

# Thermoforming

## QUARTERLY

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

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# Thermoforming

## QUARTERLY

A JOURNAL OF THE THERMOFORMING DIVISION OF THE SOCIETY OF PLASTICS ENGINEERS  
"WINNER 2003, 2004 & 2005 AWARD OF EXCELLENCE"

## Winning Entries in the 15th Annual 2005 Thermoforming Parts Competition

**People's Choice Award**  
Compressor Canopy  
Spencer Industries, Inc.  
812.937.4561



**Roll Fed Consumer Electronics Award**  
Western Digital's  
Portable USB Drive  
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608.754.0276



**International Submission Award**  
Electronic Fiber-Optic  
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**Roll Fed Critical Barrier Award**  
Perfecseal Medical Barrier  
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**Cut Sheet Electronic Enclosure Award**  
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System 200 Series  
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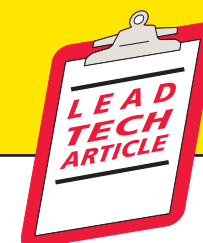
**Pressure Formed Award**  
Portable X-Ray Machine  
Mayfield Plastics  
1.800.339.3476



**Thermform + Other Process Award**  
Tractor Side Panel  
Plastics Unlimited, Inc.  
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More Winners on Page 4



**"PLUG SURFACE PROPERTIES"**  
BY LIEBING, TESSIER, BUSH AND EYERER – see page 18

Web Site: [www.thermoformingdivision.com](http://www.thermoformingdivision.com)

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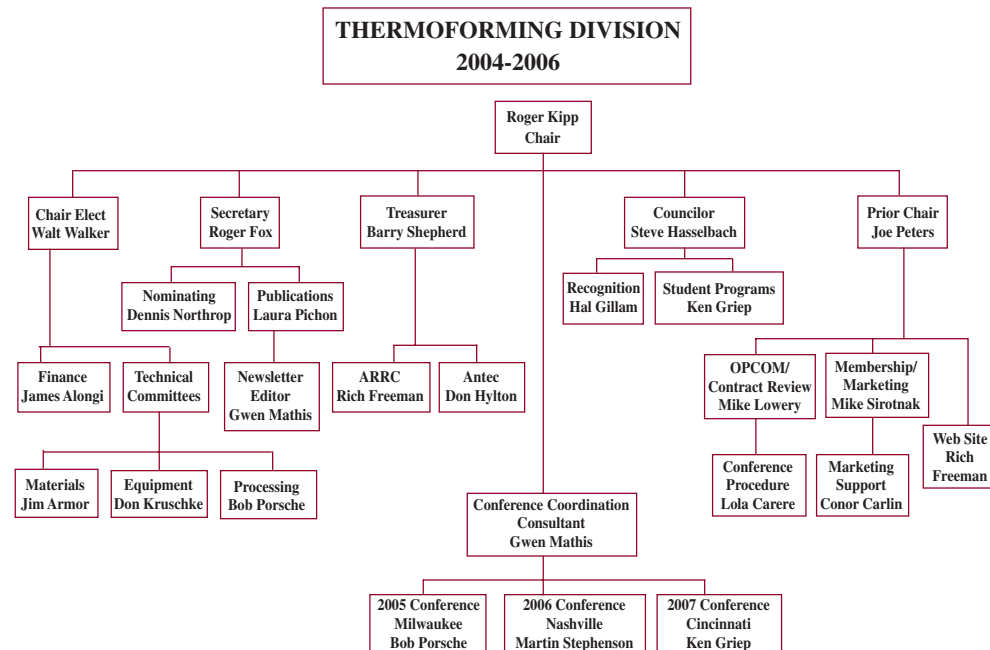
Our mission is to facilitate the advancement of thermoforming technologies through education, application, promotion and research.

SPE National  
Executive Director  
Susan Oderwald  
Direct Line: 203/740-5471  
Fax: 203/775-8490  
email: Seoderwald@4spe.org

Conference Coordinator  
Gwen Mathis  
124 Avenue D, SE  
Lindale, Georgia 30147-1027  
706/235-9298 • Fax: 706/295-4276  
email: gmathis224@aol.com

**Website: <http://www.4spe.org/communities/divisions/d25.php>  
or [www.thermoformingdivision.com](http://www.thermoformingdivision.com)**

### THERMOFORMING DIVISION ORGANIZATIONAL CHART



**THERMOFORMING DIVISION HOT LINE 800-233-3189**  
Roger Kipp, Chairman, Extension 225 at McClarin Plastics, Inc.

## Executive Committee 2004 - 2006

### CHAIR

Roger Kipp  
McClarin Plastics  
P.O. Box 486, 600 Linden Avenue  
Hanover, PA 17331  
(717) 637-2241 • FAX (717) 637-1728  
rkipp@mcclarinplastics.com

### CHAIR ELECT

Walt Walker  
Prent Corporation  
P. O. Box 471, 2225 Kennedy Road  
Janesville, WI 53547-0471  
(608) 754-0276 • FAX (608) 754-2410  
wwalker@prent.com

### TREASURER

Barry Shepherd  
Shepherd Thermoforming & Pkging, Inc.  
396 Clarence Street  
Brampton, Ontario L6W1T5 CANADA  
(905) 459-4545 Ext. 229 • FAX (905) 459-6746  
barry@shepherd.ca

### SECRETARY

Roger Fox  
The Foxmor Group, Inc.  
373 South County Farm Road, Suite 202  
Wheaton, IL 60187  
(630) 653-2200 • FAX (630) 653-1474  
rfox@foxmor.com

### COUNCILOR WITH TERM ENDING ANTEC 2006

Stephen D. Hasselbach  
CMI Plastics  
P. O. Box 369  
Cranbury, NJ 08512  
(609) 395-1920 • FAX (609) 395-0981  
steve@cmiplastics.com

### PRIOR CHAIR

Joe Peters  
Universal Plastics  
75 Whiting Farms Road  
Holyoke, MA 01040  
(413) 592-4791 • FAX (413) 592-6876  
petersj@universalplastics.com



# CHAIRMAN’S CORNER

BY ROGER KIPP, CHAIR



## GROWTH EXTENDS – TEAMWORK – EXTENDS GROWTH

The 15th Annual Conference highlighted the extension of the growth through teamwork accomplished by the Thermoforming Division.

Our Conference Chairman, Bob Porsche, supported by his Technical Chairmen, Ed Probst and Walt Walker, with superb audio visual production provided by Walt, SPEC led the way as Thermoforming “Spread Our Wings” in Milwaukee.

With 1,102 registrants and 101 exhibitors, this was one of our largest Conference events ever. However, success cannot be measured by numbers. It is the value that counts. From all the accolades heard, at the Conference, and the feedback we have received since, the message is clear that this was a valuable experience for both exhibitors and attendees.

The networking opportunity was extended with the special sponsor awards presentations at the Milwaukee Art Museum, along with International participation including exhibitors from five counties beyond North America.

Thank you Bob, Ed, Walt and Walt, your Committees and the entire Board for your focus on providing a Conference with all of the successful aspects from previous events and enough change to make this one special.

Of course this event could not be pulled together without the dedication of our Conference Coordinator Gwen Mathis. Thank you, Gwen.

As Chairman, it is my responsibility to provide our membership with the Annual Report.

I am pleased to report our business is very much in order and we continue to be one of the most successful SPE Divisions.

The backbone of our extended growth through teamwork is our Board of Directors. These individuals supported by their employers volunteer their time and cover all of the expenses to participate as Board Members. The accomplishments of this Division that I can report here are the result of their leadership. Please take a look at the list of Board Members on the inside back cover to this Quarterly. Pick a Board Member and give them a call to discuss our industry and thank them for their involvement.

Advancing Thermoforming technology through education, application, promotion and research. This is the mission of our Division. It is each Division member’s responsibility to participate in the completion of this mission while the Division’s Board has the responsibility to provide the necessary tools.

At Antec 2005 in Boston, I was privileged to accept the pride and Outstanding Division Award for the Thermoforming Division. The criteria for a Division to earn this Award include:

- Implementation of programs supporting scholarships  
In 2005 we presented \$10,000.00 in scholarships and have provisions in place to present up to \$15,000.00 annually.
- Performance in training development  
During the last 12 months, Bill McConnell provided a symposium in Dallas and Art Buckel did a Thermoforming Seminar in Chicago in conjunction

with Division support. Numerous other members provide Thermoforming Workshops within their sections.

The 2004 Conference in Indianapolis, included 1018 Attendees and over 100 Exhibitors. This Annual Conference continues to be our flagship event for knowledge development.

- Support of Education Programs  
Equipment grants totaling \$31,011.50 were provided by our Division for Plastics’ Programs at Universities in Wisconsin, Pennsylvania and Alabama.  
  
The Division provides continuing support to the National Plastics Museum’s Plastics Van Program with over \$10,000.00 committed to the Van matching fund program during this past business year.
- Provide Alliance Development  
From input through alliance comes further creativity and growth. Our Division nurtured teamwork alliance with the Product Design and Development Divisions, the Decorative and Assembly Division, the European Thermoforming Division and the Extrusion Division resulting in their involvement at the Milwaukee Conference.
- Add Value to Membership  
Membership value is highlighted by our award winning Thermoforming Quarterly.  
  
The information packed Thermoforming website at [www.ThermoformingDivision.com](http://www.ThermoformingDivision.com).
  - The “Thermoforming Tips” Manual.
  - The “What Is Thermoforming” DVD.

I encourage you to please make use of these scholarships, equipment grants, education programs and value products to further your business or in support of an education institution near to you. The maximum value will be gained through involvement.

Financially the Division continues to maintain sufficient resources necessary to meet our obligations to our mission.

- Assests at \$580,000.00
- Twelve month increase at \$159,649.00
- Twelve month expenses at \$144,500.00
- Net profit at \$15,148.00

To our Members, thank you for investing in the SPE Thermoforming Division. Without your interest and involvement our team would not be able to provide these winning results. World class organizations avoid mediocrity by promoting education, training, alliance and value.

# THERMOFORMING DIVISION BOARD OF DIRECTORS

**James A. Alongi - 2006**  
MAAC Machinery  
590 Tower Boulevard  
Carol Stream, IL 60188-9426  
TEL (630) 665-1700  
FAX (630) 665-7799  
[jalongi@maacmachinery.com](mailto:jalongi@maacmachinery.com)  
*Machinery Committee*

**Jim Armor - 2008**  
Armor & Associates  
16181 Santa Barbara Lane  
Huntington Beach, CA 92649  
TEL (714) 846-7000  
FAX (714) 846-7001  
[jimarmor@aol.com](mailto:jimarmor@aol.com)  
*Materials Committee*

**Phil S. Barhouse - 2006**  
Creative Forming  
100 Creative Way  
P.O. Box 128  
Ripon, WI 54971  
TEL (920) 748-1119  
FAX (920) 748-9466  
[phil.barhouse@creativeforming.com](mailto:phil.barhouse@creativeforming.com)  
*Materials Committee*

**Michael Book - 2007**  
C&K Plastics  
159 Liberty Street  
Metuchen, NJ 08840  
TEL (732) 549-0011  
FAX (732) 549-1889  
[mbook@candkplastics.com](mailto:mbook@candkplastics.com)  
*Processing Committee*

**Arthur Buckel - 2008**  
McConnell Co., Inc.  
3452 Bayonne Drive  
San Diego, CA 92109  
TEL (858) 273-9620  
FAX (858) 273-6837  
[artbuckel@thermoforming.com](mailto:artbuckel@thermoforming.com)  
*Processing Committee*

**Lola Carere - 2008**  
Thermopro, Inc.  
1600 Distribution Drive  
Suite D  
Duluth, GA 30097  
TEL (678) 957-3220  
FAX (678) 475-1747  
[lcarere@thermopro.com](mailto:lcarere@thermopro.com)  
*Materials Committee*

**Conor Carlin - 2008**  
Sencorp, Inc.  
400 Kidd’s Hill Road  
Hyannis, MA 02601  
TEL (310) 487-3287  
FAX (323) 874-7849  
[ccarlin@sencorp-inc.com](mailto:ccarlin@sencorp-inc.com)  
*Machinery Committee*

**Bob Carrier - 2006**  
C & K Plastics  
159 Liberty Street  
Metuchen, NJ 08840  
TEL (732) 549-0011 EXT. 203  
FAX (732) 549-1889  
[bob@candkplastics.com](mailto:bob@candkplastics.com)  
*Processing Committee*

**Richard Freeman - 2006**  
Fretech Plastics  
2211 Warm Springs Court  
Fremont, CA 94539  
TEL (510) 651-9996  
FAX (510) 651-9917  
[rfree@fretechplastics.com](mailto:rfree@fretechplastics.com)  
*Processing Committee*

**Hal Gilham - 2007**  
Productive Plastics, Inc.  
103 West Park Drive  
Mt. Laurel, NJ 08045  
TEL (856) 778-4300  
FAX (856) 234-3310  
[halg@productiveplastics.com](mailto:halg@productiveplastics.com)  
*Processing Committee*

**Ken Griep - 2008**  
Portage Casting & Mold, Inc.  
2901 Portage Road  
Portage, WI 53901  
TEL (608) 742-7137  
FAX (608) 742-2199  
[ken@pcmwi.com](mailto:ken@pcmwi.com)  
*Machinery Committee*

**Donald C. Hylton - 2007**  
646 Holyfield Highway  
Fairburn, GA 30213  
TEL (678) 772-5008  
[don@thermoforming.com](mailto:don@thermoforming.com)  
*Materials Committee*

**Bill Kent - 2008**  
Brown Machine  
330 North Ross Street  
Beaverton, MI 48612-0434  
TEL (989) 435-7741  
FAX (989) 435-2821  
[bill.kent@brown-machine.com](mailto:bill.kent@brown-machine.com)  
*Machinery Committee*

**Don Kruschke - 2007**  
Stopol, Inc.  
31875 Solon Road  
Solon, OH 44139  
TEL (440) 498-4000  
FAX (440) 498-4001  
[donk@stopol.com](mailto:donk@stopol.com)  
*Machinery Committee*

**Mike Lowery - 2007**  
Premier Plastics  
9680 S. Oakwood Park Dr.  
Franklin, WI 53132  
TEL (414) 423-5940 Ext 102  
FAX (414) 423-5930  
[mikel@lowerytech.com](mailto:mikel@lowerytech.com)  
*Processing Committee*

**Wm. K. McConnell, Jr. - 2008**  
McConnell Co., Inc.  
3030 Sandage St.  
P.O. Box 11512  
Fort Worth, TX 76110  
TEL (817) 926-8287  
FAX (817) 926-8298  
[billmc@thermoforming.com](mailto:billmc@thermoforming.com)  
*Materials Committee*

**Vin McElhone - 2007**  
Stand-Up Plastics  
5 Fordham Trail  
Old Saybrook, CT 06475  
TEL (860) 395-5699  
FAX (860) 395-4732  
[vjmpacesales@aol.com](mailto:vjmpacesales@aol.com)  
*Materials Committee*

**Stephen R. Murrill - 2006**  
Profile Plastics Corp.  
65 S. Waukegan  
Lake Bluff, IL 60044  
TEL (847) 604-5100 EXT. 21  
FAX (847) 604-8030  
[SMurrill@thermoform.com](mailto:SMurrill@thermoform.com)  
*Processing Committee*

**Dennis Northrop - 2006**  
Avery Dennison  
Automotive Division  
650 W. 67th Avenue  
Schererville, IN 46375-1390  
TEL (219) 322-5030  
FAX (219) 322-2623  
[Dennis.Northrop@averydennison.com](mailto:Dennis.Northrop@averydennison.com)  
*Materials Committee*

**Laura Pichon - 2008**  
Ex-Tech Plastics  
P.O. Box 576  
11413 Burlington Road  
Richmond, IL 60071  
TEL (815) 678-2131 Ext. 624  
FAX (815) 678-4248  
[lpichon@extechplastics.com](mailto:lpichon@extechplastics.com)  
*Materials Committee*

