Thermoforming Quarterly®

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

SECOND QUARTER 2009 ■ VOLUME 28 ■ NUMBER 2

Resource Efficiency: Getting the Most From Your Regrind

page 10

INSIDE . . .

THERMOFORMING NETWORKING RECEPTION AT NPE

THERMOFORMERS ATTENDING NPE

Are Cordially Invited to Join Members of
SPI's Thermoforming Institute (Ti)
and SPE Thermoformers

TIME
Tuesday, June 23, 2009
4:00 p.m. to 6:00 p.m.

LOCATION
SPE Thermoforming World Pavilion
McCormick Place, West Hall, Booth 119025
Chicago, IL

RSVP
Jill Brandts – Thermoforming Institute
jbrandts@plasticsindustry.org
+1 949 261 6979

Technology Central @ NPE2009

EMERGING TECHNOLOGIES PAVILION*

West Hall, Booth 117011

- Four quadrants of research and development, divided initially in a pod/booth setting.
  - Nanotechnology
  - Sustainability
  - Energy conservation
  - Bioplastics
  - Others to be added
- Organized by NPE and the SPI Science & Technology Division and the NPE New Technology Committee.
- SPI's Science & Technology Division will reach out to the university, governmental and corporate communities for current research and development.
- You can submit proposals for consideration to be evaluated by SPI'S Science & Technology Division. Participants do not have to be exhibitors elsewhere at NPE2009.
- SPI is working to secure corporate underwriting for support of the Emerging Technologies Pavilion.
  - Platinum Exclusive Sponsor: $35,000
  - Gold Sponsors: $10,000
  - Silver Sponsors: $2,250 (SPI members); $3,600 (Non-members)

Sponsor advantages include: recognition for support of and participation in the exhibit; recognition on all promotions and signage; speaking privileges in the Technology Theaters and exhibit floor poster sessions.

Cost

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Non-members: turnkey kiosk, $3,600

NEW TECHNOLOGY PAVILION*

West Hall, Booth 107011

- Limited to exhibiting companies that want to introduce new technology or new technology processes. Requires proposal submission.
- NPE2009 review panel, composed of international editors, will review proposals. Applications for participation are currently in development.

Cost

$2,250 – $3,600 based on critical mass; includes turnkey kiosks/booths.

TECHNOLOGY THEATERS*

West Hall Booth 113017
North Hall Adjacent Booth 60048 & 60148

- Two enclosed theaters for 20-minute presentations using video format, PowerPoint or public speaker. Schedule to be determined, but will run throughout the show in 30-minute cycles.
- Priority: 1. Technology Pavilions participants
  2. Specialty Pavilions exhibitors
  3. NPE2009 exhibitors

Cost

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For information on all technology and specialty pavilions, call NPE @ +1.312.321.5171, e-mail exhibit@npe.org.

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.*

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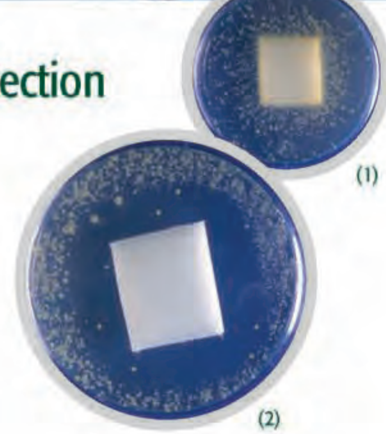

(1)

(2)

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Thermoforming Quarterly®
SECOND QUARTER 2009
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Thermoforming Quarterly®

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

If you are like me, then you are weary of all the negative news flooding the airwaves and media lately. Don't get me wrong – I have not put my head in the sand, nor am I looking the other way. Manufacturing has been a pillar of this country for centuries, despite all the challenges. One need only read a history book to be reminded that during WWII various manufacturing plants were transformed from making custom products one day to building military equipment the next.

As a Harley Davidson enthusiast, I recently toured one of their manufacturing facilities. I saw a video presentation about a 100-year-old company that grew from building a few motorcycles in a 10' x 15' shed to a global motorcycle powerhouse. As part of the video, I was reminded of the many challenges that Harley Davidson faced over the decades, yet the company has continued to find ways to flourish.

In mid-February we concluded our winter Board of Directors' meeting. It was at this meeting that we began intense discussion regarding the annual Thermoforming Conference. As the meetings continued, focus on the conference intensified, until we reached the conclusion that a conference in September 2009 would not provide our sponsors, exhibitors or attendees with the high quality product we are all accustomed to. This was a difficult decision, but in light of worsening economic conditions, I have no doubt that the Board of Directors acted correctly. We will return to Milwaukee with a Thermoforming Conference in 2010, and I look forward to seeing all of you there.

June is just around the corner, and that means NPE. I have vivid memories of this show as a young 15-year-old high school student walking the exhibit floor with my father. I will never forget the distinct smell of melting plastic at the entrance to each hall. As a first-timer, I had no idea what we were doing there or what to expect. All I know is that by the end of the day, I was carrying a frisbee, a resin chair and a five-piece place setting. I felt lost, and at subsequent NPEs, I still got lost.

That will all change this year.

For the first time, the SPE Thermoforming Division is sponsoring a Thermoforming Pavilion. Located in the **West Hall, Booth 119025**, this area will allow the Division to showcase both thermoforming technologies and all the educational efforts supported by the Division. Several board members and non-board members have taken a very active role to ensure that the pavilion is a success and the division can grow its membership and overall footprint within the plastics industry. We are using this pavilion as an opportunity to attract new sponsors, exhibitors and attendees for the 2010 Thermoforming Conference and as a highly visible platform to showcase all that has been accomplished in the world of thermoforming over the years.

For those who are interested, there is still time to sponsor a portion of the pavilion with your corporate logo. The cost is $2,500 and your company banner will be positioned near one of the technical areas within the pavilion (Machinery, Processing or Materials). If you are interested, please contact me directly as soon as possible. With this sponsorship, you will also be able to distribute your company literature. With over 70,000 attendees, the cost comes out to be less than a nickel per copy. I don't know a marketing manager that can pass up such a great opportunity.

I want to thank you all again for your continued support of the Thermoforming Division. I look forward to seeing many of you at NPE. In fact, our good friends at the Society of Plastics Industry - Thermoforming Institute, will be hosting a Thermoforming Reception in the Pavilion on Tuesday, June 23, 2009 from 4pm - 6pm. This reception is open to thermoformers and will provide a great opportunity to network and socialize.

Get involved with the sponsorship of the pavilion and show your support by telling the world how thermoforming fits into today's manufacturing environment.

Brian Ray
Chair

New Members

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Thermoforming in the News

Dust to Dust: Thermoformed coffin made of biodegradable plastics

By MPW Staff
Published: January 28th, 2009

Although biodegradable plastics are seeing greater use in smaller packaging applications, until now thermoforming of these for large, thick-walled parts from cut sheet has been very limited. One processor, Bauer, which usually serves the automotive industry, has developed the extrusion and thermoforming processes sufficiently to now offer biodegradable coffins formed from the Arboblend material supplied by Tecnaro GmbH (Ilsfeld-Auenstein, also Germany).

Tecnaro takes lignin (a complex polymer found in plant cell walls) and compounds this with natural fibres (flax, hemp or other fibers) and natural additives to produce a composite.

mpweditorial@cancom.com

Berry to invest $80 million in new thermoforming operation

By Tony Deligio
Published: January 22nd, 2009

Berry Plastics (Evansville, IN) will invest $80 million in building and equipment for an expansion of its thermoforming operations. Startup is targeted for the first quarter of 2010, and as yet, the company has not settled on a site for the expansion, but believes it will create 150 new jobs. In a release, Jonathan Weinzapfel, mayor of Evansville, IN, where Berry is headquartered, said his city will "do all that we can to ensure this new investment and job creation happens in Evansville." Berry had already recently invested $40 million dollars in Evansville, for an expansion of its global headquarters on Oakley Street and a new warehouse/distribution center at the Evansville Regional Airport, with those initiatives resulting in 300 new jobs.

Berry's in-house thermoforming capabilities go back to 2001, and they were expanded in 2003 with the acquisition of Landis Plastics Inc.'s five U.S. plants for $228 million. More recently, Berry acquired certain assets of Erie County Plastics Corp., a custom injection molder of plastics packaging and components. Erie filed for bankruptcy protection on Sept. 29, 2008.

Primarily through 21 acquisitions starting in the '90s, Berry has grown to include nearly 14,000 employees and 66 U.S. manufacturing sites, as well as operations in Mexico, Canada, Italy, Belgium, and China. Berry is owned by private equity investors, Apollo Management L.P. and Graham Partners Inc., which purchased the company in 2006. Berry's management team also holds a stake.

tony.deligio@cancom.com

Thermoformer PWP preparing to open recycling plant

By Roger Renstrom, Plastics News Correspondent
Posted: March 17th, 2009

Food packaging thermoformer PWP Industries is moving toward opening an 80,000-square-foot in-house plastics recycling facility in Davisville, W.Va., during the second quarter of 2009. The site is less than 10 miles from a PWP production site in Mineral Wells, W.Va.

