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A NOTE TO PROSPECTIVE AUTHORS

TFQ is an "equal opportunity" publisher! You will note that we have several categories of technical articles, ranging from the super-high tech (sometimes with equations!), to industry practice articles, to book reviews, how to articles, tutorial articles, and so on. Got an article that doesn't seem to fit in these categories? Send it to Barry Shepherd, Technical Editor, anyway. He'll fit it in! He promises. [By the way, if you are submitting an article, Barry would appreciate it on CD-ROM in DOC format. All graphs and photos should be black and white and of sufficient size and contrast to be scannable. Thanks.]

Thermoforming QUARTERLY

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

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MEMBERSHIP

BY CONOR CARLIN, MEMBERSHIP CHAIRMAN

This year's conference in Nashville was another success for SPE. As expected during an NPE year, attendance was down 9% from our record year in Milwaukee. Still, given the diversity of attendees, it is clear that we are part of a global industry. The conference provides an opportunity for the Thermoforming Division to review membership numbers. Here are a few statistics on our division that might interest you:

- Section D25 (Thermoforming) is the third largest primary division by membership within SPE National. Injection molding and extrusion are the two largest divisions, meaning that thermoforming is larger than automotive, blow molding and rotational molding.
- There are eighty geographic sub-divisions represented in Section D25. This includes the US, Canada, Mexico, Europe, South America, Asia and Oceania.
- The European Thermoforming Division is Section D43. As a member of D25, you are eligible to join D43 as a secondary division when you register/renew.
- In the month leading up to the conference, we had 67 new registrations/renewals. That represents a 4.8% increase in one month.

While we continue to build on our successes, it is important to remember that our division is like a thermoforming machine: it must be maintained and revitalized for optimum performance. Education and investment in "knowledge capital" are two of the most critical areas addressed by involvement in the Thermoforming Division. For the twelve months ending on June 30th, 2006, we allocated over $175,000.00 to education. Student scholarship programs, ANTEC and equipment matching grants are just a few of the areas that benefited from the organization's ability to stay true to its mission statement. As a non-profit organization, we reap our real benefits in the form of new ideas, companies and individuals participating in our division.

On occasion, I will still hear someone ask, "Why should I join SPE?" Perhaps you have also encountered this question. If so, take a minute to enlighten your colleague with some features and 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.
- New and innovative part design at the Parts Competition.
- Open dialogue with the entire industry at the annual conference.
- Discounts, discounts, discounts on books, seminars and conferences.
- For managers: workshops and presentations tailored specifically to the needs of your operators.
- For operators: workshops and presentations that will send you home with new tools to improve your performance, make your job easier and help the company's bottom line.

As we near the end of another calendar year, I'd like to make a humble request of our loyal members: for you and/or your company to sponsor one other person for membership in our division. Think of a new hire, an intern, an academic partner or perhaps someone who has been thinking about joining SPE. With your help, we can grow our division and reach new heights. It's all about adapting to form the future. ■

Questions? Comments? Ideas?
Email me:
ccarlin@sencorp-inc.com

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Need help with your technical school or college expenses?

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

Our mission is to facilitate the advancement of thermoforming technologies through education, application, promotion, and research. Within this past year alone, our organization has awarded multiple scholarships! Get involved and take advantage of available support from your plastic industry!

Start by completing the application forms at www.thermoformingdivision.com or at www.4spe.com. The deadline for applications is January 15th, 2007. ■

SPE

Thermo Forming Division

THERMOFORMER OF THE YEAR CRITERIA FOR 2007

Every year The SPE Thermoforming Division selects a individual who has made a outstanding contribution to our industry and awards them the Thermoformer of the Year award.

The award in the past has gone to industry pioneers like Bo Stratton and Sam Shapiro, who were among the first to found thermoforming companies and develop our industry. We have included machine designers and builders Gaylord Brown and Robert Butzko and toolmaker John Greip, individuals who helped develop the equipment and mold ideas we all use today. We have also honored engineers like Lew Blanchard and Stephen Sweig, who developed and patented new methods of thermoforming. Additionally, we have featured educators like Bill McConnell, Jim Throne and Herman R. Osmers, who have both spread the word and were key figures in founding the Thermoforming Division.

We're looking for more individuals like these and we're turning to the Thermoforming community to find them. Requirements would include several of the following:

- ➢ Founder or Owner of a Thermoforming Company
- ➢ Patents Developed
- ➢ Is currently active in or recently retired from the Thermoforming Industry
- ➢ Is a Processor – or capable of processing
- ➢ Someone who developed new markets for or started a new trend or style of Thermoforming
- ➢ Significant contributions to the work of the Thermoforming Division Board of Directors
- ➢ Has made a significant educational contribution to the Thermoforming Industry.

If you would like to bring someone who meets some or all of these requirements to the attention of the Thermoforming Division, please fill out a nomination form and a one- to two-page biography and forward it to:

Thermoforming Division Awards Committee
% Productive Plastics, Inc.
Hal Gilham
103 West Park Drive
Mt. Laurel, NJ 08045
Tel: 856-778-4300
Fax: 856-234-3310
Email:
halg@productiveplastics.com

You can also find the form and see all the past winners at www.thermoformingdivision.com in the Thermoformer of the Year section.

You can submit nominations and bios at any time but please keep in mind our deadline for submissions is no later than December 1st of each year, so nominations received after that time will go forward to the next year.

Thermoformers of the Year ...

1982
William K. McConnell, Jr.
McConnell Company

1983
E. Bowman Stratton, Jr.
Auto-Vac Corp.

1984
Gaylord Brown, Brown Machine

1985
Robert L. Butzko
Thermtrol Corp.

1986
George Wiss, Plastofilm Industries

1987
Dr. Herman R. Osmers
Educator & Consultant

1988
Robert Kittridge
Fabri-Kal Corporation

1989
Jack Pregont, Prent Corporation

1990
Ripley W. Gage, Gage Industries

1991
Stanley Rosen
Mold Systems Corp.

1992
Samuel Shapiro
Maryland Cup
Sweetheart Plastics

1993
John Grundy, Profile Plastics

1994
R. Lewis Blanchard
Dow Chemical

1995
James L. Blin, Triangle Plastics

1996
John Griep
Portage Casting & Mold

1997
John S. Hopple, Hopple Plastics

1998
Lyle Shuert, Shuert Industries

1999
Art Buckel, McConnell Company

2000
Dr. James Throne
Sherwood Technologies

2001
Joseph Pregont, Prent Corp.

2002
Stephen Sweig, Profile Plastics

2003
William Benjamin
Benjamin Mfg.

2004
Steve Hasselbach, CMI Plastics

2005
Manfred Jacob
Jacob Kunststofftechnik

2006
Paul Alongi, MAAC Machinery

THERMOFORMER OF THE YEAR 2007

Presented at the September 2007 Thermoforming Conference in Cincinnati, Ohio

The Awards Committee is now accepting nominations for the 2007 THERMOFORMER OF THE YEAR. Please help us by identifying worthy candidates. This prestigious honor will be awarded to a member of our industry that has made a significant contribution to the Thermoforming Industry in a Technical, Educational, or Management aspect of Thermoforming. Nominees will be evaluated and voted on by the Thermoforming Board of Directors at the Winter 2007 meeting. The deadline for submitting nominations is December 1st, 2006. 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: ______________

Firm or Institution: ____

Address: _________________________ City, State, Zip: _______________

Phone: ______________ Fax: _________________ E-mail: ____________

Signature: _____________________________ Date: _______________

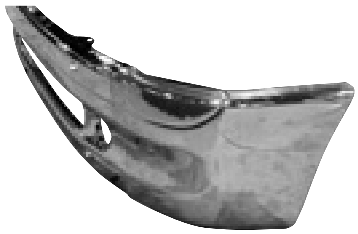
(ALL NOMINATIONS MUST BE SIGNED)

Please submit all nominations to: Hal Gilham,
Productive Plastics, 103 West Park Drive
Mt. Laurel, New Jersey 08045

2006 THERMOFORMING PARTS COM

A major highlight of the Thermoforming Conference is the Parts Competition and Showcase. The competition's panel of judges – six industry professionals from the cut-sheet and roll-fed industries – selected winners based on criteria that included technical mastery, creativity, surface finish, market viability, originality, material difficulty, mold complexity, and secondary operations. The People's Choice Award goes to the entry receiving the greatest number of votes cast by Conference attendees and exhibitors. This year the Conference sponsored a new category – Parts Submitted by Universities – to solicit input from schools that offer classes in thermoforming. Following is a description of the award-winning parts, listed according to competition category:

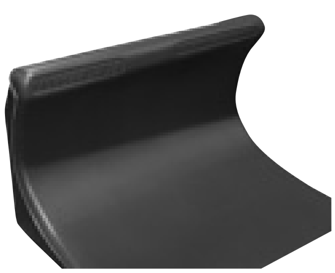
People's Choice Award **– Commercial Vehicle Facia**



The winner of the People's Choice Award and the Automotive Award – the Hendrickson Aero Bright (HAB) bumper for the freightliner Columbia – utilizes a three-piece design that allows for replacement of damaged individual components rather than the entire bumper, reducing the service cost to the end user. The center section is draw-formed steel chrome that provides impact protection to the vehicle's front end, radiator, and other components. Made from Solvay Engineered Polymers' Sequel E3000 TPO, and laminated with Soliant LLC's "Bright Film," the endcaps are attached to the bumper's center section with brackets, mechanical fasteners, and double-sided VHB tape. Hendrickson Bumper and Trim says that the task of creating the thick-sheet thermoformed endcaps was challenging, made more difficult by the use of TPO and the requirement for a durable Class A mirror finish. The thick-sheet pressure forming was provided by Profile Plastics and the tooling by Portage Casting and Mold.
Hendrickson Bumper and Trim; 815.727.4031; www.hendrickson-intl.com

Cut-Sheet Competition

Consumer Product Award



The Soccerwave is a unique and original tool intended for use by soccer players and their coaches to teach ball control. It was required that the device be durable, portable, and watertight, and provide a one-year warranty against manufacturer defects. When players kick the ball toward the ramp, the ball should encounter zero resistance while traveling onto and through a full sweep at any angle of approach. The Soccerwave features reinforced knitting along the back panel that is partially fused to the front face, to prevent it or the play surface from "pillowing out" when filled with water and to maintain a smooth surface for ball travel. The knitting must be exceptionally strong along the perimeter of the wave, where the two tools meet. Two separate sheets of 1/4-inch HMWPE, supplied by Extrusion Technologies, were used to form the part. The front lip of the Soccerwave is a near knife edge, and the 1/2-inch material was compressed to about 1/8-inch pinch. The close-tolerance front edge prevents the ball from jumping as it enters and rolls up the soccer wave. The vacuum-forming twin-sheet method allows for additional strength and leakproof seams, and the use of articulating tooling provides excellent material distribution. Peninsula Plastics designed and built the tooling to make it applicable to the vacuum-forming twin-sheet process.
Peninsula Plastics Co., Inc.; 248.293.6509; www.peninsulaplastics.com

Twin Sheet Product Award

The award-winning surgical helmet, for use by doctors to enhance their ability to see during surgical procedures, was twin-sheet thermoformed on a high-speed rotary press. The single-oven twin-sheet process was used. Creation of very sharp detail using core-pull needles with 80 psi of internal air pressure was achieved, and strong twin-sheet welds with thin-gauge sheet on a rotary press were attained. Multi-level parting lines presented further challenges. Spartech Plastics supplied the polypropylene material in 0.045-inch and 0.065-inch gauges. As a result of requirements for softness and flexibility, and the part's zero draft areas, it was exceptionally difficult to demold without damage. The helmet is CNC trimmed to ±0.010 inch, and fixturing from the opposite side created numerous challenges. Tooling was designed and built by Associated Thermoforming.
Associated Thermoforming, Inc.; 970.532.2000; www.thermoforms.com

Multipart Assembly Award

The winner of the Multipart Assembly Award features seven pressure-formed parts that enclose a multiplexing micro-array processor used for genomics and proteomics testing. The sweeping curve of the design is a key visual element, along with the crisp appearance of the pressure-formed panels and the concealment of visible fasteners. The industrial design demanded an aesthetically appealing and functional enclosure. Operation of the unit requires frequent lifting of the front panel by

an automated hydraulic mechanism and opening of the side panel doors by the operator. To achieve accuracy of assembly and realignment after opening, the components incorporate a formed-in undercut design, with tooled double-tiered steps locating the adjacent single-tiered step to the mating part. Mating lines of the multiple parts intersect in nine locations. Kleerdex Co. supplied the Kydex T acrylic/PVC from which the enclosure components were made. For the two-tone color scheme, each component uses one of the colors in custom-color material. Protogenesis, Inc. constructed the tools, which were later and separately textured (MT 11030) by Mold Tech.
Specialty Manufacturing, Inc.; 858.450.1591; www.smi-mfg.com

