Thermoforming Quarterly®

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

FIRST QUARTER 2009 ■ VOLUME 28 ■ NUMBER 1

Workforce Development: Ensuring Future Success

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SEADOO

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West Hall, Booth 117011

- Four quadrants of research and development, divided initially in a pod/booth setting.
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  - Sustainability
  - Energy conservation
  - Bioplastics
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Founded in 1937, SPI represents the third largest manufacturing industry in the United States. SPI's members represent the entire plastics industry supply chain, including processors, machinery and equipment manufacturers and raw material suppliers. The U.S. plastics industry employs more than 1.1 million workers and provides more than $379 billion in annual shipments.

NPE2009: The International Plastics Showcase is produced by SPI, the plastics industry trade association.
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** The full program is under development and subject to change.*

Thermoforming Quarterly®

FIRST QUARTER 2009
VOLUME 28 ■ NUMBER 1

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

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Chairman's Corner

Brian Ray

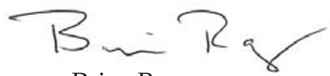
It is hard to believe another year is behind us and for many, 2008 has been a year like no other. The financial markets have seized up and credit has tightened. Pricing pressures backed by record oil prices in July 2008 have now retreated to new lows in a short six-month period. Bailouts, bankruptcies and bitterness seem to sum things up, and maybe the worst is yet to come.

As a Division, it is critical that we continue to offer technical information and support to ensure our process and its technology emerge from this downturn in a better position. However, it is said that a crisis is a terrible thing to waste. Now more than ever is the time to upgrade capabilities: renew the focus on your workforce; review and audit your electricity, compressed air and lighting requirements; look to the state or other agencies to offer matching funds to ensure that you can become a more efficient manufacturer and a stronger competitor. This is also the time to find a way to incorporate technology and automation.

In June, we will be sponsoring a thermoforming pavilion at NPE. The first-of-its-kind pavilion will offer attendees a central place to learn about everything related to thermoforming. We will be registering attendees and exhibitors for the Milwaukee Conference and showcasing prior parts competition winners. There will be information booths staffed by suppliers and practitioners of the thermoforming process. This is going to be a fantastic event and provide a new opportunity to reach out to thousands of people and showcase our process capabilities.

September 19th – 22nd, 2009 will be the dates for our **19th Annual Thermoforming Conference in Milwaukee**. The theme for the conference is ***"Charting a Sustainable Course"*** and will feature an inaugural session titled ***"Sustaining a Profitable Business,"*** sponsored by SPI and the Thermoforming Institute.

A glance at any major news outlet today is all that is required to hear more bad economic news. However, these hard facts offer clear evidence that we need to get more involved and be better prepared for the future of our industry and our country. We all must play our role to ensure that the manufacturing of thermoformed products remains an engine for growth, continued innovation, and quality employment for generations to come.



Brian Ray
Chair

• Renew the focus on workforce

• Review and audit electricity, compressed air and lighting requirements

• Incorporate technology and automation

• Look to the state or other agencies for matching funds to ensure more efficient manufacturers and stronger competitors

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Penda and Durakon merge to create bed liner, tonneau cover powerhouse

Heavy-gauge thermoformers and suppliers of truck bed liners and tonneau covers, Penda Corp. (Portage, WI) and Durakon Industries (Lapeer, MI), will merge the respective No. 1 and 2 suppliers in the market to create the largest, global supplier of truck bed liners. Penda, owned by private equity firm Resilience Capital Partners (Cleveland) since August 2007, and Durakon, owned by private equity firm Littlejohn & Co. LLC (Greenwich, CT) since 1999, will join in a new company that retains the Penda name and is headquartered in Portage, WI, with Resilience acting as the majority owner by a slim margin, according to Cathy Cromey, VP corporate services for Penda.

Cromey described the merger as complementary, especially from a technology standpoint, with Durakon bringing shuttle presses and twin-sheet thermoforming to the combined company, and Penda adding co-extrusion, among other technologies. In terms of combined revenue – approximately $100 million – and units, the new company will have a commanding lead in the market for truck bed liners. Cromey said at this time there are no intentions of closing any facilities, and that Penda will retain Ulf Buergel as president and CEO of the new company, while Ed Gniewek, Durakon's CEO, will step down. Jim Smith, Durakon's CFO, and John Montagna, VP advanced products, will be retained.

In addition to the sites in Michigan and Wisconsin, the combined company will also have manufacturing in Clinton, TN, and Lerma, Mexico. Durakon, which expanded its business in March 2004 to include paint-film technologies at a site in Clinton, TN supplies bed liners, tonneau covers, and cargo van panels for OEM and aftermarket supply. It used the paint-film technology to move into decorative, thermoformed thermoplastic polyolefin (TPO) exterior panels that applied laminated paint films or co-extruded color layers for Class A running boards, stone guards, rocker panels, and bumper fascias.

Penda has been thermoforming truck bed liners since 1983, doing so independently since 1994, when it split from its parent company of the same name. The company's manufacturing footprint includes 13 rotary, sheet-fed, four-station vacuum-forming machines; mold and fixture capabilities; one 85-ton injection molding machine; and in-house sheet fabrication via five, 6-inch co-extrusion lines. In 2003, the company launched Penda Premier Solutions as a custom thermoforming unit.

A press release said the new company would have three strategic units – automotive components, automotive accessories, and custom thermoforming. The first business unit, Penda Automotive Components, will serve automotive OEMs as a Tier One supplier, while the second unit, Penda Automotive Accessories, will target aftermarket products with items like truck bed liners and tonneau covers. The company describes the final unit, Penda Premier Solutions, as a custom thermoformer targeting a variety of industrial applications.

Founded in 2001, Resilience has acquired 14 companies with revenues exceeding $750 million. Littlejohn & Co. LLC was founded in 1996 and manages three funds with committed capital of approximately $1.6 billion. So-called drop-in bed liners have come under some pressure from spray-in polyurethane-based systems. |

Tony Deligio, Plastics Today (Canon Communications) January 2009

Packaging leading the way, thermoforming looks to top 6 billion pounds

Growing at a compound annual rate of 4.3%, the global market for thermoformed plastic will expand from 4.9 billion lbs. last year, to 5.1 billion lbs. in 2008, and some 6.3 billion lbs. in 2013. The data, culled from a new BCC Research (Wellesley, MA) report, broke the thermoforming markets into packaging, appliances, building/construction, automotive, aircraft, industrial/commercial, and consumer products, with packaging occupying the largest share, consuming 3.4 billion lbs. of materials in 2007. In 2008, packaging is estimated to use 3.6 billion lbs., and grow 4.6% annually to 4.5 billion lbs. in 2013.

Appliances ranked second, using 558 million lbs. of materials in 2007, with that figure expected to reach 584 million lbs. in 2008 and 682 million lbs. by 2013, for a compound annual growth rate (CAGR) of 3.2%. Building and construction ranks third, using 286 million lbs. in 2007, with 2008 estimated at 295 million lbs., and CAGR growth of 3.6% to reach 352 million lbs. in 2013.