**Robert G. Porsche - 2006**  
General Plastics, Inc.  
2609 West Mill Road  
Milwaukee, WI 53209  
TEL (414) 351-1000  
FAX (414) 351-1284  
[bob@genplas.com](mailto:bob@genplas.com)  
*Processing Committee*

**Brian Ray - 2008**  
Ray Products  
1700 Chablis Avenue  
Ontario, CA 91761  
TEL (909) 390-9906  
FAX (909) 390-9984  
[brianr@rayplastics.com](mailto:brianr@rayplastics.com)  
*Machinery Committee*

**Mike Sirotnak - 2007**  
Solar Products  
228 Wanaque Ave.  
Pompton Lakes, NJ 07442  
TEL (973) 248-9370  
FAX (973) 835-7856  
[msirotnak@solarproducts.com](mailto:msirotnak@solarproducts.com)  
*Machinery Committee*

**Walt Speck - 2007**  
Speck Plastics, Inc.  
P. O. Box 421  
Nazareth, PA 18064  
TEL (610) 759-1807  
FAX (610) 759-3916  
[wspeck@speckplastics.com](mailto:wspeck@speckplastics.com)  
*Processing Committee*

**Dr. Martin J. Stephenson, Ph.D. - 2006**  
Placon Corporation  
6096 McKee Road  
Madison, WI 53719-5114  
TEL (608) 275-7215  
TEL (800) 541-1535  
FAX (608) 271-3162  
[mstephenson@placon.com](mailto:mstephenson@placon.com)  
*Materials Committee*

**Jay Waddell - 2008**  
Plastic Concepts & Innovations, LLC  
443 Long Point Road  
Suite H  
Mt. Pleasant, SC 29464  
TEL (843) 971-7833  
FAX (843) 216-6151  
[jwaddell@plasticconcepts.com](mailto:jwaddell@plasticconcepts.com)  
*Processing Committee*

**Brian Winton - 2007**  
Modern Machinery  
P. O. Box 423  
Beaverton, MI 48612-0423  
TEL (989) 435-9071  
FAX (989) 435-3940  
[bwinton@modernmachineinc.com](mailto:bwinton@modernmachineinc.com)  
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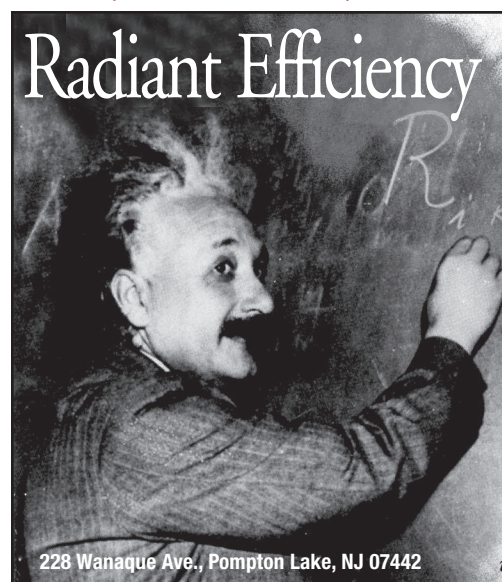
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TFQ is an "equal opportunity" publisher! You will note that we have several categories of technical articles, ranging from the super-high tech (sometimes with equations!), to industry practice articles, to book reviews, how to articles, tutorial articles, and so on. Got an article that doesn't seem to fit in these categories? Send it to Jim Throne, Technical Editor, anyway. He'll fit it in! He promises. [By the way, if you are submitting an article, Jim 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.]

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

#### Editor

**Gwen Mathis**

(706) 235-9298 • Fax (706) 295-4276  
[gmathis224@aol.com](mailto:gmathis224@aol.com)

#### Technical Editor

**Dr. James Throne**

Sherwood Technologies, Inc.  
1797 Santa Barbara Drive  
Dunedin, FL 34698-3347  
1-800-273-6370 • Fax (727) 734-5081  
[throne@foamandform.com](mailto:throne@foamandform.com)  
[jthrone@tampabay.rr.com](mailto:jthrone@tampabay.rr.com)

#### Sponsorships

**Laura Pichon**

(815) 678-2131 Ext. 624  
Fax (815) 678-4248

[lpichon@extechplastics.com](mailto:lpichon@extechplastics.com)

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## MEMBERSHIP MEMO

# High Life in Milwaukee



BY MIKE SIROTNAK, MEMBERSHIP CHAIRMAN

If you missed the 15th Annual Thermoforming Conference in Milwaukee, you missed one of the best overall conferences ever! Returning to Milwaukee offered a great atmosphere and plenty to do. Bob Porsche, Conference Chairman, and Gwen Mathis, Conference Coordinator, took advantage of everything Milwaukee had to offer. Many of us attended the new and improved Miller Park to take in a Brewers game. The new ballpark was awesome and the atmosphere was great. The Thermoformer of the Year dinner held at the Milwaukee Art Museum was fantastic. Bob and Gwen took a huge chance trying something different and it really paid off.

The Technical Program is always the most difficult aspect of the Conference to put together. Ed Probst and Walt Walker did an outstanding job. The challenge of putting together a fresh and pertinent program is daunting. Trying to convince our industry to speak in front of a couple of hundred people is like pulling teeth. I encourage everyone to get involved in the Technical Program, especially those of you who gripe about the

given topics. Don't just complain behind people's backs, get involved. The exhibit floor was very promising. It's great hearing people making deals and discussing new projects. Our exhibit floor is unique because of the way we all work together to educate and help the customer. Joe Peters did an out-

cating the industry from start to finish. The plant tours were a huge success. Steve Murrill of Profile Plastics and Walt Walker of Prent Corporation need to be recognized for opening their facilities to this industry. Stopol, Inc. and MAAC Machinery, along with all the sponsors, did a nice job on the casino night to raise money for the scholarship funds.

I want to encourage all of you to continue to support this Division and the SPE as a whole. Remember that there is numerous divisions within SPE and some of them can be secondary division for you at a minimal cost.

Nashville 2006 will be your opportunity to make up for missing Milwaukee.

Nashville is always a great spot for a conference. Dr. Martin Stephenson is working hard to put together a conference that can top 2005. Please try to support the technical sessions and the parts competition.

I feel we are finally back on track and you don't want to miss out.

God bless America!



### MEMBERSHIP REPORT as of 9/30/05

Primary Paid .....	1,161
Secondary Paid .....	476
Total Membership .....	1,637
Goal as of 6/30/2006 .....	2,000

standing job on the Parts Competition and the participants should be congratulated. It is always refreshing seeing the youth of our industry at the show. Watching the college students walk from booth to booth to discuss our industry is uplifting. Our scholarship program is right on the mark; Ken Griep is doing a great job. Watching the school children at the Plastics Van never gets old. It really shows what the whole Division is all about, edu-





## To Our New Members

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Interplast SA De  
CV  
San Juan, Mexico

Corey Rogers  
Federal Foam  
Technologies  
New Richmond,  
Wisconsin

Mike Shea  
Flexpak  
Corporation  
Phoenix, Arizona

Dirk Smith  
Boca Raton,  
Florida

Brett A. Stephens  
Colborne, Canada

Denis Tanjic  
Winpak Portion  
Packaging, Inc.  
Chicago Heights,  
Illinois

Robert D. Van  
Winter, Jr.  
Van Winter  
Associates  
Cumberland,  
Rhode Island

Thomas Weigl  
Sukano Products  
AG  
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## WHY JOIN?

*It has never been more important to be a member of your professional society than now, in the current climate of change and volatility in the plastics industry. Now, more than ever, the information you access and the personal networks you create can and will directly impact your future and your career.*

### Active membership in SPE:

- keeps you current
- keeps you informed
- keeps you connected

*The question really isn't "why join?" but ...*

## WHY NOT?



# 2005 THERMOFORMING PARTS

**P**arts on display in the Parts Competition and Showcase are a perennial highlight of the Thermoforming Conference. Made up of six industry professionals from the cut sheet and roll fed industries, the competition's panel of judges 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. Following is a description of the award-winning parts, listed according to competition category.

## **People's Choice Award – Compressor Canopy**

The Ingersoll-Rand AirSource portable air compressor canopy, made of Solvay Engineered Polymers E-3000 TPO custom-colored material, is virtually indestructible, corrosion and chemical resistant, paintable, and sound deadening, and features good low-temperature impact resistance and high UV resistance. In addition to being aerodynamic, the canopy opens to 90° for excellent service access to the compressor without having to remove the canopy. The lightweight canopy (1850 lbs.) is chip and dent resistant and lowers the compressor's center of gravity, making the unit more fuel efficient and stable when being towed. The large sectional 76 x 46 x 31-inch integrated four-piece structural canopy is twin-sheet thermoformed by Spencer Industries. Tooling Technology built the molds.

**Spencer Industries, Inc., 812.937.4561**  
**[www.spencerindustries.com](http://www.spencerindustries.com)**

*\* picture featured on front page \**

## **Roll Fed Competition**

### **Most Unique Package Award**

The DePuy Orthopaedics Tempfix External Fixation System package consists of five individual thermoformed parts. Each of three modular inner trays carries one of four different fixation devices, along with the tools for their application. One universal cover snap-fits onto each of the modular inner trays, while one universal outer tray holds and protects any of the inner/cover combinations. Each product tray with cover is loaded into the sealable outer tray for sterilization. The cover provides an area for a graphic feature. All inner trays and cover are formed from .040 Blue Tint PETG. The outer tray is formed from .045 Blue Tint PETG Goex Corp. supplies the materials.

**Prent Corp., 608.754.0276; [www.prent.com](http://www.prent.com)**

## **Consumer Electronics Award**

The packaging for Western Digital's Portable USB Drive is a unique set of four thermoforms, each with a specific role to play in creating the package. Two static dissipative inner thermoforms snap together to secure the hard drive inside trays that are sealed together using radio frequency (RF). The inner parts are made from 0.020-inch clear Pentastat ASKPET 56 supplied by Klockner Pentaplast of America, Inc., and the trays are made from 0.030-inch clear GAG supplied by Thai Kodama Co. Ltd. ASKPET 56 offers ESD protection for the actual product, and the use of GAG provides the ability to RF seal. This 100% recyclable plastic design meets product-protection requirements while providing product visibility, ESD protection, and shelf appeal. The packages, which afford both front and back views of the product, require less shipping space because they interlock when every other one is rotated 180° in the shipping carton.

**Perfecseal (A Bemis Co.); 920.303.7000**  
**[www.perfecseal.com](http://www.perfecseal.com)**

*\* picture featured on front page \**

## **International Submission Award**

Designed by Plexipack Packaging Services (a company located in Australia), the fiber-optic cable packaging was required to hold eight optic cables separately, load them easily, and ensure that the fragile connectors were protected throughout transport and handling. The end user is able to remove each cable with ease without tangling or damaging the connectors. The package lid fits snugly and can be easily removed without disturbing the cables. The cable packaging is constructed from 0.6 Black Antistatic HIPS from Masrac Plastics in Australia.

**Plexipack Packaging Services; phone 03.10.2005**  
**[www.plexipack.com.au](http://www.plexipack.com.au)**

*\* picture featured on front page \**

## **Industrial Packaging Award**

The Electronic Dunnage Tray was designed and manufactured by Plexipack Packaging Services to provide packaging for components manufactured for the export trade and for product protection during overseas transportation. In addition to accommodating the packaging of a greater number of parts, the redesigned trays nest inside each other, reducing the requirement for storage space. When loaded, the trays can be



# RTS COMPETITION WINNERS

stacked on top of each other without damage to the components in the trays beneath. The packaging is constructed from 0.9 Black Antistatic HIPS from Masrac Plastics in Australia.

**Plexipack Packaging Services; phone 03.10.2005**

## Consumer Houseware Award

These unique plastic drink tops, in 8 mm and 12 mm sizes, were designed to hold a typically sized CD/DVD and to simultaneously provide a perfect fit to cover standard soda cups. Used as promotional incentives by movie theaters, fast-food chains, convenience stores, and entertainment events where drinks are sold, the thermoformed beverage lid/CD/DVD holders are strong enough to protect the enclosed disk from hazards – e.g., extreme temperatures, liquids, and rough handling. The clear lids allow the CD/DVD to show through, and they are able to accommodate various straw sizes while preventing beverage contact with the CD. Two styles of lids are available: a two-piece and a clamshell. The CD rests on the lower piece of the lid, and a top piece snaps over it, protecting the disc and preventing any leakage of liquid from the cup. The lid can be removed from the cup with a pull-tab.

**Creative Forming, Inc.; 800.278.8483**

**www.creativeforming.com**



## Consumer Packaging Award

The retail air freshener lid-and-base package assembly was designed to hold and display an air freshening device, air freshening disk, AC adapter, and accompanying literature. Intended to protect the contents during shipping, the package also enables the consumer to view each component of the device. Because of the package shape, the parts were processed on large, roll-fed matched metal equipment. The female lid was a relatively deep draw for a roll-fed male part with deep inner cavities. Design challenges involved creation of smooth exterior lines, multiple oblique internal product fit and capture, areas for graphic display, and an irregular lid-to-base fit.

**Creative Forming, Inc.; 800.278.8483**

**www.creativeforming.com**



## Cut Sheet Competition

### Electronic Enclosure Award

The camera cabinet for the IVIS Imaging System 200 Series was designed by Bridge Design in collaboration with engineers from Xenogen Corp. and Freetech Plastics. The unit body is composed of Spartech R59 (FR-Rigid ABS/PVC) and general-purpose polycarbonate from Sheffield Plastics is used to create the deep-draw dome that sits atop the unit. This part features undercuts for attachment features and is textured to partially to partially conceal equipment it covers. Tooling, designed and developed by Freetech Plastics, includes radical undercut features and badge placement ID contours.

The IVIS Imaging System 200 Series is a fully integrated fluorescent/bioluminescent spectral imaging unit capable of creating 3D surface topography using Xenogen Corp.'s new technology called in vivo photonic imaging. The technology, pioneered by scientists from Lawrence Livermore Laboratories, enables researchers to use real-time imaging to observe and record cellular and genetic activity within a living organism, in this case a live mouse. Previously, the organism would have been killed and dissected, thus altering the organism and making research results unreliable. The IVIS Imaging System 200 Series is utilized in genome research and in pharmaceutical and biotechnology R&D to help scientists better understand drug metabolism.

**Freetech Plastics, Inc.; 510.651.9996**

**www.freetechplastics.com**

*\* picture featured on front page \**

### Automotive Award

The front bumper fascia, also called a bumper cover, is used as an exterior



trim ornament for most passenger vehicles and light trucks. It conceals the structural steel bumper beam and carries a number of components, including lighting and a lower air dam. Traditionally injection-molded and painted, this fascia is reported to be the first full fascia produced as original equipment for an OEM vehicle program that utilizes a thermoformed Class A paint film/TPO laminate, a process that eliminates the need for injection molding and painting. The substrate is made from TPO produced by Solvay Engineered Polymers, and Soliant produces the paint

*(continued on next page)*



## 2005 THERMOFORMING PARTS

film; the TPO is extruded and laminated to the paint film by Southtech Plastics. Parker Tooling and Design produced the mold for the fascia.

**Meridian Automotive Systems; 313.253.3572**  
**www.meridianautosystems.com**

### Twin Sheet Award

The instrument tray, an elective medical-device tray used on an ultrasound cart, was designed by Philips Medical Systems. The iE33 echocardiography system and other Philips' systems utilize the award-winning tray. The twin sheet process was chosen because it produces a lightweight, hollow tray that offers superior rigidity. Pressure forming was incorporated into the twin-sheet process in order to ensure a design capable of meeting the challenges of cantilevered loads and impact forces. Additionally, pressure forming offers the ability to insert-mold threaded nutserts rather than installing them in a costly secondary operation. This procedure was especially challenging as a result of the close proximity of adjacent walls, which restricted material flow. A style line that eliminated the usually visible pinch line improved the tray's aesthetics, and the entire surface of the pressure-formed tray features molded-in texture. Custom-colored Kydex acrylic/PVC eliminates the need for paint, and results in cost savings and reduced time to market.



