

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 AWARD OF EXCELLENCE"

Thermoforming Division

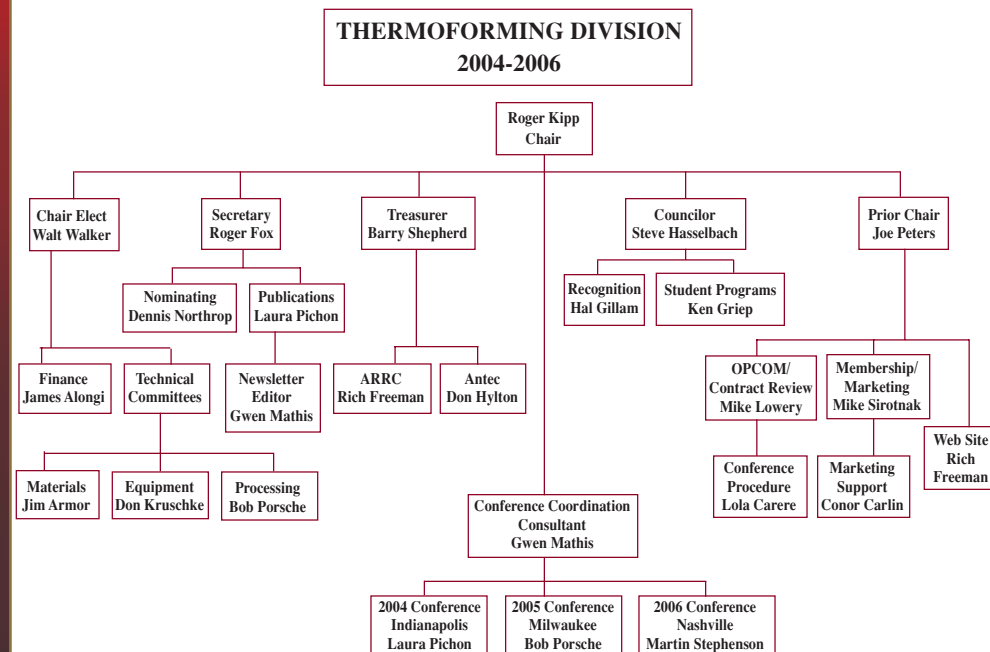
Our mission is to facilitate the advancement of thermoforming technologies through education, application, promotion and research.

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**LEAN MANUFACTURING AT
PRODUCTIVE PLASTICS**
A Customer-Driven Approach

"ARTIFICIAL NEURAL NETWORKS TO CHARACTERIZE ABS, HIPS"
BY F. ERCHQUI AND A.N. KANDIL, QUEBEC – see page 10

LEAD TECH ARTICLE

Web Site: www.thermoformingdivision.com

CHAIRMAN'S CORNER

BY ROGER KIPP, CHAIR



IT'S ABOUT PLASTICS!

In October I attended the SPE National Council Meeting in Cleveland. This Forum is the opportunity for divisions and sections to steer the future of the Society. Hundreds of hours of committee and sub-committee time is dedicated to "Good Works" for the Society.

Focus on SPE products, division officer training, GAP analysis, Pride report revisions, restructuring division boards and numerous other administrative topics consume many of these hours. Concerns with section and division associations as well as value of membership were prevalent both in committee and social gatherings.

I completed several days of observation and discussion around the many pieces of a foundation for why we should be members of the Society of Plastics Engineers, and the effort to continue to define the value of membership. These committee discussions and actions were all well thought and well intended. But I could not help but think that we failed to make a case ...

WHAT IS THE VALUE OF SPE MEMBERSHIP? IT'S ABOUT PLASTICS!

We as plastics engineers must demonstrate to the global markets and to public policy leaders the unique and vital role plastics manufacturing plays in product development as well as the U.S. economy.

A strong National/International organization focused on the technical growth and equally important marketing of the importance of that technology is vital to the demonstration of the value of the plastics' industry. As plastics engineers, our combined resources through SPE will support our future and the future of our industry.

Thermoforming Division members have recently received the ballots for Board position elections. This is your opportunity to support the value of membership by placing your well thought vote for individuals you believe will continue the support and promotion of our industry. Please complete your ballot and return by the January 31, 2005 deadline.

The Thermoforming Industry has come of age. However, as it was pointed out at the SPE European 2004 Thermoforming Conference, only a small number of the potential customer base knows anything about our process.

The Thermoforming Division leadership with the focused effort of Jack Hill, Walt Walker, Walt Speck and the marketing committee has completed the "What Exactly is Thermoforming?" DVD included in this quarterly edition for our division members. We hope that you will share this presentation in the support of continuing education on our process.

As members of the Society and the Thermoforming Division, it is the responsibility of each one of us to promote and maintain the growth of plastics and thermoforming. To accomplish this we must manage the relationship with that potential customer or group. Managing these relationships requires:

- 1) Cultivation - Building positive perception
- 2) Acquisitions - Closing the deal with that perspective account
- 3) Development - Generating repeat thermoforming programs
- 4) Retention - Build loyalty to our process and programs
- 5) Growth - Increased use of our products

The keystone to these relationship stages is service. As SPE National, the Thermoforming Division, our companies, and individuals we are all involved in service marketing. Most of our experience and education is based on product marketing. The thermoforming process of formed and trimmed components has minimal product distinction. As product marketers, we can either reduce price or more appropriately add value. Adding value relates to providing service.

The ability to cultivate the thermoforming process will come down to our vision of the added value service provided from our industry. This responsibility, of cultivating this vision, is not limited to the hands of individual engineers. It is not limited to the thermoforming processors. It is, however, the responsibility of all individuals and companies participating in the total thermoforming supply chain; equipment manufacturers, resin processors, extruders and thermoformers.

The Thermoforming Division Executive Committee is administering a division structure that involves all of these players. It is our vision that the service philosophy must be in balance as the baton is handed throughout our thermoforming industry team.

With focused cultivation, this group will see the successful acquisition of new markets and continued development, retention and growth.

SPE membership assures our chance to have input into the process of building a positive perception of acquiring more believers, developing further opportunity, with retention and growth of our thermoforming industry.

If you are not currently a member of SPE and the Thermoforming Division, I urge you to join us, and please feel free to contact me at rkipp@mcclarinplastics.com and remember ...

IT'S ABOUT PLASTICS!

Roger C. Kipp, Chairman

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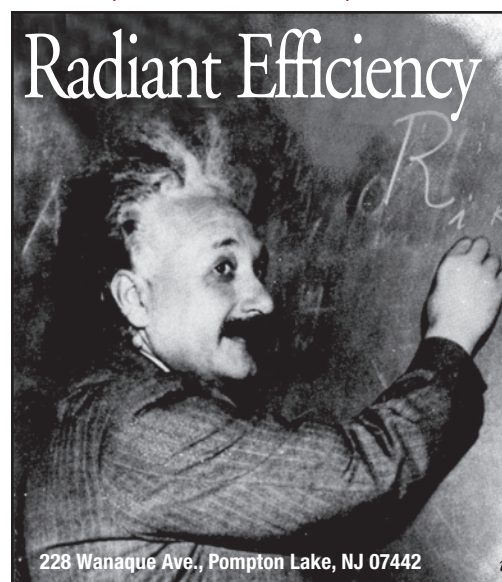
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TFQ is an "equal opportunity" publisher! You will note that we have several categories of technical articles, ranging from the super-high tech (sometimes with equations!), to industry practice articles, to book reviews, how to articles, tutorial articles, 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.]

THERMOFORMING[®] QUARTERLY

A JOURNAL PUBLISHED EACH CALENDAR
QUARTER BY THE THERMOFORMING DIVISION
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The Many Challenges Ahead!



BY MIKE SIROTNAK, MEMBERSHIP CHAIRMAN

Being a member of the only thermoforming exclusive group does come with some responsibilities. We do have the challenge to do the right things to protect and grow our industry. That is why I am so proud to be a member of the Thermoforming Division and an active member of the Board of Directors. Enclosed in this issue is an educational DVD that gives the viewer a 6-minute voyage of our great industry. This DVD can be used in the classroom to educate the next generation or can be brought to the boardroom to have a customer consider thermoforming for their product. Fellow Board member Jack Hill spearheaded this project and did an outstanding job.

As a tight family-oriented group, I feel it is imperative that we do what we can to support our own. In a global world it is important to remember that this industry

has grown because of the networking that we do together. Whether you are purchasing a machine, plastic, molds, heaters or whatever, remember which companies support our industry and which companies are only in it for the

grow this industry. There are still a lot of good products being built right here in our own backyard by Division supporters.

This Division continues to do great things: DVD, scholarships, *Thermoforming Quarterly* and the Conference. Milwaukee is looking great and Bob Porsche is doing an outstanding job. Our Board of Directors continues to push itself to come up with new innovative ways to educate and grow the industry. We urge you to consider joining us for a meeting and con-

sider joining the Board. As always, feel free to contact me with any questions regarding your membership or the Division itself.

Happy New Year and God Bless America! ■



MEMBERSHIP REPORT as of 1/4/05

Primary Paid	1,200
Secondary Paid	427
Total Membership	1,627
Goal as of 6/30/2005	2,000

money. We see a lot of "new" companies popping up each year; we need to consider if these companies are good for our industry. Many of us run our own businesses and do not get to be involved in the day-to-day decision-making on where to purchase every single item. This does not excuse us from supporting the companies that have helped



To Our New Members

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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?

