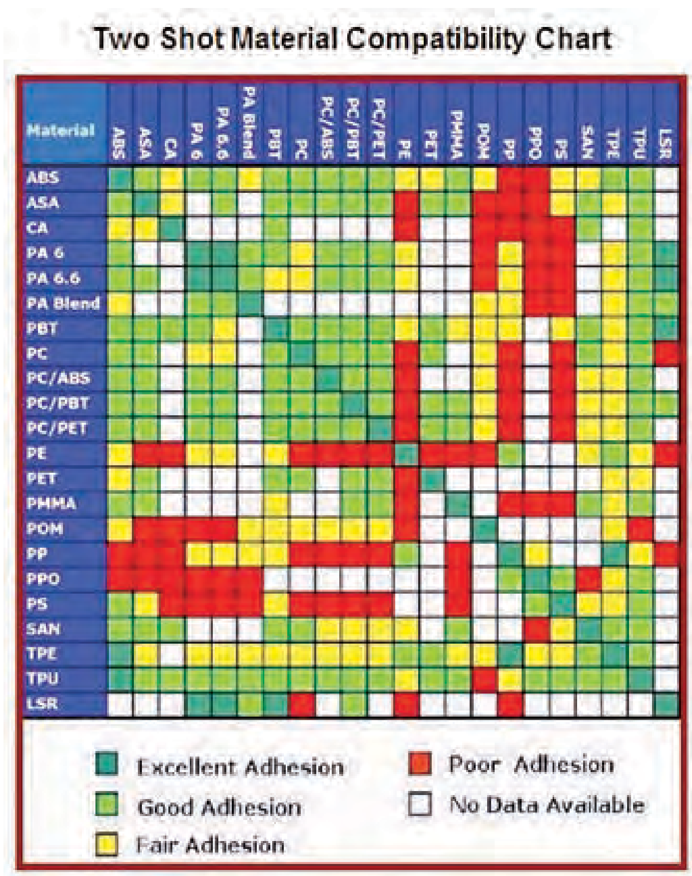


FIGURE 1. Material compatibility chart developed for coinjection molding [4].

The compatibility observations noted were simply qualitative in nature. The simple criterion was based on the following breakdown: did the materials adhere at all; did they break upon flexing; did they break upon shearing with a scissors; or did they form a strong bond not easily separated. The process of characterization of the mechanical strength of a laminated structure has since been refined by the acceptance of several ASTM and ISO specifications. The application of each is dependent on the nature and direction to resistance of stress whether it be tensile, shear, flexural, or impact. The following is a summary of commonly applied tests, starting with the substrate materials and through the net composite.

Testing of Substrates

Testing of the homogeneous polymer substrates of a lamination on an individual basis is the typical starting point in evaluating a laminate design. The ASTM standards applicable for testing of plastics include ASTM D638-10 [5] or D882-10 [6] for tensile testing, depending on thickness, ASTM D790-10 [7] for flexural properties and ASTM D256-10 [8] for determining impact resistance by the Izod method. These tests will help determine the weakest potential link in the matrix due to a cohesive failure. When evaluating materials versus manufacturing capabilities, data should be taken relative to process conditions, strength and modulus must be evaluated versus an appropriate elevated temperature and a comparable strain rate. Often, this is the data required by numerical simulation programs.

Testing of a fiber filled reinforced layer is the next level of consideration. ASTM has published standard specifications for glass fiber strands within ASTM D578/D578M-05 [9] and several specifications for carbon fiber reinforcements depending on the application. The standard test method for testing the tensile properties of glass fiber strands, yarns and roving for use in reinforcing plastics is detailed in ASTM D2343-09, "Standard Test Method for Tensile Properties of Glass Fiber Strands, Yarns, and Rovings Used in Reinforced Plastics" [10].

To measure the adherence of the resin to the reinforcing strand, no ASTM standard has been established to date. One method that has gained acceptance in the aerospace and defense industry has been the microbond test, particularly in high-impact ballistics applications. This method, developed by Miller, Muri and Rebenfeld [11], involves the application of a drop of resin onto the surface of a single fiber, curing the fiber-resin system to form a solidified droplet, and then applying a shearing force and measurement of the resistance to pull the fiber out of the droplet. Figure 2 shows the basic set up.

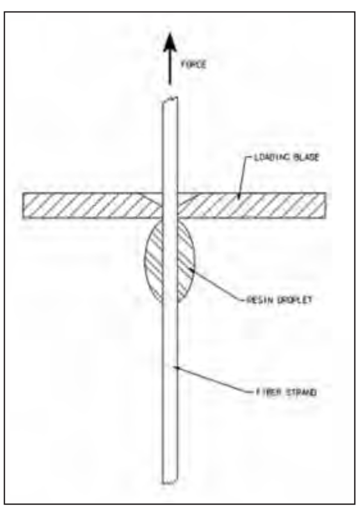


Figure 2. Schematic of a microbond test apparatus.

This force is the basis of the interface shear strength, τ, calculation where:

$$\tau = \frac{F}{\pi d L} \qquad (12)$$

with d being the diameter of the fiber and L, the adhesive length. The accuracy of the measurement may be affected by the amount of gap between the fiber and the loading blade (or knife or microvise). Studies have been conducted with both a sharp entry diameter, as in Figure 2, and concave entry [12], which showed these conditions affect stress distribution and strength measurements. It has also been shown that results may vary due to the size of the drop's meniscus, which corresponds to its overall diameter and its viscosity, and test speed. A meaningful microbond test has been characterized as one with no fiber break prior to separation of the droplet.

Testing the Laminate Structure

The standards for testing fully constructed composite laminations are summarized in ASTM D4762-11a [13], "Standard Guide for Testing Polymer Matrix Composite Materials" and ASTM D6856/D6856M-03 [14] "Standard Guide for Testing Fabric-Reinforced 'Textile' Composite Material. ASTM D4762-11a lists 110 separate test standards for characterizing and evaluating composite materials. ASTM D6856/6856M-03 lists 28 standards, some being crossover. Table 1 of the D4762-11a standard presents each with a graphic representation, a test description, and describes its advantages and disadvantages alongside its test standard designation. The later standard provides a brief description of terms and definitions related to woven materials, unit cells, weave and braid patterns, yarn counts, yarn sizes, yarn spacing and yarn contents. Sampling, test specimen geometry, fabrication, conditioning, and test methods and reporting are directed in the referenced standards.