Electronic Enclosure Award

Freetech Plastics, Inc. partnered with Hoya ConBio to manage the exterior design and the manufacture of exterior plastic panels for the Hoya ConBio VersaWave dental laser program, winner of the Electronic Enclosure Award. Freetech says the challenges encountered in development of the VersaWave included the creation of an attractive look for a highly functional laser – without making any changes to the existing platform. Actuated molds were used to form dramatic undercut features and reduce the number of mold cavities. End-user requirements necessitated the incorporation of painted and unpainted surfaces, so texturized tools were used where needed. Freetech also incorporated attachment systems and coatings to obtain the required EMI shielding and make assembly easier. Airflow was maximized by the addition of louvers to the side panels. Industrial design was provided by Stirling Design, and the material is Spartech Plastics' R59 in a custom color.
Freetech Plastics, Inc.; 510.651.9996; www.freetechplastics.com

Industrial Application Award

The battery cell processing tray, winner of the Industrial Application Award, was designed and built by Associated Thermoforming. The tray is used in the battery industry to hold battery cells as they are run through an oven prior to assembly. As it hangs supported from each end in a 160°F oven for a period of 20 hours, the tray must bear the weight of the cells (180 lbs.) with less than 0.125-inch deflection. Made from CE 1820 ABS/polycarbonate blend in 0.125-inch and 0.187-inch gauges supplied by Spartech Plastics, the tray is formed by precise heating of both sheets using infrared line scanners that ensure uniform heat within 5 degrees F across the sheets. Sharp detail is achieved with internal core pull needles with 60 psi of air. Two steel ribs are insert molded into each part and are fully encapsulated into the part. Strategic weld points throughout the part also aid in achieving the necessary stiffness.
Associated Thermoforming, Inc.; 970.532.2000; www.thermoforms.com

Point-of-Purchase Award

The point-of-purchase display for the "Scarecrow," an automatic outdoor animal-deterrent device, was designed and manufactured by CSL Plastics. The Scarecrow, equipped with a motion-activated sprinkler, releases a burst of water intended to startle and scare away an unwelcome animal near a garden or fishpond. The point-of-purchase display for the Scarecrow demonstrates its function – within a watertight case – allowing the consumer to view a working demonstration of the product in an indoor retail setting. As the customer walks past the display, the motion detector is activated, triggering the sprinkler to spray water against the inner wall of the display. The sound and sight of the display attracts the customer's attention and demonstrates the Scarecrow's function. The twin-sheet forming process uses two simultaneous vacuum or pressure-forming operations to force two plastic sheets against the side of a mold, resulting in a twin-walled part with a central airspace. CSL engineers designed a plug-assist tool that allows a thinner gauge material (clear acrylic supplied by Cyro Industries) to be used without sacrificing the quality or durability of the display. Total Industries International made the tools.
CSL Plastics, Inc.; 604.888.2008; www.cslplastics.com

Recreational Product Award

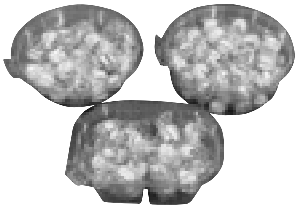
Louis Garneau Sports designed the high-performance, ultra-light Titan Carbon cycling helmet that was worn by the Bouygues Telecom team in the 2006 Tour de France. The helmet's "Titanium Ringlock," a very stiff and lightweight titanium frame ring, prevents the helmet from bursting upon impact, and the carbon V-shaped frame reinforces the helmet's bridges. Made from 0.06-inch polycarbonate, Makrolon GP from Sheffield Plastics, the Titan Carbon

(continued on next page)

helmet contains three thermoformed parts: two of polycarbonate and one of carbon fiber. The plastic sheet is screen printed with several colors before forming. Accurate print-screen registration and thermoforming are therefore essential to ensure the precise position of the drawing on the helmet. Since there are a number of colors on the sheet, the oven temperature must be precisely controlled; in fact, radiation absorption on the sheet varies with color. A high-quality plastic with no stress is important in ensuring accurate control of the thickness and the position of the drawing. Because of the helmet's numerous undercut angles, the thermoforming molds, made by Les Moules Samco, Inc., are constructed with two movable cam inserts to enable the demolding of the plastic shell. The plastic is cut with a five-axis CNC machine and the tool path is made using a digitizing arm. The forming and cutting processes must be precise because the form part is inserted into an injection mold in order to bond it to the expanded polystyrene. Quality of the plastic shell is a key factor in the film insert process.
Louis Garneau Sports; 418.878.4135; www.louisgarneau.com

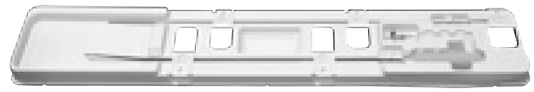
Roll-Fed Parts Competition

Consumer Packaging Award



PWP Industries' Tamper-Evident thermoformed packages offer a convenient way to assure the consumer that package contents have not been tampered with prior to purchase or consumption. Additionally, the packaging products include unique leak-resistant, resealable features that help retain product freshness. The packages can be designed using translucent materials that are ideal for deli, produce, confectionery, and bakery goods applications and for industrial applications. Tamper-Evident packages can be made from a variety of rigid materials, including PET, PP, PLA, CPET, and OPS, and can be formed into various shapes and sizes through the roll-fed thermoforming process. Roll-fed thermoforming offers consistent forming and trimming of plastic products by conventional aluminum production tools, foam plugs, and steel-trim dies. The packages do not require the use of ultrasonic/RF welding or UV-activated adhesive processes, and shrink bands or adhesive labels are unnecessary. No new capital equipment is required, new-product time-to-market is reduced, and material and labor costs are minimized. Packages displayed at the Thermoforming Conference were made of PET supplied by Commodity Supplies and PLA by NatureWorks; the toolmaker/designer was PWP Industries.
PWP Industries; 323.513.9000; www.pwpindstries.com

Medical Packaging Award



The Enpath Universal Catheter Tray accommodates any of three catheters with diameters ranging from 3 to 20 french and lengths up to approximately 40 inches. Designed by Mark Ralph of the Prent Corp., the package eliminates the need for expensive tooling, parts, and inventory that would be required for the packaging of three different products. Because of the fragile nature of the product, retainers and plastic tubes are traditionally used to package catheters. The award-winning package utilizes design elements to secure the product, thus eliminating the need for additional package parts. Die-cut flaps fold over to securely hold and prevent damage to the varied catheter diameters. Each tray is enclosed in a pouch that serves as a protective shipper. Primex Plastics Corp. supplied the material (0.035-inch white high-impact polystyrene), and tooling was designed and built by Prent Corp.
Prent Corp.; 608.754.0276; www.prent.com

Electronic Packaging Award

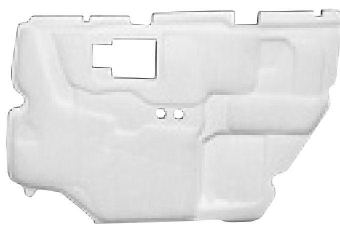
Plastic Ingenuity, in conjunction with Rod Borst, developed the tooling and the machine that produces parts for the Inward Flange Tray, a package designed to preserve the integrity of devices used in the electronic communications industry. The package currently houses an array of Nokia cellular phone models, locking them in an unconventional closure system to provide a "cocoon" of protection and security. The Inward Flange Tray features smooth, gently rounded flanges in contrast to the sharp, abrupt edges of conventional packaging. The retail-goods package may serve as a post-purchase storage container for the cellular phone itself or for an assortment of other items. Utilizing a unique process, Plastic Ingenuity achieved a vertical flange that is trimmed inside the outermost formed features of the tray. HIPS, PVC, HDPE, and PET are used in making the tray.
Plastic Ingenuity, Inc.; 608.798.3071; www.plasticingenuity.com

Food Container Award

EDV Packaging designed the high-transparency container for fruit and cream desserts for babies. The PP/EVOH/PP material (1.6 μm in thickness) is coextruded and thermoformed in the company's production plant

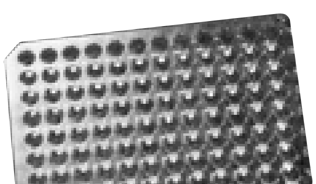
in Barcelona, Spain. The consumer-friendly container is recyclable, impact-resistant, puncture-resistant, easy to transport and open, and eye-catching. For vertical stability, the cup features a base with rounded crown, and the interior walls are completely smooth for content accessibility. The cup has a mouth diameter of 80 mm, brimful capacity of 140 cc, and depth of 50 mm. The EVOH layer serves as a barrier to UV rays, oxygen, and moisture, and an additive in the external PP layer provides antistatic properties. The barrier structure allows hot filling and withstands thermal treatments. The cup can be heated in a microwave oven or in a double boiler. Under optimal conditions, the containers can be stored for up to 12 months.
EDV Packaging; +34 938 427 000;
www.edvpackaging.com

Industrial Packaging Award



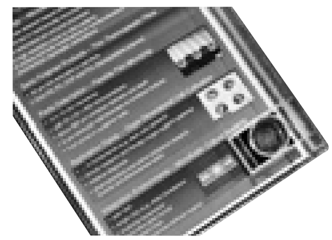
A water and sound-deadening shield for car-door assembly, manufactured using the inline thermoforming process, won the Industrial Packaging Award. Production tooling, designed by Amros Industries and built by Amros and Waugs, Inc., consists of a water-cooled aluminum mold and temperature-controlled plug assist. The need to simultaneously form and bond two materials – polyester fiber and polyethylene foam – presented the foremost challenge in manufacturing this product. During the forming process, the two layers of materials are preheated to different temperatures and formed into dissimilar profiles on the top and bottom layers. Part functionality depends on achieving a permanent bond between materials.
Amros Industries, Inc.; 216.433.0010;
www.clamshellusa.com

Most Challenging Roll-Fed Application Award



Many types of assay procedures help scientists isolate specific components of a solution (such as an antibody or a virus) contained in a mixture of components. DNA assays, for example, quantitatively measure amounts of DNA, RNA, or proteins in a given test mixture. Assays are usually tested using microgram-level solutions. The assay trays holding the solutions are critical for successful completion of any testing performed. The 96-well polycarbonate assay trays, designed and manufactured by Perfecseal Mankato, called for critically formed, draw ratio "challenged" cavities in close proximity. The wells had stringent minimum thickness requirements with no surface flaws and had to withstand several high-temperature cycles. The use of polycarbonate necessitated custom tooling and processing, as additional drying was needed because of the material's sensitivity to moisture. Perfecseal Mankato fabricated the custom tooling to accommodate the heated molds, and fabricated plug-assist material from an engineered polymer that was chosen for the polycarbonate manufacturing process. Perfecseal performs quality inspections to ensure flawless, pinhole-free trays that prevent loss of any assay tests.
Perfecseal, Inc.; 920.303.7100;
www.perfecseal.com

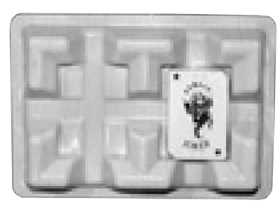
Best International Entry Award



The cell-culture microarray, manufactured by Forschungszentrum Karlsruhe GmbH (Institute for Biological Interfaces and Institute of Microstructure Technology), is reported to be the first thermoformed micropart to be introduced. Constructed on a flexible-film microchip, the cell-culture microarray enables three-dimensional cell cultivation for fundamental (e.g. stem cell) research, clinical research and therapy (organ support systems), medical diagnosis, and pharmaceutical and active substance research (toxicity and effectiveness tests). The 10 x 10 mm microarray supports 625 microcontainers arranged in a 25-row configuration. Each container is approximately 300 μm in diameter and in depth, with a 5-μm minimum bottom-wall thickness and 3-μm pores in the walls. The arrays are fabricated from Pokalon 50-μm gauge polycarbonate from Lofo High Tech Film GmbH, using a combination of microscale-adapted trapped sheet thermoforming and ion track technology. Forschungszentrum Karlsruhe GmbH (Institute for Microprocess Engineering) built the tooling.
Forschungszentrum Karlsruhe GmbH; +49 7247 82 4439 and 4496; www.fzk.de

Parts Submitted by Universities

Best Overall Process Utilizing Plug-Assist and CNC Trimming



Students enrolled in a product-design class instructed by Dr. Lou Reifschneider at Illinois State University (ISU) designed the award winner, the "ISU Straight Dealer," and developed the mold and trimming tooling using resources of the school's Department of Technology. Recognized for its complexity of tooling and forming, the part is a cut-sheet formed tray that neatly holds pick-up and discard cards during games that require stacks of cards, e.g. rummy and Uno. The Straight Dealer is designed to

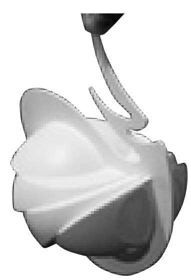
(continued on next page)

2006 THERMOFORMING PARTS COMPETITION AND SHOWCASE WINNERS

facilitate dropping cards into the stacks and picking up cards easily. It maintains proper card alignment so that discarded cards below the top card cannot be seen. The three-dimensional product design and corresponding pattern were rendered in CAD. The pattern was created with a rapid-prototype machine and was cast at the school foundry to create the mold. The mold and a required trimming fixture were designed and built by students in the Department of Technology's Integrated Manufacturing Sequence. The Straight Dealer was produced using 0.125-inch ABS on the school's MAAC ASP industry-scaled forming machine obtained through a grant from the Thermoforming Division for use in plastics processing and product-design courses. Because of the geometry of the product, web assist was used during forming, and the part was trimmed by CNC using a vacuum fixture. All steps required to make the Straight Dealer were similar to those used in industry.