An unidentified supplier is providing the recycling equipment and technology and, currently, is training PWP employees.

"Recycling PET bottles will allow PWP to increase its product range containing post-consumer resin, save energy, reduce carbon dioxide emissions and keep plastic materials out of landfills," Ira Maroofian, president and chief operating officer, said in a statement.

Coca-Cola Recycling LLC of Atlanta will be the primary supplier of recycled PET flake that PWP will use as Food and Drug Administration-compliant resin for food packaging. The limited liability company is a subsidiary of publicly traded Coca-Cola Enterprises Inc., the largest bottler of Coca-Cola products.

Phase one of the PWP project is projected to have an annual capacity to recycle 40 million pounds of flake and, in the process, cut annual emission of 30,000 tons of carbon dioxide and reduce annual energy requirements by 398 million kilowatt hours.

PWP says manufacturing of post-consumer-resin PET uses about two-thirds less energy than production of virgin PET.

Establishing the recycling facility is part of a PWP company-wide initiative called Earth's Pack through which PWP has introduced new packaging composed of biodegradable and compostable materials from agricultural scrap.

Vernon, Calif.-based PWP thermoforms PET and polypropylene for food packaging at plants in Vernon, Mineral Wells and Abilene, Texas.

For energy conservation, builders of the Davisville facility and an addition at the Abilene site incorporated designs for maximum natural lighting, high-energy efficient lighting and on-off motion-occupancy detectors.

David M. Bestwick
Tray-Pak Corporation
Reading, Pennsylvania

David M. Bestwick was born October 3, 1933 in Grove City, Pennsylvania. Dave graduated from Grove City College in 1957 with a degree in Business.

Bestwick joined General Fireproofing as a salesman in 1957. He bought his first business, Business Equipment and Supply and moved to Reading, Pennsylvania in 1967, selling the company to a partner in 1974.

David Bestwick, along with partners, acquired the thermoforming operation of W. R. Grace in 1975. Tray-Pak started with eleven machines and thirty-six employees, manufacturing cookie and candy trays. In 1981, Dave bought his partners' shares and created a vision for Tray-Pak that is followed today: focus on what the customer needs and direct all of your effort toward supplying a quality solution in a timely and cost- effective manner.

David Bestwick introduced HIPS trays to the mushroom industry in 1977. The transition from pulp to thermoformed trays increased shelf life in the supermarkets 30- 40%.

Dave has always maintained a focus for Tray-Pak to support the development of new materials and their application in the marketplace. Tray-Pak was involved in the early development of CPET – dual ovenable trays in the 1980's. Tray-Pak's early involvement in sustainable packaging was further enhanced in the mid-1990's when they were thermoforming recycled or post-consumer PET. Tray-Pak continued to stay in front of the sustainable industry, co-presenting to the industry on NatureWorks PLA material.

In the early 1980's, under Dave's guidance, Tray-Pak began working with customers to introduce new designs created for customers to sell more product. In 1982, Tray-Pak added in-house tool fabrication through the purchase of S. R. Schlegel. In 1991-1992, along with Ben Franklin Partners, Tray-Pak integrated their process into CNC and Autocad Technology. Bi-Color Clamshells were introduced and Tray-Pak's I-POP™ (Images Printed on Plastic) put pre-printed sheet in the marketplace in 1995. Tray-Pak's Design and New Product Development groups added rapid-prototyping and digital scanning to their in-house capabilities. Twelve people now provide creative solutions for a variety of industries.

Dave's vision always challenged his employees to look at new markets and products to enhance the value of Tray-Pak to its customer base. In 2000, TPSource was added to support the needs of captive thermoformers. It supplies tools, materials, and tech support to customer. In 2003, with the help of the late Scott W. Bestwick, Tray-Pak launched *Fusion-Pak*, a unique concept that married the graphic capabilities of printed board to the flexibility of thermoformed packaging. Tray-Pak utilized this platform for direct mail programs earning users response rates in excess of 20%. Tray-Pak was awarded a 2009 American Design Award from Graphic Design USA for this program.

David Bestwick has grown Tray-Pak from 36 employees in 1975 to over 250 dedicated employees today. Operating 44 thermoforming machines in nearly 200,000 square feet of space, Tray-Pak offers custom design, in-house tooling and engineering, and automation expertise. Tray-Pak converts a myriad of material types including polystyrene, polypropylene, HDPE, LPDE, PET, and PVC as well as co-extruded and laminated materials. Dave also directed Tray-Pak's efforts into markets such as food and food service, automotive, consumer, electronic, health and beauty, industrial, medical, and pharmaceutical products.

Bestwick and Tray-Pak have also received the 2002 Pennsylvania Department of Commerce Award, the 2003 Ben Franklin Technology Partners Grant for Economic Development, and the 2007 Ben Franklin Technology Innovation Award.

David Bestwick has served on the Berks County Manufacturers Board of Directors, the Ben Franklin Partners at Lehigh University, and the Reading YMCA Board of Trustees.

He is a member of the Society of Plastics Engineers, Society of Plastics Industry, and the Ben Franklin Technology Group.

David Bestwick continues to serve his community and support the growth and the sustainability of the plastics industry.

Letters to the Editor

Dear Sir:

I have just read the *Industry Practice* section in the First Quarter 2009 *Thermoforming Quarterly*. While I agree completely with the panel regarding the need for a clear, documented understanding between the thermoformer and the sheet extruder, I was surprised that the resin producer was not included in this partnership. I was also surprised by Mr. Siekierski's point that the extruder should be the one to take the responsibility for the decision about which material should be used and how it should be extruded without taking into consideration the liability that it places on the extruder. Typically, the resin manufacturer is the one to design a specific formula for an application. A combined effort by the resin manufacturer, extruder, thermoformer, and the customer is a must, especially in critical applications. If the resin manufacturer has designed a particular resin and has given the extruder, the thermoformer, and the customer the technical specifications of the sheet with tested results (and recommended this material for a particular application) it allows all parties to be more comfortable making a decision. Since the resin manufacturer has promoted a product for an application, as long as all recommendations regarding extrusion, thermoforming and tooling techniques are followed, and the application fits the parameters of that application, liability is placed squarely on the manufacturer of the resin to ensure repeatability and performance. With more and more sophisticated resins hitting the market, all factors should be considered when designing a thermoformed part to fit an application including the original intention of the resin manufacturer.

I am not recommending that anyone other than the thermoformer's client make the final decision on what material should be used for his application. It is the thermoformer's responsibility to furnish the client with all available information and specifications regarding the appropriate materials gathered from the resin manufacturer, the extruder, and their own experience and expertise with those materials. Ultimately the decision must rest with the client. If he is unsure or feels incapable of making a decision based on all the information, the responsibility lies with him to call in a consultant or someone in his organization to review all input. His decision has to be based on the material specifications and costs associated with the different materials, the life expectancy of the application, warranty requirements and what will meet either his or the client's expectations.

When the client makes a decision regarding what material he wants to use on his project, it is up to the thermoformer to work with the extruder and resin manufacturer to meet client expectations. Maintaining a documented set of specifications to ensure consistency of the material from the extruder (who in turn should document his requirements to the resin manufacturer) is essential. The thermoformer is then responsible for forming the material to another documented standard (tooling, temperature, etc.) to ensure the end result is achieved as projected to the client.

Sincerely,

Lola Carrere
Thermopro, Inc.
1600 Distribution Drive, Suite D
Duluth, GA 30097

****

Dear Sir:

I read your recent article with great interest. The issue of sheet specifications and quality verification is essential but not addressed by industry in any satisfactory way. Part producers are at the mercy of sheet providers – no matter how well requirements are specified. What is lacking is a simple means to measure performance of incoming sheets vs. a control. Measuring MFR or melt tension on granulated materials or determining impurity or regrind is of no use if a part does not have the same thermoforming behavior.

To address this issue (which has confronted us for some time), we have developed a patented test device. We have demonstrated this test device at thermoforming conferences/shows and have presented results at ANTEC and in the *Thermoforming Quarterly*. In the last two years, we have perfected automation and data acquisition software and have used test equipment to solve many complex material related issues. People do find it novel and useful, though despite these advances, no one is coming forward to support it! What we need is a simple industry-standard test which gives out multi-varied information (thermoforming, processing window, heating rates, sag distance, moisture problem, orientation issues). I have spent enormous amount of personal resources to get where we are. I need some industry folks to help me to pull this through.

I am willing and open to speak with anyone on this.

Regards,

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Early Supplier Involvement: The Power of Alliance

Mark Kraussman, Business Development Manager
McClarin Plastics, Inc.