Fellow research firm, The Freedonia Group, described the U.S. thermoformed plastics industry as a $5.2 billion market, with six private firms accounting for a 27% share of the packaging segment, and eight private companies holding 27% of nonpackaging demand. |

Matt Defosse, PlasticsToday.com, October 2008

PLA stands up to heat

Biomax Thermal 300 is a proprietary heat-stabilizing modifier from DuPont Packaging that allows PLA thermoformed packaging to withstand elevated temperatures during transport, storage and use. Its introduction extends the use of PLA to applications beyond chilled-storage packaging.

The polymer modifier increases the dimensional stability of PLA packaging materials to temperatures of up to 95 degrees C (203 degrees F) when used at recommended levels (between 2-4% by weight) and in two-stage forming processes, for above temperatures that packages could be exposed to during storage and shipping.

The addition of Biomax Thermal 300 to PLA at low levels has also been demonstrated to have a minimal impact on the material's clarity, as well as to accelerate cycle times during two-stage thermoforming. The product contains 50% renewably sourced content by weight. However, due to its tendency to deform at temperatures of 55 degrees C (131 degrees F) and above, its adoption to date has been largely restricted to the packaging of chilled food and beverages.

Plastics in Packaging, November 2008

Membership Benefits

- Access to industry knowledge from one central location: www.thermoformingdivision.com.
- Subscription to **Thermoforming Quarterly**, voted "Publication of the Year" by SPE National.
- Exposure to new ideas and trends from across the globe. If you don't think your company is affected by globalization, you need to think again.
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The Industrial Thermoforming Business Review and Outlook 2009

Dr. Peter J. Mooney
Plastic Custom Research Services

If the recent past is prologue for the companies in the North American industrial thermoforming business, extremely challenging economic conditions lie ahead. Plastics Custom Research Services (PCRS) has been tracking this business since 1995, publishing 4 multi-client reports in 1995, 1998, 2001 and 2004. We have just completed our 5th study, and we can share here some of the primary findings from our research, based on extensive interviews with processors, commercial sheet suppliers, thermoforming machinery builders, and other participants in this market space.

We probed several issues in this most recent research program, yet we tended to focus on two issues of over-arching importance – namely, 1) recent and likely future sales growth and 2) technological changes of importance to the processors and their customers. The consensus among the survey participants can be succinctly summarized as follows. Most processors experienced modest growth in 2007 up through the middle of 2008 when orders languished. And in view of the recessionary conditions coursing through all three North American economies, there were few processors brave enough to forecast meaningful sales growth in 2009; the common expectation is a sales pullback.

In our 2004 report we determined that largely due to the 2001 recession and the subsequent recovery the regional industrial thermoformers experienced no real (adjusted for inflation) sales growth over the period 2000-2004. Published data relating to sales of companies specializing in heavy-gauge sheet forming point to a 4.1% average annual increase in nominal sales for this group over the period 2003-2007; adjusting this figure for inflation leaves little to no real volume growth. Thus the composite database would suggest that industrial thermoformers in this region have experienced no real growth since the start of the decade.

What factors underlie this pattern? On the one hand, one could point to challenging conditions in key markets for industrial thermoformers – the bursting of the bubbles in building and construction and electronic equipment, the rise and subsequent collapse of consumer demand for boats and recreational vehicles in the face of volatile fuel pricing and stagnant real household income, and so on. On the other hand, one could put forward the rather glib notion that the business of industrial thermoforming has simply reached maturity.

However, we don't regard either explanation as convincing. Rather we tend to focus on the steady loss of the industrial thermoformers' market share to alternative plastics processors. Every group of thermoplastic and thermoset processors capable of producing structural and semi-structural parts has its own traditional market space dictated by 1) the size and complexity of the part and 2) the volume of part production. As a result of 1) the gradual shift of consumer spending from manufactured goods to services and 2) globalization (e.g., offshoring), the size of the total structural plastics "pie" has shrunk, and so have all the pie slices. Faced with costly over-capacity, all the structural plastics processors have been forced to migrate into non-traditional market "spaces". This is particularly true of the injection molders who with the dual benefit of cheap Chinese tooling and ample capacity have been "infringing" on applications traditionally the preserve of the heavy-gauge sheet thermoformers.

How should the industrial thermoformers counter this attack on their traditional applications and markets? Credit conditions likely to apply throughout 2009 are hardly propitious, but these companies need to find some way to upgrade their machinery and equipment to be in a position to produce parts with superior aesthetics and functional performance. They need to devote what limited time and resources are available to explore new sheet materials that will permit them to defend existing accounts and penetrate new ones. They need to research new markets, new applications that have managed to maintain growth in the current economic environment. And they will have to become "sharper-penciled" in their bidding for new part programs to turn back the challenge of the alterative plastics processors and the metal-benders. In this way they just may be able to recover the growth dynamic they enjoyed in the 1980s and 1990s.

Dr. Peter J. Mooney is an economist and president of Plastics Custom Research Services based in Advance, NC. Information on his industrial thermoforming report series can be found on the PCRS website www.plasres.com.

Education & Industry: A Critical Partnership

Dr. Majid Tabrizi, University of Wisconsin - Platteville

Editor's Note: This article was completed prior to the recent tumultuous economic events therefore some of the numbers referenced will have changed. However, the central thesis remains true: U.S. plastic manufacturing companies are facing a shortage of skilled labor. In order to address this critical concern, it is imperative that companies both invest in and take advantage of existing academic/technical institutes to develop relevant training for future employees.

Current available careers in manufacturing in the United States are high-tech and high-wage. The National Association of Manufacturers (NAM) projects the need for 10 million new, skilled workers nationwide by 2020. Yet a future workforce shortage may be on the horizon. It appears that negative public perception – one that brings to mind low wages, assembly-line work and lay-offs – is thwarting young adults from pursuing manufacturing careers across the country.

The U.S. plastics industry is the third largest industry with value of goods shipped was $379 billion. The U.S. Plastics Industry offers more than 1.1 million jobs, operating in every state in the U.S. The U.S. plastics industry operates in 18,585 facilities with a $23 billion annual payroll (Carteaux, 2008).

The average income in this industry is estimated to be $21,000/year. It is predicted that by the century the United States, the plastic industry will employ 1.5 million persons with an average income of $37,000 per year. This represents payroll of almost $55 billion and $14 billion in capital expenditures. The industry has been growing at an accelerated rate of 7.2% since 1988. This growth rate has doubled in less than 10 years. This indicates that by the year 2020 the industry potentially needs to employ 2.2 million persons. By the year 2040, the industry will need 4.4 million employees.

Wisconsin, although considered the "Dairy State" and perhaps known for the paper industry, is a powerful hub for the plastics and plastics processing industries. In Wisconsin, the plastics industry can be found in every corner of the state. Statistics show that 80% of all counties in the state house a plastics-related enterprise (*Forward Wisconsin*, 2007). Waukesha and Milwaukee counties with 56 and 54 plastics companies respectively are ranked first and second in the nation as the metropolitan areas with the highest number of plastics-related industries.

The State of Wisconsin is the second-most dependent state on manufacturing in the United States. About 20% of state income comes from the manufacturing sector. In addition, 62% of the 1,000 manufacturers recently surveyed by WTCS (2004) expect to boost employment during the next two years, providing an additional 8,700 positions to the state's manufacturing jobs.