THERMOFORMER OF THE YEAR

CRITERIA FOR 2006

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

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

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

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

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STRONGER THAN EVER

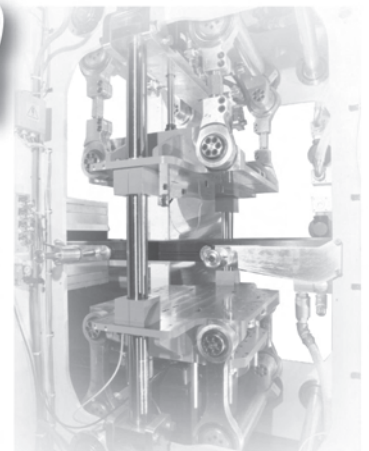


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1983

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Auto-Vac Corp.

1984

Gaylord Brown
Brown Machine

1985

Robert L. Butzko
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1986

George Wiss
Plastofilm Industries

1987

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1988

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1989

Jack Pregont
Prent Corporation

1990

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1991

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Mold Systems Corp.

1992

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1993

John Grundy
Profile Plastics

1994

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Dow Chemical

1995

James L. Blin
Triangle Plastics

1996

John Griep
Portage Casting & Mold

1997

John S. Hopple, Hopple Plastics

1998

Lyle Shuert, Shuert Industries

1999

Art Buckel
McConnell Company

2000

Dr. James Throne
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2001

Joseph Pregont, Prent Corp.

2002

Stephen Sweig, Profile Plastics

2003

William Benjamin,
Benjamin Mfg.

2004

Steve Hasselbach, CMI Plastics

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: _____

Street Address: _____ City, State, Zip: _____

Telephone: _____ Fax: _____ E-mail: _____

Biographical Information:

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

Individual Submitting Nomination: _____ Title: _____

Firm or Institution: _____

Address: _____ City, State, Zip: _____

Phone: _____ Fax: _____ E-mail: _____

Signature: _____ Date: _____

(ALL NOMINATIONS MUST BE SIGNED)

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

THERMOFORMING DIVISION SPRING 2005 BOARD MEETING SCHEDULE

May 4 – 8, 2005
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Wednesday, May 4, 2005

Executive Committee and Technical Chairs
 Arrive

Thursday, May 5, 2005

8:30 am - 9:30 am - Technical Chairs Meet
 with Executive Committee - Boardroom -
 Sheraton Four Points

9:30 am - 5:00 pm - Executive Committee
 - Boardroom - Sheraton Four Points

Friday, May 6, 2005

8:00 am - 3:00 pm - Committee Meetings -
 Boardroom - Sheraton Four Points

3:00 pm - 4:00 pm - Tour National Plastics
 Museum

Dinner on Your Own

Saturday, May 7, 2005

7:30 am - 8:30 am - Breakfast - National
 Plastics Museum

8:30 am - Noon - Board of Directors'
 Meeting - National Plastics Museum

12:00 pm - 1:00 pm - Lunch - National
 Plastics Museum

1:30 pm - Board Bus at Sheraton Four
 Points - Travel to Universal Plastics for
 Plant Tour

4:00 pm - 5:00 pm - Hosted Cocktail
 Reception at Colony Club - DRESS
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5:00 pm - 6:30 pm - Dinner - Colony Club
 7:00 pm - Bus Trip back to Sheraton Four
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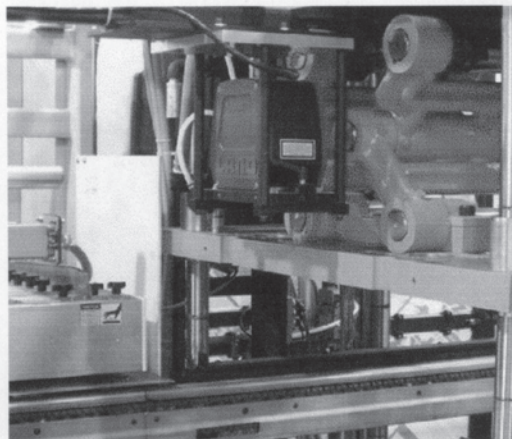


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Lean Manufacturing at Productive Plastics

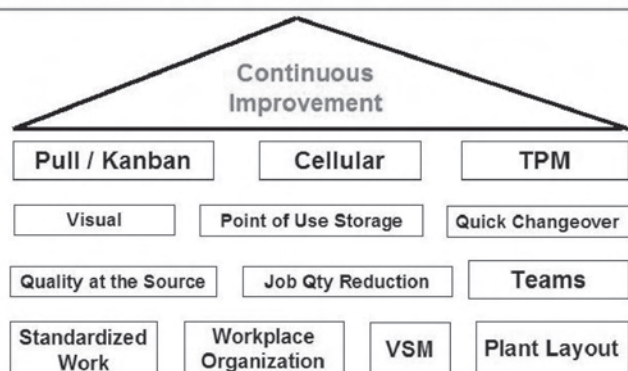
A Customer-Driven Approach

Gerald J. Bose and John Zerillo, Productive Plastics, Mt. Laurel, NJ

When the concept of lean manufacturing was presented to the management team at Productive Plastics, Inc. (PPI), many of the common obstacles typically raised by shop personnel were voiced. Comments like “Lean is not for us,” “We are a built-to-order house,” and “we don’t make 1,000 widgets a day” were the norm and needed to be overcome before any new corporate management philosophy and practice could be instilled.

In contrast, the executive team felt strongly that lean techniques would work well in our custom thermoforming job shop environment. In fact, it is this new philosophy that PPI is busy implementing throughout the business. The challenge is creating awareness with our customers, employees and suppliers, training associates in all aspects of lean techniques and creating an environment conducive for change within our two manufacturing facilities in Mount Laurel, NJ and Greene, NY.

Lean Building Blocks



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Lean manufacturing can be defined as the systematic elimination of waste throughout the operation. “Waste” is any activity that does not add value to the product. Common waste components are inventory, moving, transporting, defects, waiting, overproduction, underutilized people and non-value added processing.

Rather than attacking the entire business, we first selected a segment of business as our pilot,

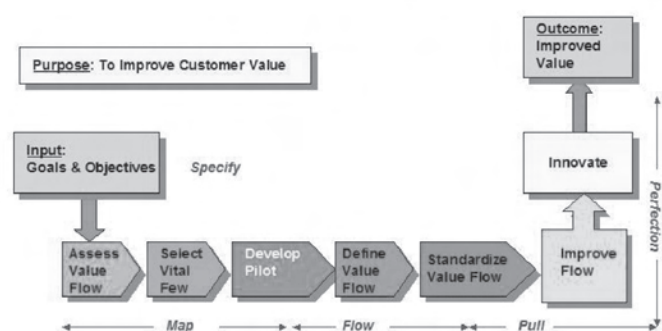
which represented around 20% of annual revenue spread over approximately 100 part numbers. Each plant produced roughly 50% of this demand, so total involvement would be assured. Annual volumes for each part ranged from a maximum of 2100 to a minimum of 10.

Our customer, who was pushing for reduced lead times and inventories, had clearly stated their goal: reduce purchase order lead time from the standard 8 weeks to 5 business days. This would call for releasing product from a local third-party warehouse on a daily basis ultimately reducing their inventory levels to 5 days. The incentive for reaching this goal was significant: customer would pay PPI 5 days after receipt of order (ARO).

Finding a customer who was actively seeking suppliers who would partner with them to “lean” the supply chain was critical. As in most good lean pilots we sought the customer out to specify their goals and objectives, next we mapped the process and the pilot out carefully, then began to work on creating the streamlined flow of products and information. Currently, we are standardizing the flow to create “pull” as shown in the figure below.

Lean Projects

Implementation Overview

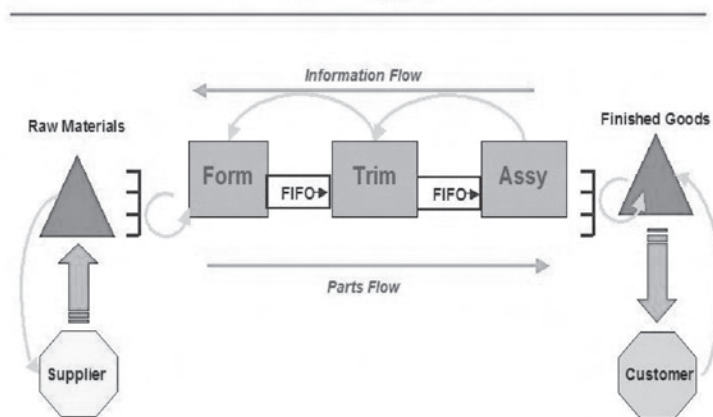


We identified three key success factors required to accomplish our goal. First, we needed to build a partnership with our customer that required them to provide access to their daily demand. Prior to this, they had only provided monthly forecasts

by part number. PPI was required to have the upcoming month of supply in stock by the end of the proceeding month. Obviously, this practice created excess inventories and a misallocation of resources.

Secondly, to be successful our sheet suppliers and prime sub-contractors would need to reduce their lead times significantly. Since the part numbers we selected comprised multiple sheet sizes and colors, many production runs were as low as 250 pounds, which created production inefficiencies for our sheet extruders. So, it was critical that we bring our suppliers into the value chain and share forecasts and schedules so they could better plan for our requirements. One side benefit of providing this information was that it allow for more consolidated production runs, enhanced efficiencies and lower inventories for our sheet extruder.

The Basic Supply Chain



Finally, we had to apply “lean thinking” to the administration component of our plan. Customer service had to gain a keener awareness of customer demand in order to shorten reaction times to unexpected changes in the forecast/build plan. This meant a more frequent, closer review of the demand/supply projection for all critical parts. In turn, this allowed Purchasing and Production Control to react in short order. To fully leverage the opportunity, we had to streamline and improve our systems for handling orders, demand planning and shop scheduling and PO releases.