Dr. Reifschneider, Department of Technology, Illinois State University; 309.438.2621; www.tec.ilstu.edu

Best Artistic Design Award



A birdhouse made from 1/16-inch polystyrene and vacuum-formed from a wooden mold features an entrance that also serves as a drain hole and a hole at the apex for hanging. Rather than constructing a typical box-shaped avian abode, Jason Liu, a student at San Jose State University, sought to create a work of art symbolizing the grace of a bird's flight and evoking a sense of relaxed inspiration, such as that of autumn leaves, stirred by a gentle breeze, drifting on currents of air. Using a lathe, the designer formed a wooden sphere, cut it into shapes of various angles, and positioned and assembled the pieces into an imaginative pattern. When the two-dimensional cutouts were vacuum-formed and glued together, the result was a three-dimensional structure that confers the sensation of a graceful downward floating movement. The cocoon-like, rounded edges of the sphere's form promote a sense of rest.

Jason Liu, San Jose State University; 408.924.1000; www.sjsu.edu

Best Assembly Award

This award was presented to Cassie Tweed, a second-year student enrolled in the industrial design program at San Jose State University. The goal was to explore form through a number of processes and materials. The assignment was to create a tabletop flower vase of interesting composition by resolving relationships between positive and negative surfaces, two-dimensional and three-dimensional volumes, and details. Additionally, the project focused on two processes: using a wood lathe to create molds and a thermoformer to pull white styrene (supplied by GE Polymershapes) over them, and using an APM Frugal Elite 2424 single-heat, single-platen thermoformer obtained through a grant from the SPE Foundation, Thermoforming Division. The concept of the molded two-dimensional pieces and how they would relate to the overall three-dimensional design was important to the project because it necessitated understanding of a harmonious interaction between two- and three-dimensional volumes and how the two formed pieces would be joined during the production process. Rather than approach the project from a conventional perspective by joining two positive volumes together to create the overall form, the designer chose to combine one positive and one negative volume to craft a form that made use of both. This approach resulted in a design that was not only innovative to the history of this project, but also solved the problem of how the two forms – negative and positive, two-dimensional and three-dimensional – would be joined.

Cassie Tweed, San Jose State University; 408.924.1000; www.sjsu.edu

RICH FREEMAN RECEIVES LIFETIME ACHIEVEMENT AWARD

Richard Freeman has been involved in Thermoforming for over 35 years, the last 30 with Freetech Plastics in Fremont, California. His experience providing pressure-formed products in the close tolerance, technically demanding, and highly competitive environment of Silicon Valley has led to a number of key innovations. It also gives him a unique perspective on Production, Quality, Marketing, and Design Issues.

Rich's articles, company and products have been featured in *Plastics Engineering, Appliance Manufacturer, Innovation, Machine Design, Plastic News, Mechanical Engineering*, and *International Designer* to name a few. He has spoken out about many issues important to thermoformers over the years. Considered one of the founders of the West Coast style of thermoforming, he's been a regular feature of the SPE Thermoforming Division conference programs, both in the USA and in Europe, as well as other SPE and industrial design forums. His continual promotional efforts in behalf of the industry have benefited not just his own company but the thermoforming industry as a whole. Rich has spoken at numerous SPE thermoforming conferences and has had a major influence on almost every heavy gauge program since the conference's inception.

Freetech Products has won numerous industry awards including the 1996, 1999, and 2004 People's Choice Awards, the Thermoforming Industry's top prize. Freetech has provided the pressure-formed parts for 7 *ID Magazine* award winners and has worked hard to make the design community aware of thermoforming possibilities. Since 1998 he has both spoken at and put on many exhibitions on behalf of the Thermoforming Division at IDSA conferences to raise awareness of our industries' many capabilities

Rich's first thermoforming project at 8 years of age was a draped formed acrylic candy dish for his Mom. It was the first, but not last, time he burned off his fingerprints on hot sheet.

Rich started Freetech Plastics in 1976. Their first thermoformed product was polycarbonate voice coil protectors for early hard disk drive components for IBM.

Not happy with the quality of the cast tooling then available needing to provide high detail parts for Silicon Valley but not having pressure forming equipment, Rich saw possibilities of combining CAD-CAM and thermoforming. He then developed a a tooling method for achieving high definition parts without the use of pressure. With CNC trimming, Freetech could produce parts with very close tolerances, machined components, and other features not usually associated with thermoforming. This led to what's known as the West Coast style of pressure forming. This method utilizes dramatic shapes, sharp detail and extreme undercuts to create a whole new look for thermoformed products. As more modern equipment became available this only got better.

Walt Walker, Chair of the Thermoforming Division, is shown presenting the 2006 Lifetime Achievement Award to Rich Freeman.

Rich first got involved in Thermoforming Division activities when Bill McConnell challenged him to do something about improving our industry's quality image. This led to a speech at 1988 ANTEC entitled "It's Time For a New Era of Quality in Thermoforming."

Rich has been an active member of the SPE Thermoforming Division Board of Directors since 1991. He currently is responsible for the Thermoforming Division's web page and Machinery Grant program. As a member of the Division's good works committee, he developed the Thermoforming Machinery Matching Grant Program which has placed thermoforming machines and other related equipment in 14 schools so far.

All told Rich has worked hard to move thermoforming and our division ahead. Fellow SPE board member Haydn Forward said it best when he declared: "Rich forced us all to get better." ■

2006 NASHVILLE CONFERENCE REVIEW

PRINTED WITH PERMISSION FROM ALICE BLANCO, SENIOR ASSOCIATE EDITOR, PLASTICS ENGINEERING

The 16th Annual SPE Thermoforming Conference, sponsored by the SPE Thermoforming Division, took place at the Nashville Convention Center in Nashville, Tennessee, September 17th - 20th. Highlighting the important role of "Creativity & Innovation in Thermoforming," the Conference included exhibits representing more than 90 companies that provide products and services to the thermoforming industry worldwide. Nine hundred attendees registered for the event, which included workshops, an outstanding technical program, and the Parts Competition and Showcase.

Do You Enjoy Your Job?

"… Then tell your face!" advised plenary speaker Dr. Dale Henry, who introduced himself as being "from the South, where gravy is a beverage." His formula for success: "The value you bring to your company, to this organization, has nothing to do with a price tag; it has to do with what you do for everybody else. Drive the road less traveled – that road of service. It's very simple. Just be you. Smile at people."

Dr. Henry accurately assessed his smiling audience of thermoformers as "a group of people who study reactions and the way things work together." "If you want to learn something," he said, "hang out with people who have experience." This Conference was the place to do just that. As Art Buckel counseled, "Bring your production people to this Conference and have them share when they get back."

Creativity and Innovation: A Global View

Going Global?

"We're already there," said speaker Jay Waddell of Plastics Concepts and Innovations in his presentation titled "Thermoforming: Where Are We? Where Are We Going? Is Our Future Global?" Mr. Waddell believes "Globalization is our future … we must understand the world we live in … we have to be the best there is."

The place of the U.S. in the global economy is starting to change and as a result, the resin markets are starting to change, said Phil Karig of Spartech Corp. in his presentation titled "Global View of the Resin Market." North America's advantage of abundant and inexpensive natural gas as feedstock and as fuel for electric power generation has been lost, and events outside the U.S. are increasingly affecting resin pricing. North America is being drawn into the way the rest of the world is operating, he said, into the spot, or cash, market.

About 20% of the world's total GDP is currently represented by a mature U.S. market, while markets in Brazil, Russia, India, and China, which now account for 25% of the world GDP, are expanding at approximately 5%/yr. Before the Industrial Revolution, China and India accounted for nearly 50% of world GDP. "In a lot of ways, what we are seeing now is that … it's likely that we are starting to move back to a world that looks very much like it did before the Industrial Revolution," said Mr. Karig, with China and India commanding major roles in the world economy. "The bottom line is that looking at resin markets on a global basis isn't just an academic exercise anymore."

"China and India are emerging as major centers for thermoforming," said Jay Waddell. "Those guys are running."

Demand For Resin

As for demand for resin, Asia, especially China, with its immense population, is where all the action is taking place, Mr. Karig said. For now, most of the products produced in China are exported to the U.S. and Europe. "That is what is starting to shift. Things are starting to move to more internal consumption in China."

Like China, India is home to more than 1 billion people. Unlike China, India has the advantage of a legal system based on English Common Law, an important plus to U.S. companies seeking to conduct business there. And countless companies in India need plastic parts. With an aspiring middle class made up of 300 million potential consumers, it is a huge marketplace, full of opportunities, yet fraught with caveats. A Conference workshop titled "How To Do Business in India," led by Kumkum Dalal, outlined in detail the incentives and the challenges.

Seeking a Competitive Edge

One approach for companies seeking to attain and maintain a competitive edge in a global economy is to update to the latest technology, to run top-quality machines. "Old machines without proper heat and control systems hurt competitiveness and profit," said Art Buckel in his presentation, "Survival of the Strongest."

"Thermoforming Trends in Europe," presented by Hubert Kittelmann of Marbach Tool & Equipment, reiterated Mr. Buckel's recommendation. Mr. Kittelmann focused on machines and equipment built for the packaging industry in Europe – where energy costs are triple those in the U.S., taxes are high, and environmental regulations are rigorous. Parts and products are growing smaller (e.g., more convenient single-serve-size packages), he said, while the machines to make them are becoming larger, faster, and more technologically advanced.

Furthermore, said Jay Waddell, it is critical to develop better training systems for engineers and plant employees. "If they don't know what they are doing with the equipment … if they don't know what they are doing with the process, with the materials, then how are they going to control the processes?"

"Bio" to the Rescue?

Will bio-based plastic materials help solve the industry's energy-supply and energy-cost problems, while promoting a cleaner environment? Can businesses dedicated to biotechnology produce products embraced by consumers? Can those companies turn a profit? An afternoon of Conference sessions titled "Bio and Sustainable Resins in Thermoforming" was devoted to exploring the possibilities and the progress.

Daniel Gilliland of Metabolix, Inc., addressed those quandaries in his presentation, "PHA Plastics: A Disruptive Technology for a Sustainable Future." His company, in a joint venture with Archer Daniels Midland, is currently demonstrating applications – on conventional thermoforming equipment – with key customers for market trials through 2007. The joint sales company is establishing supply agreements for full commercial production of fermentation-based plastics, made from domestic agricultural sugars and oils, to begin in 2008 in a 50,000-tpa plant in Clinton, Iowa.

According to Frederic Scheer of Cereplast, Inc., in his presentation titled "Displacing Petroleum Plastics With Bio-based Resins," consumers, some U.S. government agencies, packagers of food products, brand owners, and retailers and restaurants are requesting, if not demanding, renewable plastic products.

Much more information on bio-based plastics will be forthcoming at SPE's Global Plastics Environmental Conference, scheduled for March 6th - 7th, 2007 in Orlando, Florida.

Awards, Scholarships, and Grants

Paul V. Alongi was honored as Thermoformer of the Year. In his first job as a power-transmission specialist, Mr. Alongi provided engineering and product-selection services to a manufacturer of thermoforming equipment and was thus introduced to the industry. In 1982, he established Maac Machinery Co., a major manufacturer of cut-sheet thermoforming equipment. Mr. Alongi has been very supportive of the SPE Thermoforming Division through his numerous fundraising endeavors for the Division's scholarship fund and has worked to advance the thermoforming industry's technology through education, application, promotion, and research.

Richard Freeman was named recipient of the Division's Lifetime Achievement Award, and the Outstanding Achievement Award, presented by the Thermoforming Board, went to Roger Fox of the Foxmor Group. Bob Porsche of General Plastics received the Board's Outstanding Member Award.

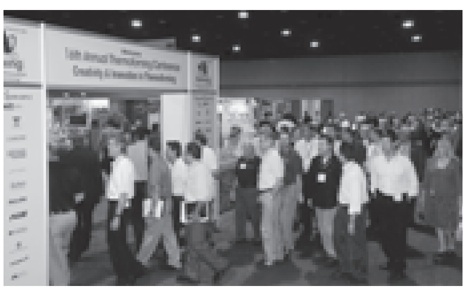
The Segen Memorial Scholarship, in the amount of $5,000, was presented to Lucas Stallbaumer, a graduate student in plastics engineering technology at Pittsburg State University, Kansas. Kim Acinger, a senior majoring in plastics engineering technology at Pittsburg State, won the Griep Memorial Scholarship in the amount of $5,000.

Paul Bertsch Memorial Scholarships, in the amount of $5,000 each, were awarded to four students: Kurtis Shultz, a senior at Western Washington University, working toward a degree in plastics engineering; Stephen Probert, a graduate student studying mechanical engineering at the University of Washington; Adriane Wiltse, majoring in plastics engineering technology at Pittsburg State; and Justin Dameron, also studying plastics engineering technology at Pittsburg State.

The Division awarded an additional 26 scholarships, of $1,000 each, to university students during the past year. Matching grants totaling $60,000 for the purchase of thermoforming equipment for use in university laboratories were also awarded by the Division. ■

2006 NASHVILLE CONFERENCE …

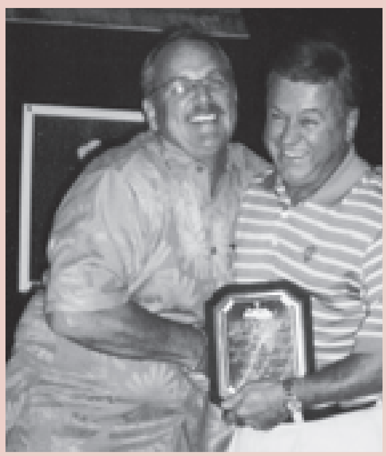
Nashville 2006
Thermo Forming
"Creativity & Innovation in Thermoforming"



2006 NASHVILLE CONFERENCE …

Thank You … 2006 Sponsors! The success of our conference is due to your support.