(continued on next page)

According to the same study, "highly trained manufacturing professionals are in demand, yet enrollment [in manufacturing programs] has dwindled." This situation potentially can create a shortage of qualified manpower in the manufacturing sector. More broadly, it can also pose a serious threat to the state's financial strength as well as to the lifestyle to which we are accustomed.

If we look at the present time and the year 2012 (the year that today's entering high school freshmen will be attending prom and possibly joining the work force), the industry will need to employ several thousand qualified production personnel in addition to what is being employed today. This is almost an impossible task given the lack of structured educational programs related to plastics and plastics processing in middle school, high school and even in great number of colleges and universities in this nation.

Among all private and public universities throughout the United States, only 140 have association with SPE (*Society of Plastics Engineers*, 2009) and among them only a handful of institutions offer four-year degree programs in plastics engineering or technology. Only three other institutions offer two-year associate degree programs. Thus, the institutions of higher learning which produce middle/high school faculty capable of teaching plastics technology industry are very limited.

The importance of the role taken by the Center for Plastics Processing Technology at the University of Wisconsin-Platteville, SPE-Milwaukee Section, and a number of progressive plastics industries in promoting plastics education programs in middle and high schools throughout the state cannot be emphasized enough.

To sustain such a level of industry is highly dependent on the availability and existence of a well-qualified and competent workforce. Additionally, attraction to and promotion of plastics industries can eliminate the need for young individuals to migrate to industrialized cities, far from the comfort of family. This is particularly true in states with large rural populations. Workers can stay in their home town, enjoy a local support system and contribute to the betterment of their communities and local economies. |

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4SPE.org, Student Chapter.
www.4spe.org

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Quarterly Deadlines for Copy and Sponsorships

ALL FINAL COPY FOR EDITORIAL APPROVAL

15-JAN Spring	**15-APR** Summer
31-JUL Fall *Conference Edition*	**15-OCT** Winter *Post-Conference Edition*

All artwork to be sent in .eps or .jpg format with minimum 300dpi resolution.

Getting Uniform Heat Throughout the Sheet on Roll-Fed Thermoformers

Technical Editor's Note: This article is taken from Adolf Illig's book "Thermoforming: A Practical Guide," Chapter 5 - Heating of Thermoplastic Forming Materials. Achieving a uniform material temperature throughout the sheet on a roll-fed machine has some unique challenges that must be addressed before the sheet enters the pin chains. As always, we assume that readers are custom thermoformers running a variety of materials and tool sizes.

A Note on Thermal Imaging

(This paragraph was not taken from Illig's book.)

Thermal imaging units (some with automatic zone temperature adjustment) are now being installed in many new machines, both roll-fed and sheet-fed. It is the best way to determine any variations in temperature anywhere on the sheet prior to forming. However, because the sensors are reading temperatures on the sheet, the sheet must be fed into the chains and a reasonable amount of material must be indexed at the speed anticipated for production to be able to provide a scan that will mimic production conditions. Thermal imaging is ideal for fine tuning temperatures in each heater zone and for providing instant feedback for the duration of the production run. Defective heaters, changes in ambient temperature, index speed adjustments and minor fluctuations in material thickness can show up on the thermal image and corrective action can be taken quickly. However, there are oven set up procedures which should be done prior to feeding a sheet into the pin chains in order to minimize wasted material. Those procedures are as follows.

Compensating for Chain Rail Heat Loss

Figure 1 shows a typical chain rail transporting the sheet through the oven. Heating and convection losses in the outer regions adjacent to the chain rails must be compensated for by increasing the temperature settings on the heaters in those regions. Generally zoning on roll-fed machines allows for this temperature adjustment on the ceramic rectangular elements that are 3" wide or panel heaters 6" wide that are longitudinally mounted (in the machine direction) in the oven.

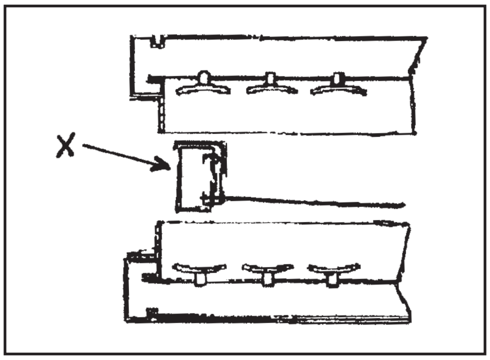

Figure 1. X – Heat loss caused by chain rails.

Compensating for Sag

Figure 2 shows a sheet sagging as it travels closer to the form station. Depending on the material being formed and the web width, this sag could result in the center of the sheet being 4 to 6 inches (100 – 150mm) closer to the bottom heater than at the chain rails. Consequently the temperature settings on the center zones of the bottom heater should be lowered. This illustration shows shaded bars that depict temperature settings in the center heaters lower than in the outer heaters.

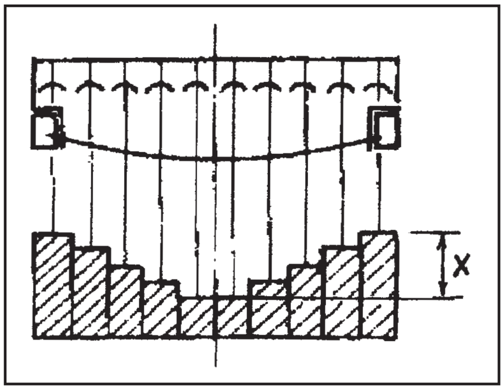

Figure 2. X – Lower heat on center zones.

Compensating for Oven/Form Station Gap

Some machines and tooling configurations leave a gap between the oven enclosure and the mold as much as 4 inches (See Figure 3, GAP.) So consequently when the cycle is in the cooling stage the material in that gap is stationary and exposed to ambient temperature. Every effort should be taken to move the form station or the oven enclosure as close together as possible. Obviously there must be some gap to allow clearance (ideally less than 1" or 25mm) for press travel. It will almost always be necessary to adjust the heaters adjacent to the form press higher to compensate. Usually the machinery builder will install a separate zone that runs across the machine in this area instead of longitudinally so that this adjustment can be made.

Compensating for Index/Oven Length Difference

This is the most difficult adjustment to make unless the zoning on the machine is done in such a way as to allow sections of the ovens at the in-feed end to be shut off in 3" increments. Figure 3 (a) shows a side view of a typical oven

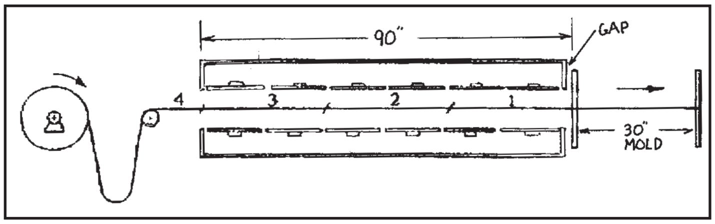

Figure 3 (a). Full indexes 30" (760mm) in the oven.

set up with a proportional index length to oven length (index length will divide evenly into the oven length). Assuming the machine was built with an oven that will accommodate 3 - 30" (760mm) indexes, if the mold dimension in the index direction is 24" (610mm), the index length on the chain drive must index every 24" (610mm). The maximum mold length allowable on this machine is 30", hence the oven length would normally be built to 89" (2.26m) long to provide 3 full indexes of material in the oven plus a 1" (25mm) clearance for press vertical travel. Working back from the form station 24" (610mm) at a time, 4 - 24" (610mm) indexes would have the first index into the ovens with 18" (460mm) of material being heated and the other 6" (150mm) outside the oven, see Figure 3 (b), resulting in a 6" (150mm) strip on the back end of the shot colder than the rest of the shot. The longer the cycle time or cooling time, the more pronounced this difference would be.