Some of the recommended standards, per ASTM D6856/D6856M-03 include ASTM D3039/D3039M [15] for unnotched tension testing of textile composites. Here uniaxial tension tests are performed on specimens of a recommended size with a ratio of specimen width to unit cell width of 2:1. The specimen width being at least two unit cells within the specimen gage section. The standard is quite similar to ASTM D638-10 [5] for homogenous materials, but the reporting requirements include identifying ply stacking sequence, ply thickness, and orientations within the specimens, stress and strain data, calculations of modulus of elasticity and Poisson's ratio, and failure mode. Graphic representations potential failure modes and associated reporting codes are provided for reference.

For flexural testing, ASTM D790-10, "Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials", and ASTM D7264/D7264M-07 [16], "Standard Test Method for Flexural Properties of Polymer Matrix Composite Materials" may be performed. The later is more general. Another commonly referenced standard is ISO 1430-1997 [17], "Fiber-Reinforced Plastic Composites — Determination of Apparent Inter-Laminar Shear Strength by Short-Beam Method." This method calls for a three point bending test with free ends, which is very similar to D790-10 [7].

Specimens are selected in the principal usage direction, or both longitudinal and transverse directions. The apparent shear stress is given by the beam equation:

$$\tau = \frac{3f}{4bh} \quad (13)$$

with f, the maximum load at failure, b is the width and h is the specimen thickness. This standard also provides figures to characterize modes of failure for comparison and reporting including single and multiple end shear indications, tensile and compression failure indications and mixed modes.

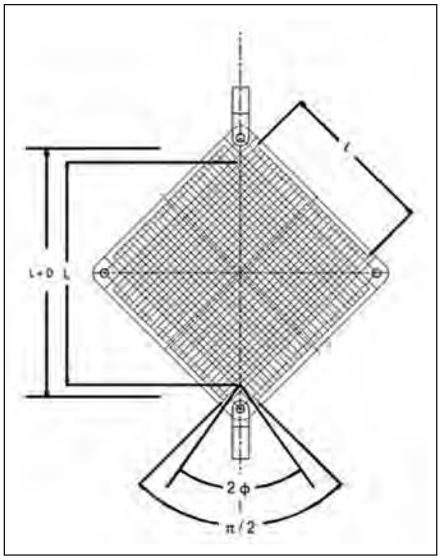


FIGURE 3. In-plane shear test clamp with material.

For in-plane shear testing of textile composites, ASTM Standards D3518/3518M [18], D5379/D5379M-12 [19] or D4255/D4255M [20] may be utilized depending on the weave construction. The first, ASTM D3518/3518M is the simplest to administer, as it does not require any special fixturing. Another method to make shear characterization was described by Lomov et al. [21], requiring a specialized picture frame clamp. Here a 90-90 weave specimen is inserted in a four-sided clamp which is mounted in a standard tensile testing machine as in Figure 3.

The calculations required to define a shear modulus and viscosity are as follows. First the shear angle θ is established from:

$$\theta = \frac{\pi}{2} - 2\varphi = \frac{\pi}{2} - 2\cos^{-1}[\frac{(D/2)+(L/2)}{l}] \quad (14)$$

with the shear force described as a function of the force read by the cross head load cell, F_{XHD} and the angular extension ϕ as:

$$F_s = \frac{F_{XHD}}{2\cos\varphi} \quad (15)$$

and the shear modulus described by:

$$G = \frac{F_s}{l \cdot h \cdot \tau} = \frac{2F_s}{l \cdot h \cdot \sin\theta} \quad (16)$$

with h being the thickness of the material and τ, the shear stress.

To determine the shear effective viscosity variable, μ, the following equation can be utilized:

$$\mathrm{F = S} \times \mu \times \mathrm{d}\theta / \mathrm{dt} \quad (17)$$

where S is the planar surface area of the material [22]. The apparatus can also help determine the alpha-lock threshold level of shear within the weave. This is an angular limit when the fibers in the longitudinal, warp, and the transverse, weft, can no longer translate in a planar motion and lock together. Further strain causes buckling and shear modulus becomes non-linear. Shear testing and evaluation of effective viscosity are particularly important in determining process capabilities, process optimization, and are required inputs for numerical simulations.

For impact resistance testing ASTM D256-10, "Standard Test Method for Determining the Izod Pendulum Impact Resistance of Plastics" [8] can be utilized. The standard does make allowance for creating multi layered representative samples to achieve thickness requirements of the standard coupon blanks. Following the blank directional diagram, the impact notch is manufactured on the side of the laminate sandwich. This standard orientation may or may not be meaningful in design considerations. Results must include a report of the use of composite materials.

Another characteristic called for in material definitions of numerical simulation programs is stiffness. One standard referenced in this regard is ASTM D1388-96 "Standard Test Method for Stiffness in Fabrics" [23]. This standard calls for the use of specialized test equipment to consistently feed and measure the chord length of a cantilevered section of material. The application of the standard and usefulness of the equipment has been found to be limited in their range of textiles. This is not useful in characterizing solidified resin-heavy materials, but the concept has been taken to help quantify stiffness at process temperature in the viscoelastic state. Unfortunately, the standardized equipment is generally not available for use at elevated temperatures.

Testing the Adhesive Bond

The final level of characterization is that of the adhesive bonds between dissimilar layers. Here two modes of failure were investigated, shear and peel, the later being dependent upon fracture toughness and normalized tensile force [24]. For adhesive shear strength evaluation, the general description of specimen preparation and test procedures are outlined in ASTM D1144-99 "Standard Practice for Determining Strength Development of Adhesive Bonds" [25] and ASTM D3163-01, "Standard Test Method for Determining Strength of Adhesively Bonded Rigid Plastic Lap-Shear Joints in Shear by Tension Loading" [26]. ASTM D7616/D7616M-11 is similar but more rigorous. Although this standard was designed for thermoset plastics, the methodology can be carried over to thermoplastic reinforced laminates. Here overlap lengths are specified and should be recorded with actual substrate thicknesses and any applicable geometries and orientations. Reporting must include speed of test, maximum force sustained by the specimen, apparent shear strength and one of the following failure modes, overlap splice joint failure, delamination, adhesive failure, cohesive failure (failure of adhesive at mid-plane of bond line), thin layer cohesive failure, fiber-tear failure, light fiber-tear failure, or failures away from the splice which include, net section failure, longitudinal splitting, net section failure due to kink or tab failure. If net section failure occurs, tensile strength at breakage should be reported.

ASTM D1876-08, "Standard Test Method for Peel Resistance of Adhesives (T-Peel Test)" [27], defines the measurement of adhesive fracture toughness by peel tests procedure. Peel strength is explained as the average load per unit width of bond line required to separate progressively a flexible member from a rigid member or another flexible member [27]. The apparatus utilized is a standard tensile test machine, capable of sufficient extension, loading range, constant rate of motion and capable of autographic data collection. Test specimens are cut from laminated panels with bonded lengths of 241 millimeters, adjacent to unbonded lengths of 76 millimeters with widths of 25 millimeters. The unbonded lengths are bent apart perpendicular to the bond line. The procedure calls for at least 10 specimens tested by mounting the unbounded ends in the grips of the machine as in Figure 4.