**Specialty Manufacturing, Inc.; 800.491.1652 or 858.450.1591; www.smi-mfg.com**

### Pressure Formed Award

The front feet are two of the nine parts made by Mayfield Plastics for Hologic, Inc.'s portable X-ray machine. The feet are pressure formed from 0.250-inch thick Kydex, supplied by Kleerdex Co. They are custom colored with a textured-mold finish. Portage Casting and Mold, Inc. made tooling, and texturing was done by Mold-Tech. Trim jigs, fixtures, and programming were done in-house.

**Mayfield Plastics, Inc.; 800.339.3476 or 508.865.8150**  
**www.mayfieldplastics.com**

*\* picture featured on front page \**

### Industrial Application Award

The radome, a part for communication equipment on boats and other marine applications, is pressure-formed from 0.350-inch thick ABS supplied by

Spartech Plastics. Finished thickness of the part is critical. Portage Casting and Mold, Inc. made tooling. The trim jogs, fixtures, CNC programming, and painting and finishing were done in-house.



**Mayfield Plastics, Inc.; 800.339.3476 or 508.865.8150**  
**www.mayfieldplastics.com**

### Vacuum Formed Award

The American Standard whirlpool bathing tub and integral front apron panel are formed from one sheet of acrylic material, supplied by Aristech Acrylics. Designed for an extra-deep soak with a spacious interior, the tub is outfitted with "comfort jets" that enable a clean, updated look and adjustable flow rate. Toolmaker was Portage Casting & Mold.



**American Standard; 732.369.4037**  
**www.americanstandard.com**

### Consumer Electronic Award

The rear housing for a monitor was designed to enable the easy relocation of a large monitor. The part is also used on a portable X-ray machine. It is pressure formed from two sheets of 0.156 Kydex, supplied by Kleerdex Co., and Portage Casting and Mold, Inc. made the tooling. The trim jigs, fixtures, CNC programming, and painting and finishing were done in-house.



**Mayfield Plastics, Inc.; 800.339.3476 or 508.865.8150**  
**www.mayfieldplastics.com**

### Recreational Award

The five-passenger, 7'9" long pedal boat is said to be one of the largest and most complex parts manufactured by the twin-sheet thermoforming process. Molding takes place on a four-station rotary thermoforming machine equipped with gas burners. The aluminum mold with cast-in cooling lines, from Modelage Simon, Inc. is 105 inches long x 74 inches wide x 44 inches high. As a result of the complexity of the piece and the high draw ratio



## PTS COMPETITION WINNERS

required in some areas, plugs are needed to mold some parts of the piece. Provisions for adequate flotation of the boat are included during the molding process. Because of the extraordinary size and weight of the part, special equipment had to be designed for trimming and assembly. The material used was 0.250 HMWPE sheet supplied by Petromont S.E.C.

**Pelican International, Inc.;** 450.664.1222 or 800.463.6960; [www.pelicansport.com](http://www.pelicansport.com)

### Multipart Award

The panoramic analog dental X-ray enclosure required a total of nine parts (12 parts for the digital model), all of which were pressure formed into machined aluminum water-cooled, textured molds. The texturing of molds allows for a consistent part finish for all parts and eliminates evidence of sink marks, knit lines, and gate marks that are typically associated with injection molding. Clean part-to-part fit is accomplished with undercuts in the molds, which are pneumatically articulated with solenoids tied into the digital programming logic of the forming machines. Because of the elliptical contours of the enclosure's design, the undercuts are broken into multiple sections for each side of the parts. Tight process control of molded-in color and texture for consistent part-to-part appearance was required. The material used was 0.187 to 0.375 gauge Kydex T, supplied by Kleerdex Co.

**Profile Plastics;** 800.252.6458 or 330.877.1771  
[www.profileplastics.com](http://www.profileplastics.com)

### Point-of-Purchase Award

The 50 x 42-inch styrene Miller Lite Nascar hood is a point-of-purchase display advertisement supplied to distributors of Miller's products to restaurants and bars. The hood is preprinted in four-color process with a protective, glossy clear coat, formed in a large three-station rotary, and CNC trimmed to size. It is produced by General Plastics, a custom thermoformer that makes parts for the point-of-purchase and OEM industries.

**General Plastics, Inc.;** 414.351.1000  
[www.genplas.com](http://www.genplas.com)



### Thermoform + Other Process Award

The tractor side panel air scoop fits on the rear side of a combine used to harvest crops such as soybeans or corn. Made from an innovative process called TEC (Tool-less Engineered Composites), the lightweight air scoop features a thin skin (about 0.090-inch thick) that is formed on a standard thermoform tool. The thermoformed skin is placed in a simple holding fixture, where it is backed with a composite, using a vacuum-bag type process. The system combines the best properties of thermoformed parts with those of composite parts. There is no requirement to invest in the tooling typically associated with the manufacture of a composite. High impact resistance (Izod > 18 ft lb/inch), strength, UV resistance, and molded-in color are advantages of the TEC process. The process can produce several parts per hour.

**Plastics Unlimited, Inc.;** 563.689.4752  
[www.plasticsunlimited.net](http://www.plasticsunlimited.net)

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## THERMOFORMING DIVISION CONFERENCE



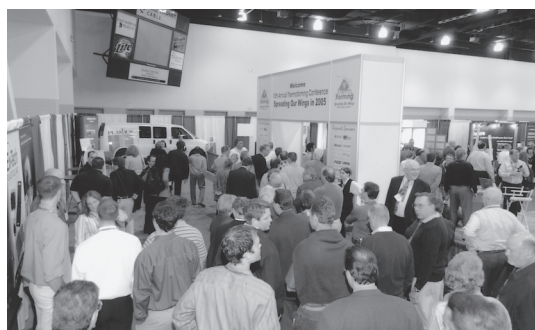
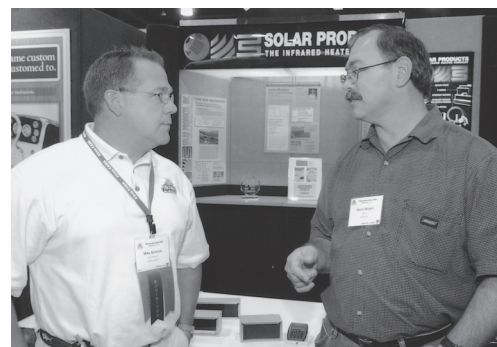
## MILWAUKEE 2005





Under the banner of the Conference theme, "Spreading Our Wings," more than 1,100 attendees gathered September 24th-27th in Milwaukee's Midwest Airlines Convention Center for the 15th Annual SPE Thermoforming Division Conference. The Conference featured 100 exhibits representing plastics industry manufacturers and service providers worldwide; plant tours showing industry companies – Profile Plastics, Prent Corp., and Goex Corp. – in action; workshops; a technical program; and the Parts Competition and Showcase. Exclusive to this year's Conference was a Sponsor Appreciation Dinner held at the spectacular Milwaukee Art Museum on the shores of Lake Michigan, followed by Casino Night at the Conference headquarters hotel. All proceeds from that festivity go directly to the SPE Thermoforming Scholarship Fund. In addition to providing student scholarships and grants for the purchase of thermoforming equipment to universities that offer plastics engineering programs, the Thermoforming Division recently contributed \$45,000 to the National Plastics Center and Museum in Leominster, Mass., for the purchase of a new PlastiVan. The Center's PlastiVan travels throughout the United States to introduce students, educators, and the public to the chemistry, history, processing, and environmental issues associated with plastics. ■

## SPE'S TH





# THERMOFORMING 2005 ...



**SPREADING  
OUR  
WINGS  
at the  
15TH  
ANNUAL  
CONFERENCE  
in  
MILWAUKEE**



## CARERE RECEIVES LIFETIME ACHIEVEMENT AWARD



**L**ola Carere's job history proves that relationships count in the close-knit world of thermoforming, especially the cut-sheet custom variety.

Carere was named the winner of the Lifetime Achievement Award on September 25th at the 2005 Thermoforming Conference.

Some tears flowed, but she was among friends.

A long-time Board of Directors member for the Society of Plastics Engineers' Thermoforming Division, Carere was in constant motion in Milwaukee, checking on the registration table, monitoring the presentations and walking the show floor.

Her thermoforming career has been spent working in the Southeast. All but one of her thermoforming employers have been small companies.

Her first thermoforming job came in 1984, when she became purchasing manager for Allied Plastics Inc. of Tucker, Ga. She spent a decade at Allied, getting promoted to production control manager and then becoming regional sales manager.

From 1994-99, Carere was sales coordinator for Multiplastics Inc. in Mount Pleasant, S.C. Then she moved to a big company, becoming Southeast account manager for St. Paul, Minn.-based TPI, a unit of Wilbert Inc.

She worked at TPI from 1999-2002, then became sales manager of Multiplastics Georgia Inc. in Suwanee, Ga., a sister company of Multiplastics.

The whole time, she kept in touch with one of her largest accounts, Gould LLC, a Duluth, Ga.-based maker of materials-handling bins and office products like literature display racks.

"First, they were just buying the products and when they were doing that, I was at Allied Plastics and they were my customer. And I moved to Multiplastics because they moved their business there," Carere said.

In the late 1990s, Gould decided to start thermoforming its own parts. Then in January of this year, Gould sold its line of display racks to Safco Products Co., changed its name to ThermoPro Inc. and reinvented itself from captive to a custom thermoformer.

Guess who they called to handle sales? Carere, who became a ThermoPro account executive.

In thermoforming, everybody knows everybody, Carere explained. "I would say the average thermoformer probably does somewhere between \$5 [million] and \$10 million a year. There are a lot of family businesses," she said.

Carere's dedication to the Thermoforming Division is a big reason she won the Lifetime Achievement Award. She joined SPE in 1987 and quickly volunteered to help out at the Southern Section, covering Georgia, Alabama and part of South Carolina. She has served on the Thermoforming Division's Board of Directors since 1994.

The 2005 Conference, held September 24th-27th in Milwaukee, brought back intense memories for Carere and other thermoformers. The last time the SPE Thermoforming Division held its Conference in Milwaukee was September 15th-18th of 2001 – just a few days after the September 11th terrorist attacks.

On September 11th, Carere, who was Chairwoman of the Thermoforming Division, was headed to the Atlanta Airport with Conference Coordinator Gwen Mathis. "We kept trying to get flights out," Carere said. "You know, we felt like we needed to be here in Milwaukee. So we actually rented a car and drove to Milwaukee."

Heads spinning with emotion at the tragedy, they headed north. Should the 2001 Conference be cancelled?

"We didn't know what to think, but we needed to get there and make a decision, because people had already shipped machinery," Carere said. "It was crazy."

A good number of other Board members made it to Milwaukee too.

"It was hard, but the Executive Committee and the Conference Chair, we all sat around the table and took a vote on whether we should have it or not."

They decided to go ahead – and ended up with a respectable attendance of about 750. Attendees got a free pass to the following year's Conference and Division leaders issued credits to sponsors. They donated proceeds to the American Red Cross.

"We caught a lot of grief for having it, but a lot of people supported us, too," Carere said. ■

*Reprinted with permission from  
Plastics News, Bill Bregar*

# Throne in India

Jim Throne was invited by the Indian Plastics Institute to present a plenary overview of the thermoforming industry to more than 400 technologists at the IPI meetings in Mumbai (Bombay) on March 25th and in Delhi on March 28th. Jim began his several-hour presentation by summarizing the history of thermoforming. He then outlined new developments in materials, machinery, markets, mold and part design, and controls. Reliance Industries Ltd., Supreme Petrochem Ltd., Irwin Research and Development Inc., and Wonderpack Industries PVT. Ltd. sponsored his presentations. During his ten-day stay in India, he discussed thermoforming technology with more than a dozen thermoformers, machinery builders, and material suppliers, many seeking cooperative efforts with North American companies.



If you wish to learn more about thermoforming opportunities in India, Jim can be reached at Sherwood Technologies, Inc., Dunedin Florida, 1-727-734-5081 or at [throne@foamandform.com](mailto:throne@foamandform.com).

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## Past Thermoformers of the Year Honored at Conference



In attendance were, front row, L-R: 1999 Art Buckel, McConnell Co.; 1991 Stan Rosen, Mold Systems; 2005 Manfred Jacob, Jacob Composites; 2004 Steve Hasselbach, CMI Plastics. Back row, L-R: 2003 Bill Benjamin, Benjamin Mfg.; 1982 Bill McConnell, McConnell Co.; 1993 John Grundy, Profile Plastics; 2000 Dr. James Throne, Sherwood Technologies; 2001 Joe Pregont, Prent Corp.; and 2002 Steven Sweig, Profile Plastics.





## Manfred Jacob Honored as 2005 Thermoformer of the Year



*Thermoforming Division Chairman Roger Kipp and European Thermoforming Division Ken Braney shown jointly presenting the 2005 Thermoformer of the Year Award to Mr. Jacob.*



*Also shown are members of the European Thermoforming Board in attendance to support Mr. Jacob, who is one of the founding members of the European Thermoforming Division.*

## SPE Student Chapter Members Attending 2005 Conference



*SPE Student Chapter Members attending the Thermoforming Conference widen career horizons by sitting in on Conference seminars and sessions, meeting industry professionals, and lending a hand to provide assistance to Conference staff. This group of students and their professor from Pittsburg State University was one of several student groups attending the Conference. Pictured from left to right: Lucas Stallbaumer; Bernice Nzioke; Kim Acinger; Adrienne Wiltse; Dr. Christopher C. Ibeh, Professor, Plastics Engineering Technology; and Rama Etekallapalli.*

## James Alongi Receives "Outstanding Board Member Award"



*Hal Gilham, Awards Chair, is shown presenting James Alongi with the 2005 "Outstanding Board Member" award.*

## Jack Hill Receives Division "Outstanding Achievement Award"



*Walt Walker, Vice Chairman of the Thermoforming Division, is shown presenting the Achievement Award to Jack Hill.*



**It's over!! See you in 2006!!**

## 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](http://www.thermoformingdivision.com) or at [www.4spe.com](http://www.4spe.com). The deadline for applications is January 15th, 2006. ■



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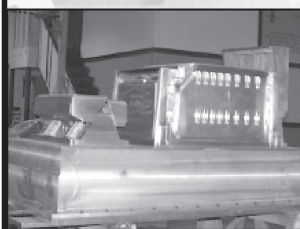
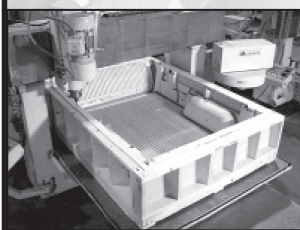
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# **THERMOFORMER OF THE YEAR**

## **CRITERIA FOR 2006**

**E**very 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. Osmer, 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](mailto:halg@productiveplastics.com)

***You can also find the form and see all the past winners at [www.thermoformingdivision.com](http://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.***

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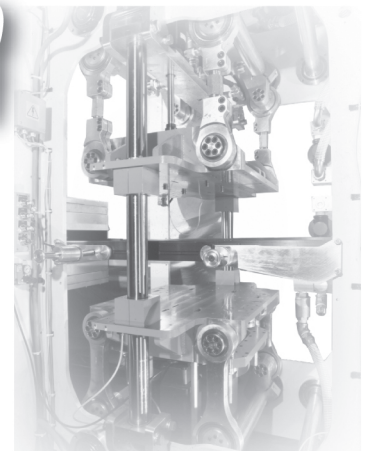


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1986

George Wiss,  
Plastofilm Industries

1987

Dr. Herman R. Osmer  
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1988

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Fabri-Kal Corporation

1989

Jack Pregont, Prent Corporation

1990

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1991

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1994

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Dow Chemical

1995

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Portage Casting & Mold

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1998

Lyle Shuert, Shuert Industries

1999

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2000

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Sherwood Technologies

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2002

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2005

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# THERMOFORMER OF THE YEAR 2006

*Presented at the September 2006 Thermoforming Conference in Nashville, Tennessee*

The Awards Committee is now accepting nominations for the 2006 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 2006 meeting. The deadline for submitting nominations is December 1st, 2005. Please complete the form below and include all biographical information.