Without the luxury of a multitude of zones at the in-feed end, the only way to compensate for this is to baffle or screen the heat from the sheet in the first 18" of the oven leaving 3 full 24" (610mm) indexes or 72" (1.8m) of material exposed to the heaters as shown in Figure 3 (b). Screening can consist of metal pans supported by brackets that shield the heat from the material and that can be moved easily to adjust as necessary. |

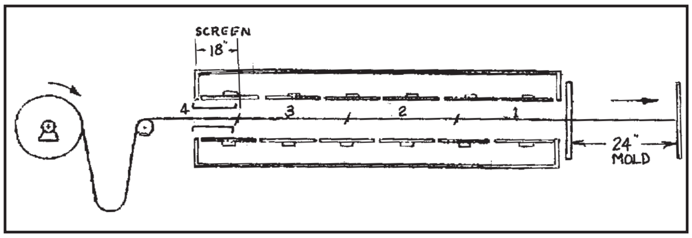

Figure 3 (b). The first index into the oven only heats 18" (460mm) of material. The solution is to screen off 18" (460mm) of heat.

Strong Opinions Clash Over Sheet Specifications

Technical Editor's Note: Our Thermoforming 2.0 article in the last issue titled "Specifying Sheet" was sparked by a discussion in the panel session at the September Minneapolis Thermoforming Conference. The article drew a response from Mr. Michel Siekierski of PLM Solucoes Em Plastico in Brazil who had asked the original question in that panel question. We very much appreciate Mr. Siekierski's participation both at the conference and recently by email. With his permission, we have printed his comments below along with responses from three of the panel members: Mark Strachan (GTTI), Robert Browning and Don Hylton (McConnell Associates). All comments have been edited for formatting purposes only.

Dear Sir:

My name is Michel, I work for an extruding and thermoforming company in Brazil and I was at the 2008 Thermoforming Conference, which by the way, was a wonderful event, where I could learn a lot and meet many interesting people.

The reason I am writing this e-mail is to complain about a report called "Specifying Sheet" in Thermoforming Quarterly *[4th Quarter 2008]. In this report, the writer refers to a discussion at the conference where an extrusion company representative told people it was not necessary for the thermoformer to give the extruder detailed sheet specifications. Well, I was the extruder involved in that discussion and my comments were completely misunderstood.*

The panel asked if there was an extruder willing to answer some questions so I raised my hand. Then someone asked what could thermoforming companies do to confirm that the chemical formula of the sheets was the same formula they specified. My answer was that they shouldn't have to specify the chemical formula of the sheet to the extruder because that's his (the extruder's) responsibility. What is really important is to define the specifications of the sheet (exactly the opposite of what was written in the magazine), where and how the product is going to be used. Once you tell the extruder which formula he has to use, YOU are taking a lot of responsibility for something that you shouldn't be responsible for, so there is no reason to do it!

Instead, just tell them what you need and let them work it out for you. If you do that with different sheet suppliers, you can see which one presents you with the solution with the best cost benefit. That way you can save money and still have good sheet to work with. If something goes wrong with the sheet, the extruder will have no argument and you will have no responsibility for any mistakes made during the sheet developing process.

Thank you very much for your time and I hope now that I made myself clear.

Respectfully, Michel Siekierski

Mark Strachan (GTTI)

The conversation started with the use of regrind in the sheet. A comment was made that if not specified by the thermoformer, the extruded sheet supplier could "sweep the floor and add the contaminated regrind to the mix." This then prompted the question as to whether the thermoformer has a right to dictate how much regrind is allowed to be used in the sheet. The panel unanimously agreed that the extrusion sheet supplier should have to comply with such requests from the thermoformer. At this point the moderator requested if any extrusion sheet supplier would like to comment which is where Mr. Siekierski fearlessly stepped in.

I agree 100% with Jim Throne's comments made in his book "Understanding Thermoforming". The thermoformer must become more involved with the sheet extrusion company and must familiarize themselves with the sheet extrusion process in order to take command of the sheet quality they are buying, e.g., percentage of regrind used in the process.

The IV or MFI range required in the final blend is greatly affected by the quality and quantity of regrind used during extrusion and the amount of times it has been subjected to a heat history (extrusion, thermoforming, grinding, re-pelletizing, drying). If the thermoformer is sending his regrind back to the extrusion company, he then also has every right to request that only his regrind be used and at what percentage. He also has the right to dictate the allowable orientation (MD and TD) and gage tolerances for the sheet. As Jim Throne states, moisture levels (PET, ABS, PC, etc.) are also important. Sheet blemishes for out-of-spec material orders such as die lines, fish eyes, and gels all have to be agreed upon.
I highly recommend that the thermoformer always keep a sheet swatch (1' to 2' of material) from each shipment filed away for later reference. If any discrepancies are found with the sheet, the samples (proven sample and new problematic sheet sample) should then be sent to a reputable and independent lab for tests such as the Plastics Manufacturing Center or a local college or university with a plastics processing department. The report containing the material data can then be presented to the sheet extrusion company to resolve any disputes.

Don Hylton & Art Buckel (McConnell)

This subject – sheet specifications – is one that I try to address each time I have an opportunity to speak to thermoformers. I try to emphasize that establishing specifications is a mutual responsibility between the extruder and the thermoformer. They should approach the process as partners with open communications with a synergistic goal in mind. Both are in it for the same reason, that is, to make a profit.

My comment relative to the discussions at hand and what I attempted to get across at the conference is that the extruder and the thermoformer should sit together to develop comprehensive specifications based on the thermoformer's and extruder's needs and capabilities. This should include material sources, formulations, aesthetics, dimensions and performance criteria.

An important component of the process is the need for measurements and controls with documentation. It is our opinion that the outcome of this approach to doing business will result in higher quality, more consistency, less rejects and improved profitability.

Robert Browning (McConnell)

This is a very important and critical topic which deserves the time and effort to make sure everyone understands perspectives.

When I was in school, one of my professors was a retired executive from both the government (military intelligence) and Coca-Cola. The one thing that he emphasized over and over was the need for complete and total documentation on everything you do. When everyone is on the same page, knows and has the same information, it eliminates errors and problems and creates a history for correcting problems they do come up. As they say, knowledge is power.

It is essential that the thermoformer sit down with the sheet extruder to create a specification that everyone can and will live with. One of the problems we have seen, especially lately, is that promises are made for quality and consistency in the sheet material which are not being kept by the sheet extruders.