As we launched our pilot, we set a goal to reduce total lead-time from receipt of order through invoice from 8 to 4 weeks and began to identify the following actions for success:

- Identify and train group leaders and dedicated set-up personnel
- Produce “golden parts” that meet customer specifications

- Manufacture “mistake-proof” check fixtures to ensure operators can easily and efficiently assure part quality conformance
- Ensure production methods and bills of material have a high degree of accuracy
- Identify and maintain dedicated staging areas for tooling, fixtures, cutters, hand tools, etc. to reduce changeover times
- Reorganize our facilities to provide improved product flow and optimize visibility for team leaders and operators

We are confident the results will be a much more profitable business segment that will specialize in small lot production, be flexible to changing customer demand, have shorter lead times and improved quality and on-time delivery. To be sure, expectations are extremely high at PPI as we embark on this journey. We are encouraged by both the challenges and the results, thus far, with the pilot program where we are focused on the following goals:

- Reduced setup times by up to 75%
- 50% reduction in lead times
- 70% increase in throughput
- 25% reduced WIP and Finished Goods Inventories
- 98% on-time delivery
- 98% quality conformance
- 10% cost reduction

Summary/Conclusion

The lean journey is long and rife with roadblocks, which can be expected any time a company adopts a new business model and embraces change as a way of life. Despite the “bumps along the way,” the Executive Team is convinced that Lean is the way to go.

What makes Lean different than other business improvement processes is that you involve the customer right from the beginning. Since, the customer is on board and demanding change as quickly as it can be realized, turning back to “the way we’ve always done it” is simply not an option. ■

Gerald J. Bose is Vice-President, Manufacturing at Productive Plastics, Inc. and leading the lean transformation. John Zerillo is Vice-President, Sales at PPI and is leading this pilot program.

Neuronal Networks Application for Characterization of Softened Polymers¹

BY F. ERCHIQUI AND A.N. KANDIL

UNIVERSITE DE QUEBEC ABITIBI-TIMASCAMBINQUE, QUEBEC CANADA

Abstract

Recent progress in computer-aided polymer processing analysis demonstrates the need for accurate description of the material behavior under the conjugated effect of applied stress and temperature. In this work, we are interested in the characterization of circular thermoplastic membranes, ABS and HIPS thermoforming grade, under biaxial deformation using the bubble inflation technique. Hyperelastic (Mooney-Rivlin, Ogden) models are considered. First, the governing equations for the inflation of a flat circular membrane are solved using a dynamic finite element model (triangular membrane elements), and thereafter, a neuronal algorithm is employed to determine the materials constants. Moreover, the influence of the Mooney-Rivlin and Ogden constitutive models on the thickness and the stress distribution in the thermoforming sheet are analyzed.

Introduction

Deformation of a flat polymer sheet clamped around its edges into a 3D shape is the main feature of the thermoforming process. Generally the deformation is very rapid, is of a non-uniform multi-axial type, and takes place at a forming temperature that is above the glass transition temperature. The neuronal networks approach [8] is employed to determine the material constants. The experimental set-up used for this work has been described elsewhere [3]. The pressure inside the bubble and the height at the hemispheric pole are recorded during the experiments and are used to

solve the non-linear equations governing the dynamic inflation process [8]. In this work we use this technique to describe the behavior of a sheet of an ABS and of an HIPS thermoforming grade heated at 145°C and 150°C, respectively, using both the Mooney-Rivlin and Ogden models. Then a dynamic finite element analysis is carried out to compute the time evolution of the bubble polar height for a given air flow rate. The principal extension ratios as well as the stresses are also calculated as a function of time.

Experimental

The materials considered in this work are the ABS and the HIPS. The initial sheet thickness is 0.46 mm for ABS and 0.97 mm for HIPS. The exposed circular domain of radius $R_0=3.175$ cm is heated to the softening point inside a heating chamber using infrared heaters. When the temperature is quite uniform over the flat sheet, the inflation is started using compressed air at a controlled flow rate. In most inflation tests, the experiment ends when the bubble bursts. The bubble pressure, its height at the pole and time are recorded simultaneously using a video camera and a data acquisition system.

Theory

The bubble inflation process is simulated using the dynamic finite element method. The mathematical formulation of the problem closely follows the approach detailed by Erchiqui [8] and is not repeated here. The governing equations of the inflation problem are solved by total Lagrangian finite element method using membrane triangular elements and explicit finite difference scheme for time integration to describe the material behavior.

¹ This paper was presented at ANTEC 2004, Chicago. It has been reviewed and edited. All alterations to the paper are the responsibility of the Technical Editor.

The Money-Rivlin [6] and Ogden [7] models are used.

Mooney-Rivlin:

$$W = \sum_{i,j} C_{ij} (I_1 - 3)^i (I_2 - 3)^j$$

W is the strain energy function, I_1 and I_2 are the primary and secondary strain tensor invariants given by:

$$I_1 = \sum_{i=1,3} \lambda_i^2 \text{ and } I_2 = \sum_{i=1,3} \lambda_i^{-2}$$

where $\lambda_1, \lambda_2, \lambda_3$ are the principal stretch ratios in the longitudinal, azimuthal, and thickness directions of the membrane and are related by the incompressibility condition $\lambda_1 \lambda_2 \lambda_3 = 1$. C_{ij} are material constants. Two constants, C_1 and C_2 , are used here.

Ogden:

$$W = \sum_i \frac{\mu_i}{\alpha_i} (\sum_j \lambda_j^{\alpha_i} - 3)$$

Where α_i and μ_i are the material constants. The use of three sets of constants ($I=3$) in the series is usually sufficient to describe the material nonlinear response under deformation.

The Neural Networks Approach


Artificial Neural Networks (ANN), whose operation is based on certain known properties of biological neurons, comprise various architectures of highly interconnected processing elements that offer alternatives to conventional computing approaches. They respond in parallel to a set of inputs and are more concerned with transformations than algorithms and procedures. They can achieve complicated input-output map-

pings without explicit programming and extract relationships (both linear and nonlinear) between data sets presented during a learning process. ANNs are massively parallel, so that, in principle, they are able to respond with high speed. Furthermore, the redundancy of their interconnections ensures robustness and fault tolerance, and they can be designed to self-adapt and learn.

In this proposed work, these ANN strengths are exploited to model the relationship between the mechanical parameters, the experimental height, h , and the corresponding pressure, P . The well-known multi-layered perceptron (MLP) is used as a pri-

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mary test in this application. More complex and advanced ANN types will be tested later for better results. The ANN used consists of an input layer, one hidden layer, and an output layer. In the output layer, only one neuron is needed to anticipate the mechanical parameters, for a given pressure, P , while the input to the ANN is the variance of the corresponding pressure.

Simulation data are used for training the ANN. However, experimental data are used for testing the ANN. Hence, the testing data were not used during the training process. All inputs are normalized before training. The well-known Generalized Delta Rule (GDR), also called error back propagation algorithm, is used to train the layered perceptron-type ANN. However, instead of applying the steepest descent method characterized by slow convergence and long training time, an approximation of Newton's method called Levenberg-Marquard algorithm is used. This optimization technique is more powerful than gradient descent, but requires more memory. The theory behind this approach may be found in [9].

Results

Theoretical material constants for Mooney-Rivlin are obtained by using the neuronal networks approach for ABS at 145°C and HIPS at 150°C. The material constants are given in Table 1. For the 6-parameter Ogden model, we had difficulty identi-

Table 1

HIPS and ABS material constants at 145°C for Mooney-Rivlin models

HIPS: $C_1=0.085$, $C_2=0$ ABS: $C_1=0.230$, $C_2=0$

Table 2

HIPS material constants at 145°C for the Ogden model

$\mu_1 = +0.17435$ MPa $\alpha_1 = +1.85226$
 $\mu_2 = +0.10469$ MPa $\alpha_2 = +0.01498$
 $\mu_3 = +0.52915$ MPa $\alpha_3 = -0.02208$

fying all values using the neuronal networks approach. For this case, the air bubble inflation technique [1,2] was used to fit the constitutive models. The material constants for Ogden model are given in Table 2 for HIPS and Table 3 for ABS.

Table 3

ABS material constants at 150°C for the Ogden model

$\mu_1 = +0.146913$ MPa $\alpha_1 = +0.52668$
 $\mu_2 = +0.3661$ MPa $\alpha_2 = +1.91694$
 $\mu_3 = +0.0293$ MPa $\alpha_3 = -0.079$

Figures 1 and 2 show experimental measurements with numerical curves for Mooney-Rivlin and Ogden models, respectively. The error on the measurements is of the order of 10%. It is noted that when the maximum pressure is reached, the bubble height is about equal to the initial membrane radius. Beyond this critical point, the bubble height increases rapidly while the pressure falls.

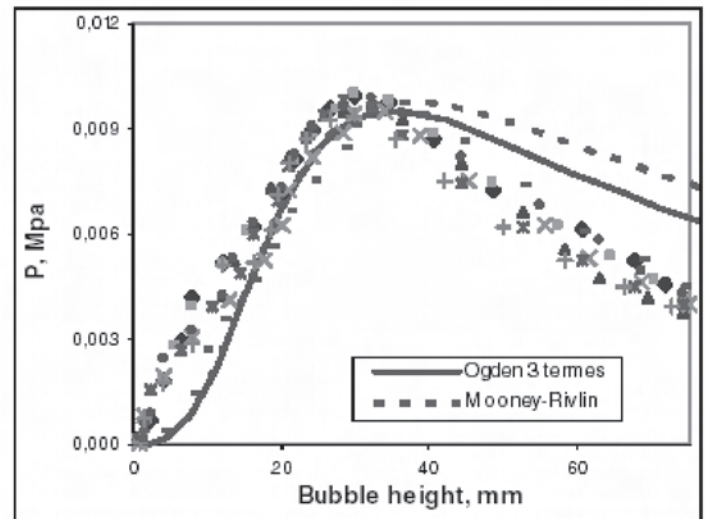


Figure 1. Experimental pressure v. bubble height, HIPS.