What Constitutes Product Development?

New products, existing product change and continuous improvement are all product development initiatives. Competitive pressures and rapid technology changes have shortened product life cycles and driven demand for new products. Existing product changes resulting from regulations and safety considerations also initiate product modifications. Global competition drives change relating to cost reduction and thus the need for continuous improvement processes.

What is Driving "Early Supplier Involvement"?

Keeping pace with rapid technological and materials development has made it a necessity to tap into a supplier's capabilities allowing an access to innovative technologies that can result in an increase in market share. The power of alliance improves the overall design and quality and thus enhances the manufacturability of the product and eliminates any non-value elements. There are also demands to perform with shorter Product Life Cycles. Alliance is the way of gaining strategic flexibility and supporting design development, engineering change, reduced concept to end-user development time, and increased efficiency. As industries move toward increased outsourcing the importance of the development of a supplier – buyer interdependence and division of tasks relating to the technology expertise becomes more apparent.

How Can Early Supplier Involvement Provide a Value Solution?

Early supplier involvement is a form of vertical cooperation where manufactures involve suppliers early in the innovation process. Suppliers will need to turn up their engineering intensity and increase their responsibility in product system design and manufacturing. The buyer (manufacturer) will need to orchestrate cooperation from internal departments such as purchasing and engineering in order to realize maximum value from the new relationship. Early supplier involvement should be part of the planning, design, and manufacturing phases of product development.

The planning phase involves the functional specifications of product development. In this phase early involvement with the supplier will support:

- The understanding of product definition: how the product is used and to what conditions it will be subjected.
- A defined supplier-buyer interface where buyers determine the functional specifications and suppliers provide detail engineering.
- Platform design specifications to determine the restrictions within the product systems interface.

The design phase provides opportunities for savings through the integration or product design with the supply chain. Cooperative design FMEA, CAD Models, BOM, and prototype development will provide cost savings results. Approximately 80% of the manufacturing cost of a product is determined by its design.

Value-added initiatives in the manufacturing phase generated through early supplier development eliminate waste and support lean manufacturing through:

- Joint manufacturing FMEA
- Design for manufacturing
- Improved product development coordination
- Inventory reduction
- Cooperative *kaizen* events

Early supplier involvement can develop into a strategic partnership. The degree of supplier-buyer interdependence relates to the extent of supplier involvement in product development. This will lead to capabilities benchmarking, trust development, and creation of inter-firm knowledge. These strategic partnerships will result from:

- The supplier and buyer sharing common beliefs relating to "best practice methodology."
- Risk and investment assumption by the seller associated with outsourcing and early involvement including demand variability.
- A documented agreement between the supplier and buyer supporting their interdependence.
- A high asset and technology commitment specific to the buyer by the seller leading to a single source relationship preference.
- A very resource-demanding association for both parties. However, available resources are combined in new ways to introduce expanded innovation.

Early supplier involvement encourages access to the resources of other firms that can be as important as the resources within the firm.

The Use of Regrind in Thermoforming

Don Hylton and Bill McConnell, McConnell Company

Regrind consists of trimmed salvage, uncontaminated rejects and unused roll or sheet stock. The use of regrind is the systematic reprocessing of materials that have been exposed to at least one pass through a plasticizing extruder. The word systematic is intentionally included in the description to imply that the use of regrind is incorporated according to a specified formulation with consideration for the effect it may have on the overall synergy of the system in which it is used. There are significant positives in the use of regrind. These include cost savings and processability. Thermoforming routinely generates 25-50% scrap material. Therefore it is advantageous from a cost perspective for the material to be reprocessed and to be reused in the same or similar product. Sometimes, however, the extrusion output suffers as the percent of regrind goes up. This is very obvious in thin gauge extrusion of PET. A thermoformer of circles (lids), depending on the tooling, can generate up to 50% trim. As this is blended with virgin PET for extrusion, the output suffers because of the bulk density feed changes when compared to that of a lower percent trim.

Another advantage of reprocessing is the apparent improvement in the processing characteristic of a mixture of virgin material and regrind. Extruder feedstock containing regrind is easier to extrude than virgin feedstock without regrind. The result is increased throughput. Consequently it is desirable for the extruder to incorporate some amount of regrind in the process. As with almost every system in the universe, with advantages there are also corresponding disadvantages. The most significant disadvantage to using regrind is the deterioration of properties associated with multiple heat histories. Most studies and reports on material effects focus on physical properties such as tensile strength and impact. Studies have indicated that the use of regrind including multiple passes does not significantly degrade physical properties. Therefore regrind is a viable approach for routine processing.

In addition much consideration is given to the change in melt flow index (MFI) or intrinsic viscosity (IV). Although the general conclusion is that the changes in MFI or IV are not a deterrent, we must warn that it is not as simple as it appears. MFI and IV are rheological measurements that relate directly to the molecular weight of the material. For most thermoplastics, multiple heat histories result in a reduction of molecular weight. The change in molecular weight is indicated by an increase in MFI and a decrease in IV. This fact is one of the primary reasons for the improvement in extrusion of regrind containing materials. On the other hand, thermoforming can be negatively impacted by a decrease in molecular weight. For the processor, a reduction in molecular weight reduces hot strength and can have negative implications on part formation and material distribution.

There is no compelling reason not to use regrind. For many companies the right amount of regrind to use is the same percentage as the amount generated in their thermoforming operation as long as it is less than 50%. However, the thermoformer must be aware of the possible negative ramifications of regrind incorporation. In fact, the amount of regrind and its source should be included in sheet specifications and strictly followed. Using quality regrind in extruded sheet and film is a viable and economical practice, as long as you have clean (uncontaminated) regrind with physical properties that fall into the processing parameters.

Examples:

Manufacturers of Picnic Ice Chests: These processors generate about 31% trim and rejects. Consequently, for the last 45 years this industry has specified 30% of their regrind be blended with virgin on all sheet material – ABS, HDPE and HIPS.

Refrigerator Manufacturers: When thermoforming their liners, they generate 32-40% regrind and extrude their sheet – ABS, HIPS and PP – with an average of about 35% regrind.

Manufacturers of RV and Mobile Home Tubs, Shower Stalls and Sinks: Using ABS, Acrylic and PVC, they generate 25-40% regrind depending on part size and configuration. Again, they use regrind at the same percentage as they generate.

Luggage Industry: Co-extruded ABS sheet with 30-40% regrind in the core stock has been used for over 30 years. For appearance the surface is normally color-matched, pigmented, co-extruded virgin or extrusion laminated printed film.

Disposable Cups and Plates: Co-extrusion with 30-45% regrind is quite common.

Styrene Foam Food Containers: FDA has approved up to 50% regrind use.

Athletic Shoe Soles: Twin sheet formed TPU with 30% regrind has passed strength and flexibility specifications.

Many other markets in both roll-fed thin gage and cut-sheet heavy gage materials use regrind on a continuing basis. Following are some of the thermoplastics that are regularly blended with regrind:

Thermoplastic	Acronym
Acrylonitrile Butadiene Styrene	ABS
Amorphous Polyester	APET
Ethylene Vinyl Acetate Copolymer	EVA
High Density Polyethylene	HDPE
High Molecular Weight Polyethylene	HMWPE
High Impact Polystyrene	HIPS
Polycarbonate	PC
Polyethylene Terephthalate Glycol	PETG
Polymethyl Methacrylate (Acrylic), (extruded sheet only)	PMMA
Polypropylene	PP
Polyphenylene Oxide	PPO
Polyvinyl Chloride	PVC
Thermoplastic Elastomer (Flexible formulation or blended with rubber)	TPE
Thermoplastic Elastomer-Olefin (Rubber)	TPO
Thermoplastic Urethane	TPU

Heat Histories

What are "heat histories"? Each time a sheet or film is subjected to heat at or above the heat distortion point it is considered one "heat history."

Heat histories occur during the following processes:

1. Compounding
2. Extrusion
3. Calendering
4. Grinding
5. Compression Molding
6. Thermoforming

Compounding, Extrusion and Calendering: In recent years the development of excellent heat stabilizers, more efficient screw design and better microprocessor and computer controls has enabled sheet producers and compounders to keep material degradation to a minimum.

Grinding: Trim, salvage and clean, non-degraded rejects should be ground to the proper size as soon as possible after forming. If unable to immediately insert into a grinder, the trim parts should be cut up and placed into a large plastic bag that is usually inside a Gaylord container. Keep the top on the container or the bag tightly shut except when loading. Otherwise, static electricity will draw dust and dirt on to the plastic and the open box is tempting for use as a trash container. Blades must be sharp at all times. Dull blades cause excessive shear and friction heat that can degrade the material which can cause agglomeration (sticking of the particles into clumps or knots).

