Thermoforming Quarterly®

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

SECOND QUARTER 2011 ■ VOLUME 30 ■ NUMBER 2

The Future Is Now

Thermoforming Center of Excellence at Penn College

INSIDE . . .

Thermoforming Quarterly®

SECOND QUARTER 2011
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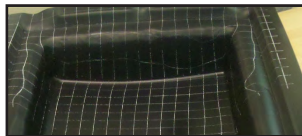

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Thermoforming Quarterly®

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

Editor
Conor Carlin
(617) 771-3321
cpcarlin@gmail.com

Sponsorships
Laura Pichon
(847) 829-8124
Fax (815) 678-4248
lpichon@extechplastics.com

Conference Coordinator
Gwen Mathis
(706) 235-9298
Fax (706) 295-4276
gmathis224@aol.com

Ken Griep

Committed to the Next Generation

During the past 4 years, your board has been engaged in a major undertaking to help fund and develop The Thermoforming Center of Excellence at the Pennsylvania College of Technology in Williamsport, PA. We recently returned from our Spring board meeting which was held on the campus. On behalf of the board, I want to thank Dr. Hank White, Director of the Center, as well as the staff members of PCT for their hospitality during our visit. I am pleased to report that the future of our industry looks promising.

The Center is by far the most technologically advanced center dedicated to the art and science of plastics processing. The facility offers services in material testing, weather testing and analysis, as well as material compounding. The board members were also able to see the range of processing capabilities on display, including injection molding, rotational molding, sheet and film manufacturing, blow molding and, naturally, thermoforming. The thermoforming machine is a MAAC Machine Model 43SPT, a 36" x 48" Single Station Pressure Former with Twin Sheet capabilities and 3rd motion plug assist. This machine will give the students first-hand, practical expertise on processing, machinery operation and material testing.

The Center has received $10,000 in seed money from your division along with $50,000 for equipment. In addition, the SPE Foundation has donated $10,000. Several board members, Mark Strachan and Jay Waddell, deserve special recognition for their contributions to the Center. MAAC Machinery continues to deliver equipment for educational purposes. Finally, I want to offer a special word of thanks to Roger Kipp and McClarin Plastics for all the hours and devotion to the success of this important project.

It is truly remarkable to see these young men and women roll up their sleeves and get directly involved in all elements of the thermoforming process: developing working models, running detailed experiments and producing high-quality technical papers. Two such papers appear in this issue of the *Quarterly* as a testament to our continued focus on workforce development.

"Thermoforming High Density Polyethylene Sheet Using Temperature-Controlled Aluminum Tooling," presented by Brett Braker, illustrated the differences of thermoforming HDPE using temperature-controlled and non-temperature-controlled tooling. In so doing, the paper aimed to prove that HDPE can be used with success in the thermoforming industry as long as temperature controlled aluminum tooling is used.

The second presentation was given by Aaron Lapinski, entitled "Thermoforming ABS for Dimensional Consistency." This project was aimed at mold comparison in which dimensions, shrinkage and mechanical properties of thermoformed ABS were compared on two different mold types. The purpose of this project was to demonstrate to the thermoforming industry that a temperature-controlled mold is essential for maintaining dimensional consistency in the finished product.

It is critical that our industry understand the importance of training the next generation of toolmakers, designers and machine operators. Understanding the manufacturing process is key to maintaining a competitive edge and should not be overlooked as the core of this new workforce enters the job market. This should be a primary goal for all thermoforming companies. As our industry grows, we need to bring in new, educated ***and trained*** talent that is equipped with the tools and knowledge to advance our industry for years to come.

Thank you for your continued support and get the word out – Do Thermoforming!

Please feel free to contact me with your views and comments. I would like to hear from you!

ken@pcmwi.com

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Chinese Computer Giant Accused of Stealing Packaging Patent

Reflex Packaging says Lenovo stole intellectual property

By Matthew Robertson, Epoch Times, March 29, 2011

Kenny Doyle was out on a routine sales call in southern California when he noticed something odd in the corner. The customer he was visiting had just purchased new computers for the office, and the packaging was in the trash heap.