Person Nominated: \_\_\_\_\_ Title: \_\_\_\_\_

Firm or Institution: \_\_\_\_\_

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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: \_\_\_\_\_

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(ALL NOMINATIONS MUST BE SIGNED)

Please submit all nominations to: Hal Gilham,  
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## THERMOFORMING DIVISION WINTER BOARD MEETING SCHEDULE

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### Tuesday, February 7, 2006

Executive Committee Arrives  
 Technical Chairs Arrive

### Wednesday, February 8, 2006

7:30 am – 8:00 am – Breakfast for EC &  
 Technical Chairs - Monaco Parlor  
 8:00 am – 9:00 am – Technical Chairs Meet  
 with Executive Committee - Monaco  
 8:00 am – 5:00 pm – Executive Committee  
 Meeting - Monaco Board Room  
 12:00 pm – 1:00 pm – Lunch for EC –  
 Monaco Board Room  
 4:00 pm – 5:00 pm – James Alongi, Finance  
 Chair meets with Executive Committee

### Thursday, February 9, 2006

8:30 am – 9:00 am – Breakfast – Malta Foyer  
 9:00 am – 11:00 am – Materials Committee  
 Meeting – Monte Carlo Room  
 9:00 am – 11:00 am – Machinery Committee  
 Meeting – Gibraltar Room  
 9:00 am – 11:00 am – Processing Committee  
 Meeting – Barcelona Room  
 12:00 pm – 1:00 pm – Lunch - Terrace Atrium  
 1:00 pm – 5:00 pm – All Other Committee's -  
 Malta A & B

### Friday, February 10, 2006

7:30 am – 8:30 am – Breakfast – Malta Foyer  
 8:30 am – noon – Board of Director's Meeting  
 - Malta A & B  
 Afternoon on your own  
 6:00 pm – 9:00 pm – Board Dinner Arnold  
 Palmer's Restaurant

### Saturday, February 11, 2005

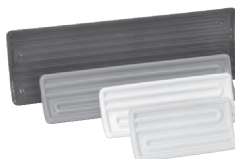
4<sup>th</sup> Annual TF Golf Tournament – The Golf  
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 6:00 pm – 7:00 pm – Reception – Presentation  
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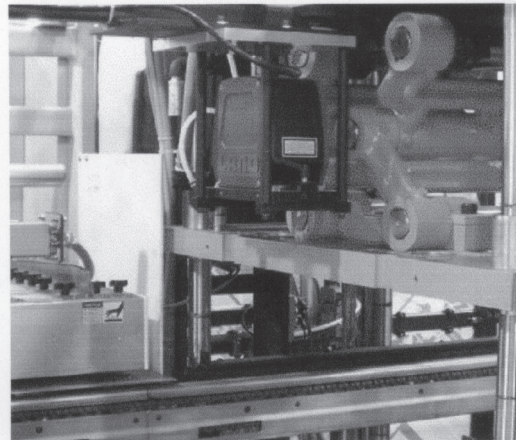


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# Investigation of Surface Properties of Pre-Stretching Plugs<sup>1,2</sup>

BY D. LIEBING, UNIVERSITY OF STUTTGART, GERMANY; N. TESSIER, CMT MATERIALS, INC., ATTLEBORO, MA; T. BUSH, FABRI-KAL CORPORATION, KALAMAZOO, MI; AND P. EYERER, UNIVERSITY OF STUTTGART, STUTTGART, GERMANY

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## Abstract

In plug-assisted thermoforming, the pre-stretching phase is the most important step of the forming process. Therefore, the properties of the plug have a huge influence on the final part quality. However, the behaviour of plug materials under the forces over a long period of time is unknown. In this work, plugs that have been subjected to different loads were investigated with a focus on their surface properties.

## Introduction

In most thermoforming applications, the sheet is pre-stretched by means of mechanical assistance before the final molding is carried out by differential pressure. Usually, up to 90% or more of the total stretching of the sheet is achieved during the pre-stretching phase. The pre-stretching plug has great influence on the quality of thermoformed products concerning wall thickness distribution, opacity, gloss, and stiffness [2]. The properties of the thermoformed product are influenced significantly by the properties of the plug material. Thus, creation of quench marks, wall thickness distribution, and optical properties can be selectively affected.

It is therefore important that a pre-stretching plug should not change its properties measurably when exposed to high mechanical and thermal loading for a long period of time. In this work, the ageing

of a pre-stretching plug and the influence on its thermoforming performance is investigated using HYTAC®-W from CMT Materials, Inc. as an example.

## Experimental

### Material

HYTAC®-W [3] is a syntactic foam which consists of hollow glass microspheres with a diameter of 10 to 100 µm embedded in a thermoset matrix. HYTAC®-W has very low thermal conductivity and is recommended for the forming of PS, PVC and PE.

A set of plugs made of HYTAC®-W (Fig. 1) were used in a running production of cups of polystyrene. Plugs were removed from the tool at each time period: newly made, 1 day and 1 week of production time (table 1).



Figure 1: Tested plug and corresponding cup.

---

<sup>1</sup> This paper has been edited by the Technical Editor, who is solely responsible for any errors or omissions.

<sup>2</sup> This paper is a continuation of Mr. Tessier's presentation at the session on plug materials and design given at 2004 SPE Thermoforming Conference.

**Table 1: Tested Plugs**

Plug description	Removed from	Running time
Sample 1	Newly made	–
Sample 2	Cavity 41	1 day
Sample 3	Cavity 31	1 week

Because the plug assists did not enter completely into the sheet, the plugs did not contact the sheet over their entire surfaces and were therefore loaded mechanically only on a part of their surfaces. Color darkening and an increase in surface roughness are seen when comparing the unused plug (sample 1) with the used plugs (samples 2 and 3).

### Light Microscopy

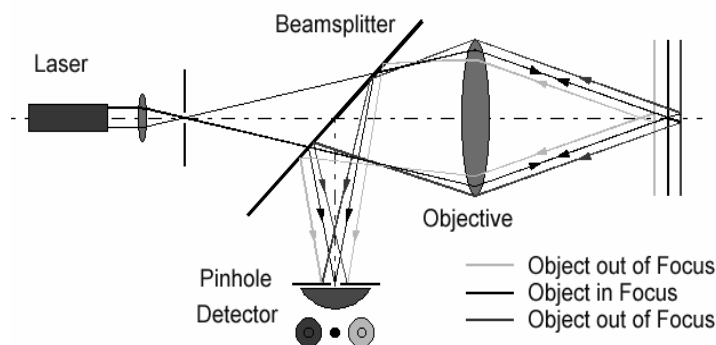
A macroscope from Wild Heerbrugg, type M420 with 20-times magnification was used for the light microscopic analysis. The images were taken by a CCD-camera, type Leica DC200.

### Confocal Laser-Scanning Microscopy

The confocal microscopy is an established robust technique to investigate volume distribution and surface topographies. A point-like light source is incident on the object. The reflected light from the object is focussed on a point-like detector. The signal of the detector is only maximum when the object is placed in the common focus plane from the point-like light source and the detector. If the object is placed in front of or behind the focus plane, the illumination on the object and the image on the detector are diffuse and the detected intensity is accordingly lower. Because of the point-wise mode of operation, the whole surface has to be scanned by the focus in all three directions in space, if a three dimensional topography is to be recorded.

### Fourier-Transform Infrared Spectroscopy

The FT-IR spectroscopy method is used to identify organic substances in solid, liquid or gaseous state. The samples must be prepared in an adequate manner to perform an infrared spectroscopy. If sample preparation is not possible, measurements can be performed using the technique of alleviated total reflection. All



**Figure 2: Confocal principle [4].**

preparation methods are made difficult or impossible with filler materials.

### Gas Chromatography

Gas chromatography involves a sample being vaporized and injected onto the head of the chromatographic column. The sample is transported through the column by the flow of an inert, gaseous mobile phase. Components of the sample mixture with a high degree of affinity for the stationary phase are strongly retained while components with low affinity for the stationary phase migrate rapidly through the column. As a consequence of the differences in mobility due to affinities for the stationary phase, sample components separate into discrete bands that can be qualitatively and quantitatively analysed.

### Biaxial Deformation Test

For the biaxial deformation test, a plastic sheet is deformed by a hemispheric deformation body [1]. This test is similar to the instrumented dart test, DIN EN ISO 6603. For this purpose the sheet is clamped in such a way that it is not able to slip out of the clamping device. The sheet is heated up to processing temperature in a temperature chamber. During deformation, the deflection of the deformation body as well as the force on the deformation body is measured.

Within the scope of this investigation the plugs removed from the running production were used instead of the hemispherical deformation body to determine differences in the deformation behaviour of the plugs that have been exposed to different loadings. Subsequently, the deformed sheet was

(continued on next page)



cooled down and removed from the mould. Finally the wall thickness distribution was measured. For that purpose, the deformed sheet (Fig. 3) was cut down the sheet side and a mechanical calliper was used to measure along this line in millimeter steps. The beginning point (measuring point 0) is located in the middle of the bottom of the cup, the end of the measuring line is placed at the seam of the cup (measuring point 75).

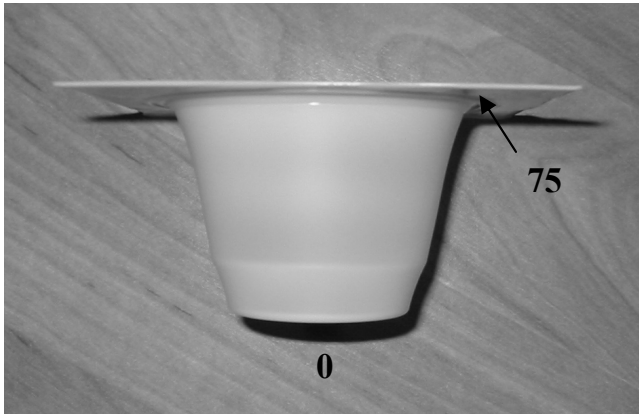


Figure 3: Deformed sheet.

## Results and Discussion

### Investigation of Discoloration

The hollow glass microspheres as fillers in the syntactic foam made the measurements by infrared spectroscopy very difficult. Hence the unfilled thermoset resin of the syntactic foam HYTAC®-W was tempered to investigate changes in the material due to heat treatment. Then, comparable measurements between material in the delivery state and tempered material were performed. The infrared spectroscopy was performed by using the method of alleviated total reflection (ATR).

As result of the infrared measurements, it was seen that there was one absorption band missing in the spectrum of the heat-treated resin. The missing band may be caused by volatile matters. To analyze for these substances, an extraction of both treated and untreated resin using acetone was carried out. From extraction measurements, it was determined that the untreated resin contained an amount of a material at a level three times higher than that from the treated resin. This supports the assumption of emission of a volatile substance.

The extracted substances were analyzed by gas chromatography. The main component detected was an anhydride hardener for epoxy resins. Because the infrared spectroscopy was performed in reflection mode and not in transmission mode, only regions close to the surface could be investigated. Contrary to the infrared tests, not only the soluble substances from surface areas but also from the core of the resin were extracted. So, one can assume that the hardener is emitted in layers near the surface during heat treatment.

Because the extracted resin remains dark in colour, it is very likely that the darkening is caused by changes in the material like oxidation or by high molecular weight substances that are too large to be extracted or volatile.

### Investigation of Surface Roughness

A visual observation shows a clear difference in surface roughness between the used plugs and the new plug. The close-up view via microscope of the plug surface verifies this observation. Fig. 4 shows the surfaces of the different loaded plugs. It can be seen, that the surface structure after one day loading differs clearly from the structure of the new plug. Longer loading (1 week) does not have a big influence.

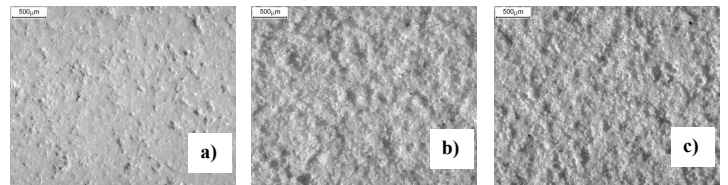


Figure 4: Light microscopy pictures of the surfaces of a) sample 1, b) sample 2, c) sample 3.

The surface roughness was quantified using a Zeiss LSM 410 laser scanning microscope. The result of these measurements is a three-dimensional surface profile as displayed in Figure 5.

For the used plugs (samples 2 and 3), an arithmetical mean deviation  $R_a$  was determined between 16 and 18 microns. The new plug (sample 1) shows a value of 6 microns. This confirms on the one hand, the light microscopic investigations and on the other, this shows clearly the level of increase in surface roughness.

Sample 1 was used to deform ten sheets in the bi-axial deformation test and it already showed

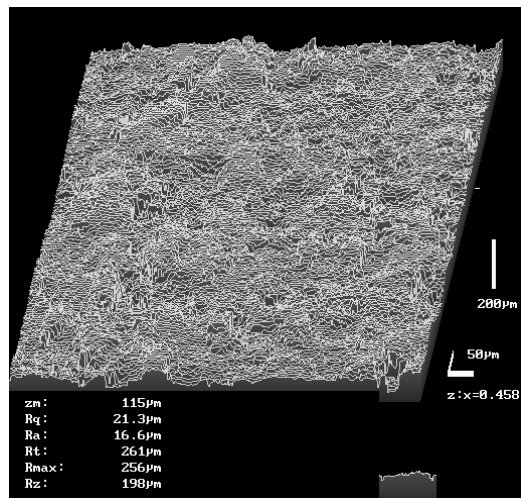


Figure 5: LSM surface profile (sample 3).

after this low loading a clear increase in surface roughness. This surface roughness is comparable with the arithmetical mean deviation of the used plugs. The whole surface is affected by the changes in the surface structure, independent on the contact area of the plug with the sheet. One can conclude that the surface is not changed abrasively but other effects occur.

Sample 1, which had been loaded in the biaxial deformation test, was polished (Fig. 6a) and exposed again to a temperature of 140°C for the duration of one day to investigate the influence of the temperature on the plug material. Fig. 6b shows the surface after heat treatment. One cannot detect a difference in the surface roughness, but again a darkening in colour takes place.

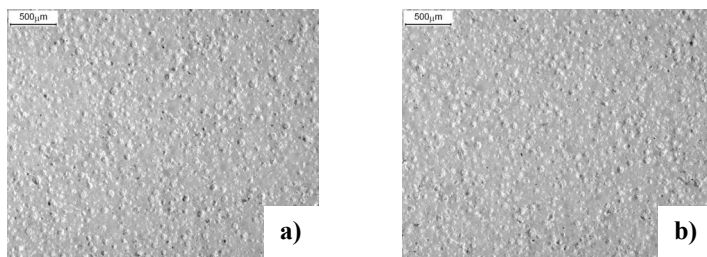


Figure 6: Polished plug surfaces before (a) and after (b) the heat treatment.

To analyze the influence of the thermal loading in combination with the mechanical loading, the polished plug was subjected again to the bi-axial deformation test. Again, an increase in surface roughness could not be detected.

A definite cause for the increase in surface roughness cannot be determined. However, one can

assume that the machining of the plug induces residual stresses or even microcracks in the surface, which may be relieved by heat treatment and result in flaking of the surface area.

### Effects on Thermoforming Behaviour

The effect of the changes in the material and of the increasing roughness were analyzed by the bi-axial deformation test [1]. The required force for forming the sheet and the wall thickness distribution of the deformed sheets as well as parts from the running production were considered as criteria. In Fig. 7, a slight difference in the deformation force is shown. However the differences shown are within the standard deviation of the test series. The deformation behaviour is therefore considered to be independent of the influence of different loadings on the plug assists.