Thermoforming Application

As with the circular viscoelastic membrane blowing application of the previous section, in this section, we also use the dynamic approach with a load applied in terms of the linear air flow rate, to study the thermoforming of a container made of ABS or HIPS material. The geometries of the mold and the sheet are marked with a grid using the triangular elements membranes. The initial sheet configura-

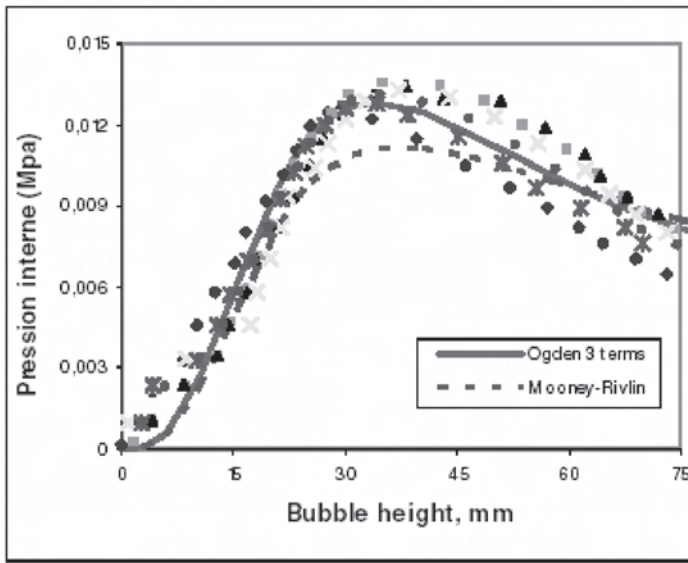


Figure 2. Experimental pressure v. bubble height, ABS.

tion is a rectangular sheet with a length of 25.4 cm, a width of 15.24 cm and a uniform thickness of 0.16 cm and its edges are considered as fixed. In this paper, we present a comparative analysis of the thickness and the stress distribution in the thermoforming sheet for the hyperelastic behaviour (Mooney-Rivlin, Ogden). The materials parameters used for these materials are given in Tables 1 to 3.

For the contact of the preform and the mold, we consider the assumption of sticking contact, because it is estimated that the polymer cools and stiffens quickly and that the pressure of working is not sufficient to deform the part of the sheet that is in contact with mold. Figures 3 and 4 present two different views of the sheet mesh deformation process. Figure 3 presents the evolutions of the ($\lambda_1, \lambda_2, \lambda_3$) extensions at 0.10 second, at the time of working of the formed polymeric part using the Ogden model (HIPS). Figure 4 presents the different views of the deformations distribution, at the end of deformation of the thermoformed part for ABS using the Mooney-Rivlin model.

In Figures 5 and 6, we present the final thickness distribution for ABS and HIPS materials on the half-planes of symmetry XZ and YZ in the thermoformed container for the Mooney-Rivlin and Ogden models. According to these figures, we observe a maximum thinning of 10%, which is reached at the respective positions of 8.01 cm and 18.07 cm. In the center of the lower part of the part, the thinning is 32.5%. These thinnings are almost similar

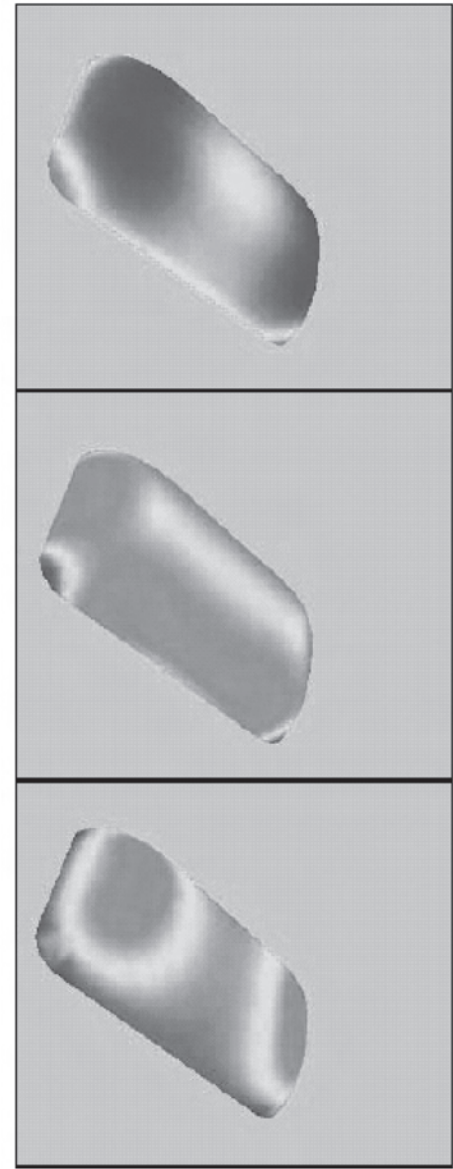


Figure 3. Steps of sheet deformation ($\lambda_1, \lambda_2, \lambda_3$), Ogden model at $t=0.10$ sec for HIPS.

to those obtained with the Mooney-Rivlin and the Ogden model.

In thermoforming numerical simulation, the thickness prediction is an important goal but the stress estimation is also helpful for part design. Indeed, the prediction of the residual stress and the shape stability of the part are strongly related to the estimated stress. In this section, the stress prediction obtained from the investigated constitutive models is discussed. The localized thinning effect of the deformed membrane is generally accompanied by the increase in the Cauchy stresses or the true stresses of the material. Figures 7 and 8 present the final von Mises stresses distribution, as pre-

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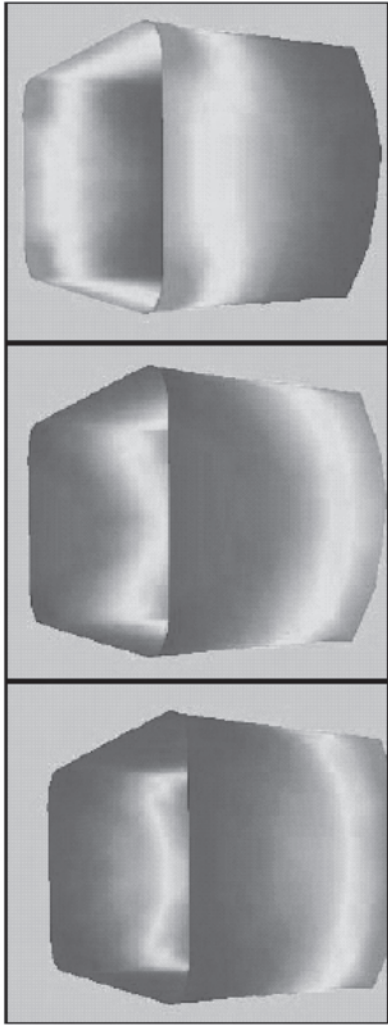


Figure 4. Distribution of extension after inflation for ABS with Mooney-Rivlin model.

dicted by using different constitutive models, on the XZ and YZ halfplanes of symmetry in the thermoformed container.

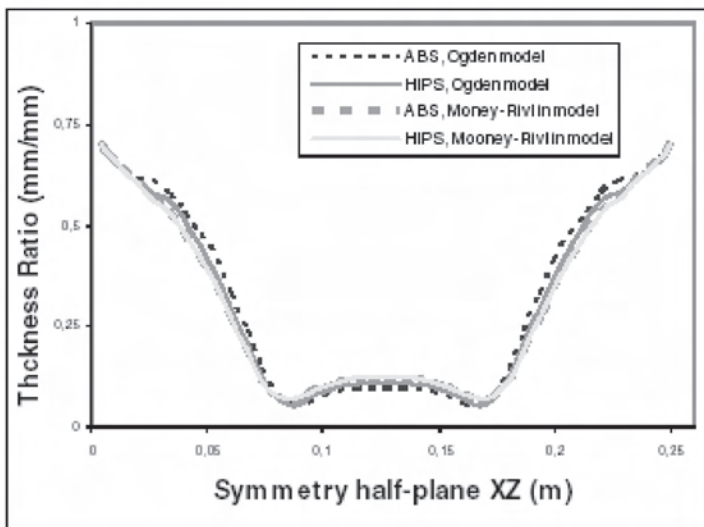


Figure 5. Thickness distribution, symmetry plan, XZ.

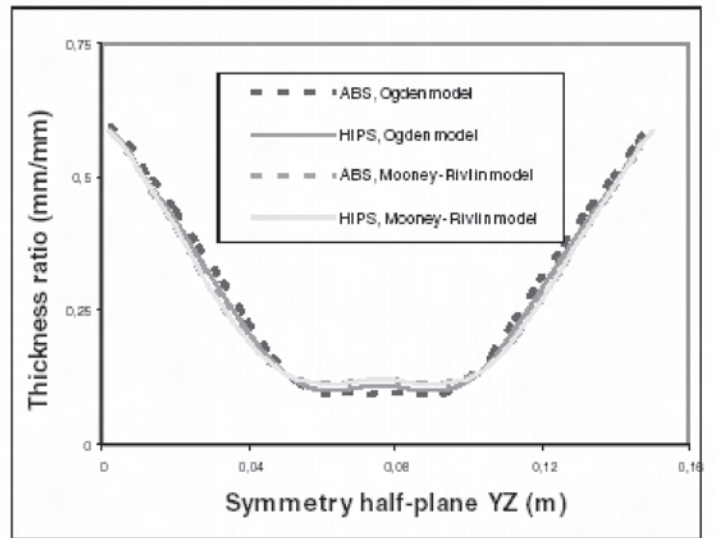


Figure 6. Thickness distribution, symmetry plan, YZ.