"Something caught my eye," he says, as he looked at the plastic cushions used to protect the computers when they're inside the cardboard boxes. "It was a different color and it looked different to me," he said. "They were Lenovo boxes."

The plastic cushions he removed seemed almost identical – except that "they had just cut the top off" – to those made by the company that Doyle works for, Reflex Packaging. And they came with one of Reflex's main customers, Lenovo. But they weren't made by Reflex. Similar incidents began occurring around Forrest Smith, general manager of the firm and inventor of the packaging patent. People he knew who had just purchased a Lenovo PC would email him asking "When did you start making your parts in green?"

He hadn't. And now he is suing Lenovo – China's largest personal computer manufacturer, and fourth largest in the world (its income was $16.6 billion in 2010) – for stealing his design. When he saw the pictures, "I thought, 'Great, they took our product and made some modifications to it and started producing it,' " he said in a telephone interview. "There was no doubt in my mind, as the inventor, that this was clearly a copied product," he said. He forwarded the photos to a patent agent, who agreed. Then he got a lawyer and started talking to Lenovo.

SPOT THE DIFFERENCE: *Lenovo's alleged copy (L) alongside the product patented by Forrest Smith of Reflex Packaging (R). Smith says it is obvious that Lenovo in China simply copied his design. Lenovo says there are many differences between them. (Courtesy of Reflex Packaging)*

Lawsuit Filed

Reflex Packaging designs and produces thermoformed cushions for packaging fragile goods, like computers and hard drives. Thermoforming is a process that uses heat and pressure to make plastics; Smith uses recycled plastics, and Lenovo has won environmental awards for using his products.

For around 30 years the primary means of shipping computer parts had been foam. "We were the first to take a thermoform part and make a cushion that was able to function," Smith said. Reflex had been "grandfathered" into Lenovo's supply chain when the Chinese company came out of nowhere to buy IBM's computer division for U.S. $1.75 billion in 2005. Business was coasting along comfortably, at the rate of 5-10 thousand systems per week, with Reflex supplying the patented cushions – until around 2008, Smith recalls.

Every year, typically, computer companies spruce up their product ranges. With new designs comes the need for new cushions to protect them when shipping. Usually Smith talks with Lenovo personnel about the fresh specs. But in 2008 the conversation went slightly differently. Lenovo wanted Reflex to remove its name and patent number from the products. Smith didn't consent to the second part, "so they stopped doing business with us and started their own version," he says. Reflex's business with the computer giant in China has essentially "been eliminated." He believes that Lenovo simply took his patent to a thermoform manufacturer in China and got them to make something very similar. A year later Lenovo was shipping its products to the U.S. using stolen intellectual property, Smith says. The case was filed with the California Northern District Court in March 2010, after discussions broke down. The local *Orange County Register* reported on the story.

"Outrage"

When a customer sues its buyer, that's usually the end of the relationship, "but on the other hand, you have to protect your property or else anyone will walk in and take it," Smith said. The legal process is moving "painfully slow" for Smith. "We're probably right in the middle of the case against them," he said. The two parties are combing the minutiae of each other's claims before the case goes to trial.

Lenovo has presented several versions of events. Initially they said that one of their own people, packaging engineer Christopher Sattora, was involved in the product development. But when he worked at Lenovo all he did was tell Reflex the weight and sizes of the computers, for testing. "The guys in China were saying just stuff that a normal person would think, 'What? That's crazy, what are you talking about?' " Smith said.

Lenovo in the U.S. did not return calls or emails requesting they clarify the matter when contacted by *The Epoch Times*. Smith says he is not exactly upset, but that "the blatancy of it kind of aggravated me." Aside from what he sees as the brazen theft, he was roused by something else. "The commentary from our counsel over in China was even more frustrating, which was that your odds of suing successfully in China because of this are very low, because Lenovo is one of the 'great sons of China.' That was the message that I got back."