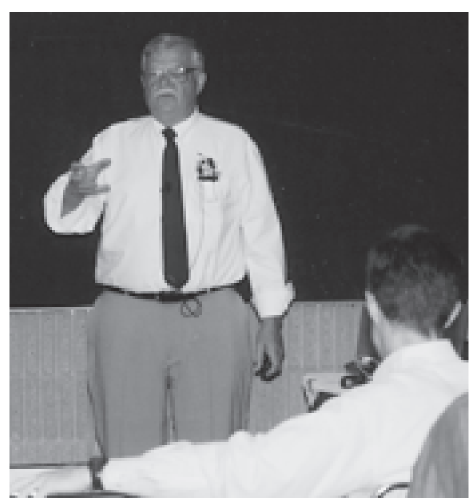
And the Winners Are …



OUTSTANDING BOARD MEMBER AWARD PRESENTED BY HAL GILHAM, AWARDS CHAIR, TO BOB PORSCHE, GENERAL PLASTICS.

OUTSTANDING ACHIEVEMENT AWARD PRESENTED BY BARRY SHEPHERD, DIVISION VICE CHAIR TO ROGER FOX, THE FOXMOR GROUP.

Well Done!
Marty Stephenson
2006 Conference Chair



Thank you … Jim Throne …
for your many years of support
to the Thermoforming Division!
We're gonna miss you!

THERMOFORMING DIVISION WINTER BOARD MEETING SCHEDULE

February 19th - 24th, 2007
Renaissance Sea World Hotel
Orlando, Florida

****Rooms have been reserved in our block starting Saturday, 2/17 thru 2/24/07 if you want to come in a few days early for vacation. These rooms are limited, so FIRST COME, FIRST SERVE:**

FOR RESERVATIONS, CALL: 407.351.5555. Be sure to request the SPE rate of $229.00.

Tuesday, February 20th, 2007

Executive Committee Arrives

Wednesday, February 21st, 2007

7:30 – 8:30 am – Breakfast – Executive Committee, Tarpon Room
8:30 am – 5:00 pm – Executive Committee Meeting, Tarpon Room
12:00 – 1:00 p.m. – Lunch – Executive Committee, Tarpon Room
2:00 – 3:00 pm – Finance Committee Chairman, Tarpon Room
4:00 – 5:00 pm – Technical Chairs to meet with Executive Committee, Tarpon Room

Thursday, February 22nd, 2007

8:30 – 10:30 am – Materials Committee, Eisenia Room
8:30 – 10:30 am – Processing Committee, Margate Room
8:30 – 10:30 am – Machinery Committee, Nomeus Room
10:30 – 11:15 am – AARC Committee, Nomeus Room
11:15 am – 12:00 pm – Web Site Committee, Nomeus Room
LUNCH ON YOUR OWN
1:00 – 1:45 pm – Student Programs, Nomeus Room
1:30 – 2:00 pm – Publications, Nomeus Room
1:45 – 2:15 pm – Recognition, Nomeus Room
2:00 – 2:45 pm – Marketing Committee, Nomeus Room
2:15 – 3:30 pm – 2007 Conference, Nomeus Room
3:30 – 4:15 pm – Membership, Nomeus Room

Friday, February 23rd, 2007

7:30 – 8:30 am – Breakfast – Board of Directors, Damselfish Room
8:30 am – Noon – Board of Directors Meeting, Damselfish Room
12:00 – 1:00 pm – Lunch – Board of Directors, Damselfish Room
AFTERNOON ON YOUR OWN
5:30 pm – Meet in Lobby for Tram to dinner at Sea World's Sandbar Restaurant

Saturday, February 24th, 2007

Non-golfers will have day on their own.
7:30 am – Tee-off time for Golf Outing, Grande Pines Golf Club. For reservations, call: Joe Peters at 413.592.4791. Cost: $132.06 for golf with cart - check payable to SPE TF Division.
6:00 – 7:00 pm – Reception & Golf Awards Presentation - Top - of -Dolphins

Sunday, February 25, 2007

Depart

LEAD TECHNICAL ARTICLE

The Effect of Sheet Sag on Radiant Energy Transmission in Thermoforming[1]

BY JAMES L. THRONE, SHERWOOD TECHNOLOGIES, INC., DUNEDIN, FLORIDA

Abstract

As sheet is heated in thermoforming, it sags away from upper heaters and toward lower heaters. The individual heater efficiencies are affected by the extent of sag. This work presents an analysis of radiant energy interchange as a function of the extent of two-dimensional catenary sag. As expected, the energy input from the lower heater to the center of the sagging sheet is greater than that for a planar sheet and the energy input from the upper heater to the center of the sagging sheet is less than that for a planar sheet. However, the average global energy input to the sheet is essentially independent of the extent of sag.

Introduction

In thermoforming, the sheet to be heated is usually placed between two planar parallel or sandwich heaters. To analyze the efficiencies of heating profiles, the sheet is usually assumed to remain planar and parallel to the heaters. However, as is well known, as the sheet heats, it sags under its own weight away from the top heaters and toward the bottom heaters. This paper discusses the significance of sheet sag on heating efficiencies. In particular, the focus is on analyzing the view factor or shape factor, being the relative amount of sheet surface seen by a specific segment of heater.

[1] This paper was to have been presented at ANTEC 2007, Cincinnati.

[2] For sag of a sheet affixed on four edges, the catenary is replaced with a hyperbolic catenoid (7,8). Although the arithmetic of hyperbolic catenoidal sheet deformation is only slightly more complex than that of the catenary model, the determination of the direction cosines, described below, is very difficult. To this author's knowledge, the mathematics dealing with the radiant interchange between planar heaters and a sheet described by the hyperbolic catenoid equation has not been published.

Caveats

The objective of this work is to examine the relative effects of sag on radiant heat transfer. To do so without substantial obfuscation, the analysis has been greatly simplified. The following caveats are in order:

- The work does not consider the amount of energy transferred between heaters and sheet.
- Therefore the work does not allow prediction of heating times.
- The work does not consider any modes of heat transfer other than radiation. In other words, conduction of energy into the sheet and convection of energy from the sheet are not considered.
- The work does not consider the relative thickness of the plastic sheet.
- For the purposes of analysis, the sheet is infinitely long, into the paper.
- For purposes of analysis, the individual heater elements are considered infinitely long, into the paper.

The Catenary as a Model for Sheet Sag

Consider a sheet of plastic affixed on two edges, L distance apart, and sagging under its own weight, as shown in Figure 1[2].

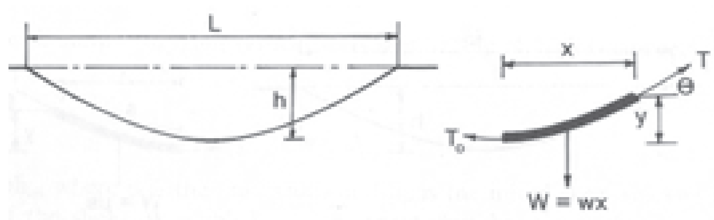


Figure 1. Geometry for Catenary or Chain Sheet Sag.

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The total vertical force supported by the edges is equal to the weight of the sheet of length S*. If the sheet weighs M units per area, the tension σ on the sheet is given as:

(1) $$\sigma \sin\theta = MS^*$$

(2) $$\sigma \cos\theta = \sigma_0$$

The slope of the sheet at any point is given as:

(3) $$\frac{dy^*}{dx^*} = \frac{MS^*}{\sigma_0} = \frac{MS^*(x^*,y^*)}{\sigma_0}$$

Where x* = 0 at the center of the sheet and y* is the deflection of the sheet at position x*. The equation is solved for the sheet length:

(4) $$S^*(x^*) = \frac{\sigma_0}{M}\sinh\left(\frac{Mx^*}{\sigma_0}\right)$$

Where $\sinh(z) = \frac{1}{2}(e^z - e^{-z})$, the hyperbolic sine.

The deflection of the sheet is given as:

(5) $$y^*(x^*) = \frac{\sigma_0}{M}\left[\cosh\left(\frac{Mx^*}{\sigma_0}\right) - 1\right]$$

Where $\cosh(z) = \frac{1}{2}(e^z - e^{-z})$, the hyperbolic cosine.

The local tension in the sheet is given as:

(6) $$\sigma(x^*) = \sigma_0\left[\cosh\left(\frac{Mx^*}{\sigma_0}\right)\right]$$

Or in terms of the deflection:

(7) $$\sigma(y^*) = \sigma_0 + My^*$$

The equations above are called catenary or chain equations [1-3]. The dimensionless sheet length is given as:

(8) $$S = \frac{S^*}{L} = \frac{\gamma}{2}\sinh\left(\frac{1}{\gamma}\right)$$

Where $\gamma = \frac{2\sigma_0}{ML}$. The local deflection is given as:

(9) $$y = \frac{y^*}{L} = \frac{\gamma}{2}\left[\cosh\left(\frac{1}{\gamma}\right) - 1\right]$$

Where $x = \frac{2x^*}{L}$. The maximum deflection is given as:

(10) $$y_{max} = \frac{y^*_{max}}{L} = \frac{\gamma}{2}\left[\cosh\left(\frac{1}{\gamma}\right) - 1\right]$$

And the dimensionless slope is given as:

(11) $$\left(\frac{dy}{dx}\right)_x = \sinh\left(\frac{x}{\gamma}\right)$$

Example 4.14 of [3] is modified and used as the illustration for the rest of this work. The following values are assumed[3]:

$$\gamma = 2\sigma_0/ML = 1.154, \; -1 < h < 1$$

Figure 2 shows the sag for these data. The maximum dimensionless sag, y_{max} = -0.0232 for τ=0[4] and y_{max} = -0.232 for τ=-30.

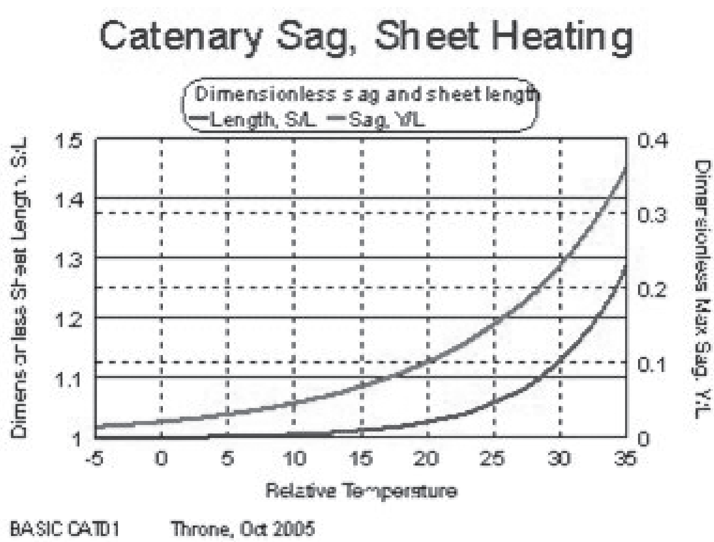

Figure 2. Catenary Sag and Sheet Length.

The Effect of Sheet Temperature on Sag

As the temperature of the sheet increases, its tensile strength decreases. One measure of temperature-dependent tensile strength is the Arrhenius equation:

(12) $$\sigma_0 = \sigma_{0,0}e^{(E/RT - E/RT_0)}$$

[3] Example 4.14 of [3] uses γ=9.54, yielding a maximum deflection value of y_{max} = -0.0217. [Note that the value given in [3] is y_{max} = -0.0265.] The modified values allow for greater deflection in the sheet.

[4] Keep in mind that the sheet sags below the horizontal.

Where $\sigma_{0,0}$ is the tensile strength at T_0. Consider the following simplification for illustration purposes only:

(13) $$\sigma_0 = \sigma_{0,0} e^{-0.07615\tau}$$

When τ = -30, γ = 11.54. When τ = 0, γ = 1.154, as given above. The effect of sheet temperature on maximum sag is shown in Figure 2. This assumes that the local sheet weight remains constant.

Effect of Sheet Sag on Local Sheet Weight

As the sheet sags, its length increases. Because the entire sheet weight is constant, the local sheet weight, M, should decrease with increasing sag. The local sheet weight is obtained by iterating on the differential sheet length. As seen in Figure 3, there is little difference in the values for maximum sag, for τ = -30 to τ = 0.