Compression Molding and Thermoforming: Care should be taken not to overheat the sheet surfaces during thermoforming. When sheet has been scorched, or the surface darkened or degraded, it becomes scrap. The temperature of both surfaces should be monitored throughout the heating process.

Note: When using less than 50% regrind mix, the "heat histories" of the regrind are always at a mathematical minimum. For example, after six (6) extrusion passes only 6.4% of the material has had four (4) or more extrusion histories. As long as the percent of good regrind used is less than 50% it can be used on a continuing basis. The following table illustrates this point:

VIRGIN/REGRIND RE-EXTRUSION PERCENTAGES

Heat Histories	Virgin Product	2nd	3rd	4th	5th	6th
60% Virgin - 40% Regrind						
Virgin resin	100.0%	60.0%	60.0%	60.0%	60.0%	60.0%
2nd Heat History		40.0%	24.0%	24.0%	24.0%	24.0%
3rd Heat History			16.0%	9.6%	9.6%	9.6%
4th Heat History				6.4%	3.8%	3.8%
5th Heat History					2.6%	1.6%
6th Heat History						1.0%
40% Virgin - 60% Regrind						
Virgin resin	100.0%	40.0%	40.0%	40.0%	40.0%	40.0%
2nd		60.0%	24.0%	24.0%	24.0%	24.0%
3rd			36.0%	14.4%	14.4%	14.4%
4th				21.6%	8.6%	8.6%
5th					13.0%	5.2%
6th						7.8%
30% Virgin - 70% Regrind						
Virgin resin	100.0%	30.0%	30.0%	30.0%	30.0%	30.0%
2nd		70.0%	21.0%	21.0%	21.0%	21.0%
3rd			49.0%	14.7%	14.7%	14.7%
4th				34.3%	10.3%	10.3%
5th					24.0%	7.2%
6th						16.8%

(continued on next page)

Points to know about using regrind:

1. All major material specifications should be reviewed by the thermoformer and the sheet supplier, together, with a processing window agreed upon. Specifications such as melt flow (should be within ± 2%), impact strength (falling dart and izod impact), elongation, tensile strength, modulus of elasticity, color (degradation of material will show up first on a color computer with the color going toward yellow), sheet orientation (± 5% all the way across the extrusion web and within a lot, and from lot-to-lot). Of course, gage tolerance, surface finish, and other necessary specifications need to be decided.

2. For many applications a co-extruded virgin cap stock is recommended. This will hide regrind pits, usually caused from dust, dirt, and the fibrous particles (or "fines") of the ABS when ground. This dust and residue carbonizes when extruded, leaving black specks. Virgin cap stock also makes it easier to maintain a color match.

3. **Cross Linking**: When thermoplastic material is subjected to a heat history, such as extruding, thermoforming and granulating the material goes very slightly toward a thermoset (or slightly cross-links) which gives the material marginally improved hot strength. Hot strength is the elasticity, or stretchability, of the sheet material while at forming temperature and the uniformity of how it stretches (no thick or thin spots).

4. The extruder must produce a homogeneous, accurate blend of the regrind with virgin. All of the regrind should be tested before blending and certified to the thermoformer, listing what the test results were. The mixed regrind/virgin resin should again be tested before extrusion Periodic testing should be done as the sheet is extruded. As mentioned before, a complete written understanding of the specifications, tests, and procedures should be provided by the material supplier.

5. Some thermoformers have experienced overall improvement in the process with use of regrind because the regrind has been homogeneously mixed through prior runs. If thoroughly blended with the virgin material, it is possible to have a better forming sheet. With the use of good, quality regrind, the thermoformed part will not show signs of degradation.

6. The extruder may be able to run more throughput with a 30-45% regrind/virgin mix if he blends into a precise homogeneous mixture before the resin enters the extruder or pelletizes the regrind. Regrind will also mix much more easily if it has been passed through a strainer to remove the fines. With a good, homogeneous blend the extruder can get "on-stream" quickly and stay there more easily. For best results the total run should be pre-blended and thoroughly mixed before being introduced into the extruder.

INFRARED HEAT: A Simplified Approach – Part One

Mike Sirotnak, Solar Products

Technical Editor's Note: This is the first installment of a two-part paper on heating elements for the thermoforming process. We thank Mike Sirotnak of Solar Products for providing the information and editing it for this publication. Part Two will appear in the next issue of Thermoforming Quarterly.

The Basics

For some unknown reason the heating industry has created a shroud of mystery over the infrared spectrum. Many companies have given heaters names which actually have no basis in engineering reality. In this paper, we will reviewing some of the principles of physics and apply them to simple selection criteria. This quick exercise will give a clearer understanding of what truly makes radiant/infrared heaters tick, and therefore enable you to select the type of infrared heater needed for a particular job.

There are only three ways to transfer heat:

- **Conduction**: *via contact*
- **Convection**: *via gas/hot air*
- **Radiation**: *via electromagnetic radiation*

In this paper we are concerned only with radiant heaters. Many people question the difference between *radiant* and *infrared* heat when in actuality there is none. Infrared is one of four ways in which to transfer heat via radiation:

- Ultraviolet
- Infrared
- Microwave
- Radio Frequency / Induction

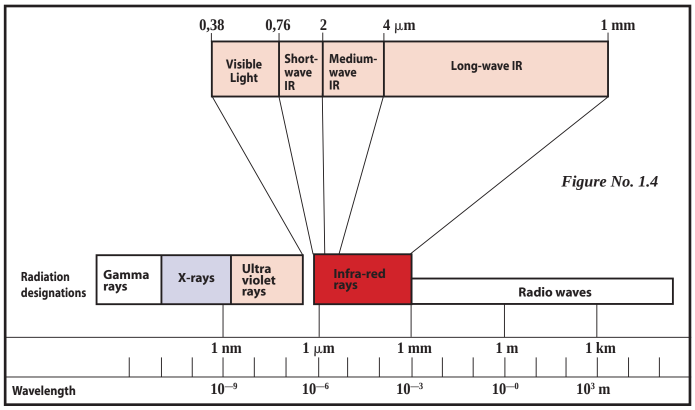
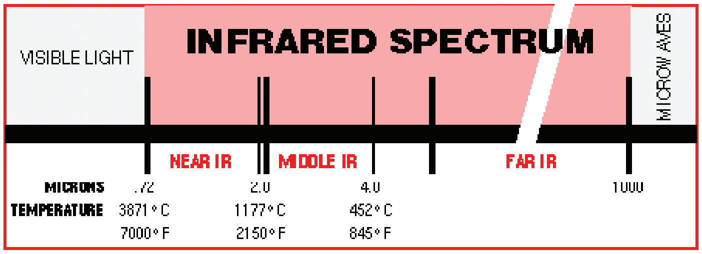


Figure No. 1.4

Find the infrared spectrum within the electromagnetic spectrum. Notice that it is bordered by the visible spectrum on one end and the microwave spectrum on the other. The infrared region ranges between 0.72 and 1,000 microns.

Within the infrared spectrum there are short, medium, and long wavelengths. What is the difference?

- Shortwave, or near IR (Infrared), is defined as the area from .72 to 1.5 microns.
- Medium wave, or middle IR, is defined as the area which ranges from 1.5 to 5.6 microns.
- Long wave, or far IR, is defined as the area from 5.6 to 1,000 microns.

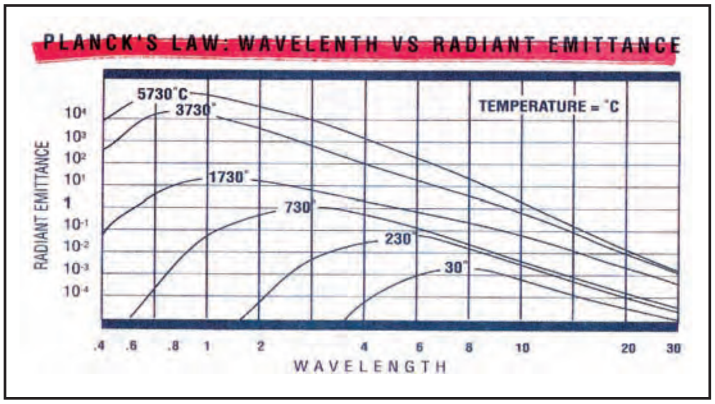


To determine whether a heater falls into the category of a short, medium, or long infrared heater, 80% of your effective output should be within a defined range.

- A short wave IR heater should emit 80% of its energy from .72 to 1.5 microns. To do this most of its points should be between 3538˚C (6400˚F) and 1658˚C (3016˚F)
- A medium wave IR heater should emit 80% of energy from 1.5 to 5.6 microns. To do this most of its points should be between 1658˚C (3016˚F) and 244˚C (471˚F).
- A long wave/far IR heater should emit the majority of its energy from 5.6 to 1,000 microns. To do this most of its points should be less than 244˚C (471˚F).

How Much Heat?

So now that we've established the ground rules for determining the output of the three types of infrared heaters, you should have the confidence to make a decision and review the facts.