Lenovo has close ties with the Chinese Party-state. It is held up as a model of China's development, an ideal "China Story," writes the author Ling Zhijun in her book "The Lenovo Affair." Originally a state-owned entity, it was later spun out as a private concern, but the regime still owns the largest share and exerts control. The company became well-known in the West only after its bold 2005 acquisition of IBM's personal computer business, which it soon resuscitated and spring-boarded from. The IBM buy-out was understood within China as a "powerful blow" to the "plot by global Western enterprises" to take over the Chinese computer market, Ling writes. It makes Lenovo, or Lianxiang in Chinese, a standard bearer among the new cohort of nationalist Chinese companies that succeed in the domestic market before launching out to tackle the global competition. The Chinese communist leadership wishes to stake out key commercial territory for Chinese companies, Ling writes, and Liu Chuanzhi, the founder of Lenovo and "godfather" of China's IT industry, was able to market himself in that mold. He won the support from Party leaders crucial for his business's success.

The official connection is particularly galling to Congressman Dana Rohrabacher (R-CA), a long-term crusader against Chinese predations against American companies. "You have a situation where private companies are doing this, and that's bad enough, but to know that companies where the government has a stake are directly engaged in these types of predatory practices, it makes it even worse," he said in a phone interview. He added: "When the public learns the full details about what's going on to American companies … we're going to have not just upset but outrage."

Smith plans to pursue legal action in other countries that Lenovo ships to. Ideally he would like them to stop copying the product and buy it from him instead. Failing that, the court may only be able to stop the product entering the United States. Lenovo, in emails to Smith, said that there are many differences between the two products. They wrote: "We all respect and protect your intelligence and work." |

PROSPECTIVE AUTHORS

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

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.

Within this past year alone, our organization has awarded multiple scholarships! Get involved and take advantage of available support from your plastic industry!

Here is a partial list of schools and colleges whose students have benefited from the Thermoforming Division Scholarship Program:

- UMASS Lowell
- San Jose State
- Pittsburg State
- Penn State Erie
- University of Wisconsin
- Michigan State
- Ferris State
- Madison Technical College
- Clemson University
- Illinois State
- Penn College

Start by completing the application forms at www.thermoformingdivision.com or at www.4spe.com.

Thermo Forming Division

The National Study of Business Strategy and Workforce Development surveyed organizations about their responses to the aging workforce including the adoption of a range of flexible work options. Information was gathered about a range of factors that could explain variation in workplace responsiveness, including: characteristics of the business environment, priority business strategies, HR challenges, workforce development, and workplace culture and workforce demographics. Data were collected to distinguish "early adapters" from other organizations.

Key Research Questions

- To what extent have employers considered if/how the aging of the workforce might affect their business operations?
- What steps have employers taken – including the implementation of flexible work options – to recruit, engage, and retain talented employees at different career stages?
- Do employers see relationships between their key business strategies and different approaches to talent management, including the engagement of late-career employees?

The following is excerpted from a comprehensive study on workforce development conducted by The Sloan Center on Aging & Work at Boston College. We are grateful to the authors for giving us permission to reprint the main findings in this issue Thermoforming Quarterly *which features technical articles from students of thermoforming science and process. As the division chairman states in his remarks, the success of our industry depends on our ability to attract and retain a new generation of practitioners.*

Selected Findings

Phase I

Phase I of the National Study of Business Strategy and Workforce Development surveyed a benchmark sample of employers responding to the aging workforce.