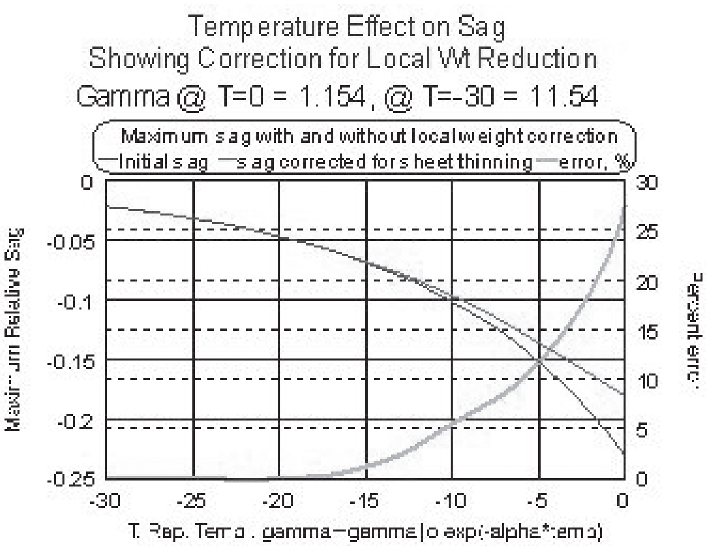

Figure 3. Temperature effect on sag, showing correction for local weight reduction. Percent error shown on rightvertical axis. $\gamma(\tau=0)=1.154$. $\gamma(\tau=-30)=11.54$. X-axis: $\gamma=\gamma_0 \exp(-\alpha\tau)$.

The Radiation Equation

Consider the radiant interchange between two differential surfaces, ΔA_1 and ΔA_2, Figure 4.

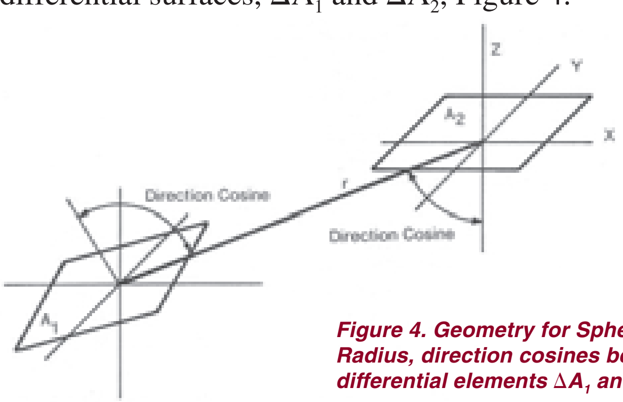

Figure 4. Geometry for Spherical Radius, direction cosines between differential elements ΔA_1 and ΔA_2.

Consider "1" to represent the element on the radiant heater and "2" to represent the element on the sheet surface. Of primary concern is the projected areas of each element in the directions of the other elements. The net rate of radiation between these differential elements is given as [4,5]:

(14) $$\Delta q_{1\leftrightarrow 2} = \left(E_{b_1} - E_{b_2}\right)\left[\frac{\cos\phi_1 \cos\phi_2}{\pi r^2}\right]\Delta A_1 \Delta A_2 = \left(E_{b_1} - E_{b_2}\right)\Delta F_{1\leftrightarrow 2}\Delta A_1 \Delta A_2$$

The term $\Delta q_{1\div 2}$ is the differential energy interchange, E_{b_1} and E_{b_2} are the maximum energies[5] emitted from elements "1" and "2", and $\Delta F_{1\div 2}$ is the local view factor. The terms cos ϕ_1 and cos ϕ_2 are the direction cosines for elements "1" and "2". The term "r" is the distance between the two elements and "πr^2" is the result of the intersection of element "2", say, with the steradian ray from element "1", say.

Parallel Planar Radiation Equation

For parallel planar heaters and sheet, the direction cosines of the elements are given as:

(15) $$\cos\phi_1 = \cos\phi_2 = z/r$$

Where "z" is the spacing between the differential elements. For two-dimensional energy transfer, the distance between any two elements is given as:

(16) $$r = \sqrt{x^2 + z^2}$$

The local view factor, $\Delta F_{1\div 2}$, is given as:

(17) $$\Delta F_{1\leftrightarrow 2} = \left[\frac{\cos\phi_1 \cos\phi_2}{\pi r^2}\right] = \frac{z^2}{\pi\left(x^2 + z^2\right)^2}$$

For three-dimensional energy transfer, the distance between any two elements is given as:

(18) $$r = \sqrt{x^2 + y'^2 + z^2}$$

Where y' is the distance along the heater and sheet surfaces, into the paper. The local view factor in three dimensions, $\Delta F_{1\div 2}$, is given as:

(19) $$\Delta F_{1\leftrightarrow 2} = \left[\frac{\cos\phi_1 \cos\phi_2}{\pi r^2}\right] = \frac{z^2}{\pi\left(x^2 + y'^2 + z^2\right)^2}$$

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[5] The maximum emitted energy is called the "black body energy."

The local view factor is then summed over all "2" elements to determine the average amount of energy interchanged with element "1". To get the total energy interchanged, these average amounts of energy are then summed over all "1" elements [6]:

$$q_{\Sigma_{A_1}\Sigma_{A_2}} = (E_{b_1} - E_{b_2})\sum_{A_1}\sum_{A_2}\left[\frac{\cos\phi_1\cos\phi_2}{\pi r^2}\right]\Delta A_1 \Delta A_2 = (E_{b_1} - E_{b_2})\sum_1\sum_2 \Delta F_{1\leftrightarrow 2} \quad (20)$$

Consider a sheet with four edges. Because the heaters and sheet are finite in dimension, view factor values at the edges of the sheet are less than those at the center, and the view factor values at the corners are less than those at the edges. As a result, the edges of the sheet receive less radiation than the center of the sheet, and the corners of the sheet receive less radiation than the edges of the sheet. This effect is called the "energy dome," as seen in Figure 5.

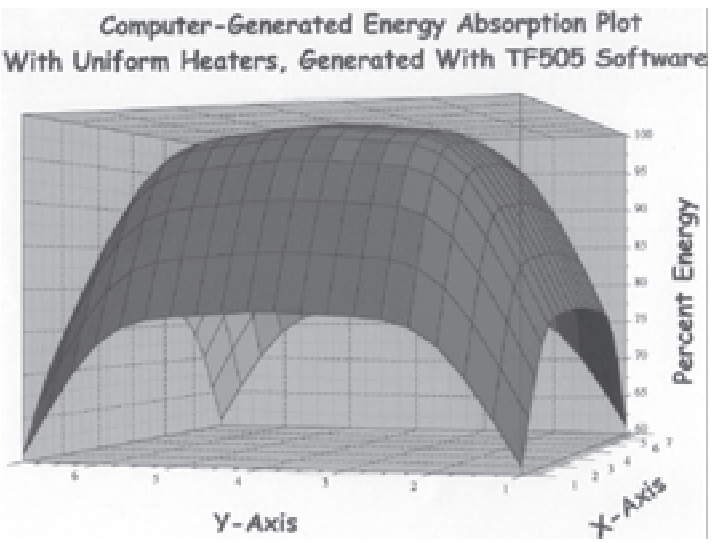

Figure 5. Energy dome result of uniform heat flux input for sheet affixed on four sides.

In the current example, the sheet has only two edges, being infinite into the page. Thus the effect should be one in which the values of the view factors at the clamped edges of the sheet should be less than those at the center of the sheet.

Modification for Sag

When the sheet sags, the differential direction cosines are no longer dependent of the (x,y) coordinates of the element. Instead, the direction cosines must be determined for each heater element and each sheet element. Consider a two-dimensional catenary example, Figure 6, where the spacing between the initial sheet plane and the top heater plane, Z=1. As an example, the angle between the heater element at L=2 and any sheet surface is determined by obtaining its tangent. The angle between the sheet surface element and the heater element is obtained by first determining the angle of the normal to the sheet surface, n, and then adding the heater angle. The direction cosines are determined from these angles.

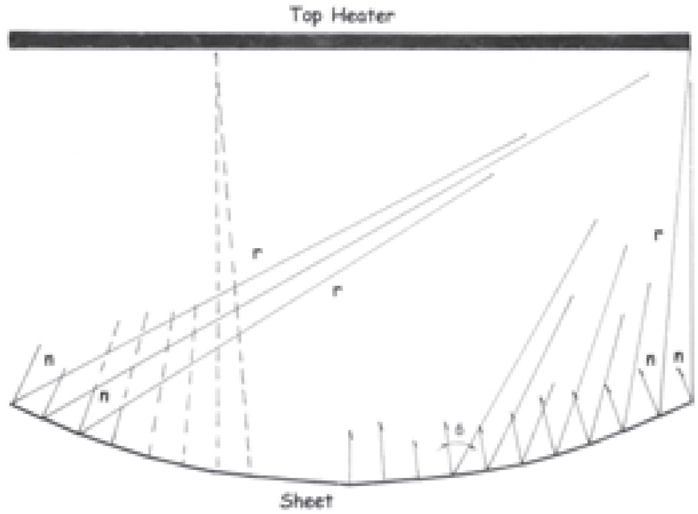

Figure 6. Ray Map from top heater to sagged sheet.

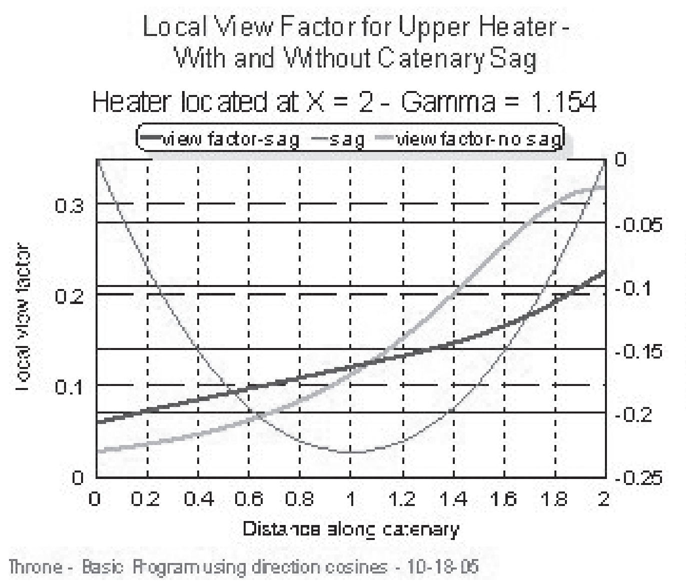

Figure 7. Upper heater view factor, with and without catenary sag [sag is U-shaped curve, right vertical axis].

Figure 7 is a plot of the local view factor at the upper heater element at L=2, γ=1.154, for each sheet element, from x=0 to x=2. The sheet sag is also shown.

As is apparent when comparing local view factors for sheet with and without sag, sag tends to even out the local view factor value. By examining Figure 6, it is apparent that the slope of the sheet at x=0, say, is toward the L=2 heater element and this acts to increase the projected area of that element and thus increase the local view factor value. On the other hand, the slope of the sheet at x=2 is away from the L=2 heater element. This acts to decrease the projected area of that element and thus decrease that local view factor value.

Again, as the sheet sags, the center moves away from the top heater, and toward the lower heater. Again, the rays from a given heater element at L=0 on the bottom heater are shown intersecting the sagging sheet, for γ=1.154 and Z=1, Figure 8.

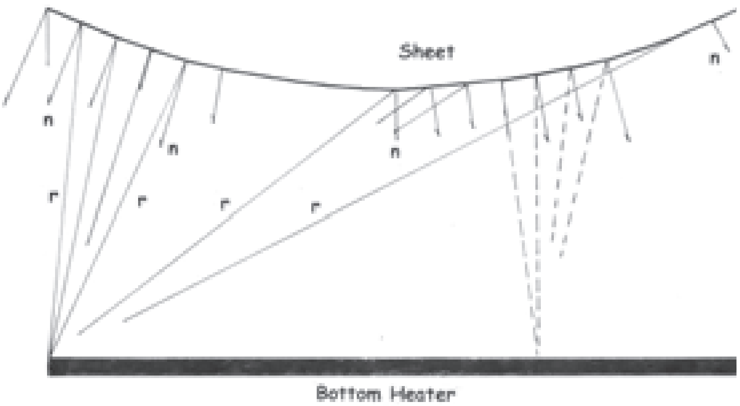

Figure 8. Ray Map from bottom heater to sagged sheet.

It is apparent that at some point, the angle of the normal to the sheet is at right angles to the ray from that heater element. The projected area becomes zero and the heater element cannot see sheet elements beyond that point. A comparison of the local view factor with and without catenary sag is sown in Figure 9 for the heater element at L=2, γ=1.154, and Z=1. It is apparent that the heater cannot see the sagging sheet from x=0 to around x=0.5 or so. It is also apparent that as the sheet sags, it sees increasing energy very close to the sheet clamps.

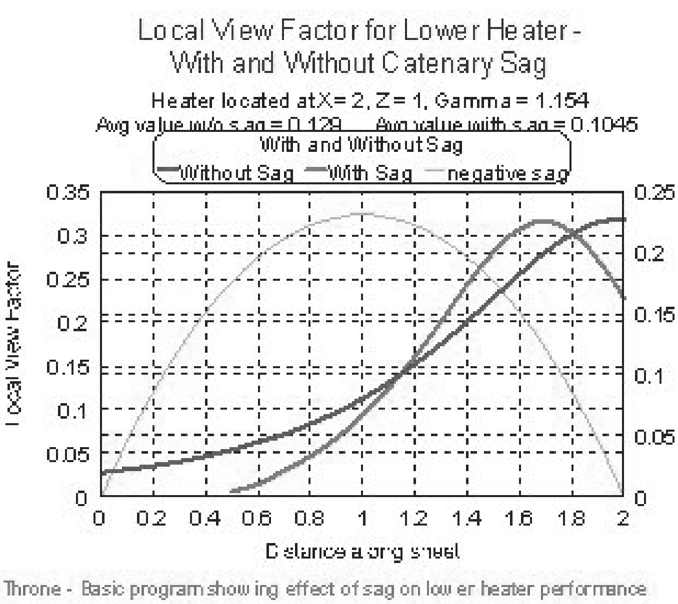

Figure 9. Lower heater view factor, with and without catenary sag [sag is Hum-shaped curve, with axis to right].