We know where the infrared area is and how it is divided, but what determines if a heater will fall into the near, middle or far area of the infrared spectrum? We know it must peak within a particular wavelength. Wavelength output is a function of temperature - the higher the temperature, the shorter the peak wavelength. Graph #3 illustrates Planck's Law. Planck inserted a point source into a glass sphere. Then he changed the temperature inside by raising the power. This resulted in a higher temperature and shifted the peak of the output curve to shorter wavelengths. Planck's Law defines the relationship of wavelength output to temperature. The output curves of infrared energy are governed by Planck's Law. This law applies to Blackbody Point Sources in a vacuum. But what does this really mean? What was Planck doing, and what is the significance of the curves? Remember that the reason the curve (total power) is bigger as we go to higher temperatures is that Planck had to apply more power to achieve a higher point source temperature.

Example: A curve for 2000°C might have required Planck to apply 10 watts to the point source, whereas to get a 500°C curve, perhaps only 3 watts.

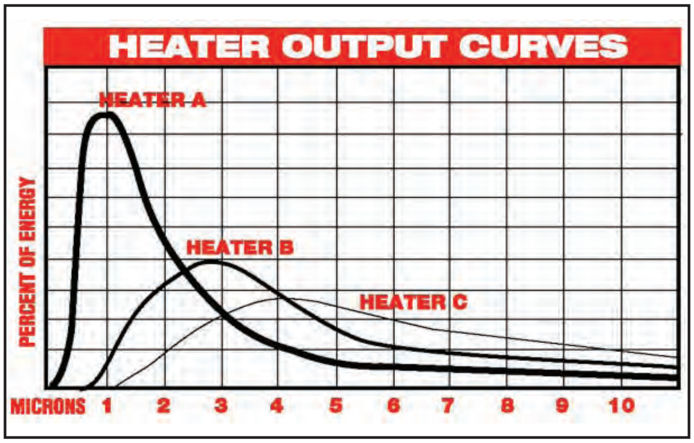
A heater is made up of many millions of point sources, not just one as in Planck's curve. Depending on a heater's construction, these point sources can all be at one temperature, or many different temperatures. The total output of a heater is the sum of all point sources. To calculate the output curve of a particular heater, plot the curve for each point of the heater and then add all of the curves together. The total power output will be the area under the curve. Remember this will not be a smooth curve like Planck's because most heaters have many points at many different temperatures.

For example, let's say we have three heaters, each covering a l0" x 10" area, with an output of l000 watts.

- Heater A is one 1000 watt quartz lamp in a 10" x 10" reflective housing. The operating temperature of the lamp is 2200°C. The reflective housing is at 150°C because it is water-cooled.
- Heater B is two quartz tubes, each at 500 watts with internal reflectors in a 10" x 10" housing. The operating temperature of the tube is 1000°C.
- Heater C is a ceramic face with 10 imbedded coils, each at 100 watts. The operating temperature of the coil is 650°C. The ceramic in between the coils is at 300°C.

So what do the output curves of these three heaters look like? Let's say that a 10" x 10" area has a million points. That's 10,000 points per square inch. Differences are shown in the graph below.

- Heater A has 50,000 points at 2200˚C which has a peak of 1.17 microns. It has 950,000 points at 150˚C which has a peak of 6.8 microns.
- Heater B has 100,000 point s at 1000˚C which has a peak of 2.27 microns.
- Heater C has 500,000 points at 650˚C which has a peak of 3.1 microns. It also has 500,000 points that are around 300˚C which has a peak of 5 microns.



As you can see, three heaters that are rated the same, actually have different outputs. These curves can change again if we use a controller to regulate the temperature. From the above examples, we can conclude that similar watt heaters can deliver totally different outputs.

What about the heater you are considering? What do you want it do? To match the temperature output of a short-wave heater you must use a quartz lamp with an element enclosed in a vacuum. For medium-wave, all panel-type heaters, quartz tubes (non-vacuum) ceramics, and metal-sheathed rods emit the majority of their energy in the medium IR region. For a long-wave heater, you must control to less than 470F. This is not very practical for most applications.

PROSPECTIVE AUTHORS

Thermoforming Quarterly® is an "equal opportunity" publisher! You will notice that we have several departments and feature articles. If you have a technical article, send it to Barry Shepherd, Technical Editor. All other articles should be sent to Conor Carlin, Editor. Please send in .doc format. All graphs and photos should be of sufficient size and contrast to provide a sharp printed image.

REDUCE!
REUSE!
RECYCLE!

REDUCE!
REUSE!
RECYCLE!

Thermoformer of the Year 2010

The Awards Committee is now accepting nominations for the **2010 THERMOFORMER OF THE YEAR**. Please help us by identifying worthy candidates. This prestigious honor will be awarded to a member of our industry who has made a significant contribution to the thermoforming industry in a technical, educational, or managerial aspect of thermoforming. Nominees will be evaluated and voted on by the Thermoforming Board of Directors at the Spring 2010 meeting. The deadline for submitting nominations is December 1st, 2009. Please complete the form below and include all biographical information.

Person Nominated: ____________________________________ Title: ___________________

Firm or Institution____

Street Address: ____________________________ City, State, Zip: ______________________

Telephone: _______________ Fax: _________________ E-mail: ________________________

Biographical Information:

- Nominee's Experience in the Thermoforming Industry.
- Nominee's Education (include degrees, year granted, name and location of university)
- Prior corporate or academic affiliations (include company and/or institutions, title, and approximate dates of affiliations)
- Professional society affiliations
- Professional honors and awards.
- Publications and patents (please attach list).
- Evaluation of the effect of this individual's achievement on technology and progress of the plastics industry. (To support nomination, attach substantial documentation of these achievements.)
- Other significant accomplishments in the field of plastics.
- Professional achievements in plastics (summarize specific achievements upon which this nomination is based on a separate sheet).

Individual Submitting Nomination: _______________________ Title: _____________________

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Street Address: ____________________________ City, State, Zip: ______________________

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Signature: ____ Date: ____________________

(ALL NOMINATIONS MUST BE SIGNED)

Please submit all nominations to: Hal Gilham,
Productive Plastics, 103 West Park Drive
Mt. Laurel, NJ 08045
halg@productiveplastics.com

Polypropylene – Cup Conversion From Injection Molding to Thermoforming

Piaras de Cléir, Kraft Foods Global, Inc., Tarrytown, NY

Abstract

Food containers such as cups can be made by injection molding (IM) or thermoforming (TF). Typical materials are high density polyethylene (HDPE), polypropylene (PP) and high impact polystyrene (HIPS). For many years the preferred choice for polypropylene cups was IM because it produces a high quality part with excellent part-to-part consistency. Conventional TF to make similar containers in PP results in wider dimensional tolerances. On the other hand, in-line, trim-in-place thermoforming overcomes many of the limitations of conventional TF and allows for the production of high quality containers. This paper outlines the conversion from IM to trim-in-place for a 235-ml cup and compares the physical properties of cups from each process.

Introduction

PP is a versatile material finding uses in a broad array of applications ranging from automotive, to toys, to packaging. The material can be processed by thermoforming, injection molding, blow molding, calendaring, cast and blown film, etc. Containers such as cups can be formed in a variety of materials by a variety of techniques. The most common conversion processes are thermoforming and injection molding. A conversion from injection molding to thermoforming was made for a 235-ml PP cup. The goal of the conversion was to reduce weight for improved competitiveness and sustainability. This paper describes the testing methodology used to qualify this cup for commercial production. Property comparisons versus injection molded cups are shown. It is not the intent of this paper to identify which process is the most competitive or best process to use for this or other similar applications. Such comparisons must be conducted on a case-by-case basis and the answer may be different depending on the specific application, annual production volumes, container size, recyclability, barrier requirements, end-use requirements, transportation distance, etc. Developments and breakthroughs in PP materials and conversion processes are constantly evolving and a process or material grade that is the most competitive today for a given application may be at a disadvantage tomorrow.

Solid Phase Pressure Forming (SPPF) of PP was discovered by Shell in the mid-seventies. It was found that parts could be successfully formed if a unique combination of temperature and pressure was used. A temperature just below the resin melting point (T_m) was used such that the sperulites were in the solid phase and the pressure used was much higher than thermoforming machines of the time could handle [1]. Hence it became known as SPPF. The process was commercialized and became a viable competitor to injection molding for many applications. In the conventional SPPF process sheet is extruded, cooled and wound onto rolls. This roll stock is later reheated and thermoformed into containers. PP is a semi-crystalline material and as such has a well defined point at which it changes from solid to molten. The energy required to overcome the crystallization is large [2]. Additionally, unlike amorphous materials such as polystyrene which gradually change from solid to molten over a broad temperature range of about 40°C, PP has a very narrow transition range in the order of just 2 - 5°C [3]. A good material for thermoforming should have a viscous component to permit flow under stress and an elastic component to resist flow and impart rigidity to the formed part in the absence of stress [4]. Unfortunately, traditional PP grades undergo a very rapid decrease in modulus as T_m is approached and also have very low melt strength which make them more difficult to thermoform. The effect of the high crystallinity and low melt strength is that the conventional thermoforming process can result in longer cycles, unpredictable shrinkage and less uniform parts having larger dimensional tolerances.