Figure 4. Peel T-test set up.

Specified test speed is 254 millimeters per minute. Analysis of the data begins after the initial peak value of force at the start of the peel. The average load during the peel is calculated and reported along with a complete description of the specimens, test conditions and mode of failure. The results are typically reported for comparative analysis. To evaluate adhesive fracture toughness, G_A, Kawashita et al. [37] proposed the relationship:

$$G_A = G - G_P \tag{18}$$

where G_A is the adhesive fracture toughness, G is the total input energy and G_P is a correction made for the plastic bending energy. The total external energy equation is given by:

$$G = \frac{P}{b}(1-\cos\theta) \tag{19}$$

with P representing the peel force, b, the width of the specimen and θ the angle of the peel as per Figure 5.

The plastic bending energy is given by:

$$G_P = \frac{E\varepsilon_y^2 h}{2} f(k_0) \tag{20}$$

where h is the peel arm thickness, E the Young's modulus and ε_y is the yield strain of the peel material. The function $f(k_0)$ is a proportionality relationship based on normalized curvature, k_0 and determined experimentally.

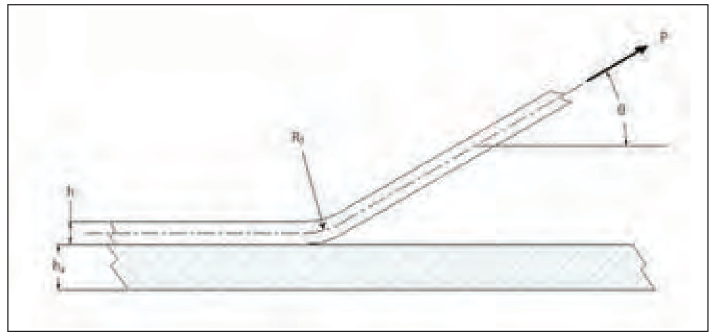


Figure 5. Diagram of peel test with variables identified.

Conclusions

In this research, the synergies of coupling of materials in composite components, leading to advanced capabilities beyond their individual strengths or weaknesses were investigated for the purpose of the development of a thermoforming process which married a woven commingled glass-polypropylene material, Twintex®, with various surface layering that would be suitable for different applications. The mechanical properties of the composites were investigated to characterize these materials starting from their base components and further through the final net product. While the advantages of tailoring composites for synergies in mechanical, thermal, chemical, corrosion resistance, electrical properties, environmental and sustainability advantages are clear, compatibility must still be considered for structural integrity. Compatibility is the result of factors of adhesion and cohesion. In order to quantify the performance in these aspects an experimental approach with appropriate testing can be utilized.

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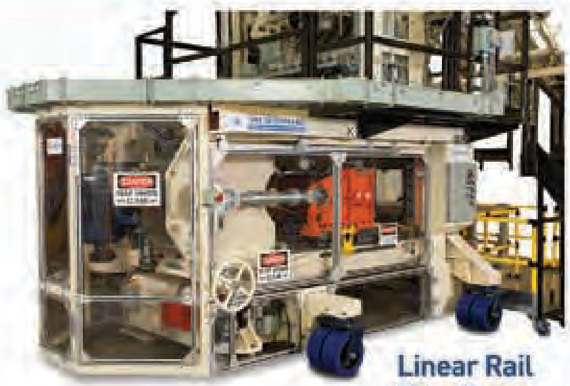

An Interview with Society of Plastics Engineers CEO, Wim De Vos

By Conor Carlin, Editor, *Thermoforming Quarterly*

Willem (Wim) De Vos came to SPE after serving as CEO of the Vitalo Group, a global supplier of plastic packaging and thermoformed products. As head of the Vitalo Group, Mr. De Vos oversaw an enterprise with worldwide factories and sales offices.

As someone who gives new meaning to frequent flier miles, the CEO of SPE continues to build new alliances in emerging markets while strengthening SPE foundations in North America and Europe. As such, De Vos is uniquely positioned to comment on global trends in thermoforming. TQ caught up with him at the inaugural SPE ANTEC in Dubai.

Conor Carlin: If we consider thermoforming in a global context, what, if any, trends do you see that are common across geographic markets?

Wim De Vos: In terms of market trends, a central theme is the clear demand from more and more OEMs and brand owners to have a green image. Increased recycled content or use of bio-based / biodegradable materials is being discussed from India and China to Europe and the US for both packaging materials in thin gauge and many structural components in heavy gauge.

Carlin: Flipping that question around, what do you see as major points of divergence?

De Vos: That's a more difficult question! We can look at this from either the business side or the technical side. In terms of points of divergence, these are related to the differences in maturity of regional markets. We see this in the different types of materials and technologies used. For example, in the west, there is a lot of competition which drives innovation. Processors look to add value in these mature markets. A good example is the use of more engineered polymers on the material side including the ability to down-gauge while retaining the same performance properties.

In the developing regions such as India, here in the Gulf Region and in Latin America where the market is still growing to maturity, there are still a lot of commodity resins and first-generation technology. That said, in the Middle East region we see investments in the newest machinery and equipment.

As a high-growth region, China is a special case. There are a wide variety of thermoformers of which a big portion, perhaps half, is supplying the lower-end, lower-demand section of the Chinese domestic market. The other portion is supplying to international OEMs and brand owners and they have to fulfill the more demanding specifications of international brands. The former group is using domestic technology for machinery and tooling. The latter group is using the latest technologies from western equipment suppliers.

Carlin: At a recent AMI Thin Wall Packaging Conference, Euromonitor presented data showing that Asia is clearly the fastest growing market for plastics packaging. Can you give an example or two of how you see thermoforming evolving in Asia?

De Vos: Outside of China, the countries in south-east Asia like Indonesia and Vietnam show higher rates of growth. But of course, you have to look at the starting point and the absolute figures. If you start at 10 and go to 100, that is a rapid rise and a fast rate of growth. If you go from 10,000 to 10,500, that is lower in relative terms but larger in absolute terms, so the absolute growth for the thermoforming business in China will remain interesting. More and more local Chinese companies are entering the market, increasing competition with the "first-mover" (mostly Western) companies. Indonesia in particular is showing tremendous growth in general for plastics.

Carlin: There has been a lot of talk recently about M+A activity in North American thermoforming. What can you tell us about M+A activity in Europe and Asia?