In a recent project, with five different batches/runs of the "same material," independent test labs found wide variations in the amount of regrind in the material (it was suppose to be 100% virgin material); contaminates in the material; blends of different grades of base polymer materials; and inconsistent overall material physical properties. If the extruded sheet material is not consistent from batch to batch and run to run, the parts can and will vary in formability, overall size, shrinkage, gloss, wall thicknesses, sag, impact, etc. These variations have profound consequences for the thermoformer who has already designed and built tooling for the job. In many cases the thermoformed parts are unusable and are rejected by the client/end users.

The point is clear: there must be checks and balances with exact, agreed-upon sheet specifications between the thermoformer and the sheet extruder. |

Thermoforming Quarterly welcomes and encourages comments from our membership.

Write to us at
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or
cpcarlin@gmail.com.

The Improvement of the Thermoformability of PC / PBT Blends

Yantao Zhu and Donald Ellington, Sabic Innovative Plastics, 1 Lexan Lane, Mt. Vernon, IN 47620

Abstract

Polycarbonate / polybutylene terephthalate (PC / PBT) blends are not typically used in thermoforming processes, due to the poor melt strength inherent in semi-crystalline materials. New PC / Polyester compositions presented here can be used to make articles by typical thermoforming processes, without equipment or process modifications. These new PC / PBT blends offer the full advantages of mechanical strength and chemical resistance typical of PC PBT alloys, while allowing the use of cost-effective production methods, such as thermoforming.

Introduction

Thermoforming is a very useful and cost-effective way of manufacturing plastic parts. [1] A plastics sheet is preheated, and then brought into contact with a mold whose shape it takes. This can be done by vacuum, pressure and/or direct mechanical force. This process normally provides close tolerances, tight specifications, and sharp detail. The tooling cost is much lower than injection molding in many cases and it is a great alternative for injection molding for large parts with relatively small- to mid-size volume.

Most plastics sheets can be thermoformed. However, not all can be formed equally easily, especially when the parts are large and complex. To be a good thermoforming candidate, a sheet needs to have a wide temperature window where it can be soft enough to take the shape of the mold, yet have enough melt strength to hold itself together. Amorphous materials normally soften gradually at temperature above their Tg and can usually provide good combination of melt strength and softness at wide temperature range for thermoforming to happen.. Semi-crystalline materials, on the other hand, are more difficult to form due to the existence of the melting point. They normally are not soft enough to provide a good mold replication until the processing temperature is very close to the melting point. When the processing temperature passes the melting point, however, the materials tend to flow too well and do not have enough melt strength to hold themselves together against gravity. This normally leads to excessive webbing at the hard-to-form corners. As a result, semi-crystalline materials usually have very narrow processing window if any at all (typically less than 10°C on small tools). [2,3]

Polycarbonate / polybutylene terephthale blends are semi-crystalline blends. They are not typically used in thermoforming applications due to the reasons presented above. Attempts have been made to increase the melt strength of PC / PBT blends using Teflon additives. Although the melt strength was greatly enhanced, the surface quality of the formed parts was not acceptable at all. (Figure 1.) Recently, we were able to discover a polymer additive that not only significantly improved the processing window for PC / PBT blends, but also provided excellent surface quality.

Figure 1. Surface defect of thermoformed part using Teflon additive.

Processing and Testing

The resin pellets were extruded into sheets (17" wide and 0.125" thick) through Davis Standard sheet extrusion line with Cloeren sheet Die in monolayer configuration without feedblock. The sheets were then formed on GEISS T8 thermoformer. They were first cut to the dimension of 17" x 26", then dried in a desiccant closed loop oven at 82°C for 12 hours and formed using an aluminum thermoforming tool (4.5" x 6" x 3"). No pre-vacuum was used. A sheet was heated to set temperature at 50% heater setting, the oven was shut and retracted. The forming tool was raised up and a vacuum was applied to force the softened sheet to take the shape of the tool. The process was repeated at different temperatures. The lower limits of the forming windows were the lowest temperature at which a part can be formed without the loss of details. The upper limits were established as the highest temperature at which a part can form without webbing.

Results and Discussion

A base non-FR PC / PBT formulation was modified with either SAN-encapsulated Teflon (TSAN) or another thermoforming additive that we found very beneficial. While they both provided enough melt strength to the blend to form parts, the TSAN containing material could not provide a defect-free surface. (Figure 2.) Fortunately, high surface quality parts can be easily obtained through thermoforming with the thermoforming additive formulations. The amount of additive used in the formulation is important in determining the size of the forming window. As shown in Figure 3, the base formulation (not shown on the graph) was not suitable for thermoforming using the process we specified in processing and testing. The addition of 5% of this additive allowed the material to be formed within a 5°C window. As more additive was used, the window peaked out at about 20°C with 10-12% additive. The use of more additive led to the window to decrease back to 5°C with 15% additive present. The same phenomena was observed when another base formulation was evaluated. This formulation was a FR PC / PBT blend. Without any additive, the base formulation showed a 10°C forming window. (Table 1.) The use of 5% additive expand the forming window to 30°C. Another 10°C was achieved by using 10% additive. This seemed to be close to the optimal amount of additive since additional 5% additive led to a decrease of the forming window from 40°C to 20°C.

Figure 2. Surface of thermoformed part using thermoforming additive.

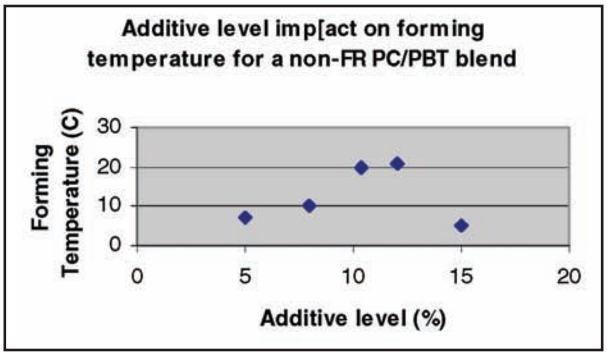

Figure 3. The impact of additive level on the forming windows of blends based on a non-FR PC / PBT blend.

While the forming of even a small part was difficult for the non-FR base formulation, the modified formulation with 12% additive allowed the easy forming of a part from a car tool with a dimension of 1390 x 280 x 135 mm^3 (Figure 4).

Table 1. Effect of additive level on forming windows for blends based on a FR PC / PBT blend.

	Additive level (%)	Forming Temperature (°C)	Forming Window (°C)
Formulation 1	0	205-215	10
Formulation 2	5	200-230	30
Formulation 3	10	205-245	40
Formulation 4	15	230-250	20

Figure 4. A big part formed from a non-FR PC / PBT formulation with 12% thermoforming additive (1390 x 280 x 135 mm^3).

The non-FR PC / PBT blends with and without the thermoforming additive were tested under G26 conditions. As shown in Figure 5, both formulations have the same DE* profile. Therefore, the use of this additive does not have any negative effect on the weatherability of the blend.