Conclusions

The behavior of a thermoplastic circular membrane was investigated both experimentally and numerically. The neuronal networks approach is employed to determine two constants of Mooney-Rivlin model. For the Ogden model, the theoretical material constants are obtained by fitting pressure deformation experimental data. The two models give different results when the bubble pressure level is close to the maximum pressure reached during experiments.

Also, in this work, we have presented the application of a dynamic finite element approach based on the total Lagrangian formulation for simulating the response of isotropic, incompressible ther-

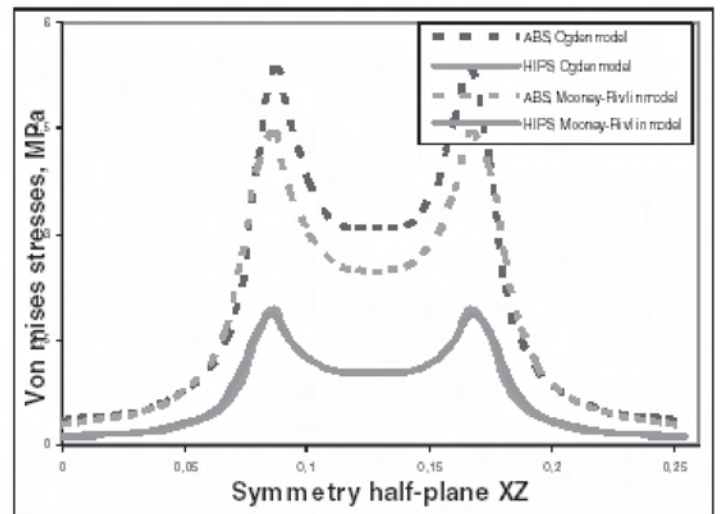


Figure 7. Von Mises stress distribution, symmetry plan, XZ.

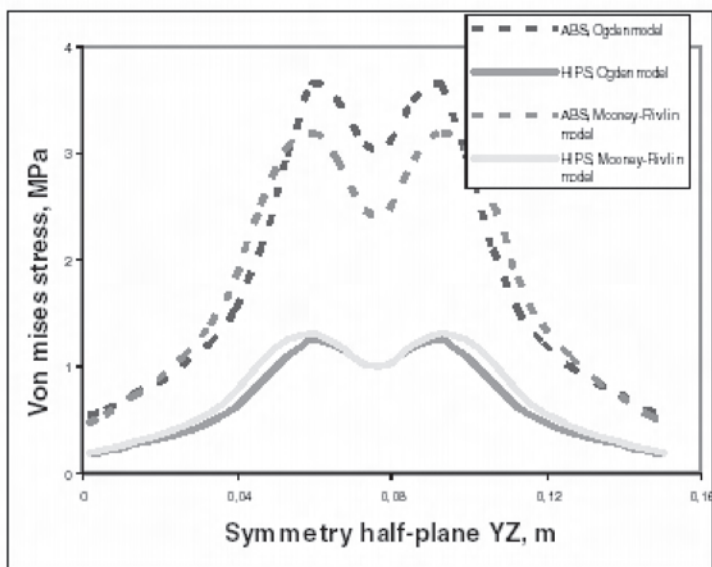


Figure 8. Von Mises stress distribution, symmetry plan, YZ.

moplastic materials during thermoforming process. The forming load function is defined in terms of gas flow rate instead of static pressure. Moreover, we have simulated the thermoforming of a rectangular container made of ABS and HIPS material and studied the influence of hyperelastic (Ogden, Mooney-Rivlin) constitutive laws on the thickness distribution of this thin part, by varying the air flow loading distribution.

The results obtained have highlighted the importance of applying the loads when expressed in terms of air flow instead of classical pressure for

efficiently describing the response of thermoplastic membrane. These preliminary studies are essential steps towards the full achievement of our mid-term goals of performing and developing tools for modeling and simulation of thermoplastic forming processes, as related in particular to the extrusion-blow molding and thermoforming processes.

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INDUSTRY SUPPORT HELPS COLLEGE PROMOTE PLASTICS INDUSTRY CAREERS

Pennsylvania College of Technology is embarking on a project to build interest among high school students for careers in the plastics industry.

With financial support from some Pennsylvania companies and an industry group, Penn College has purchased four pieces of “tabletop” plastics-manufacturing equipment that demonstrate the fundamental processes used in the industry: an injection molding machine, a blow molding machine, a thermoforming machine and a rotational molding machine.

The equipment has been installed on carts, which also will carry related tools and materials. The machines will be rotated among high schools and vocational-technical schools in Pennsylvania to give students hands-on experience with the basic tools, processes, and materials of the plastics industry.

Over the summer, faculty in the College’s Plastics Department held training sessions on the main campus in Williamsport, showing teachers from several high school and vocational-technical schools in north central Pennsylvania how to use the equipment. The program will expand later to include schools from other parts of the state.

Penn College is one of a handful of colleges and universities in the nation with a certified program in Plastics and Polymer Technology. Graduates find excellent career opportunities, but industry experts say there are not enough students entering the career field. Pennsylvania is home to nearly 1,500 plastics companies.

“The plastics industry continues to grow in Pennsylvania,” said Dr. Lawrence J. Fryda, dean of industrial and engineering technologies. “Penn College hopes to help high school students become more aware of the employment opportunities in this field and the technical skills needed for success.”

Startup costs for the initiative were offset by generous donations from an industry organization, the Society of Plastics Engineers (SPE) Foundation and SPE’s Thermoforming Division; and eight companies: Alcan Cable, PPL Corp., Arrow International Inc., Washington Penn Plastic Co. Inc., McClarin Plastics Inc., West Pharmaceutical Services, Inc., Quadrant Engineering Plastic Products, Double-H Plastics, and Kensey Nash Corp.

Penn College, a special mission affiliate of The Pennsylvania State University, also operates the Plastics Manufacturing Center, which works with industry to help solve product-development challenges.

Plastics and Polymer Technology at Pennsylvania College of Technology is one of only five plastics programs in the nation that is recognized by the Accreditation Board for Engineering and Technology. This endorsement from the leading authority in technology education results from the department’s extensive array of industrial-size plastics processing equipment, modern laboratory facilities, highly credentialed faculty with lots of real-world experience, and a comprehensive curriculum that balances classroom and hands-on time.

The department has three full-time faculty members:

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The department offers two degrees:
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Graduates from these programs are in high demand to fill plastics industry career positions in manufacturing operations, process technology, supervision, research and development, product and machine design, and many more. Starting salaries range from approximately \$35,000 to \$45,000. Graduates of the department are currently employed at companies across Pennsylvania and the country, including Honda, Toyota, General Electric, DuPont, Tyco, Owens-Illinois, Graham, Atofina, Truck-Lite, West Company, and Alcan.

For more information on Penn College, contact the Plastics & Polymer Technology Department, Breuder Advanced Technology & Health Sciences Center, Room E134, Pennsylvania College of Technology, Williamsport PA, www.pct.edu or plastics@pct.edu. ■

Students at Warrior Run High School work with the Penn College thermoforming machine.



Energy Units in Thermoforming

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

Thermoformers pay utility companies for the energy needed to heat plastics to forming conditions. Table 1 gives conversion units for natural gas and propane energy (and heating oil) to electrical energy.

In the U.S., we typically use British Thermal Units or Btu to determine the amount of energy needed to heat a sheet of plastic to the forming temperature. We size our electric heaters in kW. We buy our natural gas in cubic feet and our propane by the gallon. Conversion between units can often be a problem. For example, the energy from one 10 kW heater will boil 28.5 U.S. gallons of water, starting from room temperature, in one hour. That's about 34,000 Btu.

Table 2 relates the consumption of 100,000 Btu to other energy sources.

But conversion of units is usually incomplete unless we add in energy costs. Consider the case where electricity costs 7.3 cents/kWh, natural gas costs \$6.30/1,000 cubic feet, propane costs 91 cents/gallon, and #2 heating oil costs \$1.30/gallon. Using 100,000 Btu as our standard, we find that electricity costs \$2.14, natural gas costs \$0.61, propane costs \$0.99, and #2 heating oil costs \$0.93², with the ratio being 1 to 0.29 to 0.46 to 0.43. These values are given in Table 2. Keep in mind, though, that these values assume 100 percent conversion of energy to heat absorbed by the sheet and do not include installation, maintenance, and loss in conversion over the life of the heater.

Table 1

<u>Energy Source</u>	<u>kWh Equivalent</u>
<u>Natural Gas</u>	
Cubic foot	0.302
Cubic meter	10.66
Btu	29.3×10^{-5}
Therm	29.3
Megajoule [MJ]	0.2778
<u>Propane</u>	
U.S. Gallon	32
<u>#2 Heating Oil</u>	
U.S. Gallon	41
Liter	10.7

Table 2

<u>Energy Source</u>	<u>100,000 Btu Equivalent</u>	<u>Cost/unit¹</u>	<u>Cost/100,000 Btu, \$</u>
<u>Electricity</u>			
	29.3 kWh	8.3 cents	\$2.14
<u>Natural Gas</u>			
Cubic foot	97.02	6.3 cents	\$0.61
Cubic meter	2.75	22.2 cents	dto
Btu	100,000	6.1×10^{-4} cents	dto
Therm	1	61 cents	dto
Megajoule	105.5	0.58 cents	dto
<u>Propane</u>			
U.S. Gallon	1.09	91 cents	\$0.99
<u>#2 Heating Oil</u>			
U.S. Gallon	0.715	130 cents	\$0.93
Liter	2.74	33.9 cents	dto

¹ 1Q03, DOE. As energy costs vary widely across the nation, please use your own values here.