De Vos: I don't have a lot of data on that particular subject, but I can say that a few years ago, the general M+A activity was reduced a lot as result of the financial crisis in 2008/2009. It is quite clear that consolidation is very likely to happen in the mature markets, where there are thousands of thermoformers, mostly family-owned, fighting for the same business with very little potential for differentiation. Since 2011, there has definitely been more M+A activity in the thermoforming market (and certainly recently in North America) and more consolidation is sure to happen in Europe and also in China in the next decade.

Carlin: In your travels to India and here in the Middle East, what are the most prominent thermoforming topics you hear?

De Vos: I would say that in the Middle East, 99% of the thermoforming market is food-related packaging using commodity resins in standard thermoforming technology. The thick gauge thermoforming market is still taking baby steps here. In India, you start to see more and more thermoforming for a diverse number of B2C and B2B applications. India is seeing more growth in non-food markets as increased local manufacturing of equipment and machinery enhances the thick gauge market and the growing Indian manufacturing markets. For instance, electronic goods enhance non-food packaging thermoforming. The number of high-quality thermoformers in the Middle East is still quite low as these higher-demanding customers (such as automotive, electronics and advanced medical devices) are not yet significantly present.

Carlin: What are some of examples of innovation in thermoforming that you've seen?

De Vos: Process-wise, there has been a lot of innovation in printing and decorative technologies that are being tied into thermoforming. It's not only about printing and in-mold labeling, it's about developing new surfaces. This is true in the automotive sector and in the (food) packaging sector. In that sense, both thin-gauge and heavy-gauge thermoforming companies are exposed to this innovation.

Carlin: Do you have a favorite place to visit in your capacity as SPE CEO?

De Vos: [Exhales deeply] Let me answer like this: I would like to travel to those places where SPE is not yet present. We recently started up a Singapore section, so I'm excited about spending more time in south-east Asia in the future. As an organization, we don't currently have the resources to go everywhere we want, so we are taking a focused approach to those areas where we've currently identified interest and opportunity. We will continue to build on the work we've started in India and here in the Middle East. This has been a very interesting ANTEC for us.

Impressive skyscrapers in Dubai

Thermoforming at ANTEC Dubai, January 21-22

By Conor Carlin, Editor, *Thermoforming Quarterly*

The inaugural ANTEC Middle East in Dubai drew over 150 attendees from the Gulf Region, Europe, North America and Asia. While the technical program featured papers on technological advances in materials and machinery for a range of plastics processing, break-out workshops allowed for more a conversational approach between the presenters and attendees.

The plenary session featured a keynote from Dr. Abdulwahab Al-Sadoun, the Secretary General of the Gulf Petrochemicals and Chemicals Association (GPCA). The GPCA consists of 235 members from the Gulf Region, including companies from the chemicals, plastics and fertilizer industries. With high rates of growth set to continue into the next decade, the Gulf region continues to be a major hub of petrochemical development with significant impacts on downstream plastics.

Bill Carteaux, president of SPI, delivered a talk on the impact of shale gas on the US plastics industry. With a 440% increase in shale gas production between 2007 and 2012, shale gas will increase plastics production by 10% by 2020. The SPI data on plastics shipments, jobs and growth rates will certainly cheer up anyone who has been pessimistic about US manufacturing and specifically the plastics industry:

- Plastics is the third largest manufacturing sector on a dollar shipment basis (after oil & gas and automotive) with $373bn in 2012.
- The plastics industry employs almost 900,000 people in about 16,000 facilities.
- 10,000 new jobs were created in 2013.
- There is a $12.9bn trade surplus in plastics.

Thermoforming was represented on both days. On day one, there were technical papers on plug assist materials (CMT Materials - US), 3rd generation forming (Illig - Germany) and new package designs (Protective Packaging Systems – UK). On day two, the in-depth workshops covered thin- and heavy-gauge processing, material selection, part design and elements of extrusion. Processors from Kuwait and Saudi Arabia shared details on packaging and automotive projects, illustrating the use of both thin gauge and heavy gauge applications in the region.

The Gulf region remains dependent on technical expertise from western companies. This is true for both technology and human capital, as evidence by the large ex-pat communities in the United Arab Emirates and Saudi Arabia, for example. But there certainly is no shortage of capital. Dubai was recently selected as the host city for the World Expo in 2020, an event that will see $9bn invested in infrastructure. In addition to having the 4th largest container port and the tallest building in the world, Dubai will probably see a few more superlatives in the years ahead.

Mold Thermal Distribution

By Mauro Faé, Self Group
Rivignano, Italy

Maintaining consistent thermal distribution throughout the mold is critical to minimizing the cooling cycle and maximizing part quality metrics. Cost savings result from a more efficient cycle time and internal scrap reductions due to a tighter mold temperature process control.

Cooling the part by contact with the mold is very effective and efficient using highly conductive metal molds with aluminum being favored due to its light weight, ease of casting, machining and finishing. The use of cast is not absolute but related to the process request and costs. A small tool is probably less expensive from machined billet while large complex molds are most economically produced by foundry casting. These molds will be temperature-controlled through encapsulation of water cooling channels or by being mounted on cooling plates when the tool is made by machined billet. The fluid should maintain a turbulent flow for maximum heat transfer.

In order to produce production parts to an acceptable and repeatable dimensional tolerance, mold temperature must be kept constant during the forming period and on the tool surface with vacuum maintained for a controlled duration. These process controls are critical as allowance for thermal shrinkage of the material is built into the mold dimensions and requires that the part be removed from the mold within those predetermined parameters. A difference of 15 degrees F in mold temperature from one cycle to another can change shrinkage by .001 in/in.

Further impact on quality related to unbalanced mold temperature profiles (hot spots, cold spots) and inadequate temperature control can include the formation of chill marks, wall thickness variation, part distortion or warp, and irregular surface gloss. These are all potential cause for part rejection.

Understanding Conduction

As Dr. LeBlanc clearly stated in his recent article published in Thermoforming Quarterly (vol. 32, no. 4), conduction will move heat in a solid and will also move heat into the solid and out of the solid into a fluid. These materials must be in absolute contact for the heat to transfer by conduction and even a slight gap will prevent conduction from happening. The channel system must also be designed to move the fluid at a flow rate necessary to maintain the desired mold temperature. It may therefore be necessary (after calculating the required flow rate) to subdivide the flow through multiple manifolds and even multiple Thermolators (figure 1).

Figure 1

The need for absolute contact to achieve heat transfer through conduction is often overlooked. While fluid channel spacing and diameter are important elements of temperature control the channel layout and extent of channel encapsulation within the mold wall is very critical.