- 41% of the respondents indicated that their companies had analyzed their workforce demographics "to a great extent."
- On average, these Benchmark employers noted that they expect that 15% of their employees will retire over the next four years.
- 61% of the respondents indicated that age diversity is important to their organizations "to a great extent," compared to the 83% who indicated that gender diversity is that important and the 78% who reported that cultural diversity is important. Employers were also more likely to indicate that it is important "to a great extent" to recruit employees with diverse cultural backgrounds and to recruit both men & women than to recruit employees of diverse ages.
- Twice as many of the Benchmark employers (64%) indicated that it is important "to a moderate or great extent" to encourage early career employees to remain with the organization as did the 29% who indicated that it was important "to a moderate or great extent" to encourage late career employees to remain with the organization.
- The top three HR challenges "to a moderate/great extent" noted by the Benchmark employers were: providing effective supervision, knowledge transfer, and recruiting competent job applicants. Despite the fact that 59% of the Benchmark organizations reported that knowledge transfer is a challenge, a substantial proportion (approximately two of every five) had either not developed processes to transfer institutional memory/knowledge "at all" or had only developed these processes "to a limited extent."
- More than half of the respondents to the Benchmark Study felt that: Early-career employees tend to take initiative and be creative; mid-career employees tend to be loyal to the company, be productive, be reliable, have established networks of professional colleagues, and have high skills relative to what is needed for the job;

and late-career employees tend to take initiative, be loyal to the company, be reliable, have established networks of professional colleagues, have high skills relative to what is needed for the job, have strong work ethics, and have low turnover rates.

- 50% or more of the Benchmark employers indicated that the following flexible work options are available to their full-time employees: request changes in starting and quitting times on a daily basis; reduce their work hours and work on a part-time basis while remaining in the same position or at the same level; control when they take breaks; and choose a work schedule that varies from the typical schedule at their organizations.
- 45% of male workers aged 50 or older have access to guaranteed benefits plans at work in comparison to the 35% of the females.
- Approximately one of every five of the Benchmark respondents state that their organizations link workplace flexibility to overall business effectiveness "to a great extent" with another half (47%) indicating that this link is made "to a moderate extent."
- The barriers to flexibility identified by 50% or more of the Benchmark respondents included: implementation costs too much; administrative hassles; concerns about possible employee complaints or liability; employees don't seem to want these programs and policies; no productivity payoff anticipated; not cost-effective; concerns about increased absenteeism; concerns about treating all employees equally; the organization has other more pressing business issues.

Phase II

Phase II of the National Study of Business Strategy and Workforce Development surveyed a more representative sample of United States businesses.

- Only a minority of employers in the National Study (34%) reported that their organization had made projections about retirement rates of their employees to a moderate or great extent. One-fourth (26%) reported that their organizations had not analyzed the demographics of their workforces at all. In contrast, only 12% felt that their organizations had analyzed their workforce demographics to a "great extent."
- Since older workers' prefer flexible work options, it is important that employers also acknowledge the key role of workplace flexibility in recruiting and retaining employees of all ages. More than half of employers (59%) indicated that flexible work options were available for their employees to a "moderate" or "great extent."
- The flexible work options offered by the highest percentage of employers to "most/all" of their full-time employees include employees' ability to: request changes in starting and quitting times from time to time; choose a schedule that varies from the typical schedule at the work site; have some control over when to take a break; and take extended leave for caregiving.
- Employers are beginning to make a link between flexibility options and their core business. More than half of employers (55%) link workplace flexibility and overall business effectiveness to a "moderate" or "great" extent.
- Employers' motivations for flexibility varied, but key motivators included: (percentage agrees to a moderate or great extent)
  - To increase employees' commitments and job engagement (67%)
  - To do the right thing for your employees (66%)
  - To improve morale (63%)
  - To help retain highly skilled employees (62%)
  - To retain employees, in general (61%)
  - To increase productivity (61%)
  - To help employees manage work and family life (60%)
- When it comes to retention and recruitment of older employees, again only a minority has taken the lead: Only 37% of employers had adopted strategies to encourage late-career workers to stay past the traditional retirement age. Less than

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one-third of respondents (31%) indicated that their organizations adopted practices to recruit employees of diverse ages to "a great extent."