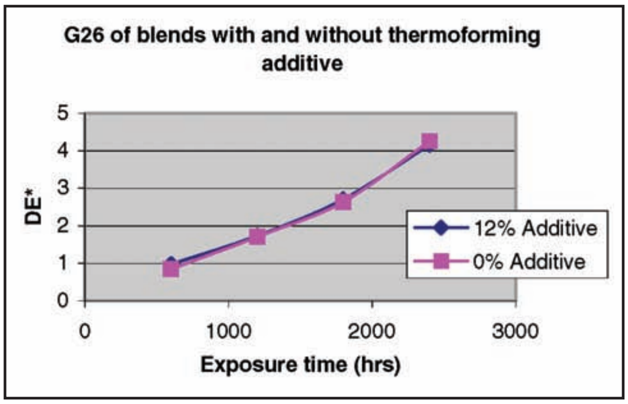

Figure 5. The effect of thermoforming additive on weatherability based on a non-FR PC / PBT blend.

Conclusions

The use of a special thermoforming additive significantly increased the thermoforming capability of PC / PBT blends. It not only provided an excellent surface, but also widened the forming window, allowing the production of big parts using semi-crystalline blends. No negative impact on the weatherability of these blends was observed.

(continued on next page)

Acknowledgement

We would like to acknowledge the aid of Kathryn Garnavish, Glen Tryson, Emmanuel Boxus, Piet van Eekelen, Jos van Gisbergen, and Pete Zuber.

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Figures and tables are provided for general information and are not for the purpose of warranty or specification. All resins and mixtures discussed herein should be thoroughly tested in actual parts under end use conditions before incorporation into any device.

Keywords

ANTEC, PC / PBT blend, Thermoforming.

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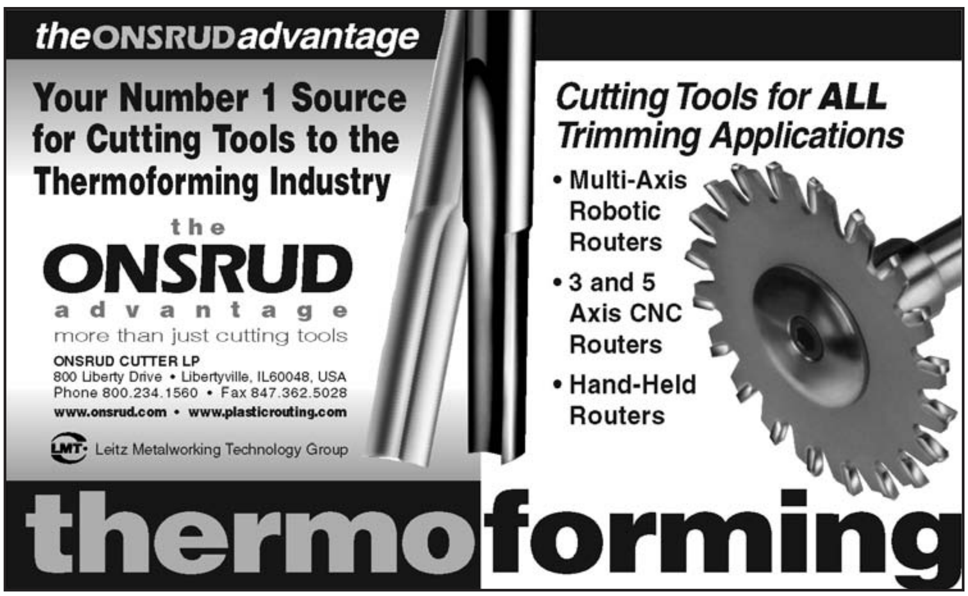
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Creating an Emerging Workforce

The benefits of the corporate "adopt-a-school" philosophy

Mary-Anne Piccirillo, Northstar Communications

Could it be that students and corporations are asking for the same thing? Students (our emerging workforce) and corporations (their potential employers) are seeking more practical experience.

According to the Every Child Every Promise* (ECEP) report from America's Promise Alliance, most high school students want more challenging work as well as work that is relevant to potential careers, while employers are looking for young people to enter the workforce with a higher level of practical skills.

"A school's goal is to develop interests and open avenues for students to explore, and along the way gain insight into the work world," said Dave Snyder, co-chair of the Career and Technology Department at Gettysburg High School. "Experiences such as working in a manufacturing cell concept, designing, problem solving and finishing, in addition to hands-on experience give our students and their employers an advantage when they enter the work force."

Many schools have found the solution in active cooperative partnerships with corporations. Such a partnership exists between Gettysburg High School in Gettysburg, PA and McClarin Plastics in Hanover, PA.

Last year, the school's Career and Technology Department was looking for a way to expand their Materials Processing Course to include more experience with plastics via an industrial quality thermoforming machine – which was out of their budget and expertise. Because of their established relationship, they went to McClarin Plastics who advised them of the Society of Plastics Engineers' Thermoforming Division Machinery Grant process and pledged to help where they could.

The thermoforming machine arrived at the school in June of 2008 thanks to the grant, federal funds from the Perkins Fund and a generous discount from Maac Machinery in Carol Stream, IL. McClarin Plastics has also taken an active role with the students by providing personnel for set-up and training, molds and sheet plastic donations.

Since its arrival, the students have designed and manufactured a flying disk mold and embossing top plate. The flying disk project has given them experience not only with thermoforming, but with design, problem solving, mold making, finishing, Auto-CAD Inventor and CNC equipment. In addition to the practical skills, the students will also receive sales and marketing experience as they plan to sell the disks.

The experience has also made an impact on McClarin Plastics. According to Morrell Myers, Corporate Production Manager at McClarin, the program has spurred enthusiasm within their work force. "Working with the students has given us a fresh perspective," said Myers. "It is also encouraging to know that if some of these students decide to work here [McClarin], they'll be able to start at a higher level and bring more to the table at an earlier stage in their employment."

But this isn't the first positive experience McClarin has had with working with schools. For the past six years, they have partnered with chambers of commerce, industry associations and other manufacturers to offer programs designed to pique students' interest in manufacturing.

During the Fall of 2006, McClarin Plastics partnered with MANTEC, a nonprofit organization dedicated to meeting the needs of small and mid-sized manufacturing enterprises in South Central PA, and the South Western School District in Central PA to offer **Adventures in Technology**. Tenth- and twelfth-grade students with diverse interests and backgrounds, their instructors and their McClarin mentor, Tim Dietz, identified an issue for which the company was seeking a solution. The students studied the process, evaluated what was happening, developed a couple of solutions, ran a cost/benefit analysis and then presented their findings and recommendations to McClarin's management. The students' recommendation was deemed a viable, innovative solution and management decided to implement it. The solution is projected to save the company about $95,000 over the next five years.

"This program [Adventures in Technology] was designed to give 'bottom line' exposure to the students and trigger ideas for their future. Manufacturing and corporate functions were disassembled so the students could understand how many disciplines fit together to make a company work," said Rob McIlvaine, Vice President of MANTEC.

"The 'adopt-a-school' philosophy is based on the fact that in order to be successful we all depend on each other: schools, students, and industry. We've seen our personnel and bottom line benefit from our involvement with the schools and we've seen a more prepared workforce come to our door," said Todd Kennedy, President of McClarin Plastics. "All in all, it benefits everyone to stimulate the intelligence, imagination, and confidence of our students."