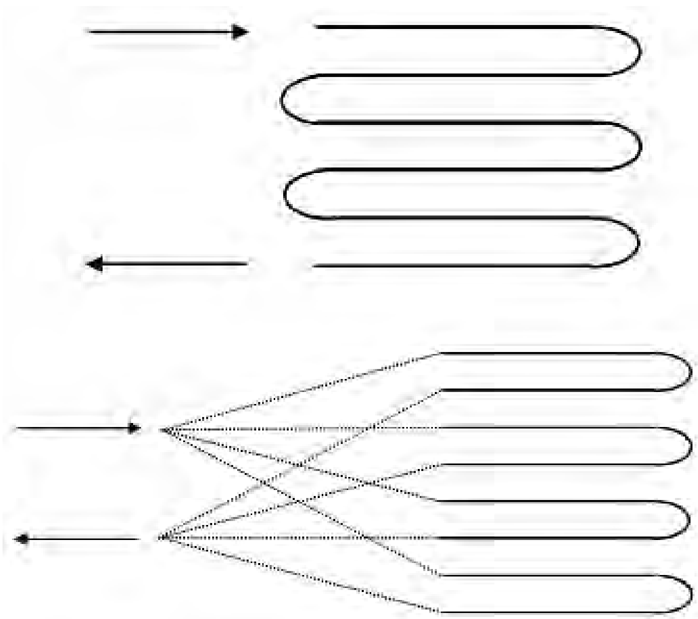

Figure 2

Properly designed channel layout in parallel configuration rather than in series (figures 2 and 3) with a maximum of a 4' run when possible as this is something related to the mold shape and difficult to guarantee. It should be a rule that all runs are the same length with appropriately designed manifold capacity.

The most important detail, however, is the total encapsulation of the channel (figure 4). If the channel is not entirely surrounded by a metal thickness equal to the mold wall the heat will not transfer evenly from the mold through the tube channel and into

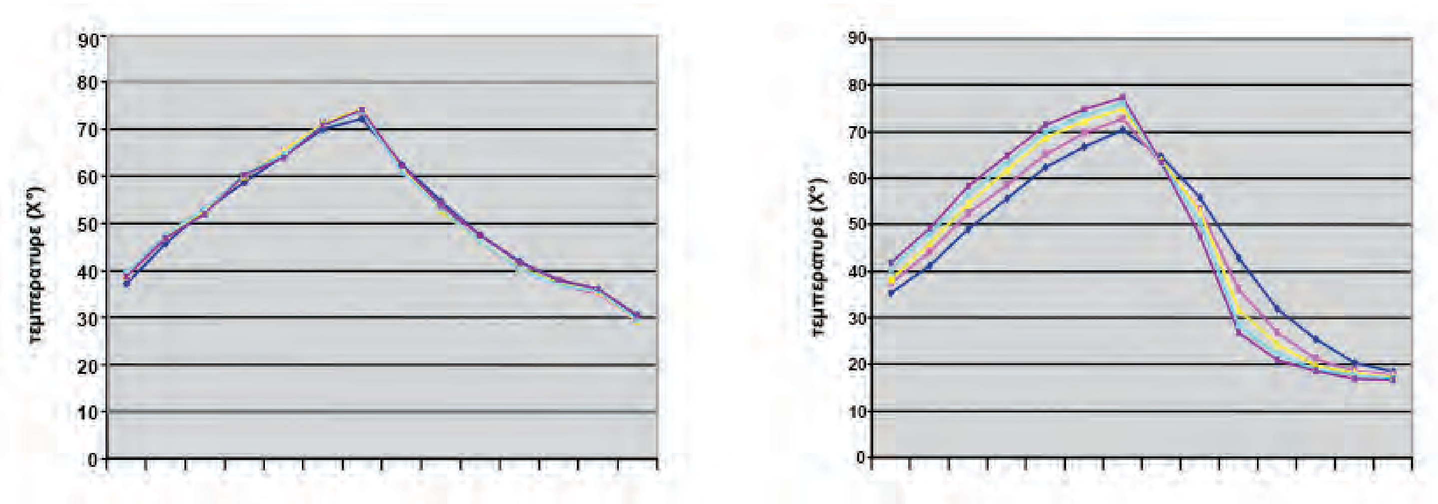

Figure 3

the fluid for recirculating. The consistency of the mold wall thickness is also critical as thin areas will create hot spots and heavy sections will create chill areas. These inconsistencies will result in improper thermal distribution within the mold temperature profile.

Figure 4

Best Practice for Temperature Control

In an effort to "save" money or salvage a tool built without temperature control, tool shops have attempted to "paste on" tubing as a secondary application. This approach is totally ineffective as there is very little absolute contact between the tube and the mold surface. Compounding the problem even further, the material used to "paste" the tubing in place is often an epoxy and serves as an additional insulator. This effort is, for the most part, a waste of time and energy because only the vacuum box or surrounding air are being heated. A recent experiment with this "paste on" approach revealed that while the Thermolator was set at 180 degrees the mold temperature only reached 85-90 degrees which was ambient temperature at the forming station.

Machining channels on the back of the mold (if the wall thickness is sufficient) and then press-fitting a copper tube would provide better results for a salvage attempt or even where a need for additional heat has been pinpointed. This solution is used primarily with machined billet molds. Even if properly managed, the temperature conductivity is only 30-50% effective because only a part of the tube is in contact with the mold material while there is a loss of energy in the ambient (figure 5).

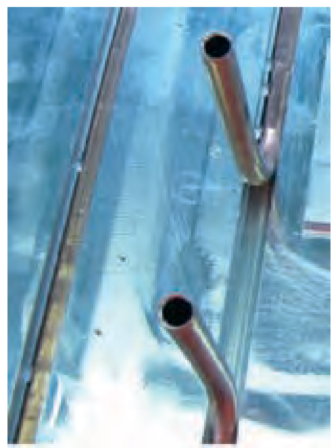

Figure 5

The insertion of thermocouples within zones throughout the mold allows for the measurement of those zonal temperatures. The ability to measure provides process management data for greater quality assurance at start up due to consistent process set-ups. Identifying those cold spots that are resulting in chill marks or inconsistent material thickness during production can help pinpoint the solution. Additional channels or heaters can then be added to those targeted areas once you are able to measure and analyze the data. In some sections it might be necessary to have higher temperature, so it is possible to use different circuits or add electrical heaters, e.g. cartridge as used in injection molds. However without a sound, repeatable thermal system initially designed in the mold the feedback data from the thermocouples will be unreliable.

Mold Material Properties

We have established that aluminum is an ideal mold material. The cooling of the part from the tool side is achieved through conduction therefore requiring the best possible design efforts within the mold construction to maximize thermal conductivity. A factor often overlooked when understanding conductivity is mold material density. Density is simply a measure of how close the molecules of a material are to each other. The higher the density, the closer the particles and the faster heat will flow through conduction. Heat flow without any break results in better conduction. When porosity is present in cast molds the decreased density and break in molecular structure will slow conduction. With cast aluminum molds it is critical to be aware of unreasonable porosity and to specify high quality castings not only for cosmetic benefits but to maximize conductivity.