- Employers identified career stages defined by three sets of factors: education and training; prior experience; and intention to pursue work in their career.
- Employers associated age ranges with career stages: early career employees (ages 21-38); mid-career employees (ages 31-47); and late career employees (ages 46-53). It is important to note that these stages and ages overlap, suggesting permeable boundaries between stages.
- Employers said that late-career employees, "have high levels of skills and strong professional and client networks, a strong work ethic, low turnover, and are loyal and reliable." In addition, contrary to some stereotypes of older workers, similar percentages of employers felt it is "very true" that late-, mid-, and early-career employees take initiative. And a similar percentage of employers felt it was "very true" that early-, mid-, and late-career employees are productive.
- Professional services firms and social service agencies are two industry sectors that offer a greater scope of workplace flexibility (taking into consideration the number of flexible work options and the extent to which these options are available to employees in the workforce).
- Factors that predict the scope of workplace flexibility include: having conducted analyses of their workforces (e.g., demographic analyses, projections of retirement, and examination of employees' career plans); having top managers aged 65 and older; having a "culture of commitment" with regard to workplace flexibility; and reporting more motivators for adopting flexible work options. Along with selected control variables, these variables explain 26% of the variance in workplace flexibility.
- Although perceptions of union considerations (as a barrier) are not a statistically significant predictor of the scope of flexible work options, union presence is related to a more limited scope of workplace flexibility. ❙

Society of Plastics Engineers
Thermoforming Europe Division
Eric Sasselaan 51 ~ BE-2020 Antwerpen ~ Belgium
Tel. +32 3 541 77 55 ~ Fax +32 3 541 84 25
spe.etd@skynet.be ~ www.e-t-d.org

First Announcement & Call for Papers

8th European Thermoforming Conference

Organized by SPE Thermoforming Europe Division



Thursday 26 April – Friday 27 April 2012
Venice, Italy

The European Thermoforming Division of the SPE has commenced its preparation for the 8th Thermoforming Conference which will be held in Venice, Italy.

The highly successful parallel commercial presentation session in Antwerp will again be included in Venice. This is in recognition of member feedback which valued the commercial track. This programme allows each sponsor an open forum to present their new developments to the conference attendees for duration of 5 minutes. This opportunity complements their marketing strategy at the event adding yet more value to the package.

It is important for us as organizers and for the thermoforming industry as a whole to benefit from this event. In order to do so, we need to 'tailor' it in the most efficient and economical fashion. You can help us do that by indicating the likelihood of your sponsorship involvement. We stress that this response would be recognised as an indicator only and would not constitute a firm commitment at this stage.

The main technical lecture programme is under development and promises to be the best ever with a number of eminent speakers already agreeing to participate.

Intention to submit a paper should be communicated to the Conference Secretariat as soon as possible. Please include the prospective title and a general outline of the work.
Authors are invited to provide an abstract (300 words maximum) of their paper **before 30 August 2011** by email spe.etd@skynet.be or by fax +32 3 541 84 25.

From the Editor

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

- New materials development
- New applications
- Innovative technologies
- Industry partnerships
- New or expanding laboratory facilities
- Endowments

We are also interested in hearing from our members and colleagues around the world. If your school or institution has an international partner, please invite them to submit relevant content. We publish press releases, student essays, photos and technical papers. If you would like to arrange an interview, please contact Ken Griep, Academic Programs, at:
ken@pcmwi.com or 608.742.7137

MET 496 Senior Project

Thermoforming ABS for Dimensional Consistency: Effects of Temperature versus Non-Temperature Controlled Tooling

Aaron Lapinski, Pennsylvania College of Technology, Williamsport, PA

Abstract

This project was a mold comparison project in which dimensions, shrinkage and mechanical properties of thermoformed ABS were compared on two different mold types. The two molds are a temperature controlled aluminum mold and non temperature controlled Ren Shape mold. A design of experiment (DOE) was also preformed on this project. The purpose of this project is to demonstrate to the thermoforming industry that a temperature controlled mold is essential for maintaining dimensional consistency in the finished product.