The Overall Effect on Heating Efficiency

Figures 7 and 9 represent the local view factor value taken for one element, viz, that at L=2. As noted earlier, the local view factor values can be determined at each of the heater elements. Because the heaters and sheet are symmetrical about the point x=0, we need only sum the heater elements from L=1 to L=2, say. The results of the summation for top and bottom heaters, Z=1, γ=1.154, are given in Figure 10.

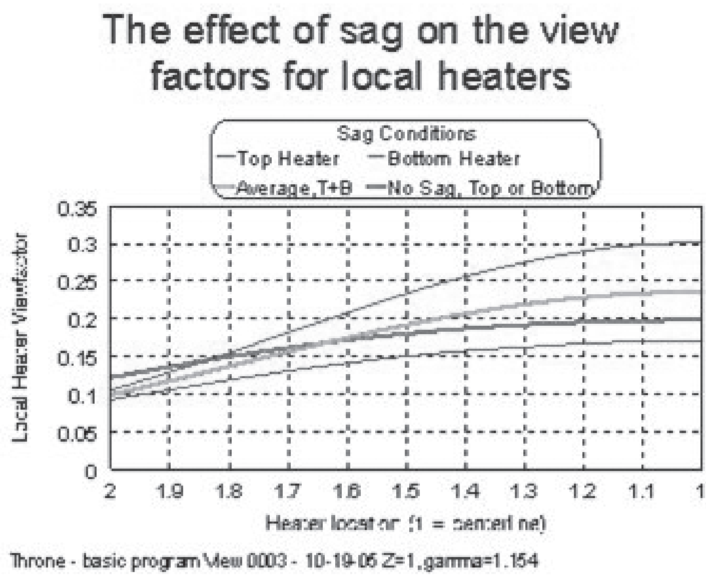

Figure 10. The effect of sag on the view factors for top and bottom local heaters, Z=1, γ=1.154.

As expected, the values for the local view factor for the planar sheet are less at L=2 than at the center of the sheet, L=1. Not surprising, the same is true for the sagging sheet. As expected, the energy input from the bottom heater to the center of the sagging sheet is substantially greater than that for the sheet that does not sag. As expected, the energy input from the top heater to the sagging sheet ***across its entire length*** is less than that for the sheet that does not sag.

The Significance of This Finding to Sheet Heating

Consider that the sheet is thin but radiantly opaque. This implies that the sheet temperature is uniform throughout the sheet thickness. This allows for an

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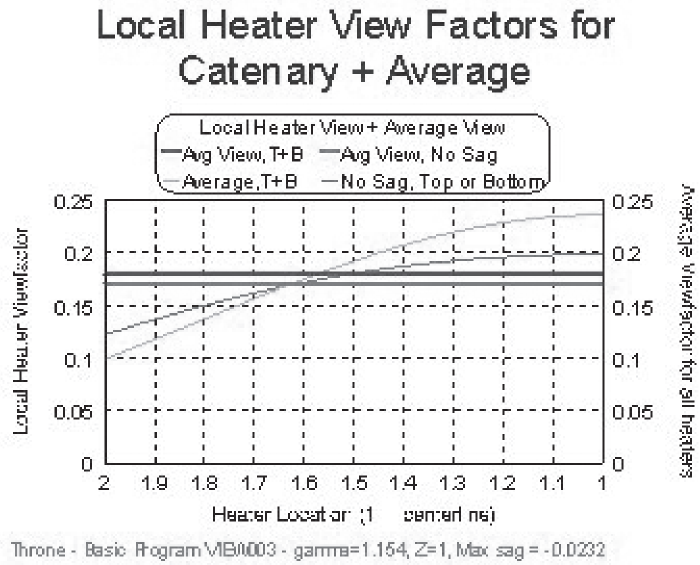

Figure 11. Local heater view factors with and without catenary sag [thin lines, left axis]. Average view factors are shown as horizontal lines [thick lines, right axis]. z=1, γ=1.154, y_{max}=-0.0232.

analysis using average energy input top and bottom across the sheet. Now consider Figure 11.

The average local energy input to the planar sheet exhibits the expected "energy dome," with less energy input at the clamp edges than at x=1. As the sheet sags, the average local energy input increases in the center and decreases at the clamps. In other words, as the sheet sags, it gets hotter in the center than it would if it did not sag. This is as expected. Interestingly, however, the ***average*** global energy input to the sheet is essentially constant.

Consider now that the sheet is radiantly opaque and sufficiently thick to cause substantial thermal inertia of inbound radiation. In other words, the sheet conducts energy from its surface to its interior. This effectively decouples energy input to the top and bottom of the sheet. In Figure 11, sag results in substantially more energy input to the bottom center of the sheet surface than is expected from planar parallel sheet energy input, and less than is expected to the bottom edges of the sheet surface. Sag results in somewhat less energy to the top surface of the sheet than is expected from planar parallel sheet energy input. However, although the "energy dome" is evident, the result is a nearly uniform reduction along the entire sheet length. Through-the-oven-wall infrared thermometers usually measure only the top surface of the sheet while it is in the oven. So, although the top sheet surface temperature may appear to be low but within guidelines, the energy imbalance to the sagging sheet can result in significant overheating of the bottom center of the sheet.

Summary

In summary, energy interchange between a thin sheet and sandwich heaters may not be dramatically affected by moderate sheet sag, but sag may significantly alter local energy input to the bottom of a thick sheet. ■

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8. See also http://mathworld.wolfram.com/hyperbola.html.

Past Thermoformers of the Year Honored at Conference

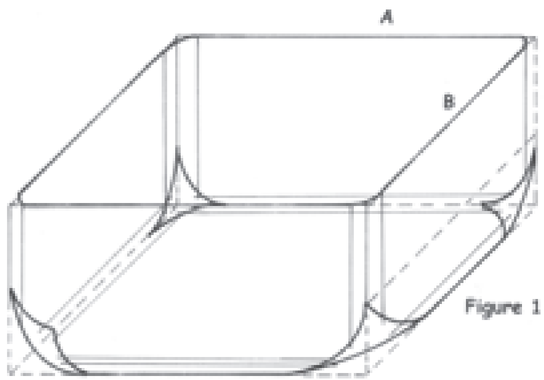
In attendance at the conference were: (L-R): 1999-Art Buckel, 2003-Bill Benjamin, 1991-Stan Rosen, 2006-Paul Alongi, 1982-Bill McConnell, 2002-Stephen Sweig, and 2004-Steve Hasselbach.

Determining the Effect of Corner Radius on Container Volume

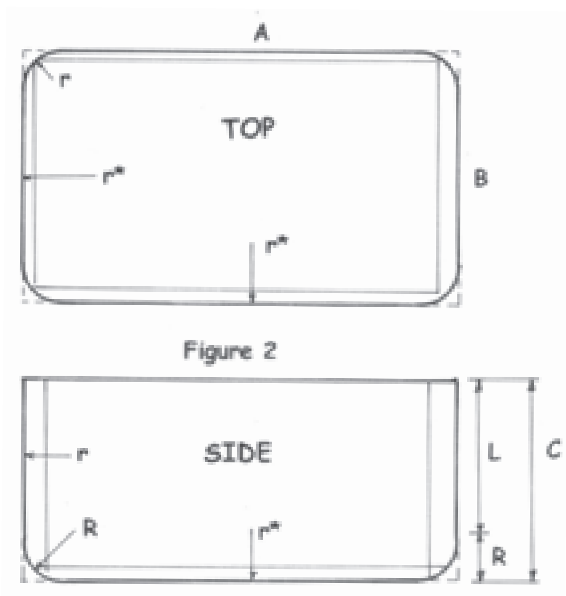
BY JIM THRONE, SHERWOOD TECHNOLOGIES, INC., DUNEDIN, FLORIDA

In a recent TF 101 lesson, I discussed corner radii and pointed out that radii remove volume from a container. In this Industry Practice article, I show how to calculate the approximate volume that is excluded by corners of various radii.

Consider a rectangular container, A units wide, B units deep, and C units in height, Figure 1.



Divide the container horizontally into a bottom portion having a height of R, being the radius of the 3D corners, and a top portion having a height of L=C-R, Figure 2.



Bottom Volume

Consider the bottom first. The volume of the bottom having all intersections of zero radius is given as AxBxR = ABR = V_{bottom}.

- The vertical 2D corners, formed by the intersection of two vertical walls, have radius r.
- The horizontal 2D corners, formed by the intersection of each vertical wall and the bottom, have radius r*.
- The 3D corners, as noted, have radius R.

For the 3D corners, the excluded volume is given as the volume of the corners having zero radius minus the volume of the hemisphere of radius R.

- The volume of the corners having radius zero = 2R x 2R x R=$4R^3$.
- The volume of the hemisphere = $\frac{1}{2}(4\pi/3)R^3 = (2\pi/3)R^3$.
- The excluded volume in the 3D corners is given as $(4-2\pi/3)R^3$.

For the horizontal 2D corners formed by the intersection of each vertical wall and the bottom, consider the A and B sides individually.

The A Side

For the A side, the excluded volume is given as the volume of the corners having zero radius minus the volume of the half-cylinder of radius r*. The lengths of the rectangle having zero radius corners and half-cylinder are the same, being A minus twice the portion of the 3D corners that impinge on the 2D corners. As an approximation, consider the lengths to be A-2R.

- The volume of the rectangle is then given as (A-2R) x 2r* x r* = $2\,(A-2R)r^{*2}$
- The volume of the half-cylinder is given as (A-2R) x $\pi r^{*2}/2$
- The excluded volume in the horizontal 2D corners is given as $(A-2R)r^{*2}\,[2-\pi/2]$

The B Side

For the B side, the excluded volume is given as the volume of the corners having zero radius minus the volume of the half-cylinder of radius r*. The lengths of the rectangle having zero radius corners and half-cylinder are the same, being B minus twice the portion of the 3D corners that impinge on

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the 2D corners. As an approximation, consider the lengths to be B-2R.

- The volume of the rectangle is then given as $(B-2R) \times 2r^* \times r^* = 2(B-2R)r^{*2}$
- The volume of the half-cylinder is given as $(B-2R) \times \pi r^{*2}/2$
- The excluded volume in the horizontal 2D corners is given as $(B-2R)r^{*2}[2-\pi/2]$

Because the bottom is only as high as the top of the 3D corner radius, we choose to ignore any portion of the vertical radius in this calculation. As a result, we can now determine the total volume of the bottom with radii, being the volume of the bottom with zero radii minus the excluded volume in the corners:

$$V_{bottom} = A \times B \times R - (4-2\pi/3)R^3 - r^{*2}[2-\pi/2](A+B-4R)$$

Top Volume

Now consider the top portion.

The volume of the top portion having zero 2D vertical corner radii is $V_{top} = A \times B \times (C-R) = AB(C-R)$.

For the vertical 2D corners, consider the excluded volume to be the volume of a rectangle 2r on a side by a length C-R – minus a cylinder of length C-R and a radius r.

- The volume of the rectangle is given as $(C-R) \times 4r^2$
- The volume of the cylinder is given as $(C-R) \times \pi r^2$
- The excluded volume in the vertical 2D corners is thus given as $(C-R)r2\,[4-\pi]$

The volume of the top is then given as:

$$V_{top} = (C-R)[AB-(4-\pi)r^2]$$

Total Volume

The total volume of the radiused box is then:

$$V_{bottom} + V_{top} = ABR - (4-2\pi/3)R^3 - r^*2\,[2-\pi/2](A+B-4R) + (C-R)[AB-(4-\pi)r^2]$$

An Example

Consider a five-sided cube, 1 unit on a side.

For the first calculation, let the 3D corner radius, R=0.2, the horizontal 2D corner radius, r*=0.1, and the vertical 2D corner radius, r=0.05. Determine the volume of the radiused box:

$$V_{radiused\ box} = 0.2 - (4-2\pi/3)0.2^3 - 0.1^2[2-\pi/2](2-4 \times 0.2) + (1-0.2)[1-(4-\pi)0.05^2]$$

$$V_{radiused\ box} = 0.2 - 0.0152 - 0.0052 + 0.7982 = 0.9778$$

As calculated, the radiused box has nearly 98% the volume of the box with zero radius corners.

A Modified Example

Now recalculate the earlier example, doubling all radii. R=0.4, r*=0.2, r=0.1.

$$V_{radiused\ box} = 0.4 - (4-2\pi/3)0.4^3 - 0.2^2[2-\pi/2](2-4 \times 0.4) + (1-0.4)[1-(4-\pi)0.1^2]$$

$$V_{radiused\ box} = 0.4 - 0.122 - 0.0069 + 0.5948 = 0.86592$$

As calculated, the severely radiused box still has nearly 87% of the volume of the box with zero radius corners. ■

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Controlling the 3 M's of Forming

BY GARY BENEDIX, SYSCON-PLANTSTAR, SOUTH BEND, INDIANA

From the 1980s when we worked with Samsonite to today and working with some of the most sophisticated thermoformers in the industry, the message has remained the same. If you can control the 3 M's of forming, ***Machine, Manpower and Material***, you will be profitable.