² In 1992, the ratio of electricity cost to natural gas cost in the U.S. was 5.4. #2 heating oil was at parity with natural gas.

Thermoforming: Growth and Evolution¹ Part I

BY JAMES L. THRONE, SHERWOOD TECHNOLOGIES, INC., DUNEDIN, FL 34698 AND
PETER J. MOONEY, PLASTICS CUSTOM RESEARCH SERVICES, ADVANCE, NC 27006

Abstract

Thermoforming is the process of heating and shaping plastic sheet into rigid containers, components of final assemblies, and stand-alone end-use parts. The value of all thermoformed parts produced in North America in 2003 exceeded US\$10 billion. Traditionally, about 3/4 of all thermoformed products are produced from sheet of 1.5 mm or less in thickness and are primarily rigid disposable packaging products. Most of the rest is produced from sheet of 3 mm or more in thickness and are primarily durable structural goods.

Thermoforming has benefited by its ability to fabricate thin-walled parts having large areas, using relatively inexpensive, single-sided aluminum tooling. Its deficiencies – variable wall thickness, the added cost of sheet and trim regrind, and extensive trimming and additional cost to reprocess the trim – are offset by the ability to economically produce low-volume, thick-walled parts or high-volume thin-walled parts.

The advances in thermoforming technology in the past decade have allowed the industry to grow at a rate that exceeded the growth rate of the plastics industry in general. However, this pattern has changed in the past few years. Newer advances in plastic materials, tooling, forming machinery, and auxiliary equipment are needed to regain earlier growth rate momentum.

This paper considers several emerging technologies such as forming composite sheet materials, surface decoration, and new material development. It also considers the effect of globalization on both thin-gauge and heavy-gauge domestic thermoformers.

Introduction

The thermoforming process begins with an extruded sheet of plastic. It is heated between infrared heaters to its forming temperature. Then it is stretched over or

into a temperature-controlled metal mold. It is held against the mold surface until it is cooled. The formed sheet is then removed from the mold and the formed part is trimmed from the sheet. The trim is then reground and returned to the extruder to be mixed with virgin plastic for extrusion into sheet.

There are two general thermoforming process categories. Sheet 1.5 mm (0.060 inches) or less in thickness is usually delivered to the thermoforming press in rolls. Thin-gauge, roll-fed thermoforming applications are dominated by rigid or semi-rigid disposable packaging products. Sheet 3 mm (0.120 inches) or more in thickness is usually delivered to the forming press cut close to final dimensions and stacked on pallets. Heavy- or thick-gauge, cut sheet thermoforming applications are primarily permanent structural components. There is a small but growing medium-gauge market that forms sheet 1.5 mm to 3 mm in thickness. Thermoformed parts are as small as thimbles with wall thicknesses less than 0.015 mm (0.0006 inches) or as large as swimming pools with wall thicknesses greater than 25 mm (1 inch).

The North American thermoforming market has traditionally been split into 3/4 thin-gauge products and 1/4 heavy-gauge products. There are about 150 thin-gauge thermoformers in North America. Sixty percent form proprietary products, 30% are custom formers, and 10% are OEMs with in-house forming capability. There are about a dozen thin-gauge formers having annual sales of U.S. \$100 million or more. The largest, Pactiv Corporation of Lake Forest, IL, has annual sales in excess of U.S. \$1,000 million.

There are about 250 heavy-gauge formers in North America. Nearly all are custom formers. Only a handful of heavy-gauge formers have annual sales of more than U.S. \$100 million. In 2003, the largest, Wilbert Plastic Services of St. Paul, MN, had annual sales of about U.S. \$140 million.

Historically, thermoforming is one of the oldest plastics processes (1). Baby rattles and teething rings were formed of camphorated cellulose nitrate or pyroxylinTM in the 1890s (2). The industry did not grow substan-

¹ The authors were invited to present this paper in a special session at 2005 SPE ANTEC, but the abstract was not accepted. The first part of the paper is presented here. The conclusion of the paper will be presented in the next issue.

tially until the 1930s when the development of cellulose acetate and acrylic provided the industry with formable sheet. The earliest roll-fed thermoforming machines were developed in the late 1930s in Europe (3). Throughout WWII, heavy-gauge forming depended on convection oven heating of the sheet and hand draping of the sheet over male or positive molds (4,5). Shuttle presses were developed in the late 1940s, and rotary machines followed in the late 1950s and early 1960s.

Growth Dynamic for the Industry

For many years, the growth rate of the industry exceeded the growth rate of the plastics industry, in general. The forming industry grew at about 8.5% to 9% annually through the 1970s. From 1984 to 2000, the heavy-gauge growth rate was in excess of 5% annually, but by the second half of the 1990s, the thin-gauge packaging business had slowed to about 3.4% annually (6). From 2000 to 2003, the overall industry growth rate dropped to zero. The forecast for the coming years for both thin-gauge and heavy-gauge forming is a growth rate below that of the plastics industry, in general (7). A maturing industry and the effects of globalization are the primary forces behind this decrease in its growth rate.

Maturation of the Industry

It is our observation that the thermoforming industry is moving into its mature stage. In the last half-century, the industry has evolved from toaster-wire heaters, using sag as a measure of formability, wooden molds, and hand trimming, to energy-efficient heaters, sheet temperature monitoring, temperature-controlled molds, and advanced trimming machines. Because of this evolution, one wag has said, "We've formed all the easy, pretty parts."

Market penetration requires ratcheting up the technical level. But it also increases piece-part costs and invites competition. Injection molders, for example, for some time have been molding plastics with superior mechanical strength to compete with structural thermoformed parts, and they are now bidding for low-volume parts to just cover their variable costs. They are once again investing in large-platen, high-tonnage presses to challenge heavy-gauge formers. Rotational and blow molders are strongly resisting inroads by twin-sheet thermoformers into hollow part production (8). Yet, as we note below, new thermoforming techniques may help counter these infringements.

Globalization

Over the last half-century, the three North American economies have been truly transformed by globalization. In the United States, the share of foreign trade in our gross national product has risen from roughly 5% a half-century ago to over 10% today. The opportunities for expanding production through exports have increased. At the same time, consumer choice has been enhanced through imports (9).

Although some domestic industries have benefited from globalization, the overall domestic plastics industry has suffered. Injection molders, in particular, have endured a continuing decrease in their markets as many domestic OEMs have either relocated their manufacturing operations to Asia and other regions of the world or have outsourced the production of parts – in some cases, entire assemblies – to foreign countries with comparative advantages in the form of low-cost labor. Injection molders are particularly susceptible to this trend because their mode of production has become standardized and automated, and their output is typically small in physical size and economical to transport in container ships.

Thin-gauge part formers have already been impacted by this trend to globalization as parts produced offshore are usually also packaged offshore. Heavy-gauge formers are just now beginning to feel the globalization effects. The major barrier that Asian heavy-gauge part formers faced in the past was poor quality sheet. This is now beginning to change. To meet the inevitable growing challenge of foreign competition, the domestic heavy-gauge part formers must be relentless in reviewing their entire operation to increase overall efficiency. And they need to explore export opportunities, which have traditionally been a small fraction of their customer base.

A Caveat on Newer Advances in Thermoforming

In Table 1, we list several recent advances of importance to formed sheet fabrication. However, we must keep in mind that thermoformers tend to be very pragmatic regarding new concepts. In many cases, formers are aware of these technologies, but they will only adopt them when the customer is willing to pay for the time and effort needed to learn how to use them. Technologies such as twin-sheet forming, multi-axis trimming of heavy-gauge parts, formable PP, and syntactic foam for pre-stretching thin-gauge parts were tested and

(continued on next page)

Table 1

**Technologies Available by 1980
But Adopted Much Later by Thermoformers**

Tungsten-wire halogen heater (late 1800s)
Nichrome wire in quartz glass heater (1930s)
Low-pressure natural gas or propane heater (1800s)
Electric platen drive (1960s, injection molding)
Enclosed oven heating (1970s, Japan)
Twin-sheet forming (late 1800s)
Pressure forming (late 1800s)
Computer models for predicting heating rates (1970s)
Polypropylene for thin-gauge forming (1970s)
Oil-less bearing surfaces (1960s)
Localized matched-tool forming or "coining" (1970s, injection molding)
Syntactic foam (1970s)
In-mold labeling (1970s)
Infrared temperature measurement (1970s)
Scrapless thermoforming (Dow STP, 1970s)
Multi-axis trimming (3-axis, 1930s metalworking; 5-axis, 1950s woodworking)
Computer-driven machining (1960s, metalworking)
Machining and bending for assembly (1940s, hobbyists)
Computer-aided distortion printing (1970s, Hollywood morphing)
Mathematical wall thickness prediction (1970s, Fukase, blow molding)

available for years before thermoformers chose to employ them. Interestingly, once thermoformers learn the value of these technologies, they quickly embrace them.

Is Thermoforming Evolving?

Nearly a decade ago, one of us (PJM) conducted the first extended survey of North American industrial thermoforming (10). At that time, he noted that most of the companies interviewed had little or no interest in the latest thermoforming technologies. In the forward to this report, the other of us (JLT) noted that many of these same companies had recently invested heavily in pressure forming, CNC trimmers, syntactic foam plugs, epoxy foam prototype tools, extensive sheet drying equipment, ceramic, quartz, and/or natural gas heaters, and in-house vacuum and pressure systems. Many of these techniques were experimental or not fully developed only a decade earlier. So, despite thermoformers' claims that they have no interest in the latest innovations, they do ultimately adopt them. This year he (PJM) conducted a follow-up survey of these processors (7) and once again, he concluded that this attitude toward new technological advances still prevails.