The literature contains many examples of means to improve the thermoformability of PP. Folland describes the morphological properties of PP and the use of controlled crystallinity and high stiffness PP for improved PP performance in TF [5]. U.S. Patent 5,209,892 assigned to Mobil describes a process for thermoforming a random copolymer of polypropylene and polyethylene. The process includes stretching in at least one direction, a film or sheet containing polypropylene and polyethylene random copolymer to partially orient the sheet sufficiently as to reduce sag during thermoforming and thermoforming the stretched sheet [6]. Whiteside, in U.S. Patent 4,666,544 describes carrier frame members that carry their own remotely operated clamps and are expandable and contractible to a condition in which, prior to molding, they control the sag in the sheet formed during heating of the sheets to differential pressure forming temperature [7].

Hilton summarizes approaches taken to overcome the thermoforming deficiencies of PP, in the areas of equipment, resin and rheological modifications, [8]. Some modifications to the resin are described by Nesterenkova. They include the use of a block copolymer of ethylene with propylene, an atactic fraction of a copolymer of ethylene with propylene, and a copolymer of ethylene with vinyl acetate as polymeric modifying additives and the effect of these compounds on the melt flow index and deformation and strength characteristics of the modified polypropylene. Results indicated that modification of PP made it possible to control the main characteristics of the material having an effect both at the stage of sheet material production and at the stage of forming of articles from sheet [9]. Many grades of improved melt strength PP were introduced to overcome its low melt strength. However, in neat form many processors found these high melt strength PPs (HMSPP) difficult to process and expensive. Various approaches to impart high melt strength to PP without these limitations were developed. For example, Dharia describes the use of blending 10 to 30% of HMSPP with linear PP to produced significant and unexpected benefits [10].

Large-size thermoforming equipment, high melt strength resins and other resin developments alone were not adequate to overcome PP limitations. New tooling was required. The design, manufacture and operation of such tooling for in-line, trim-in-place forming to compliment the equipment and resin developments is described by Biller [11,12].

In the in-line process PP sheet is extruded onto calendaring rolls, partially cooled, and then indexed into the temperature conditioner to fine tune the sheet temperature. From there it is indexed directly into the forming station. This process eliminates one cooling and reheating step; it allows for better temperature control of the sheet, it increases the cooling time in the mold, and allows the cups to be trimmed prior to ejection from the mold. The result is increased output, reduced energy usage, tighter part dimensional tolerances and a process that is a viable competitor to thin wall injection molding.

Fortunately, resin producers commercialized grades to address the material limitations and equipment manufacturers such as Marbach, OMV, Illig and Irwin developed and commercialized tooling and in-line, trim-in-place thermoforming lines [13-16]. In this paper the procedure used to test the thermoformed cups are described and the physical properties of the in-line, trim-in-place thermoformed cups are compared to injection molded cups.

Materials

The thermoforming process requires a PP grade with high melt strength to resist sag, whereas the injection molding process requires a grade with good flow so that the part can easily be filled. Therefore, the physical properties of the materials used differ for each process. For example, the TF grade has a higher modulus and molecular weight. Obviously, these differences will influence the properties of the final part. The properties of the grades used are from resin technical data sheets and are shown in Table 1.

***Table 1** – Material Physical Properties*

	Injection Molded Cup	Thermoformed Cup	Test Method
Material	Copolymer PP	Copolymer PP	-
Density	0.902 g/cc	0.902 g/cc	ASTM D792
Melt Flow Index	35 g/10 min	4 g/10 min	ASTM D1238
Tensile Strength @ Yiel	27.6 Mpa	32.4MPa	ASTM D638
Elongation @ Yield	5	7	ASTM D638
Flexural Modulus	1378 Mpa	1590 Mpa	ASTM D790
Notched Izod Impact	0.7 J/cm	1.07 J/cm	ASTM D256
Heat Deflection Temp.	113ºC	118ºC	ASTM D648

Procedure

In qualifying a new package design, material or process for a packaging application a test known as ASTM D-4169, Standard Practice for Performance Testing of Shipping Containers and Systems is used. Depending on the specific application and end-use requirements variations and additions to this procedure are common. In this application the following testing was conducted: Top Load Strength, Stack Compression Test, Hoop Strength, Oxygen and Moisture Transmission Rate, Drop Impact, Oil Canning, Seal Curve Profile, Sidewall Deformation, and ASTM D-4169. The purpose of each test and comparisons between IM and TF cups are summarized in the Results section.

Results and Discussion

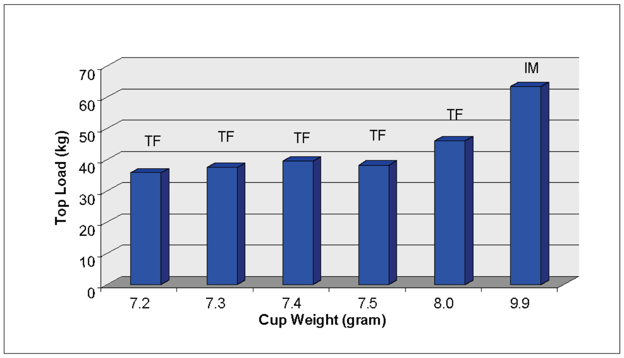
1. Top Load

Five TF cup variables of differing gram weights were compression tested to compare the top load with the target requirement. The target is set using a theoretical formula that utilizes the product weight, number of tiers on a pallet, number of pallets high in storage & transit, plus storage time, temperature and a safety factor. In this case it was determined that the minimum top load should be

(continued on next page)

30-kg. Not unexpectedly it was found that top load increased with increase in cup weight. As shown in Figure 1, the 9.9-g IM cup had the highest top load and the 7.2-g TF cup had the lowest - - but, high enough to meet the theoretical requirements of the application. This is a weight reduction of 2.7-g/cup or 27.2%, and assuming other properties are acceptable in the application it provides a sustainability benefit.

***Figure 1** – Top Load Resistance Vs Cup Weight*



2. Drop Test

Drop testing is conducted to understand the ability of individual cups to remain intact after dropping. A modified Bruceton Staircase Method was used. In this method a number of samples are used to bracket the pass/fail energy level. Then a series of 20 impacts are conducted. If a test sample passes, the drop height is increased by one unit. If a test sample fails, the drop height is decreased by one unit. The results from the 20 impacts are used to calculate the Mean Failure Height - - the point at which 50% of the test samples fail under the impact. In this test the drop height was raised or lowered in increments of 25-mm until cup breakage occurs. The cups were stored and tested in a climate controlled room at a temperature of 1°C. As shown in Table 2, the result indicates that the thermoformed cups were able to withstand higher drop heights than the injection molded container.

***Table 2** – F_{50} Drop Height*

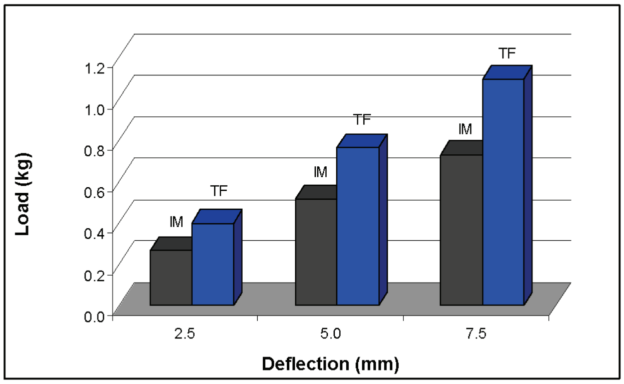
	Injection Molded Cup	Thermoformed Cup
Lowest Failure Height	81-cm	> 163-cm
Mean Failure Height	86-cm	> 163-cm

The data shows that the F_{50} of 50% breakage rate for the IM cups occurred at 86-cm, whereas the lighter weight TF cup exceeded the upper limit of the test equipment and did not break. When the IM cup broke it occurred in a straight line manner in the direction of the flow and orientation of the polymer molecules from the bottom center gate to the cup perimeter. This result is not surprising given that there is less molded-in stress generated by the TF process and a higher molecular weight resin can be utilized.

3. Hoop Strength

A hoop force applied to the rim or flange area of containers having a foil sealed membrane or lid could cause a seal rupture or hoop deformation if it exceeds the strength of the container. This test was conducted using an Instron compression tester. The thermoforming process is inherently flexible in that the thickness of sections of the container can be adjusted without retooling. In this case it was possible to direct more material into the flange area of the cup to increase hoop strength. As a result, as shown in Figure 2, the hoop strength of the TF cup was higher so it is better able to withstand hoop forces.