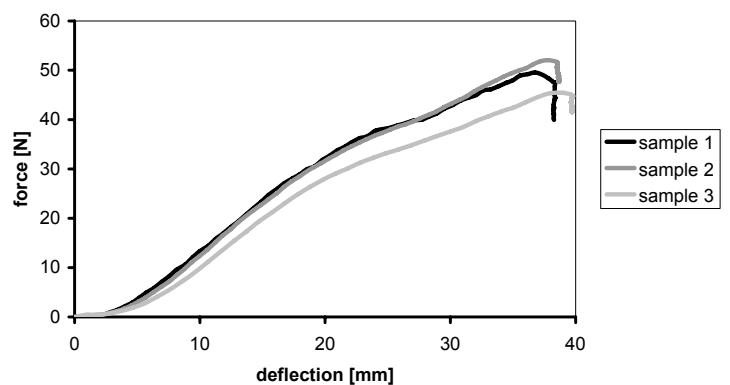


Figure 7: Force-deflection curves depending on plug assists.

In Fig. 8 (see page 22), the variations of the wall thickness distributions of the deformed sheets (Fig. 3) along the sidewalls of the cups are seen as a result of the forming with sample 1 (unused) or with sample 2 or 3. The wall thickness realized by forming with used plugs is more uniform than the wall thickness realised by forming with a newly made plug. Thus, a minimum wall thickness can be achieved with the use of thinner sheet, which is very attractive to the production of packaging articles.

### Conclusion, Outlook

It was shown that surface roughness of thermoforming plug assists made from HYTAC®-W

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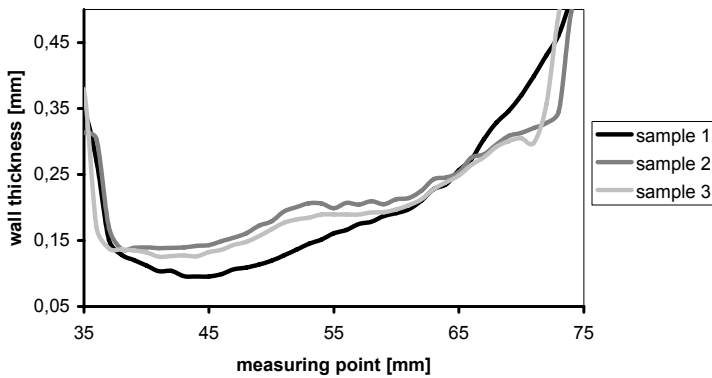


Figure 8: Wall thickness distribution of formed sheets.

increases tremendously after only a few cycles and a heat treatment at 140°C for a few hours. After reaching a certain value, the roughness does not increase further.

Neither the increase in roughness nor the discoloration have a measurable influence on the thermoforming behaviour of the plug assists, the influence of plug geometry, and forming temperature prevail. Nevertheless the deformed sheets show a differing wall thickness distribution. The shapes formed with the newly made plug are disadvantageous concerning the material distribution along the sidewalls. Further research has to be done in the investigation of the influence of the manufacturing process of the pre-stretching plugs on sensitivity against thermal and mechanical loadings. Furthermore, these insights should be proven for long-term running plugs.

## References

- [1] Hegemann, B., *Deformationsverhalten von Kunststoffen beim Thermoformen - experimentelle und virtuelle Bestimmung -*, PhD-thesis, Stuttgart, (2004)
- [2] Illig, A., *Thermoformen in der Praxis*, Carl Hanser Verlag, Munich, (1997)
- [3] Tessier, N., Murray, T., *New Developments in Plug Materials*, 14th Thermoforming Conference (SPE), Indianapolis, (2004)
- [4] [www.uni-stuttgart.de/ito](http://www.uni-stuttgart.de/ito)

## Thermoforming Division Donates \$45,000 to National Plastics Museum



The Thermoforming Division has contributed \$45,000 to the National Plastics Museum for the purchase of a new PlastiVan and new computers. Shown, L-R: Division Vice Chairman Walt Walker, Jack Hill, Margie Weiner of the Plastics Museum, Division Chairman Roger Kipp, and Board Member Steve Murrill.

**Leominster, MA** — The National Plastics Center & Museum (NPCM) received a boost from the Society of Plastics Engineers (SPE) Thermoforming Division to further their educational outreach program in several ways.

SPE's Thermoforming Division has donated the following to the National Plastics Center & Museum:

- A **new van for the Center's PlastiVan program**, an internationally acclaimed education program geared for students in grades 3 through 12, that travels throughout the U.S. teaching students, educators and the public about the chemistry, history, processing and environmental issues involved with plastics. With this new van, the Center now has four vans to accomplish their mission. SPE's Thermoforming Division also donated **new thermoforming equipment for each of the four PlastiVans**.
- **Brand new computers** for the National Plastics Center & Museum's Outreach Department.
- **\$10,000 in matching funds** for Thermoforming members.
- A **new thermoforming exhibit** that will soon be a part of the other plastics educational displays at NPCM.

"SPE's Thermoforming Division has always supported our outreach program from day one, but this is above and beyond what we expected," says Marjorie Weiner, NPCM's assistant director and outreach director. "Our outreach program will greatly benefit from their generosity, and thus the story of plastics will get heard by a wider audience as a result."

"We're happy to support the NPCM as it meets our mission of reaching the next generation so that we can develop new young polymer scientists and plastics technicians vital to the future of the plastics industry," says Roger Kipp, SPE's Thermoforming Division's Chair and Vice President of McClarin Plastics Inc. "Steve Murrill of Profile Plastics deserves much of the credit with this donation as he has championed his idea to support the NPCM and their PlastiVan Program."

A formal presentation of the scope of the donation was made at SPE's recent Thermoforming Conference held in Milwaukee. ■

# New CO<sub>2</sub> Laser Cutting Technology

As thermoforming companies introduce new products and processes within their facilities, they often find that they face many new challenges in order to meet customer requirements. The need to meet these challenges has prompted many thermoformers to consider implementing alternative trimming technologies within their facilities. A growing trend within the industry is to implement robotic laser trimming systems as part of the manufacturing process.

In the past, laser cutting solutions were considered to be technology that was costly to implement and difficult to maintain. Technical advancements within the past few years have addressed many of these issues and as a result, laser cutting technology has become practical for processing a variety of parts. Thermoformed automotive components and decorative trim products continue to be prime applications for robotic laser trimming. Automotive parts such as body side moldings, console bezels, instrument panel trim components, and fascia assemblies are just some of the thermoformed products that are being trimmed with laser. In addition, aftermarket and dealer installed components are also being trimmed with the laser process. Components formed from materials such as ABS, Polypropylene, and HDPE are just a few examples of parts that are commonly processed with the CO<sub>2</sub> laser cutting technology.

The laser process allows these parts to be trimmed in a single step, eliminating the need for manual finishing of the trimmed edge, as is the case for many parts when they are processed with die trim operations. This is due to the laser “searing” the edge of the part during the cutting process, leaving a much smoother, clean, and consistent trim line as compared to die cut parts. Eliminating the trim die process also reduces the operating costs associated with producing the part, as die maintenance is no longer required.

The laser system allows product design changes to be implemented within a matter of minutes by simply re-programming the robot, allowing the thermoformer to quickly respond to customer demands to implement “on-the-fly” product changes. A typical trim die must be sent back to the tool maker for re-work, which can often take several weeks and can be cost prohibitive. Multiple versions of the same part can also be processed with the robot by selecting a different program to cut out any optional features or to cut alternate trim lines.

These changes can be made by an operator by simply selecting the options on a graphical user interface screen.

Change over from one part style to another is also easily accommodated on the laser system. Quick change tooling methods can be included in the design of the work cell, allowing one fixture to be removed and replaced with another within a matter of minutes by a single set-up person. A fixture identification system can also allow the system to recognize the new part style as the fixture is located on the work cell, allowing the correct program to be loaded automatically by the robot controller. Changes to process parameters such as travel speeds and laser power are automatically set as well, resulting in consistent part quality from one production run to the next. This functionality serves as a built in error-proofing feature, reducing the potential for an incorrect set-up during machine change over. A typical robotic laser trimming solution includes a sealed CO<sub>2</sub> laser head with a mirrored beam delivery package that directs the laser beam from the power source to the focusing head, Figure 1.



This laser package is then integrated to a five (5) or six (6) axis articulating robot arm. The integrated design of the laser package allows the robot to achieve a wide range of motion, which in turn allows larger and more complex parts to be processed. Newer laser robots feature a laser that is fully integrated as part of the robot arm, eliminating the need route utilities such as cooling lines, RF power and DC power externally. This

*(continued on next page)*



integrated design provides a very compact and reliable laser beam delivery assembly as well. Current designs allow sealed lasers with power ranges of up to 600 watts to be implemented as an integral part of the robot arm.

With the integrated laser package, the upper arm of the robot is removed and replaced with a specially designed housing that contains the CO<sub>2</sub> laser head and RF power supply. New robot wrist axes are implemented, and they are constructed to be a part of the laser beam delivery package. This construction minimizes the number of mirrors required to deliver the CO<sub>2</sub> cutting beam to the focusing lens. In addition, this design allows the robot wrist axes to have infinite rotation, allowing more complex cut paths to be processed. This motion range also reduces the need to stop the robot in the middle of the cut in order to re-orient the robot wrist, allowing better cycle times to be achieved. The result is a beam delivery system that delivers a more defined beam path without the requirement for extensive maintenance. Periodic cleaning of the mirrors and the lens is the only normal maintenance requirement. The laser head itself requires no maintenance for 15,000 to 20,000 hours of operation, after which the laser must be re-charged.

For the system, a vacuum fixture is typically used to hold the part in a repeatable manner while the trimming process is being completed. The part holding fixture is mounted either to a fixed table or to a turntable to present the part to the laser robot. The turntable design allows two (2) parts or sets of parts to be processed simultaneously on the work cell. While parts are being cut on the inner side of the turntable, the operator can unload and reload parts on the opposing side. A typical turntable cycle of three (3) seconds or less means that robot idle time is minimized, as the only time that the robot is not trimming parts is during the turntable index. This arrangement provides the benefit of high system throughput, maximum robot utilization and better flexibility, by allowing multiple fixture styles to be processed simultaneously on the work cell.

The laser robot is placed within a fully enclosed work cell, which provides a very safe working environment around the system, Figure 2.

This approach isolates the operator from interacting with the laser process during the cutting cycle, as the barrier that is built into the turntable prevents physical and visual access to the process while the laser is active. In addition, hazardous fumes that are generated during the trimming process are collected at the point of cutting and remain contained within the enclosure. These fumes are then evacuated from the system and the air is cleaned through the use of a multi-stage air filtration unit.



Process cutting speeds continue to increase as the technology evolves and more powerful lasers become available. As the travel speeds increase, the cycle time is reduced, in many cases allowing the cutting time to match up with the forming cycle. The increase in laser power has also resulted in the ability to process thicker materials, as well as multi-layer constructions. The increase of cutting power, along with advancements in robot path performance have made it viable to process parts that were not a possibility just a few years ago.

Robotic laser trimming technology continues to advance at a rapid rate. As we continue to see dramatic changes in this technology, it is evident that laser cutting will gain popularity as a trimming option for thermoformed parts. For those who haven't taken a hard look at this technology recently, it just might be the right time to take a second look at this flexible trimming option.

Robotic Production Technology is a turnkey robotic systems solutions provider. Industries served include aerospace, appliance, automotive, composites, construction, consumer goods, marine and plastics industries. The company specializes in high path accurate trimming applications such as deflashing, laser cutting and scoring, router and water jet cutting. RPT also has process expertise in material dispensing, assembly, joining, material handling and welding. Capabilities include project management, engineering, simulation services, fabricating and machining, system integration and certification, software, training, service and support. Since 1985, RPT has been a leading manufacturer of flexible manufacturing systems utilizing multi-axis robots, with an installed base of more than 2,000 robots.

*More information on the laser cutting process can be obtained by contacting Doug Cicchini, Robotic Production Technology at 248.829.2800, [solutions@rpt.net](mailto:solutions@rpt.net) or [www.rpt.net](http://www.rpt.net). ■*

## History of Thermoforming – Part II<sup>1</sup>

BY STANLEY R. ROSEN, PLASTIMACH CORPORATION, LAS VEGAS, NEVADA

Ed. Note I: The philosopher Santayana said “Those who cannot remember the past are destined to repeat it.” Stan Rosen is undertaking a prodigious project – identifying the pioneers who laid the foundations of the industry we know so well. Although shaping of sheet extends back to pre-history – oil-heated and shaped tortoise shell and steam-heated and shaped wood, Stan begins the journey in the 1930s. We hope you enjoy the trip!

### Thermoforming Pioneers 1930-1950

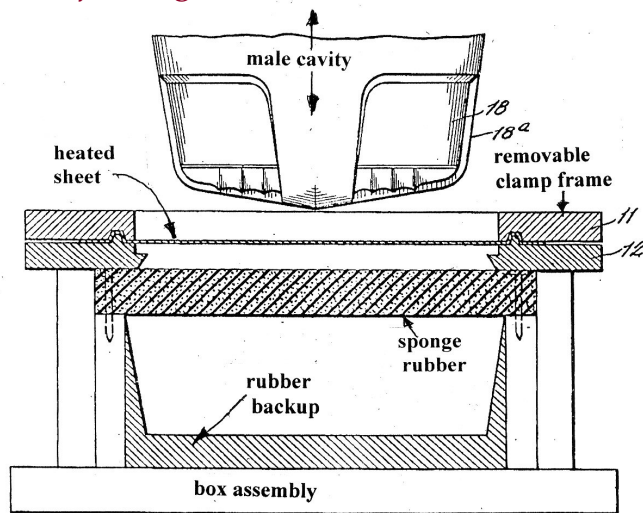


Figure 7.

Figure 7. G. W. Borkland of Borkland Lab, Marion, Indiana filed a patent on 10-2-1941 for forming a plastic lighting diffuser. A plastic sheet is held in a clamp frame above a box to which is fastened a soft thick sponge rubber membrane. The male cavity is mounted on an upper moving platen. A box assembly contains a sheet that has been heated to forming temperature and the cavity forces the sheet into the sponge rubber where it cools on the mold. Sponge rubber plays the part that vacuum or pressure forming does in present-day thermoforming.

All of these pioneers struggled with methods of sheet heating, clamping the sheet, vacuum and pressure forming techniques and the evolution of various ways of dealing with these problems. Helwig used oven preheating and hot oil. Leary tried zoned radiant heat bulbs. Braund found that convection (heated air) suited his project and Wiley experimented with steam. Borkland's early experiments forming with sponge rubber was soon abandoned for vacuum forming.

Figure 8. C. B. Strauch, assigned to the Plax Corp., Hartford, Connecticut, a patent filed 11-22-1938. This

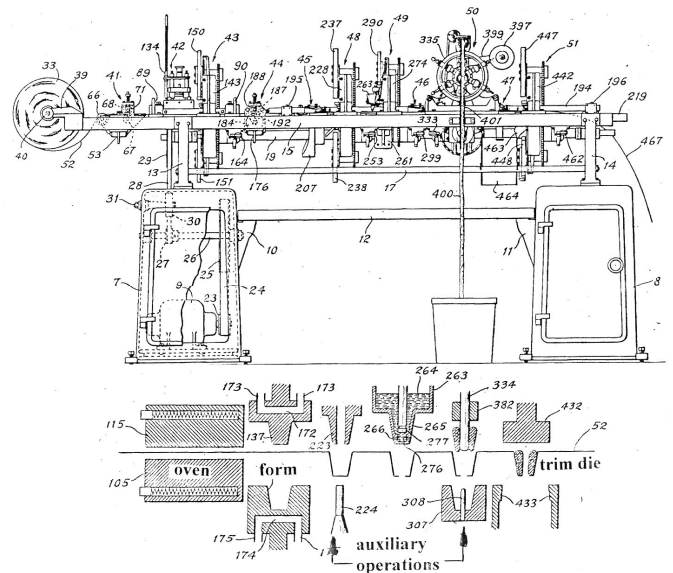


Figure 8.

magnificent all-mechanical machine was the first roll fed inline thermoformer in which a plastic web entered the machine and trimmed formed parts exited. The plastic web was indexed from heating, forming and various auxiliary operations through a trimming die by a chain belt. Unfortunately its high productivity was its curse since in 1938 there was not sufficient high volume business to feed the machine's appetite. It successfully produced ice cube trays, Christmas ornaments and cigarette mouth tips.