* *The research behind the ECEP comes from collaboration among America's Promise Alliance, Child Trends, Search Institute and the Gallup Organization.*

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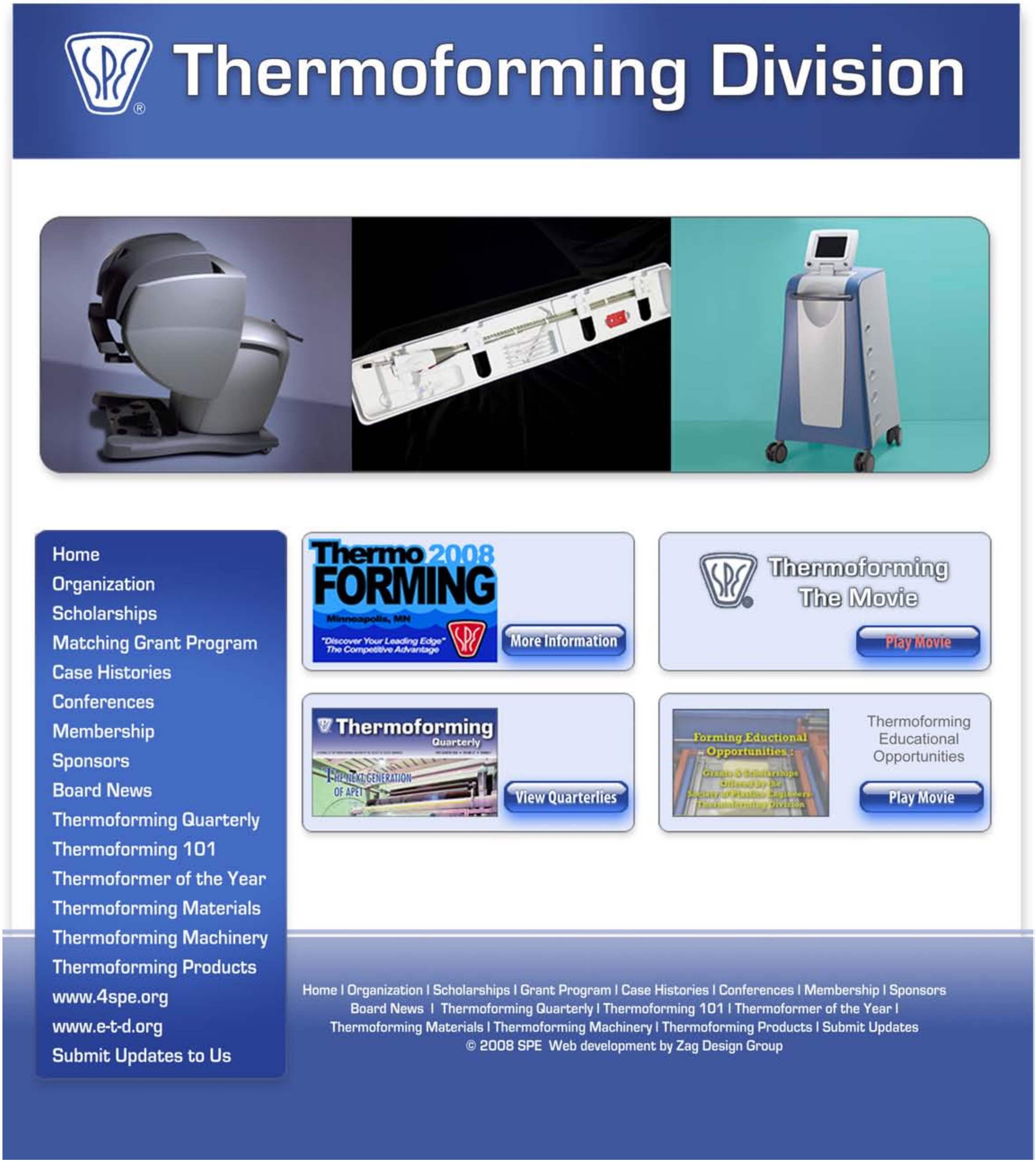

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Getting Beyond the Buzz of Sustainability

Phil Barhouse, Market Development Manager,
Spartech Packaging Technologies

As chairman of the 2009 SPE Thermoforming Conference in Milwaukee, I can't help but feel excited and privileged to bring the topic of sustainability to our Thermoforming Conference. Over the last few months, I have heard the collective sigh of relief now that gas prices are below two dollars a gallon and resin prices have dropped from their record highs. For those of us in the extrusion and thermoforming business, we welcome the lower resin and energy costs. But, when cost savings are coupled with lower sales volume, it presents complex challenges for all of us. I believe that one must look at the opportunities that this economical environment is presenting. Through sustainable business practices, we have an enormous opportunity to grow our businesses. It is those companies who choose to embrace sustainable practices that will be the market leaders. To fully embrace sustainable practices, the entire organization must be involved. But how can a company incorporate sustainable practices into their accounting, marketing, R&D, operations and other departments when the term itself seems so subjective? When you take a broad definition of sustainability like, "… using the resources of today in a manner that doesn't compromise the ability of future generations to meet their own needs," I can see how difficult the process would be.

Back in October 2005, the Sustainable Packaging Coalition (SPC) developed eight definitions that attempted to eliminate the subjectivity and provide a framework for organizations to develop their own specific actions for sustainability. These definitions and the "how to" are related to packaging but they are applicable to just about any product and market. Here is a summary outline of the SPC definitions and how you might implement them within your organization.

1. Packaging and/or product is beneficial, safe and healthy for individuals and communities throughout its life cycle. It involves corporate social responsibility including employee safety and well-being.

   WHAT YOU CAN DO
   - Review your own internal policies and practices.
   - Implement a supplier code of conduct if appropriate.
   - Understand your opportunities to eliminate packaging waste.
   - Participate in or support the development of material recovery systems.
   - Support the development of end markets for recovered materials.
   - Share your successes and best practices in the form of a Corporate Social Responsibility Report.

2. Packaging and/or product meets market criteria for performance and cost through the end of life. It must be competitive in the market place.

   WHAT YOU CAN DO
   - Review minimum packaging specifications and evaluate for over-engineering.
   - Understand the fees or regulations that apply to the materials you sell or use in packaging.
   - Can you offer materials or designs that offer environmental advantages that save your customers packaging fees or improve their compatibility with recycling systems?
   - Understand the "true" costs of packaging over its life cycle and integrate them into your product development process.
   - Help your customers understand the environmental performance of your products.
   - Collaborate with your suppliers to help identify opportunities to improve materials and packaging systems.

3. Packaging and/or product is sourced, manufactured, transported, and recycled using renewable energy. Renewable energy offers a solution to many of the environmental, social and economic issues we experience today.

   WHAT YOU CAN DO
   - Set energy efficiency and renewable energy goals.
   - Identify opportunities for savings.
   - Review the energy rating of your equipment.
   - Purchase energy efficient equipment.
   - Consider investing in renewable energy technologies at your facilities.
   - Make direct purchases of renewable energy or indirect purchases through renewable energy credits (RECS).
   - Improve fleet performance through optimized routing and better fuel efficiency.
   - Consider bio-based fuels & hybrid vehicles.

4. Packaging and/or product maximizes the use of renewable or recycled source materials. The use of renewable materials ensures that raw materials will not run out and can reduce carbon emissions. Recycled materials help to eliminate waste, conserves energy and resources and reduces the environmental impacts associated with virgin material production

   WHAT YOU CAN DO
   - Use renewable and recycled materials in your packaging.