Machines are a business owner's big capital expense. Be they rotary or in-line formers or table CNC machines, owners want to get the most out of these machines. Due to the cost of equipment and floor space requirements, they want to purchase more equipment as a last resort and have it due only to business growth. Since they are typically selling time they want to squeeze every second of production time out of the machines as possible.

When Samsonite first implemented our real-time production monitoring system, they were confident forming was operating at 80+% efficiency levels. The system quickly measured their true operating efficiency in a range of 68%-72%. After consulting with them on the methods of data gathering and calculation, they agreed. At that point they had their first benchmark for productivity improvement and eventually achieved efficiencies of 85% and more.

The "Samsonite syndrome" is quite common. Managers believe they have a good handle on machine performance. They see product moving and machines running. Everything must be good, right? Wrong. You can never know for sure if you aren't always at the machine. A monitoring system is measure. It doesn't take lunch breaks, biological breaks or time off for holidays. It knows the standards upon which product is supposed to be manufactured. It constantly measures true performance against those standards and reveals problem areas for you.

A leading thermoformer began a phased-in implementation of our system over a year ago. As you toured the factory, you saw a major backup of product queued to move into the CNC room for trimming. Since that was a problem area, this customer started system implementation there so as to get accurate data on the performance of the machines. This customer quickly saw major cycle time swings on the CNC tables caused by setup and operational issues. They corrected the problem. The logjam of product in queue was eliminated and they put the purchase of another table on hold.

Another, Spencer Industries, has used the Overall Equipment Effectiveness (OEE) calculation generated by the system to identify opportunities for improvement. Machine cycle time and Tool changeover time are just two areas they have improved. According to Ken Hedges, Director of Continuous Improvement, they have also greatly benefited from our dynamic Gantt chart Job Scheduling Board.

One common area formers target is scrap. Scrap is lost opportunity of time and material. Some large parts have a high dollar value and cost of scrap escalates quickly. A recent visit to a former revealed they had run 30% scrap on a medical product during the night shift prior to my arrival. They had no way of documenting this other than paper tracking. Management became informed when reports were generated on a spreadsheet several hours later. This was a significant cost of time, machine, manpower and material that would have been detected and corrected much sooner with the proper implementation of a monitoring system.

Most monitoring systems let you define and track your scrap reasons and quantities. When the biggest reasons are for scrap are revealed, corrective action can be taken. Sometimes it is as simple as the way product is handled. Other times it may be more complicated and based on machine control or tool setup issues. Sometimes it might even be environmentally related. Either way, once you can measure the performance, you can set benchmarks for improvement.

Oftentimes, improvement in machine and product control result in reduced labor requirements. Sometimes it may be as little as reducing the number of temporary workers a company employs. Other times the improvements may allow you to reduce overtime or eliminate weekend shifts.

Reduction in headcount has also been achieved due to the productivity improvements realized by the system. These reductions may be on the production floor or in the front office. The paper reporting systems still in use at many formers typically require a person on the floor to document production, a person in the office to collate the data and enter the data into an accounting/MRP system. This redundant data shuffling frequently leads to data entry errors or delays in generating reports because this person is interrupted during their efforts to complete the task. Electronic gathering of the data by the system will automatically generate reports at the End of Shift. Plus, most accounting/MRP systems can accept electronic data transfers from a monitoring system. You automate those tasks and, in most cases, train the person to perform more important functions to better support the company's overall mission.

As these improvements are realized, many customers then want to move into tracking and forecasting their labor. The need to gain a better understanding of the true amount of direct and indirect labor required manufacturing product. The SYSCON-PlantStar system is one of very few systems that enables you to do all three. For every product you can specify Manning Factors of both direct and indirect labor requirements. Personnel login to the system at the machine when they are performing their task; i.e. Operator, Setup, Material Handler, Maintenance, etc. Likewise, they log out when their task is complete. The date and time they logged in/logged out are documented. The amount of time spent on task is measured. This helps significantly with benchmarking tool changeovers. Operator Efficiency against standard is calculated.

Setting Manning Factors in the product standards of the system enables Labor Forecasting based on the Job Schedule. Up to 30 different labor categories can be defined, tracked and forecasted within the system. Each can have a costing factor included. Labor requirements for each category are then forecasted by the system. You can see forecasted requirements for up to 100 shifts.

Having real-time manufacturing information available at your fingertips is essential for making real-time management decisions that help you stay agile and competitive in today's fast paced environment. Monitoring systems are relatively easy to implement. SYSCON-PlantStar now has a low cost entry level system that can contains many of the functions of our larger systems to help you gain control of the **3 M's**. The common declaration we hear after a system is in place and in use is: "How did we ever operate without it?" ■

Books for a Small Company Library

BY JIM THRONE, DUNEDIN, FLORIDA

For several years now, I have been reviewing resource material in a column entitled "Book Review." In this Quarterly, for example, I review a book on plastics extrusion troubleshooting. That review is my last as technical editor of the Thermoforming Quarterly. *But I cannot leave the subject without responding to requests for a list of books suitable for a small company library. So, instead of scrapping my standard column, I provide this list under "Industry Practice." I hope the incoming editor will forgive me for this indiscretion.*

I determined that all of the books listed below, with the exception of the McConnell book, are available through www.Amazon.com. Excluding the McConnell book, I estimate the total cost for the lot is about $1,500.

General Book on Plastics

Charles A. Harper (and Modern Plastics), ***Modern Plastics Handbook***, McGraw-Hill, New York, 2000. Yeah, I know I gave this a less-than-enthusiastic review when it first issued. That was because its section on thermoforming was particularly weak and outdated. Nevertheless, it is an essentially up-to-date compendium of most recognized plastics areas. As with any general handbook, however, it is weak on details and substance.

General Books on Plastic Materials

J. A. Brydson, ***Plastics Materials***, 7th Edition, Butterworth-Heinemann, Oxford, 1999. This is an extensive descriptive compilation of most of the plastics that can be extruded into sheet and thermoformed into parts (and many that cannot). There is a smattering of physical property data. It is often used as a textbook for an introductory course in plastics.

H. Domininghaus, ***Plastics for Engineers: Materials, Properties, Applications***, Hanser Gardner, Cincinnati, OH, 1993. An extensive tabulation of physical property data for most commercial polymers. Very little descriptive material and essentially no indication of the data sources.

General Books on Plastics Processing

R. G. Griskey, ***Polymer Process Engineering***, Chapman & Hall, New York, 1995. There are many engineering books from which to choose here. This book is traditional in that it emphasizes mechanical or chemical engineering concepts such as fluid mechanics and heat transfer as applied to polymers. I think this is the most readable and has the clearest worked-out examples.

R. J. Crawford, ***Plastics Engineering***, 3rd Ed., Butterworth-Heinemann, Oxford, 1998. This book focuses on the material behavior of polymers during processing. There are extensive worked-out examples. The paperback edition is inexpensive but may not wear well in a company library.

General Book on Thermoforming

J. L. Throne, ***Understanding Thermoforming***, Hanser Gardner, Cincinnati, OH, 1999. Okay, so it is my contribution. But I wrote it specifically for just such an application.

Book on Roll-Fed Thermoforming

Stanley R. Rosen, ***Thermoforming: Improving Process Performance***, Society of Manufacturing Engineers, Dearborn, MI, 2002. An excellent presentation of most aspects of thermoforming with a focus on thin-gauge, roll-fed forming. I gave it five books out of five in my review.

Book on Cut-Sheet Thermoforming

Wm. K. McConnell, ***The Fundamentals of Thermoforming***, Society of Plastics Engineers, 2001. This is the companion volume to the two video tapes. It focuses on machine and mold aspects of thermoforming with the primary emphasis on cut-sheet thermoforming. [Caveat: I'm not certain that the volume can be purchased without purchasing the videos as well.]

Book on Extrusion

C. Rauwendaal, ***Polymer Extrusion***, 4th Edition, Completely Revised, Hanser Gardner, Cincinnati, OH, 2001. Because extruders are our suppliers, we should have working knowledge of many aspects of sheet extrusion. Although this book is designed specifically for extrusion engineers and therefore is quite technical, the general overview should be of interest to thermoformers.

Online Encyclopedia

www.wikipedia.com. As is well publicized, the items for this online encyclopedia can be created and edited by anyone and everyone. Nevertheless, many articles on plastics seem to be free of commerciality, bias, or out-and-out errors. Articles on "plastics" and "nanocomposites" appear to be first-rate but unfortunately very short. The biggest problem is that there are no articles in many technical areas. For example, there is no article on plastics extrusion. And the topic of mold making focuses on injection mold manufacture. Or plastics design … Or … Well, you get the idea.

Online Patent Search

I like www.delphion.com even though its format is really kind of dowdy. If I'm not mistaken, Delphion is an outgrowth of the IBM patent search engine. There are two modes of access – the free mode and a subscription mode. In the free mode, you can search a patent and read the abstract and figures but you can't download the body of the patent without paying for it. As with all search engines, the more information you put in, the narrower the search becomes. Delphion gives you a relevance factor for each patent it uncovers. ■

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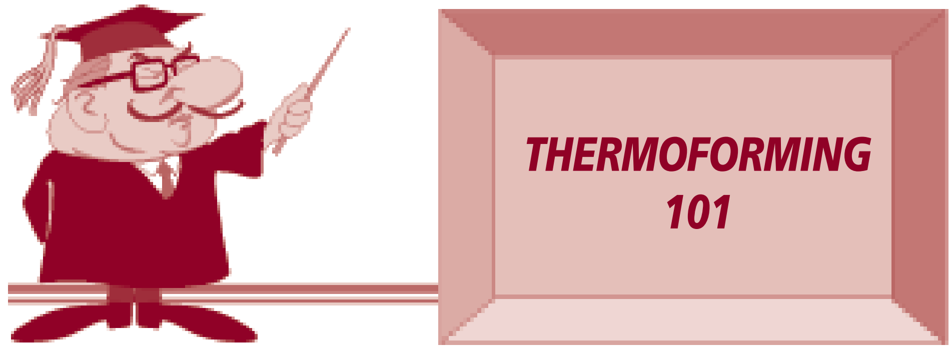
The Rim[1]

BY JIM THRONE, SHERWOOD TECHNOLOGIES, INC., DUNEDIN, FL



So, we know about draft angles and corners and wall thickness variation and on and on. But what about the rim? You know, the region of the formed part that forms the periphery of the part. This lesson focuses on some of the important issues dealing with the rim. In the next lesson, we'll look at the characteristics of the trimmed edge itself.

Does the Rim Have a Function in the Part?

Other than just being the edge of the part, let's say. In thin-gauge forming of axisymmetric parts such as cups, the trimmed-out rim is usually manipulated in a post-molding operation known are rim-rolling. Here, the cup is rotated along its axis as the rim is heated and softened. The rotating action forces the soften rim against a shaping ring that effectively rolls the rim into an annulus. The rolled rim provides great stiffness to an otherwise flimsy thin-walled container.

Staying with thin-gauge products for a moment, the rim design for lidded containers often requires interlocks and detents that must be quite precise. In certain instances, the container rim may include denesting features that allow stacked containers to be readily separated by the customer.

What about the rim on a heavy-gauge part? Often the rim is the finished edge of the part. The rim may be very simple, such as the trimmed end of a flat surface. Or it may be very complex, with radii, chamfers, and ridges. The rim may be designed to fit into or over another part, Or it may be trimmed to accept secondary assembly features. The part design may require the trim line to be "hidden," so that the rim is U-shaped with appropriate radii or chamfers.

Can We Get the Formed Part Off the Mold?

Before we contemplate this question in detail, remember that thermoformed parts shrink as they cool. So they shrink away from the sides of a female or negative mold cavity and onto the sides of a male or positive mold cavity. If we build a simple cup mold, for example, and design the rim so that the plastic is formed over a ring at the mold top, we need to provide adequate draft to get the thing off the mold. In other words, the rim will not have right-angled sides. Does this affect the design? By the way, this design is often called a "dam" design. This design minimizes excess plastic from being drawn over the edge of the mold and into the mold cavity. Frequently a trim line concentric to the dam will also be molded in. This is often called a "moat."

We discussed the hidden trim line a minute ago. How are we going to get the part off the mold? Flip-up sections? Removable sections? It is very difficult to get moving mold sections to seat without a gap between mating parts. As a result, we may wind up with a "witness line" right at the most cosmetic portion of the part. And keep in mind that, without plug assist, parts really thin rapidly when vacuum- or pressure-drawn into parallel-walled mold sections.

What About Texture?

Whenever you draw textured sheet, the texture flattens. In grained sheet, the effect is called "grain wash." The typical rule of thumb is that texture flattening is acceptable if the local draw ratio is less than about two or the local thickness is more than half the original sheet thickness. The real problem occurs in the rim area where the sheet is often drawn into sharp corner radii. One design method is to chamfer the rim. A second is to facet the surface design. A third is to use a series of steps. In each of these cases, the objective is to trick the eye into seeing local architecture rather than texture.