Louis H. Phohl in 1938 in New York City, used matched male and female wooden molds to form clear cellulose acetate domes for counter displays. He heated the plastic on a gas hot plate and transported the sheet to the molds mounted in a kick press where they formed. His firm, Plaxall Corp., Long Island City, New York, continues today as a high-quality thermoformer and is a leader in its field. His son, Jim Phohl, describes a conference in which Louis and Jim Phohl met with Bill Simms, Editor of Modern Packaging Magazine. One topic they discussed was that vacuum and pressure forming is an inclusive process, so they created the term *thermoforming*. Thereafter Modern Packaging employed the word “thermoforming” in their articles. It can be assumed that many others will also now claim the authorship of this term.

Figure 9. G. W. Borkland of Marion, Indiana filed a patent on 7-8-1947 for a vacuum forming machine. The equipment utilizes individual loose single picture frames (3) which have needles (18) protruding upwards to impale the plastic's sheet. An operator places the plastic's sheet

(continued on next page)

<sup>1</sup> Part I is found in Thermoforming Quarterly 3Q05.



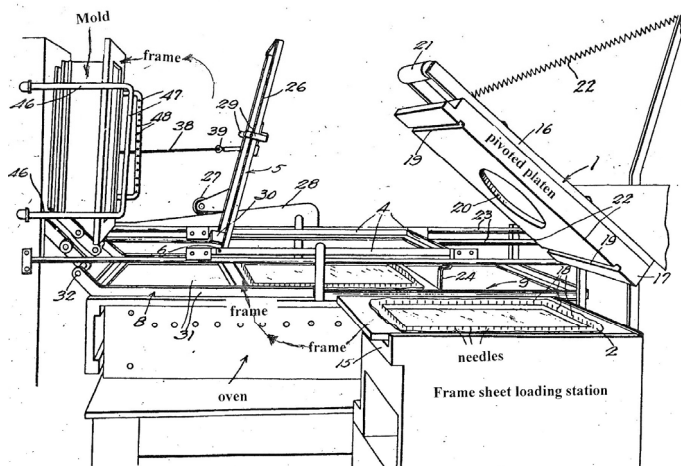


Figure 9.

on the frame (3) and manually closes a pivoted platen (21) to force the sheet firmly on the needles. The sheet and frame are carried to the vacuum former where the plastic is heated over a lower oven (9) and transferred to the mold (7) which is mounted vertically and then vacuum formed.

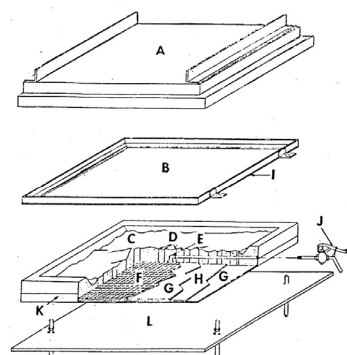
Borkland has many patents issued in the 1940s that pertain to the thermoforming field and advertised his processes at shows and in *Modern Plastics Magazine* to licensees. At the 1950 National Plastics Exhibition (NPE) in Chicago, two booths showcased thermoformed parts. Both Borkland Laboratories and Regal Plastics of Kansas City displayed their formed parts. Borkland exhibited thin walled vacuum formed packaging and Regal displayed a heavy gauge motion picture machine case formed using matching wood male and female cavities. Commercial thermoforming machines were not available to the trade until early 1952 when Industrial Radiant Heat Corp. apparently was the first to display a machine at the NPE in Philadelphia, Pa. in March 1952. *Modern Plastics Magazine*, May 1952, reviewed the exhibition and wrote the following glowing report.

"Rigid vinyl was also involved in the Industrial Radiant Heat Corp. exhibit which perhaps attracted more continuous attention than any other booth in the show. The product on exhibit was the company's machine for vacuum forming thermoplastic sheet. Most of the sheets being vacuum formed were rigid vinyl, although the suitability of the machine for forming polystyrene, styrene copolymer, acetate, and even thin acrylic sheets was also demonstrated. The machine exhibited was designed for manual operation and employed an infra-red super-heater to soften the thermoplastic sheet prior to forming.

"The operation of the vacuum forming machine and the attention it attracted effectively dramatized the possibilities of this long-

neglected process. The significance of the process as a possible alternative to injection molding for the production of large but essentially simple pieces was the subject of much comment. Some observers noted that the piece was almost as large as the inner door of a refrigerator. Others spoke of the possibility of extruding a thermoplastic sheet and vacuum forming it while still warm, as fast as it is extruded, thus creating a production set-up with vast possibilities for high speed output of numerous end products."

E. Bowman Stratton (Bow), chief of the Relief Map Division, Army Map Service, in 1947 successfully started production of relief maps using the equipment shown in Figure 10. His group built on the work of the Braund patent, Figure 5, and produced a machine with all the elements of a modern vacuum former. In January, 1952, Bow Stratton joined Industrial Radiant Heat Corp. of New Jersey as sales manager, and was present at the NPE March 1952 show where the machine drew such universal interest, as quoted above.



This view shows the relationship of the essential components of vacuum-forming equipment as used by the Army Map Service in 1947 to produce three-dimensional maps: (A) superheater; (B) angle-iron frame; (C) mold; (D) vacuum holes; (E) vacuum pipe; (F) wire mesh, 2 layers; (G) aluminum sheet, 0.032"; (H) sponge rubber, 1/4" to 3/8"; (I) sponge rubber gasket; (J) poppet valve; (K) heat-resistant tape; (L) aluminum plate, 1/2". (Courtesy, Relief Map Division, Army Map Service, Corps of Engineers, Washington, D.C.)

Figure 10.

It may be interesting to review Figure 10 and the above mentioned quotation. Both describe the oven as "super heater". Steve Hasselbach, of CMI Plastics, Cranbury, New Jersey, related an incident which occurred in the 1950s. His father owned an ancient model thermoformer oven made of glass cloth interwoven with nichrome (toaster) wire which required repair. He went for the repair to Zack Radiant Heat Corp. in New Jersey which he believed was the successor company to Industrial Radiant Heat Corp. Both corporations may have merged, closed or changed their names and are not available for comment. I believe the super heater was of the design described above.

*Modern Plastics Magazine*, February 1953, reported the following news item:

"Auto-Vac Co., 2120 Post Rd., Fairfield, Conn, is a new company producing vacuum forming machines. The new machines include a wide range of sizes and new design features for rapid, economical production. A small-pilot-plant machine sells for about \$1500; a single-table operation machine is

priced around \$5000; and a two-table machine at \$10,000. The company is also setting up a product development and testing department to further the growth of the vacuum forming process. Several machines have already been installed with deliveries running from four to eight weeks after receipt of order.

"The company has been organized by E. Bowman Stratton, who helped develop the Army Map Service vacuum process for making contour maps from plastic sheet, and R. L. Butzko, formerly of Noma Electric Co."

Bow Stratton marketed this line of vacuum formers by means of magazine articles, seminars, shows and technical society papers. By the end of 1953, many entrepreneurs became very interested in this process. Bob Butzko was an experienced engineer who quickly redesigned the early models of equipment to stand up to industrial conditions. The oven and its controls were upgraded to modern requirements as well as the clamp frame, pneumatics and mechanical features. Very rapidly a half dozen thermoforming machine companies were competing within a year of Auto Vac's founding.

The golden age of thermoforming, 1950-1960, finally had the tools to bloom.

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Phone conversation with Steve Hasselbach, CMI Plastics Corp., Cranbury, NJ, Dec 2004.

SPI (NPE now), archives from Hagley Museum and Library, Wilmington DE, for exhibitors 1950, 1952.

Modern Plastics and Modern Plastics Magazine, issues 1950-1953.

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*Ed. Note II: Each year since 1982, the SPE Thermoforming Division has honored a leader in the thermoforming field. Bow Stratton was the 1983 Thermoformer of the Year. Bob Butzko was the 1985 Thermoformer of the Year. And Stan Rosen, the author of this article was the 1991 Thermoformer of the Year. Stan can be reached at [thermoipp@earthlink.net](mailto:thermoipp@earthlink.net). ■*

## Need to produce more quality parts per hour?

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# Design of Experiments – An Overview<sup>1</sup>

BY DAVID SCHOFF<sup>2</sup>, CREATIVE FORMING, INC., RIPON, WISCONSIN

**D**esign of Experiments is already an important tool in your toolbox if you are a Six Sigma Black Belt or moving your company into a lean manufacturing environment. If you are not familiar with this tool, it can easily be learned and put to work with the help from today's software. It can be used to efficiently learn specific information about your process. This article will give you a brief overview (or review) of what Design of Experiments is, how it works, and what to consider when designing experiments of your own.

## What is Design of Experiments?

What it is not is the “next big thing.” In fact, it has been around for over seventy years. Abbreviated DOE, it is short for Statistical Design of Experiments. What it is is a structured data-gathering tool – literally “designing” experiments to learn specific information about your process.

### *Listening Versus a Conversation*

A useful analogy originated by Box and Hunter was presented to this author by Professor Conrad Fung, a statistical consultant and the statistics professor for University of Wisconsin's Master of Engineering in Professional Practice Program (<http://mepp.engr.wisc.edu/>). Consider the differences between “listening” to a process and having a “conversation” with that process. Listening is observational and passive. The data that you gather will only reveal what the process cares to tell you. It is like eavesdropping on your process and analysis is accomplished with basic statistics, such as the average and standard deviation. In contrast to listening, having a conversation with your process is experimental and active. You disturb your process to see how it responds. It is like interviewing your process, and it uses statistics that are more involved. This is Design of Experiments or DOE.

<sup>1</sup> This article has had minor editing. Any errors or misrepresentations of the original article are the sole responsibility of the Technical Editor.

<sup>2</sup> David Schoff received the 2002 Griep Memorial Scholarship while a graduate student at University of Wisconsin-Madison.

### *Unique Benefits*

DOE can be used to gather data more efficiently and effectively, with fewer people and less machine time, than trial and error methods. By using DOE, you identify which factors contribute the main effects of the process, you reveal interactions between factors, and you minimize the impact of unknown variation. Most importantly, you avoid problems that are common with one-factor-at-a-time forms of data gathering. Figure 1 shows each factor being adjusted one at a time. To see the effect of just one factor may require many trials. The temptation to adjust factors, one after another, is great and you may find yourself chasing your tail, generating data that may only provide limited information about your process.

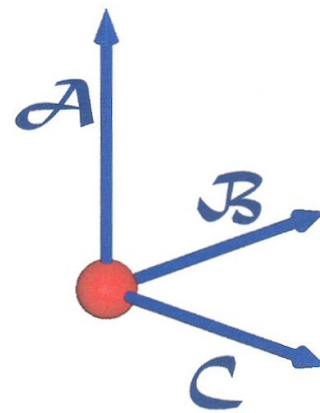


Figure 1. Adjusting factors A, B, and C, one factor at a time.

Another unique benefit of DOE is efficient process characterization and optimization. A possible outcome from DOE may be the development of a formula that shows how process factors affect your process. This may provide information on how to adjust those factors to optimize the process for the part feature you are trying to improve.

## How Does DOE Work?

In practical terms, you choose various factors and high and low levels of these factors. You then conduct a defined number of test runs at defined combinations of those factors and levels. By following this design, statistics can provide very useful information about your process.

## Designs, Factors and Levels

With DOE, you carefully plan your tests such that you maximize the information you learn about your process. It is common that a series of DOEs are completed in search of answers to a specific question. Different types of designs are useful in different situations. Screening designs permit you to screen out factors that have little or no effect on the problem you are analyzing. This helps you narrow your list of potential factors. Full designs or full factorial designs look at every combination of chosen factors at high and low levels. More commonly, partial designs or fractional factorial designs are used because they carefully limit the number of individual runs required to gather the data while still allowing the statistics to work properly. The very acceptable trade-off in exchange for more economical experiments is somewhat less information about higher-level interactions between factors and limited estimates of statistical error.

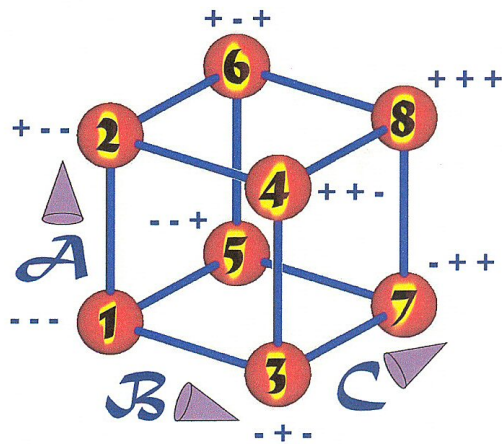


Figure 2. Orthogonal array of factors A, B, and C at all combinations of high (+) and low (-) levels of eight runs.

### Orthogonal Arrays

To get a little more technical in terms of the workings of DOE, consider the orthogonal array in Figure 2. Each corner represents a combination of the three chosen factors at high and low levels, a  $2 \times 3$  array. These eight combinations define all possible runs in this experiment. In other words, it is a full-factorial. Each factor at each level is represented twice. Now eliminate runs 1, 4, 6, and 7. The remaining runs define a half fraction of a factorial experiment or a half-factorial. Note that each level of each factor is still represented, allowing the statistics to function and to provide estimates of every main effect. Again, information about interactions is given up in exchange for economy of the experiment. Again, this is often a necessary trade-off.

### Statistics and Software

Today's software easily facilitates the data entry, statistical calculations, and reporting functions needed for DOE. It also assists you in designing your

experiments by setting the limits required to achieve statistical correctness. Many of the full statistical packages such as Minitab, Statistica and JMP all have DOE modules. Understanding the general way that each software package performs the DOE statistics is good. But more importantly, training in the proper use of the software is worth the time. And the training is readily available.

### Designing Experiments

A number of items must be considered when designing experiments:

- Measurements
- Factors
- Factor levels
- Constants
- Number of runs
- Randomize runs
- Cost

#### Measurements

What you need to measure is directly related to the problem you are investigating. Wall thickness, flange flatness and opening force are examples. More importantly, how the values are to be measured must be clearly defined so that the data are taken in a consistent manner.

#### Factors

Choosing the factors to consider may be obvious. The more you understand your process, the easier your choice will be. This is also why a series of DOEs are common, each building on the knowledge gained from earlier DOEs. In thermoforming, factors such as temperature, plugs (shape, depth, materials, radii), or platen speeds may be items you might consider.

If the choice of factors is not obvious, it is recommended that a screening design DOE be run first. This allows you to efficiently eliminate many factors that are insignificant to the part feature you are examining. The next DOE(s) can then focus on the factors that appear to have the greatest effects.

#### Factor Levels

What high and low levels do you choose? This decision can be very difficult when designing your experiment. If the range is too small, the effect of the factor may be hidden within the variation in the data. If the range is too wide, the parts may not be measurable. Consider the effect of temperature. If it is too low, the parts may not be fully formed. If it is too high, they may be deformed. Either way, the part performance may not be measurable. On the other hand, if the temperature range is too small, the temperature effect on the parts may be undetectable.

(continued on next page)



The best advice from Professor Fung is to be bold with your choice of levels. Again, knowing your process is helpful. Tests ahead of time to find the limits of the factors are worthwhile. You always want as wide a range as practical for your process and your part measurement. Realize that you may produce unacceptable parts during your DOE as you test the limits of your process. But loss of these parts is an investment in gaining process knowledge about these limits.

### Constants

Keeping everything else constant while you adjust only the chosen factors can be one of the most challenging aspects of doing DOEs. Learning about your process will help you determine if and how to keep other factors constant while adjusting the chosen ones.