So, what new developments should formers be adopting in the days and years ahead? Table 2 lists many technologies that have been around for a while but have not yet become part of the thermoformers' lexicon. Some of these will become economically important in the next few years.

Table 2

**Technologies Known Since 1980
But in Limited Use Now**

Small-particle fillers (including nanofillers)
Biodegradable and compostable polymers
In-mold decorating
Secondary reinforcement of formed part
Water jet cutting
Short, long, and continuous glass fiber-reinforced sheet
Coordinate measurement uses (other than QC)
Porous metal and porous ceramic mold materials
Formable high-performance sheet applications
Antistatic and static-dissipative sheet applications
Surface venting - poppet valve
Thin-gauge, in-mold, trim-in-place forming
High-density foam sheet
Thin-gauge wheel forming
Linear motor multi-axis trimming devices

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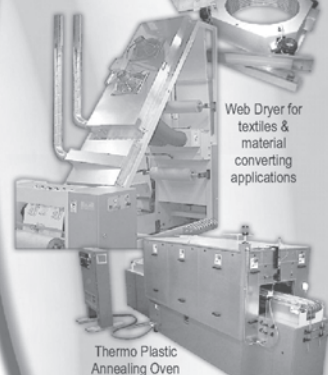
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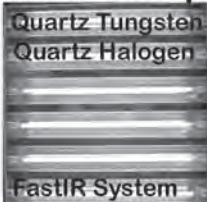
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Why is Part Design Important?

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

Throughout this series of tutorials, we have assiduously¹ avoided the issue of part design. And for good reasons. First and foremost, technologists – of which I am one – are normally not good designers. We tend to get hung up on the nuts-and-bolts of problem solving rather than the esthetics of the thing we're making. And second, there really isn't a good way of categorizing part design, particularly when there are so many applications and variants on the process.

Having cited these caveats, perhaps it is time to review at least some of the generic aspects about thermoformed part design. We try to do this in the next series of lessons. And we begin by considering some of the limitations to the thermoforming process.

Can You Make the Part the Customer Wants at the Price He'll Pay (and Still Make a Profit)?

There are some fundamental reasons for not quoting on a job, even though it appears "doable" and the potential profit is substantial. Some of these are obvious, to wit:

- The parts are too large for the available equipment

¹ Assiduously: Unceasingly; persistently.

² Coup de grace: A decisive, finishing stroke.



THERMOFORMING 101

- The parts are too small for the available equipment
- Too few parts are needed
- Too many parts are needed

Others depend on the nature of the plastic needed for the job. Consider these limitations:

- The polymer cannot be extruded into sheet
- The polymer cannot be drawn to the requisite depth
- The polymer needs to be drawn to near its extensional limit
- The polymer cannot be reground or reprocessed economically
- The design requires high-performance plastics
- The design requires highly filled or reinforced plastics

Some depend on the match between the part requirements and your forming abilities:

- The design requires complex forming techniques that you don't have
- It is more exotic than your current skills
- The design accuracy is greater than your current abilities

- You cannot trim to the required accuracy
- Your workers do not have the skills to repeatedly form quality parts
- You do not have in-house ability to test product serviceability
- You cannot prototype to determine part acceptability

And still others depend on the characteristics of the design, such as:

- The forces required to achieve the final shape are too high for the available equipment
- The design requires excessive web or trim
- Part tolerances, draft angles are unachievable in thermoforming
- Part design requires uniform wall thickness
- Part design requires stepped wall thicknesses

And finally, the *coup de grace*² – Competitive processes are more competitive! This one is probably the most difficult design limitation, simply because companies using competitive processes are now recognizing the capabilities of thermo-

forming and now are either altering their technologies to compete more effectively or are deciding to enter the thermoforming field.

What Not To Do

In most cases, we know the limitations of our equipment and ourselves. So we quote on parts we know we can mold. In some cases, however, the thrill of "taking a chance" is too much to pass by. That's when the thin-gauge part must be molded diagonally with the mold ends extending beyond the platen. Or when we try to "pressure form" in a press without a proper clamping system, hoping that the press won't open until the part has completely formed. Or when the depth of draw of the part is so great that we need to heat the sheet until it sags to the point where it drags across the tooling. Or when ... Well, you get the idea.

So, What Lessons Will We Learn?

In this series-within-a-series, we'll take a look at some simple issues such as female or negative molding and male or positive forming. We'll consider design aspects such as corners and chamfers, vent hole locations, and lip and edge formation. And surface texture, draft angles, and more. It should be fun. And maybe we'll all learn something on the way. ■

Keywords: Design, formability, dimensional tolerance, draft angle

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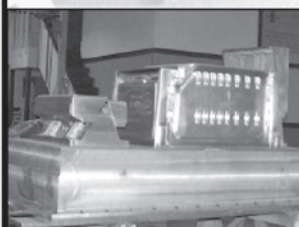
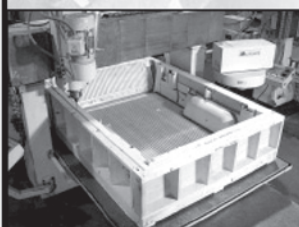
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BOOK REVIEW



Penny Sparke, Ed., **The Plastics Age: From Bakelite to Beanbags and Beyond**, Overlook Press, Woodstock, NY, 1993, 160 + vi pages, \$25.00 (paperback). [Check ebay however. I found it listed at \$7!]

First off, even though this is a very glitzy book, it isn't technical. It's a very modest history of plastics that focuses primarily on everyday applications of plastics. The monograph is divided into three unequal parts – Plastics Pre-History 1860-1914, Plastics and Modernity 1915-1960, and Plastics and Post-Modernity 1961-1990. There are sixteen essays by many experts in modern history and product design. Dr. Sparke, the editor and author of an article and of section introductions is Senior Tutor in the Cultural History Department at the Royal College of Art, London.

In many respects, this is a well-written and fabulously illustrated work. The color photographs alone are worth the

price of the book. For many topics, the glamour of the photographs overwhelms and reduces the writing to sketches. This is unfortunate, because the reader feels that there should be much more on the subject. For example, Jeffrey Meikle's chapter "Plastics in the American Machine Age - 1920-1950," has 6 full pages of photos, has, astonishingly, 31 references, but is only 14 columns long!

As noted, the work focuses primarily on consumer product design. The Italian influence on modern plastics design is clearly identified. The post-modern era is replete with the now-ubiquitous plastic chairs and kitchen utensils. Because the trip to plastic-land essentially ends in 1990, we are not treated to the radical designs of cell phones, for example. Or skateboards. Or MRI equipment cabinets. Or ...

I was disappointed with the book in two ways. First, the subtitle of the book implies that the plastic age began with the discovery of compression-molded phenol-formaldehyde, patented in 1909 by Leo Baekeland. Of course, that isn't true. Natural plastics such as amber, lac (shellac), wood, and tortoise shell have been used by mankind since our beginning. Gutta percha was extruded onto copper wire in the 1840s for transatlantic cable. Parkes and Hyatt worked to develop cellulose nitrate in the 1860s¹.

I was also disappointed that non-consumer products were given short shrift². As I said in my review of the work for Amazon.com, "we technical guys know all about how plastic pipe and siding [and] carpeting have revolutionized the construction industry and about how plastics packaging has reduced produce spoilage and product pilfering." I mean, even though Tupperware revolutionized the home shopping concept, it wasn't the first way of protecting foodstuffs and it certainly wasn't the last.

In 1972, J. Harry DuBois wrote – in my mind – the definitive book on plastics history, entitled **Plastics History U.S.A.**, Cahners Books, Boston MA³. While Sparke et al cover much the same ground as DuBois, and while Sparke et al provide the glitz that is subdued or missing from DuBois' book, DuBois provides the plastics person with a firm understanding of how the products were made. This is missing from the Sparke-edited monograph.

As a result, although I am grateful to the editor and her staff for the wonderful images of the past, I cannot in good conscience give the effort more than three books out of five. ■



~ Jim Throne

¹ For those who attend ANTECs, I presented a keynote paper on Thermoforming at the San Francisco ANTEC in 2001, using a knock-off title, "Thermoforming: From Baby Rattles to Bedsprings and Beyond."

² Short shrift. Scant attention.

³ Although this book has been out of print for many years, on occasion it appears on the eBay auction site.

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Council Report ... Cleveland, Ohio



BY STEVE HASSELBACH, COUNCILOR

This summary is intended to help you review the highlights of the Council Meeting held in Cleveland, Ohio on October 9, 2004. Please note that all support documentation remains available to Councilors and Section/Division board members at: <http://www.4spe.org/communities/leadership/0410/index.php>.

SPE President Karen Winkler called the meeting to order.

The new Council weekend format was as follows:

- Council Orientation – This new session provided an orientation for the weekend, highlighting the “big rock” topics that were discussed throughout the weekend’s meetings, including the 2005 budget, current financial status, SPE Foundation, membership, and a product portfolio review.

- Council/Council Committee of the Whole Format – There was not a separate Council Committee of the Whole meeting. However, at the Council meeting on Saturday, a new format was used to reduce repetition of reports, use our collective time more productively and keep us focused on the “big rock” items. The new format had presentations followed by open discussion on the presentations, breakout sessions at lunchtime, and ample time for general discussion. This general discussion time matched the amount of time usually committed to the CCOW meeting.