The alternative to drawing textured sheet is to texture the mold. However, as any mold maker will tell you, it is very difficult to build uniform texture into very sharply radiused corners.

You should never fall into the habit of leaving rim design to the end of product design. ■

Keywords: rolled rim, moat, dam, hidden trim line, textured sheet

[1] This is my last TF 101 column. The new TFQ editorial staff will determine whether the column will continue.

BOOK REVIEW

M. del Pilar Noriega E., and Chris Rauwendaal, **Troubleshooting the Extrusion Process: A Systematic Approach to Solving Plastic Extrusion Problems**, Hanser Publishers, Munich, 2001, 158+x pages, $89.95.

Extruders. Love 'em or hate 'em, we cannot thermoform without the product they produce. We really don't need to get intimate with the workings of these devices. Unless, of course, we're extruding some or all of our sheet ourselves. Or contemplating doing so. In either case, you'll find yourself experiencing … yes! You guessed it! PLASTIC EXTRUSION PROBLEMS!

Dr. Chris Rauwendaal is the senior author of this treatise. He is the author of **Polymer Extrusion**, one of the best selling treatises in Hanser's catalogue, now in its 4th edition. Not only has Rauwendaal "talked the talk" through his international seminars, but he has "walked the walk," having developed screw designs that are measurably superior to other commercial designs. His designs are being used in more than a hundred installations worldwide. Recently, he has focused his effort on improving injection molding machine screw designs and on the development of highly efficient screws for the secondary extruder in low-density tandem foam extrusion. His coauthor, Marie del Pilar Noriega, is a practicing engineer in Medellin, Colombia, S.A., with extensive extrusion experience in Latin America.

The monograph focuses entirely on troubleshooting single-screw extrusion. There are four chapters – Requirements for Efficient Troubleshooting (5 pages), Tools for Troubleshooting (12 pages), Systematic Troubleshooting (84 pages), and Case Studies (40 pages). There are three Appendices – Systemic Problem Solving, Machine Troubleshooting and Maintenance, and Setting Extruder Temperatures. The index is 3½ double-columned pages.

In many cases, debugging a processing problem requires skills in Sherlockian[1] deduction. The word "forensics[2]" is often used here. As is apparent, the primary thrust in this monograph is the step-by-step elimination of probable causes of processing difficulties. One usually begins with the most obvious or the simplest items. Obvious machine malfunction is always high priority. The motor, the heaters, the feed to the extruder. Then to the more subtle issues. Screw wear, corrosion, rear seal bearing wear. Then to the polymer. Thermal degradation, oxidative degradation, chemical decomposition (think rigid PVC). Then to throughput-induced processing issues such as surging, un-melt. Well, you get the picture.

The authors include thirteen case studies. They include film coextrusion problems, color variation, pipe extrusion issues, and parison extrusion problems. On a very rare occasion, a case study will exactly focus on the problem that you, the processing engineer, is facing at the very moment you are reading. At that point, it is correct to say "Voila![3]"

There are several other ways case studies can be used. They can be used as tutorials, teaching the reader the deductive process, by example. While this technique is not common in engineering, it is extensively used in business and law. Seasoned troubleshooters often use these guides in an entirely different way. The troubleshooter will propose a solution as soon as he/she reads about the problem. Then he/she will read the authors' solution. And agree or disagree with them. The authors recognize this use, writing in the Preface that they "…welcome feedback from readers, along with additional material on extrusion troubleshooting. This will allow more information to be incorporated into future editions of this book." In other words, if you didn't solve the problem the way they did, let them know your method (and why).

Several years ago, I included a troubleshooting guide in one of my books. A reviewer of the manuscript criticized me, saying that troubleshooting guides are wastes of valuable space in any book. He then included several additional problem-solving solutions to illustrate his viewpoint! I, of course, included them in the finished book.

In my opinion, the Rauwendaal-del Pilar Noriega guide is invaluable to anyone extruding sheet or to anyone wanting to better understand the problems that can occur with your sheet supply. I give this little monograph five books out of five. ■

~ Jim Throne

[1] Sherlockian = having the deduction skills of the fictional character, Sherlock Holmes.

[2] Forensics = The use of science and technology to investigate and establish facts.

[3] Voila = pronounced waa-laa (NOT voy-laa), and meaning to call attention to or express satisfaction with a thing shown or accomplished.

Council Report ...
Pittsburgh, Pennsylvania

BY LOLA CARERE, COUNCILOR

This summary is intended to help you review the highlights of the Council Meeting held in Pittsburgh, Pennsylvania, on September 30th, 2006.

The meeting was called to order by SPE President Tim Womer. President Womer welcomed all to his home city of Pittsburgh. He highlighted some of the many activities he has undertaken as Society president. He noted that the state of the Society is stable.

Executive Director Susan Oderwald reported on exciting new developments. Among them, a new website for students, a newly redesigned ***Plastics Engineering*** magazine, and a totally new venture with *Plastics News* called *Plastics Encounter at ANTEC 2007*. Details on these new developments are presented later in this report.

Past President Lance Neward gave an informative report on Parliamentary Procedure in which he explained the importance of minutes and what should be included in them.

Budget

The major Council action was the approval of the 2007 calendar-year budget. A full write-up on the budget was distributed to Councilors and to all Section and Division Board members in preparation for this meeting. The budget that was approved calls for gross income of $5,655,000, direct expenses of $3,145,000, staff & overhead expenses of $2,395,000 and a net income of $115,000. Council approved the budget by a unanimous vote unchanged from the original presentation. A full area-by-area presentation of this budget is available to Section and Division Board members at: http://extranet.4spe.org/council/index.php?dir=Pittsburgh%20Council%20Meeting/.

Membership

Our overall membership as of August 31st, 2006, is 19,186. SPE, like every other scientific and engineering membership society, and most other associations as well, has seen a decline in new member acquisition in the past 12 months.

In late September, SPE conducted a brief email survey of recently suspended members to ascertain some of the key reasons those members have allowed their SPE memberships to lapse. Results will be reported at a later date.

Plastics Encounter @ ANTEC 2007

Plastics News first approached SPE at the end of May to determine if SPE would be interested in co-locating *Plastics News'* tradeshow, Plastics Encounter, with ANTEC next year. A dialogue ensued over the summer months. As a result of these negotiations, Plastics Encounter will now co-locate with ANTEC at the Duke Energy Center in Cincinnati, May 6th - 10th, 2007.

Each event will retain its own name and identity, and they will operate under the combined title *"Plastics Encounter @ ANTEC."* In addition, each event will be cross promoted via the other's marketing materials and initiatives. *Plastics News* is devoting all of its tradeshow energies and resources to this combined event in 2007. Both groups are seeking to position these two shows as THE defining event for the plastics industry in North America in 2007. This is a one-year agreement. Providing all goes well, both parties have expressed their desire to continue this partnership in future years.

SPE hotels include the Millennium Cincinnati and the Hyatt Regency Cincinnati. A single-occupancy rate of $127 has been negotiated for SPE/ANTEC attendees at both hotels.

Plastics Engineering Redesign Presentation

Council had a "first look" at what they can expect to see in the Society's magazine for 2007.

The interior has undergone a redesign from cover to cover. The magazine has an international look and includes a global editorial perspective. *Plastics Engineering's* global debut is set for the January 2007 issue.

NEW StudentZone Website

Under the leadership of Maria Russo, the StudentZone student website was unveiled earlier this month. An eight-member committee assisted Maria in developing the site content, graphics, production, navigation, etc. One important goal of the site is to increase retention and conversion rates among student members.

ANTEC 2009 TPC

Council approved Dr. Gregory McKenna as the 2009 ANTEC Technical Program Chair.

Bylaws & Policies

A first reading was held on four Bylaws Amendments relative to the Honored Service Member and Fellow of the Society member grades and election committees. Council voted to pass along consideration of these amendments to all members (via publication of the amendments in *Plastics Engineering*) for their review and knowledge. A final vote on the amendments will take place at the January Council meeting in Charleston, South Carolina.

The Council also voted to approve four new Policies. Policies are being written to include information removed from the old Bylaws such as details on how committees are formed and function, or all the steps involved in the election of Society officers. The four policies approved at this meeting were the Policy on Policies, the Policy on Committees and Subcommittees, the Policy on Election of Officers, and the Anti-Trust Policy.

The SPE Foundation

Special campaigns are being conducted as part of the Foundation's 2006 Annual Campaign. Each campaign is being headed by a member of the Foundation Board of Trustees or the Foundation Executive Committee

A general Foundation grant of $5,500 was made to Pennsylvania College of Technology to be used for the purchase of a rotational molding data acquisition system for their Plastics Manufacturing Center.

A $10,000 Thermoforming Equipment grant was made to the University of Wisconsin-Platteville for auxiliary equipment for their new thermoformer.

Twenty-seven students are the recipients of $95,500 in scholarships for the 2006-2007 school year. **In addition, the Thermoforming Division chose to use funds from a special event at their 2005 conference to create "Director's Choice" scholarships. Each member of the board was able to select one student to receive a $1,000 scholarship. Twenty-six students benefited from this new program! As a result, the total awarded in scholarship funding by the Foundation for 2006 is $121,500.**

Susan Oderwald, Karen Winkler, and Gail Bristol have developed a plan for corporate outreach for use by both the Foundation and SPE.

Presentations

The Pittsburgh Section presented a check endowing a new Pittsburgh Section Scholarship within The SPE Foundation. The Bartlesville-Tulsa Section presented a check as a donation to the "Match Your Members" campaign, which is part of the Foundation's 2006 Annual Campaign.

Awards

The Education Awards Committee approved a new award to be known as the Outstanding Student Chapter Award. This award replaces the old STRETCH Award. The OSC Award includes a cash award of $500 (courtesy of the Thermoforming Division) to Student Chapters that meet specific criteria.

Student Chapters

Council voted to charter two new Student Chapters in India:

Amrita School of Engineering

Delhi College of Engineering

Committee Meetings

Fifteen committees met prior to the Council meetings.

The following Committee/Officer Reports were given at the Council meeting:

a) Sections – R. Corneliussen
b) Divisions – B. Arendt
c) International – J. Ratzlaff
d) ANTEC – S. Monte

Council Committee-of-the-Whole

Jim Griffing, Chair of the Committee, conducted the meeting prior to the formal Council meeting.

The next formal Council meeting is scheduled for Saturday, January 27th, 2007, in Charleston, South Carolina. ■

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In Memoriam

Robert Kostur

The Thermoforming industry has lost one of its pioneer engineers this year with the passing of Robert Kostur. For those of you that did not know Bob, he was the founder of Comet Industries in 1955. He had built more than 5,000 thermoforming machines in the 45 years that he remained active in our industry. It has been said that Bob was responsible for creating much of the thermoforming process terminology that we use today; such as plug assist, snap back, air assist, etc. Bob Kostur's innovations over the years have allowed our industry to be more competitive. He was always up to the challenge to develop new ways to process plastic for new applications. Following are just a few of the innovations that Bob helped introduce to our industry:

- Utilizing double forming stations while sharing one oven (1955)
- Began using electric motors instead of air cylinders to drive platens (1959)
- Added forming air to the molds, known as air pressure forming (1962)
- First to form a large part using the twin sheet process (1968)

Bob was an accomplished author on various topics in thermoforming, with articles published in Modern Plastics, Plastics World and others. He was a long time member of the SPE, and had been a speaker at some of our conferences.

As a testament to the durability of Mr. Kostur's machinery design, his machines live on. Comet machines are still in operation throughout the world. Whenever you get the opportunity to view a Comet machine, please reflect for a moment, and in your own way, tell Bob thanks! ■

Society of Plastics Engineers

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Demographics

Job Function *(choose only one)*
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- ❑ Design
- ❑ Education (Faculty)
- ❑ Engineer
- ❑ General Management
- ❑ Manufacturing
- ❑ Marketing/Sales
- ❑ Other
- ❑ Purchasing
- ❑ Quality Control
- ❑ R & D
- ❑ Retired
- ❑ Self-Employed
- ❑ Student
- ❑ Tech Support

Materials *(choose all that apply)*
- ❑ Composites
- ❑ Film
- ❑ General Interest
- ❑ Nylon
- ❑ PET
- ❑ Foam/Thermoplastics
- ❑ Polyolefins
- ❑ Polystyrene
- ❑ TPEs
- ❑ Thermoset
- ❑ Vinyls
- ❑ No Interest

Process *(choose all that apply)*
- ❑ Blow Molding
- ❑ Compression
- ❑ Compounding
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- ❑ Extrusion
- ❑ Fabrication
- ❑ Foam
- ❑ Injection Molding
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- ❑ No Interest

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- ❑ Decorating & Assembly (D34)
- ❑ Electrical & Electronic (D24)
- ❑ Engineering Properties & Structure (D26)
- ❑ Extrusion (D22)
- ❑ Flexible Packaging (D44)
- ❑ Injection Molding (D23)
- ❑ Marketing & Management (D37)
- ❑ Medical Plastics (D36)
- ❑ Mold Making & Mold Design (D35)
- ❑ Plastics Environmental (D40)
- ❑ Polymer Analysis (D33)
- ❑ Polymer Modifiers & Additives (D38)
- ❑ Product Design & Development (D41)
- ❑ Rotational Molding (D42)
- ❑ Thermoforming (D25)
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