Cast aluminum molds require best practice, quality foundry engineering including design of the pattern; design of the pouring channels; and knowledgeable metal preparation in order to obtain castings that will produce molds that provide the best in conduction temperature distribution. High quality cast molds with cast-in channels for direct thermal management provide the best results for thermal distribution. They can be machined to the defined dimensional tolerances while maintaining a high quality mold surface. Keep in mind the cast and machined mold provides the very best solution for large part mold production.

Conclusion

In summary, when designing molds for thermoforming the following criteria should be considered in order to assure ideal thermal distribution:

- Parallel channel layout
- Proper channel/tube contact
- High quality aluminum castings
- Sufficient manifold capacity
- Separate manifold heating circuits or cartridge electric heaters for increased mold temperature where needed
- Complete channel/tube encapsulation
- Inserted thermocouples

Paying close attention to thermal distribution can resolve the following reject causes:

- Chill marks
- Inconsistent wall thickness
- Residual stress failures
- Gloss irregularities
- Color wash

Mold design and mold quality development is a collaborative effort among the part designer, the processor and the tool maker communicated through detailed mold specifications. The quality tool maker will evaluate your specifications and provide recommendations from experience. Together the designer, the processor and the tool maker will, through this diversity of thought, create the best possible tool. ❙

Did you know

the SPE Foundation offers numerous scholarships to students who have demonstrated or expressed an interest in the plastics industry?

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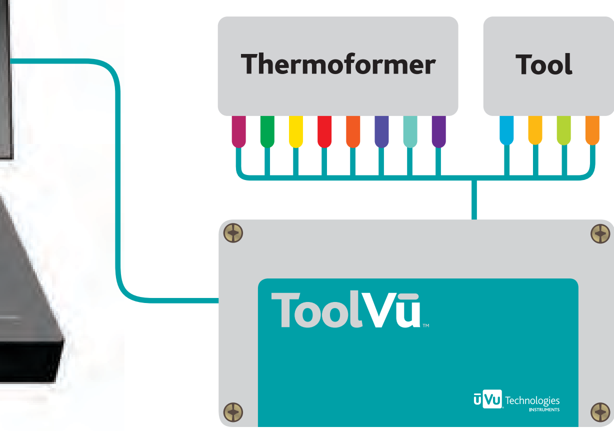

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COUNCIL SUMMARY

Roger Kipp
Councilor

A Meaningful Unique Organization

Customers are willing to pay more for products and services as long as they find benefits that are without equal. The same is true for professional organizations like SPE where members value through readily available and relevant information that they cannot find elsewhere.

Technology and commerce today are moving at warp speed. With the internet comes a true free market where everyone competes; where the courageous win and the clones lose. Technology life cycles are faster and faster with half the life of yesterday. With the internet, there are "free" plastics information resources that will attract a new, younger generation unless there are compelling reasons to join SPE.

This is the current state of the business environment and SPE governance is focused on refining the organization to meet the challenges of the 21st century.

How will SPE stay ahead of the challenges brought by today's technology and a global marketplace? Many of the changes occurring at SPE are not visual but their impact will allow the organization to remain financially viable and responsive as we move forward. These changes include staffing adjustments, governance improvements and systems upgrades.

In order to compete with "free" internet information, SPE governance is evaluating implementation of a new "e-membership" grade. This grade would, with some limitations, be robust enough to provide an introduction to SPE benefits and encourage extended membership.

SPE financial performance through 2013 showed positive results. While membership stayed to plan, hovering at 14,000, total revenue fell short of budget by 7%. The shortfall was due to a decrease in event revenue primarily related to ANTEC and EUROTEC. Fortunately, through sound management, expenses were reduced substantially resulting in a gain of $55,000 (excluding the Foundation). The Foundation did very well in 2013 with increased funds of $252,000 and a positive performance from the PlastiVan program.

A highly visible move is the continuing support of a global SPE presence. Global relationships are rapidly expanding within SPE and the Thermoforming Division. ANTEC Mumbai and ANTEC Dubai both benefit from an extremely supportive group of Thermoforming Division members. Our division members contributed program content for both of these events and they continue to analyze potential SPE Division formation in new regions, similar to the support provided to the formation of the European Thermoforming Division (ETD) many years ago. Global support of the ETD continues this April at the 9th Biennial European Conference in Prague, Czech Republic, where a number of our division members will be in attendance, exhibiting and delivering papers.

Additional changes on the horizon focus on the organization's website and SPE branding activities. The work on the $120,000 new site began mid-year 2013 with an exciting new launch of www.4spe.org coming soon. The purpose of the new website is to:

• Support the position that SPE is the premier resource for plastics knowledge
• Provide a tool for membership retention and recruitment
• Be the preferred provider of online user experience and access for plastics research

This site will accomplish these goals with a superior online and mobile experience, a tailored content delivery system and by effectively engaging prospective and current members. Much easier to navigate, this is a responsive website design that fits any device for interaction. Mobile access and functionality are critical when you consider that of the 6.8 billion people in the world, 4 billion use a mobile phone.

Engaging members within their own SPE group network will be a major function of the new site.

• Availability of Sections and Divisions (groups) to establish content management controlled by the group.
• The access can be "member only" and further refined with restriction flexibility.

All event registration will be (if so desired) accomplished with a simple click on the specific TopCon event. This will give all members a one-stop shopping experience for technical conference registration across the entire SPE network.

Along with the website change, SPE is changing our logo to create a new corporate identity consistent with furthering the attraction to younger generations. The current color and logo shape were new in 1947; it's time to have a bold and modern update. The shield will remain with some surface-sculpted shading. The letter font is changed and the dull red color will be replaced with a lively green. You will begin to see the logo changes occurring as new materials and communications are rolled out in 2014.

SPE Connect is a social media network to help engage members anytime and anyplace. Higher Logic is the planned vendor (www.higherlogic.com). With SPE Connect, members can create subgroups (communities) for special interests, invite new members through chat system communication, and still use LinkedIn with a pull into the SPE social site. Profiles can be automatically populated from the existing SPE profile. SPE continues to make changes that are relevant to the lifestyle needs of current and future members.

I invite you to email me, srkipp@msn.com, to share your thoughts and suggestions.

The Education Alliance Philosophy

Are Manufacturers Taking Responsibility?