- Non-renewable materials should maximize recycled content.
- For renewable materials, use recycled content when feasible.
- Source renewable materials from certified sources.
- ASTM D6866

5. Packaging and/or product is manufactured using clean production technologies and best practices. Integrating a preventive environmental strategy can increase efficiency and reduce the risk to humans and the environment. It includes eliminating toxic and dangerous inputs and reducing emissions and waste during production.

WHAT YOU CAN DO
- Understand your own environmental impacts.
- Air, water, solid waste and toxic emissions.
- Use best practices.
- Reduce problematic chemicals by looking into green chemistry or green engineering.
- Invest in closed-loop systems and look for opportunities to reuse or eliminate wastes.
- Request supplier certifications.

6. Packaging and/or product is made from materials healthy in all probable end-of-life scenarios. It refers to the use, presence and release of harmful substances to humans and the environment throughout the entire life-cycle including disposal or recovery. Release or accumulation of problematic substances in the biosphere and in our bodies is the subject of increasing concern.

WHAT YOU CAN DO
- Be proactive about developing materials.
- Help your customers understand the impacts or benefits of your materials in all end-of-life scenarios.
- Know the chemistry of the materials.
- Understand the potential adverse human and environmental health affects of your package from manufacture to end-of-life.
- Select and specify the safest materials available.
- Stay current with materials bans, restricted substances lists, and legislation.
- Develop tools and methodologies to assess material health.
- Transparent communication of material characteristics.

7. Packaging and/or product is physically designed to optimize materials and energy. Design decisions can influence the extent to which a package ultimately becomes waste or a resource for future generations. Design is the critical point that determines how efficiently resources are used.

WHAT YOU CAN DO
- Implement design for environment strategies, e.g. source reduction or redesigning for recycling.
- Develop internal design guidelines within the product development process.
- Design packaging that optimizes the use of energy and materials.
- Understand the energy and environmental profiles of your packaging materials.
- Consider the end-of-life recovery.

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- Develop internal design guidelines within the product development process.
- Design packaging that optimizes the use of energy and materials.
- Understand the energy and environmental profiles of your packaging materials.
- Consider the end-of-life recovery.

9. Packaging and/or product is effectively recovered and utilized in biological and/or industrial cradle-to-cradle cycles. Creating the collection and recycling infrastructure necessary to close the loop on the package and product materials. These materials provide valuable resources for the next generation of production. Building the appropriate systems for effective materials management is critical to the development of sustainable program.

WHAT YOU CAN DO
- Support the use of recycled materials.
- Work to develop and support new avenues for collection and reclamation.
- Collaborate with area recycling centers to develop clean streams of feedstock.
- Partner with innovative programs or technologies that incentivize post-consumer recovery.

As you can see from summary, there is no product or process that currently meets the definition of 100% sustainable. But it can provide a framework for the development of your own sustainability program.

Whether you are focusing on recycled or bio materials, branding and marketing your sustainable product, reduction of your energy use or improving your operations through Lean Six Sigma practices, you can find the tools and resources you need at the 2009 SPE Thermoforming Conference. The Conference will be held September 19th - 22nd in Milwaukee, Wisconsin and is a must-see conference for anyone interested in discovering how to sustain your business in an increasingly challenging environment. |

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Board meetings are open to members of the thermoforming industry.

If you would like to attend as a guest of the board, please notify Division Secretary, Mike Sirotnak, at msirotnak@solarproducts.com.

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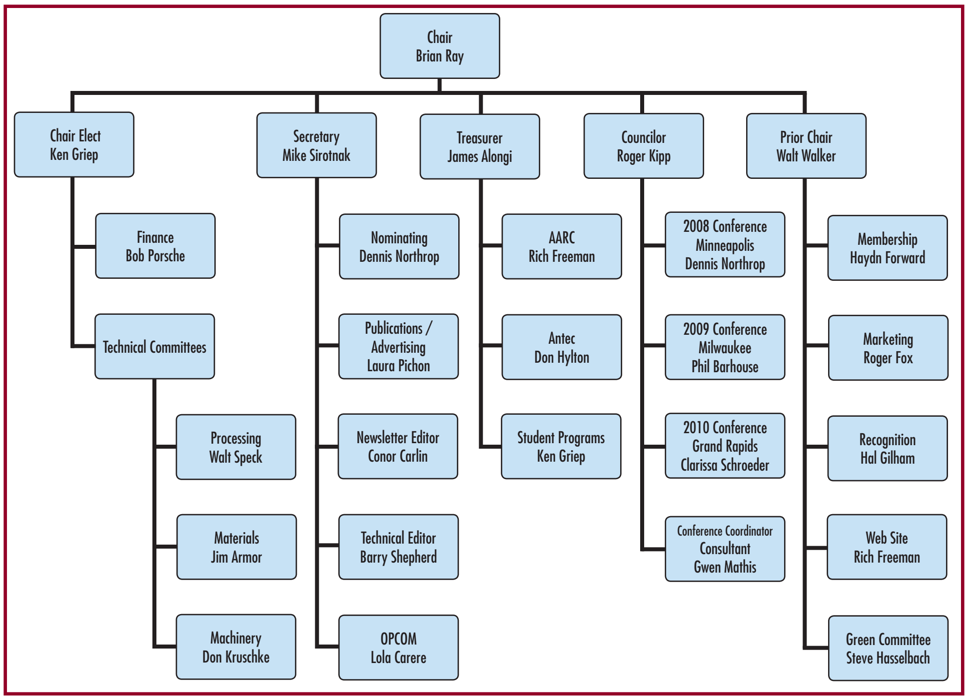
2008 - 2010 THERMOFORMING DIVISION ORGANIZATIONAL CHART



PlastiVan™

Plastics Education on the Move!




WISDOM WONDER


& WOW!

Sponsor the PlastiVan™ in Your Community

Since 2000, the SPE Thermoforming Division has contributed approximately $120,000 to the PlastiVan™ program.

The PlastiVan™ is a great way to WOW and excite young people about science and the vast opportunities the plastics industry has to offer. PlastiVans travel to schools and companies throughout North America, educating people of all ages about plastic's chemistry, history, processing, manufacturing, sustainability and application.

Plastics industry companies and other organizations are encouraged to introduce school children in their community to the marvels of plastics by sponsoring a visit from the PlastiVan. If the company chooses, time will be allotted for a company representative to address the students about their products, processes and career opportunities.

Sponsoring companies nurture the development of their future workforce by opening children's minds to careers in sciences, engineering and the plastics industry. In addition, PlastiVan benefits the sponsoring company by increasing the company's visibility in the community and often garnering local media coverage, changing the public's perception of the industry, and positively affecting the lives and minds of young people. Plus, sponsorship of a PlastiVan visit is a tax-deductible donation to the school.

For more information about the PlastiVan™ Program,
please contact Betty Coleman, Outreach Director at (781) 337-7127.

For more information about the PlastiVan Program, contact:

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Thermoforming Quarterly®

FIRST QUARTER 2009
VOLUME 28 ■ NUMBER 1

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