Moment of Silence:

The Council recognized the recent passing of the following members:

John T. (Jack) Lutz, Jr., SPE Fellow, member Philadelphia Section and Vinyl Division

Nick Rosato, SPE Fellow, Eastern N.E. Section and Injection Molding Division

Bob Ringwood, SPE Fellow, Palisades Section and Vinyl Division

Jim Courter, former Councilor, Southern Section and member Marketing & Management Division

Finances/Executive Director Update:

Susan Oderwald reviewed staff changes and provided Council with an updated organizational chart. She also reported on the launch of the new SPE WEBSITE at www.4spe.org and a new database upgrade initiative. Susan delivered a financial update through August (September numbers were not available in time for the meeting).

Finally, Susan clarified SPE’s insurance coverage with respect to General Liability coverage and Directors and Officer Liability Insurance (D&O). A full write-up on the issue was sent to Councilors and is being revised given Council discussion for distribution to Section and Division board members.

Budget

The major Council action was the approval of the 2005 calendar year budget. A full write-up on the budget had been distributed to Councilors

as well as all Section and Division board members last August. The budget that was approved calls for gross income of \$5,820,000, direct expenses of \$3,271,000, staff & overhead expenses of \$2,470,000, and a net contribution of \$79,000. 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 on <http://www.4spe.org/communities/leadership/0410/index.php>.

Other Business:

Presentations and discussions also took place on the following topics:

- The SPE Foundation Update
- State of the Society Discussion
- Educational Program Review & Discussion
- Technical Advisory Board Report
- Officer/Committee Reports
- Membership Update
- Revenue from Membership Discussion
- ANTEC Comps & Sponsorship Program & Discussion
- Constitution & Bylaw Issue

Proposed Bylaw Amendment B-7

The following first reading of a proposed amendment to the SPE Bylaws took place as follows:

All votes by Section Councilors, Division Councilors, Councilors at Large, or their proxies on issues that concern changes to fees, dues, and/or rebates shall be recorded to

include the name of the Section, or Division they are voting for, (in the case of Councilors at Large, they shall be listed as "Executive Committee"), the name of the individual, and how the person voted. The records of any such vote shall be available to any member of SPE via the SPE International website. This posting shall be available no later than ten business days after the vote is counted.

This amendment will have a second reading and be voted on at the January Council meeting.

Committee Meetings

Twelve committees met prior to the Council meetings, including: ANTEC Committee, Conference & Seminar Committee, Constitution & Bylaws Committee, Divisions Committee, Education Awards Committee, Executive Committee, Finance Committee, International Committee, Membership Growth Committee, Nominations Committee, Sections Committee, and the SPE Foundation Executive Committee.

Presentations

All presentations and supporting documentation for Council and committee discussions can be viewed on the SPE website at: <http://www.4spe.org/communicites/leadership/0410/index.php>.

Contributions

SPE is grateful to the following organizations that made contributions in support of SPE and The SPE Foundation:

- Raymond Wyer, Chicago Section & Norm Andre, Thermoset Division, presented a check for \$1,755 for the proceeds from the Thermoset Conference.
- Elliott Weinberg, Palisades Section, presented a check for \$1,000 to the Foundation
- Jon Ratzlaff, Rotational Molding Division, presented a check for \$200 for the Student Travel Fund. ■

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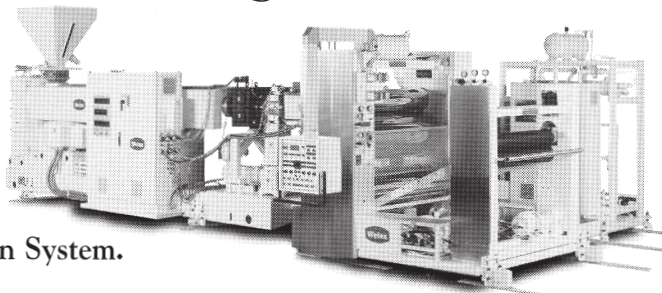
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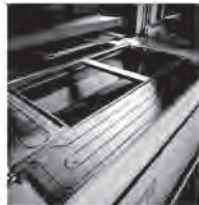
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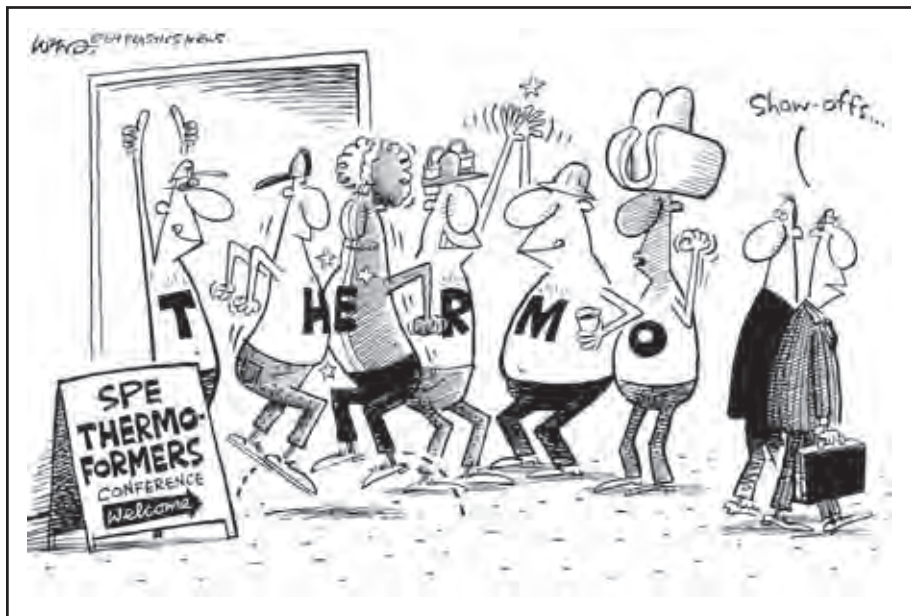
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Kinship keeps thermoformers group tight-knit

PLASTICS NEWS OPINION



It has become less fashionable to join groups. Whether we're a society too obsessed with our own work or our personal time, we don't always want to fit an association into our life. We have enough to fill up our Palm Pilots already.

Maybe it's a commentary on the era we live in. But the fact that the Thermoforming Division of the Society of Plastics Engineers could attract 1,003 people to its conference in Indianapolis in September is reason for some optimism. Those attendance numbers are holding steady from the division's previous conference in Cincinnati in 2003, a record year.

Look at what else we've seen during this decade. SPE as a whole lost half its members and was forced to lay off some staff. The Society of the Plastics Industry Inc. has had similar challenges, losing companies and some staff. It's not easy being a trade group. In other manufacturing sectors, the news has been of comparable struggles.

But SPE's Thermoforming Division is unique – a merry band of entrepreneurs that has stayed tight and true to its roots. It incorporates a mix of top corporate executives and plant engineers, most of whom work for midsize companies with annual sales of less than \$50 million.

All of them grew up together in the industry. Compared to injection molding, thermoforming is a relatively young field. Its denizens are more craftspeople than businesspeople, and they are fighting to gain a greater measure of respect.

That us-against-the-world mentality is probably what has united the group. Or maybe it's just that the group is like a tightly knit club where everyone knows each other and can relate to each other's concerns. Smoking jackets not required.

No matter, there are only about 250 thermoforming companies in North America, according to division Chairman Roger Kipp. But they all seem to know each other.

The board even commits to coming nearly a week before the conference begins to spend a few days talking business. At the meeting this year, the group added \$10,000 in annual scholarships for schools, doubling the size of that bequest. The new

funds are earmarked for technical schools offering associate degrees in the field, Kipp said.

The division also matches funds to high schools, spending \$80,000 this year to train young prospects for thermoforming, he said. The group is looking out for the future.

And another \$7,500 was parceled to the Discovery Museum in Milwaukee, for the center to prepare a DVD about thermoforming. The group wants to keep the information flow circulating.

Representatives from other SPE divisions were on hand at the conference to see how to duplicate the thermoforming division's efforts. So was SPE President Karen Winkler. About half the Thermoforming Division's profits go to mother SPE, a large sum in the association world, Kipp said.

Altogether, what the band of business owners has been able to accomplish is impressive enough. But maybe it's the type of member that has led to the group's success.

"We are a group with entrepreneurial business sense," Kipp said. "Our business owners are also managers in their businesses. We're quite a hands-on group."

We hope others can learn from their example. ■

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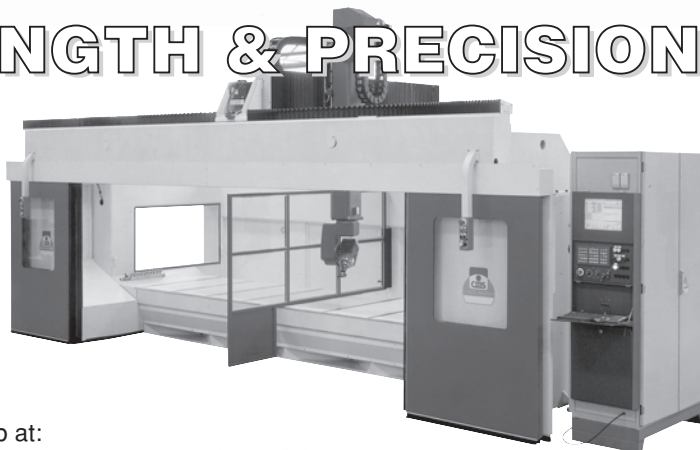
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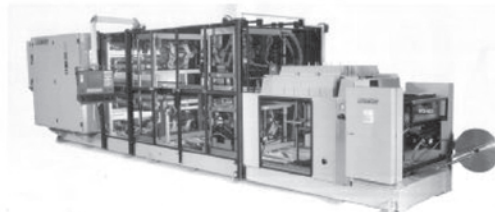
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