By Roger C. Kipp, Roger C. Kipp & Associates

When managers and business owners are surveyed regarding their biggest business challenges, the top responses are related to an aging workforce and a perceived lack of talent to replace those retiring employees. The challenge goes beyond simply replacing employees; there is a concern that today's youth are looking for career opportunities that they believe manufacturing cannot provide.

Who is responsible for developing that next generation of manufacturing professionals? The manufacturing sector often looks to education for the answer, but perhaps clues can be found closer to home.

Over the past few years, I have written several articles, initiated programs with high schools and universities to provide support for "An Alliance with Education." As I continue to work on these projects, it is clear that manufacturing must take the lead by creating and following through on programs related to technical education and skills development relevant to the future of a successful manufacturing workforce.

Manufacturing leaders must be pro-active in approaching education and they must play a key role to rebuild the image, to change the perception of manufacturing, and to define the needed skill sets. The following set of recommendations derives from my direct observations and from conversations with leaders in both manufacturing and education. Manufacturers must:

- Initiate policies in their business to support the expectations of the next generation in terms of workplace environment.
- Communicate the new vision of manufacturing to those beginning to make work choices. Cultivate innovation and empowerment within the business structure.
- Encourage manufacturing education in our schools; incorporate manufacturing science into the other, related courses such as sociology, economics, and computer science; establish a manufacturing science course.
- Provide advisory support.
- Develop a conduit to manufacturing training programs resulting in improved continuity from the classroom to the factory.
- Partner with education to develop and sustain meaningful apprenticeship programs.

What are some immediate, concrete actions that manufacturers can take to develop this alliance?

- Build a relationship with a local school; it starts with a visit.
- Participate on advisory councils.
- Provide shadowing and internship opportunities.
- Provide materials for presentations and labs.
- Support science fair and senior projects.
- Host "Introduction to Manufacturing", "Adventures in Technology", and "Teacher in the Workplace" industry introduction-type programs.
- Volunteer to provide lectures and plant tours.
- Organize a "Parade of Factories" tour for superintendents, principals, guidance counselors, and teachers.
- Sponsor scholarships tied to manufacturing careers.

With whom should manufacturers develop the alliance?

- Middle schools and high schools
- Community colleges
- Trade schools
- Colleges and universities
- Trade and industry associations, e.g. PPA, SPE, NAM, SPI

How can educators support the alliance?

- Develop certificate programs and competency-based education models to support manufacturing apprenticeship programs.
- Provide resources to establish and expand manufacturing-education alliance partnerships.
- Infuse technology in education.
- Create excitement for manufacturing careers.
- Apply manufacturing principles like "lean" in school programs.
- Expand successful youth industry introduction programs.

For manufacturers, this alliance is the foundation for progress and growth. The "Alliance with Education" will inspire our companies and our entire workforce.

We experience the reward of seeing new, young, innovative thinkers who are looking for a different path while they expand their learning from the experience of our veteran staff. It has never been more clear that industry must do everything we can to develop and sustain "The Alliance with Education."

Wouldn't you love to be part of the team that brings this trophy and $1,000 back to campus in September?

SPE Thermoforming Conference Student Parts Competition Guidelines September 15-18, 2014 Schaumburg, Illinois

APPLICATION

The competition is for a real potential application. This product is to be used for cooling items such as sunglasses, candy bars, mobile phones, etc. inside a hot car by the use of the A/C vents.

CONCEPT

To create a thermoformed product that can be mounted to a standard A/C vent in a car. The product must be able to support as a minimum the weight of a cell phone. The product must also be able to withstand the temperature changes inside a vehicle within the range of 0-140 degrees. The product will need to have a quick mounting system for easy attachment and detachment to a standard A/C vent and allow for airflow to pass from both the top and bottom of the product.

MATERIALS

The choice of material is yours. The product must be thermoformed. The attachment mechanism is left up to your own creativity. The material must be strong enough to support the weight and handle the temperature changes inside the car.

PRODUCT PARAMETERS

Not less than 2.75" wide or less than either 6" in length or more than 1" in depth.

JUDGING

All judging shall be based upon the parameters listed above. Creativity in design, mounting, venting, use of materials, and a unit part cost analysis shall be considered. First prize ($1,000) and second prize ($500) will be awarded.

CONTACT

Steve Zamprelli
2014 Parts Competition Chair
email: s.zamprelli@foremedplastics.com
phone: 516-334-2300, ext. 27

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SUBMISSION FORM

You will find the Professional Parts Competition Guidelines and Submission Form for download at thermoformingdivision.com/parts-competition/guidelinesentry-form.

Ryan Enzler of the University of Wisconsin-Stout, won for first place in 2013 for Heal Guard, a thermoformed product designed to protect hospital patients, and received the Stanley Cup of Thermoforming with his name engraved.




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Barrier Breakthrough

Is an innovative oxygen-scavenging pack about to replace the widely-used PP/EVOH container?

By Steven Pacitti, Editor, *Plastics in Packaging*

[Editor's note: This article was first published in the excellent Plastics in Packaging magazine, February 2014. We are grateful to both the author and the publisher, Sayers Publishing Group.]

With upwards of 18 patents to his name, Bob Tsai has pedigree, not least because he was one of the key scientists at American Can in the 1980s who pioneered the PP/EVOH container for shelf-stable food packaging. So successful was this development that it has been widely used for the past 30 years.

Now managing director of a consultancy firm, Amerasia Technologies, Tsai has worked with Mullinix Packages of Fort Wayne, IN for several years developing a PET/scavenger container which he believes will replace the former solution. Used for packaging foods and beverages, the PP/EVOH container is well established because of its strong oxygen-barrier properties. It does, however, still allow some oxygen permeation that restricts the shelf life of the product.

"This new solution can maintain zero oxygen permeation for four years. Furthermore, at the end of four years, the headspace oxygen is still slower than the initial oxygen," Tsai told Plastics in Packaging. In other words, he says, the PET/scavenger container is better than both metal cans and glass bottles at preventing oxidation of foods and beverages, while the crystallized PET can be heated in both microwave and conventional ovens and the amorphous PET is glass-clear.

Bold Claims

The oxygen scavenger used in Mullinix's OxyRx PET/scavenger container is a modified PET, which effectively makes it a single-material container that can be recycled in the same manner as other types of PET container. By contrast, PP/EVOH containers are composed of multiple materials.

It is often said that the most important performance requirement of plastics-based packaging for food applications is low oxygen permeation. This would appear to be the case more frequently in a modern world that is witnessing a rise in demand for healthy foods, such as polyunsaturated fats and whole grain flours which are more susceptible to oxidation than 'unhealthy' fats and highly-refined flours.