***Figure 2** – Hoop Strength Vs Hoop Deflection*



Note: Average based on 15 samples

4. Paneling

Sealed containers that are filled at elevated temperatures are subjected to vacuum or negative pressure upon cooling. Unless specially designed to accommodate vacuum or containing very stiff inflexible sidewalls this can lead to unsightly deformation. This test was conducted to determine whether the TF container, which has thinner sidewalls than the IM container, will panel when filled with water at 50°C and allowed to cool. This procedure simulates the filling process for some products filled at 45-50°C followed by cooling in a refrigerated blast tunnel. The water, at 50°C, fills the container to the appropriate volume of 214-ml. The containers were heat sealed with a foil lid immediately after filling and cooled. After the containers had cooled to the refrigerated temperature, they were inspected for deformation. The results showed that the thermoformed containers performed as well as the injection molded containers. None of the test samples showed any indication of deformation.

5. Oil Canning Resistance

An oil canning evaluation was conducted using two different designs of thermoformed cups and a standard injection molded cup. The difference in the TF cups was in the design of the base push up (an inverted area at the base to provide rigidity and eliminate "rocker bottom" or non-flat cup bottoms). The additional design had a 45 degree angle on the bottom as opposed to the standard 30 degree angle. The Purpose of this test is to determine the ability of the base of containers to withstand a point compression, which simulates the thermal expansion which can take place when heated product fills a plastic cup. This thermal expansion can cause the base of the cup to bulge out, affecting the stability of the container. The bulging out or inversion of the container bottom is known as oil canning.

Results, shown in Table 3, indicate the thermoformed containers cannot resist oil canning as well as the injection molded container. Of the thermoformed cups, the special bottom cup proved most able to withstand oil canning, but was significantly weaker than the IM design. Although there was a difference in performance it was found that the 30° angle was inadequate for the application whereas the 45° angle was acceptable.

***Table 3** – Oil Canning*

	Injection Molded Cup	Thermoformed Cup	Thermoformed Cup
Design of Base "Push Up"	30° Push Up Angle	30° Push Up Angle	45° Push Up Angle
Force to Invert the Cup base	10.1 kg-f	1.1 kg-f	2.7 kg-f

Note: Average is based on 19 samples.

6. Barrier Properties

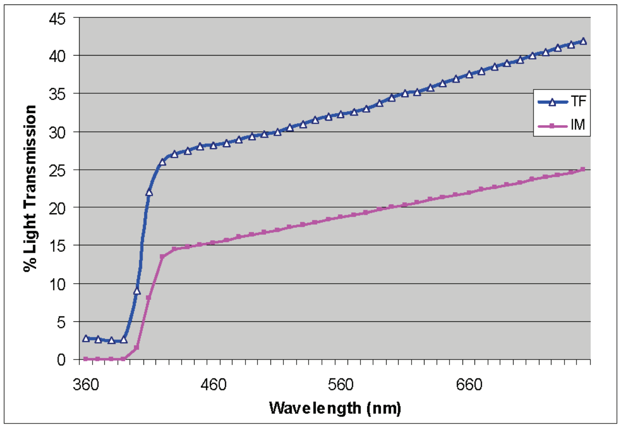
Moisture, oxygen and light transmission properties are important for protection of the contents of food containers. Therefore, barrier testing was conducted. As shown in Table 4, the oxygen and moisture vapor transmission rates (MVTR) for the IM and TF cups were identical. Given that the wall thickness of the TF cup was thinner it would be expected that the transmission properties might be inferior. But, because of the higher molecular weight of the TF grade, its' transmission rate per unit thickness is lower and was enough to compensate for the reduced wall thickness.

***Table 4** – Oxygen and Moisture Barrier Properties*

	Units	IM	TF
Average Thickness	mm	0.47	0.31
Percent TiO_2	%	1.2	1.2
MVTR	g/cup/24 hrs @ 22°C, 50% RH	0.002	0.002
O_2Trans. Rate	cc/cup/24 hrs @ 22°C, 50% RH	0.57	0.57

As shown in Figure 3, the light transmission for the TF cup was much higher than for the IM cup. Both cups contained the same percent of titanium dioxide (TiO_2) filler which acts as a white pigment to impart opacity. This is not unexpected, given that the TF cup sidewall thickness was much thinner than the IM cup sidewall. In order to protect the food product in the container the percent of TiO_2 in the TF cup was increased to compensate for the inferior light transmission property.

***Figure 3** – Percent Light Transmission Vs Wavelength*

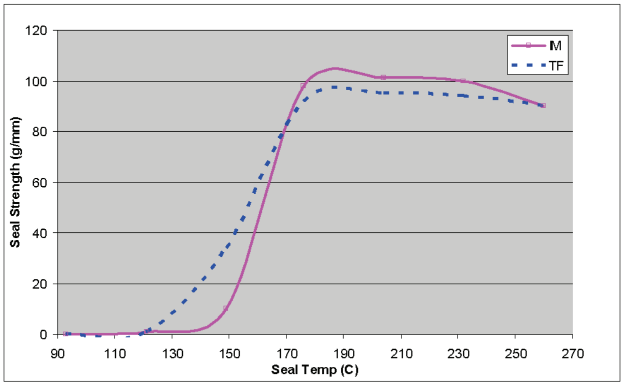


7. Sealing Parameters

A design of experiment was conducted to understand if the sealing parameters needed to be changed to accommodate the TF cup. An example of a seal curve generated for the test variables is shown in Figure 4. Seal strength required depends on the particular application. In this application a maximum strength seal is obtained when the seal flange of the cup undergoes slight melting. In this case it is seen that the seal curve for each type of container is very similar. The peel values for the IM cup are slightly higher, but within the margin of error of the test procedure so is not significant.

(continued on next page)

***Figure 4** – Heat Seal Curve*



Conclusion

Both thermoforming and injection molding are acceptable technologies for producing containers such as this product cup. There are advantages and disadvantages of each process. When making a decision on which technology to choose for a given application many factors need to be considered. It was shown in this case that it was possible to lightweight the thermoformed cup by 27% and still maintain adequate physical properties for the application. Some properties were improved such as drop impact and hoop strength. Some properties were not impacted, and other properties such as Top Load, Oil Canning Resistance, and Light Transmission were reduced, but were adequate to meet the performance requirements of the container.

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Key Words: Thermoforming, Trim-in-place, Injection Molding, Polypropylene, Thin wall.

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Travis J. Kieffer Awarded Memorial Scholarship

Travis Kieffer will be a sophomore at Iowa State University for the 2009-2010 school year, studying for a degree in industrial engineering. A Dean's List student, he is an SPE member and attended the 2008 Thermoforming Division Conference in Minneapolis.

Travis works at Plastics Unlimited, a family-owned business, during summers and as time allows during the school year. The company manufactures thermoformed, composite, urethane, and fiberglass composite/thermoplastic products. A believer in green products, Plastics Unlimited has developed a patent-pending process that incorporates soy oil in the resin that is used in this process. Travis was involved in the development of this process over the last 4 years.

He is also working on a minor in Environmental Engineering and hopes that, upon graduation, the combination of his major and minor degrees will enable him to work in applications involving agriculture and natural resources. |

From the Editor

If you are an educator, student or advisor in a college or university with a plastics program, we want to hear from you! The SPE Thermoforming Division has a long and rich tradition of working with academic partners. From scholarships and grants to workforce development programs, the division seeks to promote a stronger bond between industry and academia.

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

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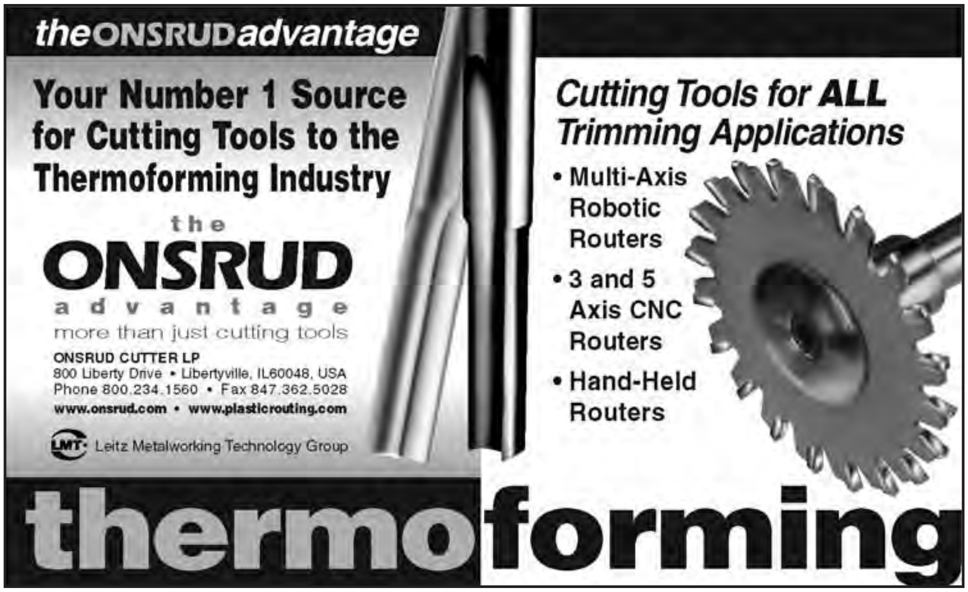

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New Waste Framework Directive – Plastics Recycling: Tailor-Made Solutions

Jan-Eric Johansson

The new Waste Framework Directive (WFD) will be a key driver towards a more resource-efficient EU. It will create incentives to direct waste from landfill, stimulating the development of innovative recycling technologies and allowing more flexibility in selecting the best waste management options.