### Number of Runs

The number of runs is prescribed by the design you are using. For example, a 3-factor full-factorial design requires eight runs. A 5-factor half-factorial design requires 16 runs. Without the prescribed number of runs, statistics cannot do what it is supposed to do. If you are able to completely repeat a set of runs, the statistics will establish levels of statistical error in addition to providing information about factor effects and about interaction between factors and process characterization. Depending on the design, the number of runs may be few or many. The design you choose and its prescribed number of runs may be a practical decision based on the cost and time invested in the DOE. If these factors seem prohibitive, consider fractional or screening designs with fewer runs. These may provide sufficient information to answer the process questions.

### Randomized Run Order

Process variability is inherent. You cannot eliminate it but you can moderate its effects. Randomizing the order of your experimental runs can help you in three ways. First, randomizing limits the effects of lurking variables that you cannot see or do not expect. Second, randomizing eliminates designer or operator bias during the run. And third, randomizing runs permits valid estimates of statistical error, allowing you to estimate the reliability of your results.

With that said, there are practical challenges in performing runs in the prescribed random order. There is the difficulty of changing plugs or mold inserts, if these are important factors. Or there is the difficulty of stabilizing your process between runs. Sometimes it may be necessary to compromise and make runs in a more convenient manner.

### Costs

Finally, as a DOE designer, the costs to run a DOE may be your biggest hurdle in order to examine the problem you are experiencing. It will cost the company money to perform DOEs. The costs include machine time, labor, and the material to produce unacceptable product during the time that the equipment could be making salable product. It is likely that one DOE will not answer your questions and that you will need to run a series of DOEs, thus adding to the cost. Management, as they should, will look very closely at these costs and weight the potential benefits against them. If your problem is particularly difficult, and if you can reduce scrap losses by a few percent, running the DOE study could put money in the bank.

### Output

Each software package offers a unique format but all will present results in a variety of easy-to-read graphs and tables. You will quickly see which factors contribute to the main effects and what the relative effects between factors are. If interactions exist between factors, interaction graphs will show this as well, as seen in Figure 3.

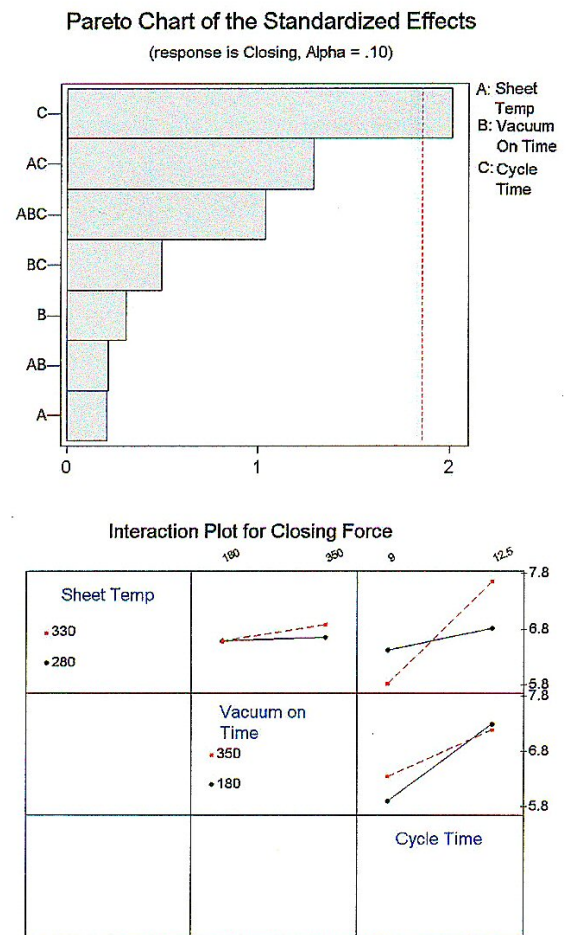


Figure 3. Sample Minitab Pareto main effects and interaction graphs

## Conclusion

DOE is an important tool in your toolbox. Careful planning and use of today's software to harness the power of statistics will provide you with specific knowledge about your process. You will be able to sort

out which factors have the greatest effect on the part feature you are examining. You will be able to determine if any interactions of factors are present. And finally, you will be able to optimize those factors to produce the best part possible, with the least scrap. ■

## UNIVERSITY NEWS

### UW-P Plastics Processing Technology Center Receives Gift of Thermoforming Machine From MAAC and Division

**T**he University of Wisconsin-Platteville Plastics Processing Technology Center recently received a gift of a new state-of-the-art thermoformer from MAAC Machine in Chicago, Illinois and the Thermoforming Division of the Society of Plastics Engineers. Additional funding for tooling and materials will come from the thermoforming industry, including an ongoing commitment from Plastic Ingenuity, Inc., Cross Plains, Wisconsin. The value of the equipment will exceed \$50,000.

The gift comes as UW-Platteville is increasingly being recognized as a major influence in the world of Wisconsin plastics processing. According to Dr. Majid Tabrizi, Professor of Industrial Studies and Director of the UWP Center for Plastics Processing in the College of Business, Industry, Life Science and Agriculture, Wisconsin is rated between eighth and 12th in plastics manufacturing in the nation. It is the fourth largest industry in the state, with over 700 plastics and plastics-related companies, employing over 52,000 people. Total sales exceed \$3,000 million annually. Over a dozen companies rank within the top 100 companies nationwide, and that figure doubles if Illinois, Iowa, and Minnesota are included.

Significantly, almost 30 percent of jobs in the industries are in companies within 250 miles of Platteville, and one of the few universities in the region training students for this industry.

Gene Schoohs, Engineer Manager for Plastic Ingenuity, Inc., explained why his and other companies continue to support UW-Platteville's plastics technology program. "We're living in a

global society which is becoming more and more competitive. We have to be able to have highly qualified people and the UW-P plastics program is a strong contributing factor in being able to do that. We find [their] graduates have the strong technical background we need to come in and help us build on our knowledge and experience," Schoohs said.

The Center's laboratory is equipped with over \$1 million worth of plastics equipment, making it one of the best equipped in the upper Midwest. Those assets, along with the expertise of the UWP faculty, make the Center a resource that provides a variety of technical services, including periodic training programs for the business community. In fact, this summer, the Center offered six workshops related to thermoforming through the continuing education department.

Anyone interested in learning more about the UW-P Plastics Processing Technology program may go to [www.uwplatt.edu/cfppt](http://www.uwplatt.edu/cfppt) or call Tabrizi to request an informational CD at 608-342-1115. ■



*Dr. Tabrizi and UW-Platteville Thermoformer.*



# The Ubiquitous<sup>1</sup> Draw Ratio

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

Probably the first thing a novice hears in thermoforming after he/she learns to spell “thermoforming,” is the phrase, “Draw Ratio.” So, this lesson focuses on the concept of draw ratio.

## Is There More Than One Definition?

Unfortunately, yes. There are at least three definitions. Let's define the common ones.

**Areal Draw Ratio**, often given the symbol  $R_A$ , is the ratio of the area of the part being formed to the area of the sheet needed to make the part. Although I promised not to use equations in our TF 101 lessons, some simple ones here won't hurt all that much:

$$R_A = \text{Area}_{\text{Part}} / \text{Area}_{\text{Sheet}}$$

A simple example, please? Consider a cylinder one unit in diameter by one unit high. The area of the cylinder and its base is  $(\pi + \pi/4) = 5\pi/4$ . The area of the sheet used to form the cylinder is  $\pi/4$ . Therefore the areal draw ratio,  $R_A$ , is 5. As an interesting aside, the reciprocal of the areal draw ratio is the average reduced thickness of the formed part, being  $1/5 = 0.20$ . In other words, the original sheet thickness has been reduced by 80%, on the average.

**Linear Draw Ratio**, often given the symbol  $R_L$ , is the ratio of the length of a line scribed on the part surface to the original length of the line. Again, in equation form:

$$R_L = \text{Line}_{\text{Part}} / \text{Line}_{\text{Sheet}}$$

For the same example, the length of the line on the cylinder is  $(1+1+1) = 3$ . The original length of the line is 1. Therefore, the linear draw ratio,  $R_L$ , is 3. The linear draw ratio is akin to the way in which the plastic is stretched in a tensile test machine,

**Height-to-Diameter Ratio**, often written as H:D, is the height of the cylinder (1), to the diameter of the cylinder (1). Or H:D = 1. H:D is used primarily for axisymmetric<sup>2</sup> parts such as cones or cylinders, such as drink cups.

In summary, for the cylinder described above,  $R_A = 5$ ,  $R_L = 3$ , and H:D = 1. So you see, there is no agreement between these definitions.

## Are Draw Ratios of Use? Importance?

So, which one do we use? Depends. First, we need to determine whether draw ratio is a useful concept.

Let's focus on areal draw ratio to determine its utility. As we have already learned, the reciprocal of  $R_A$  is the average reduced thickness. But where is this reduced thickness? Somewhere down the side of the formed part. In fact, there is probably a line around the periphery of the part

## THERMOFORMING 101

where the part thickness is exactly the average reduced thickness. So, what does this tell us about the uniformity of the part wall thickness? Or the degree of difficulty in forming the part? Or whether webs are formed somewhere in the part? Or what the plug needs to look like? Or ...? Really, nothing.

Having said that, areal draw ratio is perhaps the easiest concept to understand. Linear draw ratio, as noted, is often compared with extension limits determined from tensile testing equipment. And H:D is often used in Europe to describe formability of plastics for cup applications.

At best, draw ratios represent bragging rights rather than information about the degree of difficulty in forming the parts. Many formers will tell you that parts that have very small draw ratios are much more difficult to form reliably than parts with large draw ratios. And parts with many compartments are far more difficult to form than parts with single compartments, even when the draw ratios of the two types are identical.

[See? Those equations didn't hurt at all, now, did they?] ■

**Keywords:** Areal draw ratio, linear draw ratio, H:D

<sup>1</sup> Ubiquitous: Being present everywhere at once.

<sup>2</sup> Axisymmetric: Having symmetry around an axis.

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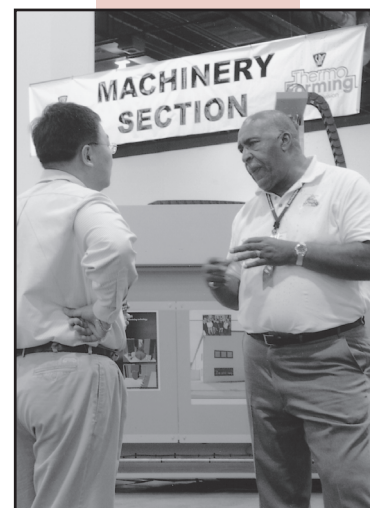


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## BOOK REVIEW



J. L. White and D. D. Choi,  
**Polyolefins: Processing, Structure Development and Properties**, Hanser Gardner Publications, Cincinnati, OH, 2005, 271+xiv pages, \$130.

The University of Akron Polymer Engineering Department has one of the premier polymer research programs in the US. Professor White is one of the founders of the program and his research efforts in polymer characterization, rheological characterization, and twin-screw extrusion are well-known throughout the world. In his latest work, he has teamed with Dr. Choi to review the past and current polyolefin technology. Dr. White's methodical, academic, almost pedantic style is reflected in an extensive review of the history of polyolefin resin production and 929 references, a prodigious number for such a slim volume. The reader may be surprised to find rather extensive references to polystyrene in a polyolefin-only book. But the authors point out that certain forms of polystyrene are crystalline and that the commodity amorphous polystyrene represents a basis for the understanding of polymers prior to crystallization.

The volume consists of eleven chapters – Origins of Polyolefins

(22 pages), Characterization Methods (26), Crystallography of Polyolefins (26), Single Crystals: Structural Hierarchy and Morphology (16), Spherulites and Quiescent Crystallization (16), Polyolefin Copolymers and Blends (14), Polymer Melt Processing, Rheological Properties, and Orientation in the Flowing Polymer Melts (24), Melt Spinning (40), Film Processing and Profile Extrusion (28), Molding (28), and Mechanical Properties of Polyolefins (9).

The reader must keep in mind that this is not an encyclopedic compendium or even a textbook. In fact, it is a modest volume that attempts to cover a vast subject. Tomes have been written on small segments of the subject, some of which have been reviewed in this column. The authors state in the preface that the book is unique in that it treats the characterization and crystallography and the development of polymer structure during fabrication. So, have the authors met their stated goal?

To a very large extent, yes. Although the book is highly technical, there is a good balance between characterization of molecular structure and the interaction between polymer structure development and processing. Process engineers and R&D technologists need to know the interaction between polymer morphology and polymer performance in, say,

sheet extrusion and melt phase thermoforming. This is particularly true for slowly crystallizing polymers such as polypropylene. There is a nice section on structure development in biaxial films, for example. The chapter on molding is terse and not terribly strong, but this is understandable considering the backgrounds of the authors. The discussion on mechanical properties is very brief and deals primarily with fibers and films. As a result, it is of marginal interest to thermoforming product designers.

The book seems quite free from typos. It is not fault-free, however. As an example, the graphics do not seem very uniform. For example, three different lettering styles are used on consecutive figures (9.1, 9.2 and 9.3). And I find two niggling problems with the writing style, in general. It seems to me that the

authors leap back and forth from very simple concepts (molecular weight distribution, filament force balance) to very complex concepts (x-ray defraction crystallography, birefringence) without adequate transitional paragraphs. And I find a problem with the fluidity of the subject matter. While I appreciate that the authors can trace each and every concept back to its origin, the presence of these historical interludes in the midst of each and every topical discussion becomes disconcerting and frankly downright annoying after a while.

Having said that, I like the book. While not every one will want to own it, I think it deserves a place in your plastics R&D bookshelf. I give it four books out of five.

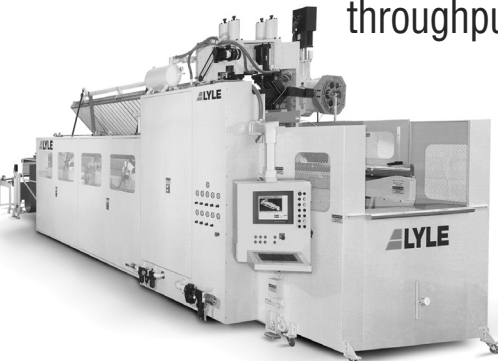
~ Jim Throne



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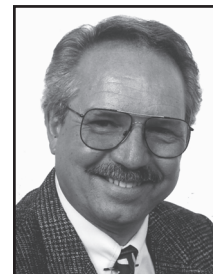
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# Council Report ... Milwaukee, Wisconsin



BY STEVE HASSELBACH, COUNCILOR

**T**his summary is intended to help you review the highlights of the Council Meeting in Milwaukee on Saturday, September 24th, 2005.

The meeting was called to order by SPE President Len Czuba. President Czuba directed Council's attention to a newly created Hurricane Relief Blog on the SPE website, which was created to help SPE members who are victims of this tragedy – <http://www.4spe.org/katrinablog>.

Executive Director Susan Oderwald reported on recent organizational changes at Headquarters. Maria Russo joined the staff as the new Divisions Leadership Liaison, replacing Debra Vogel (Ravetto); Elizabeth Mitchell is the new e-Learning Project Leader, replacing Tara Munsen; and Sara Vokes, Office Receptionist/HR Assistant, is the newest SPE staff member.

Vice President Lance Neward gave an informative report on Parliamentary Procedure in which he explained the role of a proxy as it relates to Council attendance and the proxy's responsibilities.

## Budget

The major Council action was the approval of the 2006 calendar-year budget. A full write-up on the budget was distributed to Councilors and to all Section and Division Board members in August. The budget that was approved calls for gross income of \$5,646,000, direct expenses of \$3,513,000, staff and overhead expenses of \$2,044,000, and a net income of \$79,000.00. Council approved the budget by a clear majority 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://www.4spe.org/communities/leadership/0509/materials.php>.