As such, the bar for barrier container performance is continually rising. But plastics have a long history in this area, having started in earnest during the 1970s. The availability of barrier EVOH polymers and the development of co-extrusion are the two technology pillars of the plastics-based barrier packages available in the market up to now.

Polyvinylidene chloride (PVdC) was the only polymer with oxygen-barrier properties good enough for food packaging during the 1950s and 60s, but the material is thermally unstable at extrusion temperatures while its corrosive nature requires a nickel-plated auger screw and barrel. "It also has serious environmental problems during disposal [if incineration is used] because it contains chlorine," explains Tsai, which he says limited the market.

EVOH polymers were rolled out commercially in the 1970s and, unlike PVdC polymers, they are thermally stable at the extrusion temperature. They are, however, moisture-sensitive, making their effectiveness as a barrier variable in packaging applications. The development of subsequent technology focused on method of keeping EVOH dry so that the structure would perform similar to or better than that of a PVdC-containing structure. "Due to the thermal instability problem of PVdC, such structures were primarily made by coating and laminating processes. However, a multilayer structure is best made by the co-extrusion process which is cheaper and quicker," says Tsai.

Thermally-stable EVOH polymers were therefore easy to co-extrude with polypropylene, with the PP providing the mechanical strength at an affordable cost. And this simple equation was the backdrop to three decades of success.

To achieve a zero oxygen permeation rate with EVOH you would need an infinite thickness of the material, says Tsai. "Therefore, a plastics container comprising passive barrier such as EVOH is prohibitively expensive for products with very low oxygen tolerance. A new concept involving an active barrier such as oxygen scavenger was developed initially for these products with very low oxygen tolerance."

Although oxygen scavenging sachets are well-established throughout Asia, liability concerns have caused them to struggle in penetrating the US and European markets. The key component of the sachet is iron, which requires a different formulation within the plastics to enable it to react with, and scavenge, oxygen.

In parallel to this 1990s development of PP and PE compounded with iron (PP/EVOH/oxygen scavenger) was the start of work that looked to address the modification of PET to make it capable of scavenging oxygen. Several PET-based oxygen scavengers were commercialized in the 1990s and 2000s but, as Tsai explains, these expensive but higher-performing containers were primarily used for products with very low oxygen tolerances such as beer.

However, Tsai is convinced that a new era is emerging due to recent technology advancements in materials, processing and container design, which has driven overall costs down. And cost is the key issue. The cost advantage of an active barrier container (compared with a passive barrier) depends on the oxygen absorption capability of that container. “Advancements made in the 2000s in oxygen scavenger formulation, processing and container design have resulted in a cost-competitive scavenger container for higher oxygen-tolerant foods,” he says.

Specifically, Mullinix’s OxyRx container is positioned as cost-competitive with many commercial PP/EVOH containers. For applications such as small pet food containers, which require more than 10% EVOH, Mullinix’s OxyRx PET/scavenger container claims to offer cost savings.

Proving Its Credentials

Discussing the testing phase, Tsai comments that a device from US-based OxySense was used to test the oxygen transmission rate of the container. Tsai explains: “By gluing the OxyDot on the clear inner surface of the container, the oxygen concentration inside the sealed container can be measured optically.”

Mullinix’s OxyRx container consists of two types of PET/scavenger container: CPET/scavenger container (opaque due to the crystallinity, but with high heat resistance making it suitable for retort sterilization at 260F and for heating in both microwave and conventional ovens) and APET/scavenger container (glass-clear but with lower heat resistance).

“The CPET/scavenger OxyRx container, with empty headspace, was tested side-by-side with the CPET control container. During sealing, the containers were flushed with nitrogen to 1% oxygen in the headspace. After 1000 days, the headspace oxygen of the CPET control container increased from 1.37% to 5.56% while that of the CPET/scavenger container decreased from 1.03% to 0.26%. After 1500 days, the headspace oxygen of the CPET control container increased to 7.0% while that of the CPET/scavenger OxyRx container was 0.46%, which is still lower than the initial headspace 1.03%.”

This, explains Tsai, is superior to metal cans and glass bottles which can only keep the headspace oxygen unchanged. This is achieved with a fairly thin sidewall of 20-mils.

In another test, the CPET/scavenger OxyRx container was filled with about 90% water and 10% empty headspace. A SiOx-coated barrier lidding film with an OxyDot glued on the inner surface was heat-sealed on the container. In addition to the CPET control container, the commercial PP/EVOH container was also tested side-by-side. During water filling, the containers were flushed with nitrogen to 5% headspace oxygen and then retorted at 260F for 45 minutes.

“After one month, both the CPET control container and the PP/EVOH container showed a steady increase of oxygen concentration while the CPET/scavenger OxyRx container showed a steady decrease of oxygen concentration. The poor oxygen barrier property of the PP/EVOH container shortly after retort is due to the retort shock effect (high moisture content in EVOH).

“After 70 days, the curve of the PP/EVOH container and that of the CPET control container cross over. Normally, it takes this long for the PP/EVOH container to recover from the retort shock to match the barrier property of the CPET control container. The headspace oxygen of the CPET/scavenger OxyRx container continues to decrease.

“Two years in, the headspace oxygen changes of the PP/EVOH container, the CPET control container, and the CPET/scavenger OxyRx container are +3.0%, +9.0% and -4.4%, respectively.”

Oxygen scavengers are expensive, so it is important to avoid the oxygen scavenging capacity loss during the container inventory period before food filling. Some scavenger containers use moisture in food or UV to trigger the oxygen scavenging, but this requires additional equipment in the filling line.

Another approach is to shorten the inventory period to minimize the capacity loss, and here Tsai alludes to OxyRx’s controllable incubation period. “During the incubation period, the container does not scavenge oxygen and the oxygen scavenging capacity is not wasted during the container inventory period.”

The advantages of having a controllable incubation time are that such a container can be used for both dry and moist foods, no triggering equipment is needed, and no scavenging capacity is lost during inventory.

“The container is effective in not only preventing oxygen permeation from outside but also competing with food in reacting with headspace oxygen inside the food container, to ultimately reduce the amount of oxygen reacting with the packaged food.”

While Mullinix will claim that OxyRx can reduce the headspace oxygen for food oxidation in both non-flushed and nitrogen-flushed situations, the relationship between food quality and oxidation is hugely complex, which means that OxyRx will need to be validated on a case-by-case basis.

But the promise is clear. Tsai is promising zero oxygen permeation for more than four years, along with high heat resistance, glass-like clarity, headspace oxygen reduction, and no delamination as in a three-layer PET/EVOH/PET container.

He also says that it is cost-competitive with many PP/EVOH containers and of lower cost where more than 10% EVOH is used, as in small pet food containers. And it can be recycled in the PET stream which, in the current environmental climate, is a real game-changer.

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