From the moment the European Parliament passed the WFD in June, the word "recycling" started to encompass more types of recycling technologies than ever before. The plastics industry foresees that this decision will not only encourage more sustainable ways to deal with waste that would otherwise end up in landfills, but will also ultimately simulate progress in all types of recycling options. For plastics in particular, the possibility of adapting the recycling technology to each material will result in proper waste management schemes and lead to optimized resource efficiency.

When the EU's member states implement the new directive into their legal systems over the next year and a half, the legal definition of recycling in Europe will include both traditional "mechanical" and novel "feedstock" technologies. It will be recognition by regulators that eco-efficient recycling involves more than material-to-material mechanical recycling. Feedstock allows the recycling of the material's building blocks into new products and not necessarily back into the same original material.

Mechanical recycling will remain the dominant recycling method for waste plastics, but plastics' chemical structures make them the perfect materials for feedstock. By breaking down the polymer into its elementary chemical building blocks – such as monomers, synthesis gas, and other chemical intermediates – plastics can be used as the basis to produce new materials. In many cases, this is a more eco-efficient solution.

Before the revision of the WFD, investment by the industry in new types of recycling technology was disregarded and the resulting materials not recognized as recycled. Now, innovation in new technologies will be incentivized, as they will also contribute towards the national recycling targets.

Legal requirements already force member states to reduce the volume of waste going to landfill and promote alternative activities. For the revised WFD, an ambitious target of 50 per cent has been agreed for the recycling of household waste. So far, countries such as Austria, Belgium, Denmark, Germany and The Netherlands are already achieving this goal. Others have different challenges ahead and a wider recycling definition will surely help them reach the objective.

According to the revised WFD, this hierarchy should be applied "flexibly," taking into account technical and economical viability as well as overall environmental, human health, economic and social impact. Products which cannot be reused in an eco-efficient way should go to recycling and plastics which are in principle "solid oil" and cannot be recycled in an environmental and economical way, and can instead substitute fossil fuels in a range of recovery operations. These are perfect examples of resource efficiency put into practice; making the best of each product stream.

Europe can no longer afford to waste its waste and revised WFD has recognized its importance as a valuable resource. Used plastics are now a part of a larger picture of efficiency and sustainability and to ignore this important resource would literally be a shameful waste of energy.

[Excerpted from *Plastics in Packaging*, Sayers Publishing (UK), Dec 2008]

Implementing the 3 R's in Japan

Stuart Hoggard

Japan has packaging recycling rates that are the envy of the Western world. Nonetheless, it is planning tougher measures to improve them further.

The high rates area result of the Containers and Packaging Law introduced in 1995, since when they have increased so that by 2006 were at record levels. Steel cans reached 95 per cent; glass bottles 90 per cent; aluminium cans 89 per cent; paper 60 per cent and liquid paper containers 38 per cent.

The most spectacular improvement over that period has been in plastics, with recovery and recycling for PET rising from 3 per cent to 75 per cent.

But the success of increased plastics recovery rates has drawn attention to the challenges presented by the recycling of more complex materials. Plastics containers made from materials other than PET, such as polypropylene, polyethylene, and polystyrene, are usually composites that are difficult to separate and process.

This environmental zeal is all part of a wider context in which Japan views the current global financial crisis as an opportunity to export its policies on waste management and local sustainability abroad, firstly to Asia.

The backdrop for this is the triangular collaboration between government, industry and the people which has been the bedrock of society since the late 19th century.

Even before the current global financial crisis Japan started re-writing its economic system under the recently-revised 2001 Law For Promoting a Recycling Society.

The latest development is called a new Economic Growth Strategy which was unveiled at the recent Tokyo Pack show by Economy, Trade and Industry secretary Yoshifumi Matsumura. This focuses on resource productivity and environmental technology to help the packaging industry through "tough times" by calling on industry to make "concentrated investments to "drastically improve resource productivity, and become a low-carbon society".

It also urges industry to increase R&D to enhance the value of their products, particularly environmentally, that will enable them to "carry out globalization and capture global markets".

In other words, Japanese companies have now been given the green light to export their packaging reduction technology.

[Excerpted from *Plastics in Packaging*, Sayers Publishing (UK), Dec 2008]

Peninsula Packaging Company receives the 2009 Society of Plastics Engineers Environmental Award

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Peninsula Packaging is a fully integrated PET extrusion, thermoforming and decorating company that manufactures a wide variety of food packaging products; including packaging for: produce; baked goods; convenience store foods; and, prepared goods. Integral to Peninsula's manufacturing and product offering strategies is the development of products that meet or exceed the sustainability-in-packaging requirements of retailers (such as: Wal*Mart, Sam's, Costco), processors, shippers and consumers. Peninsula's products contain up to 100% post-consumer recycled PET. In 2008, Peninsula consumed over 25 million pounds of post-consumer recycled PET.

In addition to post-consumer PET use in packaging, Peninsula has installed its own photovoltaic "sun farm" immediately adjacent to its manufacturing facility in Exeter, CA.

The clean, renewable electrical energy produced by this solar farm provides 50% of the power required to convert packaging made by Peninsula's California facility.

Peninsula's solar farm is the largest privately funded solar installation of its type in North America. Peninsula is a member of the Environmental Protection Agency's Green Power Partnership.

Peninsula has gained wide acclaim by major retailers, processors and shippers for its capabilities in sustainable packaging as well as Peninsula's unique product development expertise in designing packaging to not only support environmental responsibility in packaging but also significantly reduce shrink, waste, etc. by reducing food spoilage and transportation costs. Peninsula has been showcased on ABC, CBS, NPR etc. featuring Peninsula's solar farm. Peninsula has manufacturing facilities in Exeter, CA and Wilson, NC.

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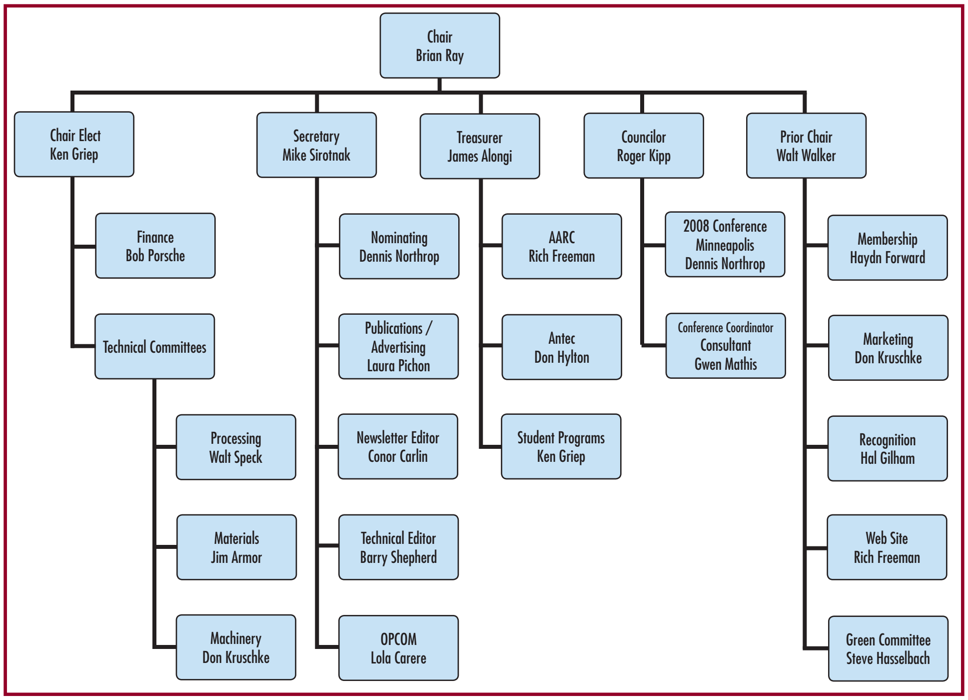

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