## Constitution and Bylaws

The following motion was approved:

*Because Council and the Executive Committee requested the Constitution and Bylaws Committee to prepare a new draft of the Society's Bylaws that combines all of the statutes of the Society's existing Constitution and Bylaws into a new document that is more clearly organized and more reflective of the current Council practice, and that document is now ready for consideration, I move that Council approve the amendment of the*

*existing Constitution of the Society by dissolving it.*

As a result of the passage of this motion, a **SPECIAL SPE BUSINESS MEETING WILL BE HELD ON SATURDAY, JANUARY 21st, 2006, AT 10:30 A.M. AT THE ALBUQUERQUE MARRIOTT HOTEL IN CONJUNCTION WITH THE NEXT COUNCIL MEETING IN ALBUQUERQUE, NEW MEXICO.**

**PLEASE BE SURE TO BE IN ATTENDANCE. This special meeting is being called in order to vote on the dissolution of the SPE Constitution. A positive vote will allow us to send this motion out to the entire SPE membership for an all-member vote, as required by the Constitution. As 50 voting members must be in attendance to hold this special meeting, a majority Council participation is necessary!**

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At the Council Meeting in Albuquerque, you will hear a second reading of, and vote on, the adoption of the new SPE Bylaws, which will replace the existing Constitution and Bylaws as soon as the Constitution is dissolved.

#### Section Name Change

Council approved the name change of the Newark Section to the New Jersey Section.

#### Student Chapter

Council voted to charter a Student Chapter at Texas Technical University.

#### Committee Meetings

Thirteen committees met prior to the Council meetings.

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

- a) Sections - A. Arduini
- b) Divisions - J. Griffing
- c) International - J. Ratzlaff
- d) ANTEC - B. Arendt
- e) Publications - E. Coleman

#### Council Committee-of-the-Whole

Barbara Arnold-Feret, Chair of the Committee, conducted the meeting prior to the formal Council meeting.

The next formal Council meeting is scheduled for Saturday, January 21st, 2006 in Albuquerque, New Mexico. ■

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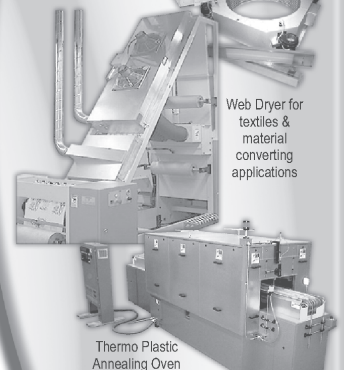
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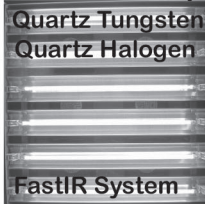
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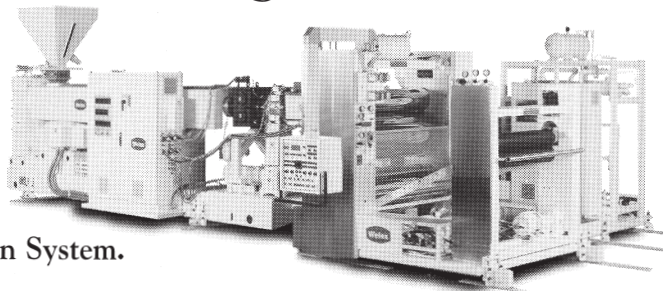


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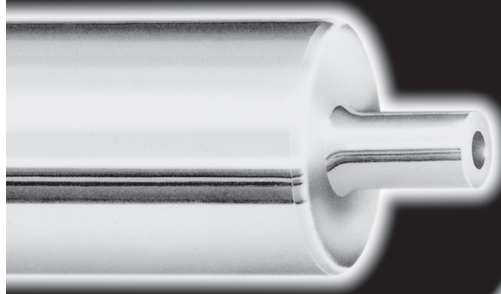
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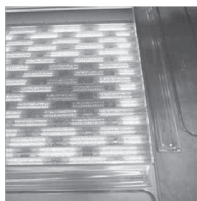


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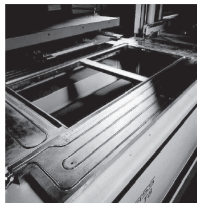
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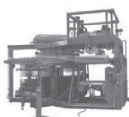


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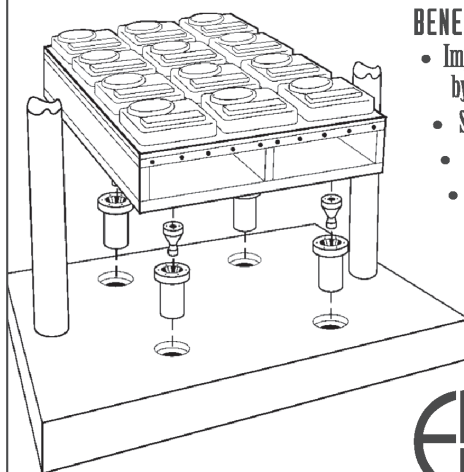
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city:	state:
zip:	country:
Phone/Fax Format: USA & Canada: (xxx) xxx-xxxx All Others: +xx(xx) x xxx xxxx	
<b>Work Phone:</b>	<b>Fax:</b>
<b>Email:</b> <i>used for society business only</i>	
<b>Home Address:</b>	
address:	
city:	state:
zip:	country:
<b>Home Phone:</b>	
(✓) Preferred Mailing Address: <input type="checkbox"/> Home <input type="checkbox"/> Business	

<b>Gender:</b> <input type="checkbox"/> Male <input type="checkbox"/> Female
<b>Birth Date:</b> (mm/dd/yyyy)
<b>Demographics</b>
<b>Job Function</b> (choose only one)
<input type="checkbox"/> Consulting <input type="checkbox"/> Purchasing <input type="checkbox"/> Design <input type="checkbox"/> Quality Control <input type="checkbox"/> Education (Faculty) <input type="checkbox"/> R & D <input type="checkbox"/> Engineer <input type="checkbox"/> Retired <input type="checkbox"/> General Management <input type="checkbox"/> Self-Employed <input type="checkbox"/> Manufacturing <input type="checkbox"/> Student <input type="checkbox"/> Marketing/Sales <input type="checkbox"/> Tech Support <input type="checkbox"/> Other
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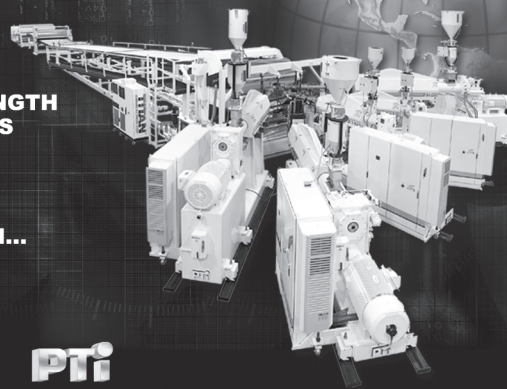
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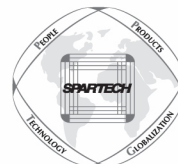
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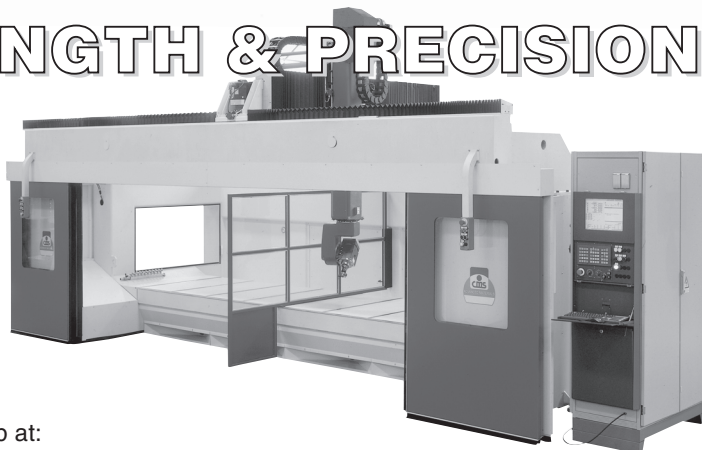
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## **STOPOL, INC. / MAAC SCHOLARSHIP FUND RAISES \$30,000**

**SOLON, Ohio (October 5, 2005)** – More than 350 trade show visitors attended the Sept. 25 Casino Night at the Society of Plastics Engineers (SPE) Thermoforming Division 2005 trade show in Milwaukee, helping Stopol, Inc. and MAAC Machinery raise over \$30,000 for the SPE Thermoforming Division's Student Scholarship Fund. The fund helps solidify the long-term future and viability of the plastics industry by helping develop engineering talent. Solon, Ohio-based Stopol is a leader in arranging the acquisition and sale of production equipment and machinery, businesses, divisions, product lines, and manufacturing licenses in the plastics industry. Headquartered in Carol Stream, Ill., MAAC is one of the top thermoforming machinery companies in the United States, providing a wide array of manufacturing services.

Hosted and sponsored by Stopol and MAAC, Casino Night allowed attendees to experience the thrill and excitement of blackjack, craps and Texas Hold'em while bidding on donated prizes during a live auction. The \$30,000 generated by donors' contributions and Casino Night went directly to the SPE Thermoforming Division's Student Scholarship Fund. "This was the ninth year we sponsored the scholarship fund and the amount of money raised may be largest ever," said Paul V. Alongi, MAAC CEO and founder. "Teaming up with Stopol really paid off. The students who receive these scholarships are the real winners."

The SPE Student Scholarship Fund offers scholarships to students who have demonstrated or expressed an interest in the plastics industry. Applicants must be majoring in or taking courses that would be beneficial to a career in the plastics industry, including plastics engineering, polymer science, chemistry, physics, chemical engineering, mechanical engineering, and industrial engineering.

"We couldn't be happier with the results," said Donald Kruschke, Stopol's Executive Vice President. "The industry really stepped up to the plate with their donations and made a strong statement about how important education is to the future of plastics."

Prizes were donated by plastics industry companies, executives and organizations, including Wilbert Plastics Services Inc., Primex Plastics Corp., Dow Chemical Company, Pelican International, Irwin Research and Development Inc., Modern Machinery, Senoplast USA Inc., Brown Machine LLC, Ex-Tech Plastics Inc., Spartech Corp., G.N. Plastics Company Ltd., Tooling Tech Inc., Sencorp Inc., Solar Plastics Inc., Geiss, New Hampshire Plastics Inc., Lyle Industries Inc., Portage Casting Mold Inc., Plastics Concepts and Innovations LLC.

### **About Stopol, Inc.:**

Headquartered in Solon, Ohio, Stopol is a privately held corporation specializing in arranging the acquisition and sale of production equipment and machinery, businesses, divisions, product lines, and manufacturing licenses in the plastics industry. With unparalleled insight into the business market and the value of potential acquisitions, Stopol takes efficient, tactical approaches to connecting buyers and sellers in the plastics industry. In direct contact with more than 27,000 manufacturers, Stopol serves as a strategic partner for merger and acquisition opportunities, helping companies find cost-effective solutions while maximizing their resources.

### **About MAAC Machinery:**

Headquartered in Carol Stream, Ill., MAAC Machinery provides an extensive array of thermoforming manufacturing services. Founded by Paul V. Alongi in 1982, MAAC is the fastest growing U.S. manufacturer of sheet fed thermoforming machinery. Integrating a world class application engineering staff with a new state-of-the art, MAAC provides an array of thermoforming services including plant assessments, machinery modifications (rebuilt, retrofits and upgrades), training, parts programming and repairs. Comprised of thermoformers, programmers and technicians, MAAC's team of highly trained service technicians is available 24 hours a day to deliver the solutions you need to keep your operations up and running as smoothly as possible. ■

# Letters to the Editor

Dear Gwen,

Thank you very much for taking time out of your busy schedule to answer all my questions prior to the Conference. As this was the first ever conference for MAGI Control, I wanted to make sure I dotted my "I's" and crossed my "T's," especially as an exhibitor.

You had a wonderful staff working with you throughout the conference. They were all very courteous and helpful. I'd especially like to recognize the great work done by Peter Vari and his team (Roger, Steve, Justine, etc.). The set-up and tear-down of our booth was flawless and we could not have done it without them.

The 2005 SPE Thermoforming Conference last week in Milwaukee proved to be very successful for MAGI Control and its first official public demonstration of our MAGI-Therm Industrial Controller.

It was a pleasure to finally meet you and I look forward to working with you again in the future.

Sincerely,  
Gino Lalli  
President  
MAGI Control Inc.

\*\*\*\*\*

Gwen,

I wanted to personally and sincerely thank you for allowing me the opportunity to attend this year's Thermoforming Conference and Exhibition. It was a rare chance to see not only cutting edge technologies, but also to learn from thermoformers from all over the world. Our SPE chapter here at ISU benefits so much from attending conferences such as this one. I was fortunate enough to have attended Jim Throne's "Roll Fed Workshop" and I learned quite a bit from him. He is a great speaker and teacher. I also enjoyed sitting in on Norman Lee's "Product Design and Development Workshop." I think the high point of the weekend came Sunday night when I won a portable DVD player with the money that I won playing blackjack at the Casino

Night. The evening was very fun and the Museum was beautiful. I am definitely looking forward to next year's event. Again, thank you so very much for affording me this unique and worthwhile opportunity. It is an experience that I will not soon forget.

Sincerely,  
Jared R. Bierbaum  
Illinois State University  
SPE Student Chapter

\*\*\*\*\*

Dear Gwen,

I want to thank you on behalf of the Thermoforming Division for another great opportunity to attend the 2005 Annual Conference. My students and I enjoyed attending the James Throne presentation Saturday. We also enjoyed the exhibition – especially the CNC milling machine set-ups. The Taste of Milwaukee – superb.

I was impressed by John Torinus and his story and I always like to hear what Peter Mooney has to say about the global economic picture.

Two special treats this year: 1) the magnificent setting for the awards dinner – not to forget Manfred Jacob's moving acceptance speech, and 2) the very entertaining Casino Night.

Please pass my thanks also to the folks coordinating the grant program. The MAAC ASP machine I was able to purchase thanks to the Division has opened another platform for product development in my lab. Both my students and I routinely use the machine to design prototype products.

Gratefully,  
Lou Reifschneider

\*\*\*\*\*

SPE Thermoforming Division Board of Directors

Good Day,

I attended the 2005 Thermoforming Conference and wanted to thank you and the staff for a magnificent event.

I have been out of the industry for a number of years and found

the Conference a welcome sign that there are people out there who take thermoforming as a serious business. I can only hope that future conferences have a broader scope. Those of us in the high speed thin sheet roll feed part of the industry felt like Oliver Twist asking "Please sir, can I have some more?"

As for you and the event itself, you can be proud of your hard work and the final results. The presentation dinner on Sunday night was particularly notable.

Rich Motill  
Proex Inc.

\*\*\*\*\*

SPE Thermoforming Division Board of Directors

It is with utmost gratitude and appreciation that I write this note. The students, faculty and administration of the plastics engineering technology program at Pittsburg State University would like to thank you for inviting us to participate in the 2005 Conference in Milwaukee. It was a very rewarding experience for our students, Lucas Stallbaumer, Adienne Wiltse, Rama Etekallapalli, Bernice Nzioki, Kim Acinger and myself, who attended the conference. The innovations in plastics thermoforming, processes and materials, plant tour, and the associated networking were some of the gains achieved at this year's conference, and we are very grateful that you allowed us the opportunity to be part of this.

May you continue to experience growth and prosperity, and it is our hope at PSU that you will continue to value the partnership we have with you. We look forward to future activities with you. Best regards.

Chris Ibeh, Director  
Center for Nanocomposites and  
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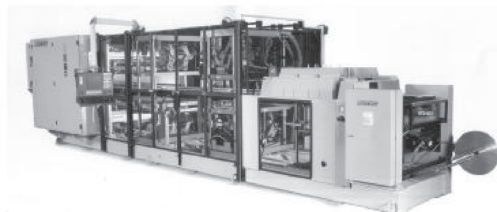
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