Introduction

In the thermoforming industry high part dimensional variation has always been a problem. This project will demonstrate that the specification range on thermoformed parts doesn't need to be near as wide as it is. The scope of this project is to determine the effects of using temperature controlled aluminum mold with and a non temperature controlled Ren Shape mold on an industrial size MAAC thermoformer. The variables being evaluated are part quality, dimensions, shrinkage, and cycle time on amorphous ABS sheets of the same color and thickness.

My project has four basic goals. The first is to determine how a temperature controlled aluminum mold and non temperature controlled Ren Shape mold of the same dimensions will affect shrinkage of a thermoformed ABS part. The second is to gain experience on the set up and operation of the industrial scale MAAC thermoformer. A third goal for this project is to develop a thermoforming lab experiment on the MAAC thermoformer for student education in Pennsylvania College of Technology's BPS program. The fourth is to demonstrate to the thermoforming industry that a temperature controlled mold is essential for maintaining consistency in the finished product.

Procedure

The first stage of this project was to obtain a temperature controlled aluminum which was supplied by McClarin Plastics, Inc. The next step was to obtain a non temperature controlled mold with the same shape and dimensions. The non temperature controlled Ren shape mold was supplied at no charge by Tooling Technology. The Ren shape mold is a Ren Shape 472 Medium-Density high temperature Polyurethane Fixture Board mold. The next step was to obtain the ABS material for my project. The material that obtained was 1/8 inch ABS; it was supplied at no charge by Spartech Plastics. The sheets needed to be prepared for the forming study. First, a 1-inch-by-1-inch grid was marked on the back of the sheet. The sheet was then dried at 180^{o} F. for 24 hours before forming. The sheets were dried off-site at Kydex LLC.

Once the sheets were dried, the Ren Shape mold was centered and hung on the top platen to better help utilize the sag of the heated sheet. This was done by placing the mold upside down on the bottom on platen and sliding it until the clamping rails could be set symmetrically around the mold. Then a new cycle to form the best possible part needed to be created. The MAAC machine parameters for this cycle were an infrared eye setting of 360^{o} F. for the sheet temperature, the heating time was set to 120 seconds, forming time was set to 100 seconds, ejection time was set to 2 seconds, the vacuum pressure was 24 in Hg and the ejection pressure was 5 psi.

After creating a good cycle, I began forming parts. The first study was a production run of thirteen samples. The first three samples were to allow everything to equilibrate and then I collected data on the next 10 samples.

The data that was collected included humidity, room temperature, mold front, mold back, mold top, sheet temperature at molding, sheet temperature at demolding, and clamp temperature. Once the production run was done, I collected dimensional data from each part. Dimensional data included height, length, width, and thickness. After 24 hours the dimensions were remeasured in the same way which showed how much the part had shrunk. The measurements were taken using a specially designed measurement jig to better assure that each part was measured consistently.

After the REN production style run samples were formed and measured, the REN mold was removed and replaced by the aluminum mold. The next study was done on the aluminum mold. The same data was collected for this run as for the REN production style run. There were a few differences that needed to be made to the cycle with the aluminum mold to be able to achieve acceptable parts. The first of these changes was to increase the infrared eye setting from 360° F. to 380° F. The other change that was made was the reduction in the cooling time from 100 seconds to 55 seconds. This was done because at any time longer than 55, the samples cooled too much and began sticking to the mold. Due to the decrease in cooling time total cycle time is then in turn shortened. This can is very beneficial for increasing production rates.

A design of experiment (DOE) was also preformed on the aluminum mold. The DOE contained two levels and three factors, so it was considered a 2x3 factorial experiment. The design of experiment can be noticed below in Figure 1.

	High	Low
Cooling Time	100	40
Circulator Temp	205	170
I.R. Eye Temp	400	340

Run	Cooling Time	Circulator Temp	I.R. Eye Temp
1	-	-	-
2	-	-	+
3	-	+	-
4	-	+	+
5	+	-	-
6	+	+	-
7	+	-	+
8	+	+	+

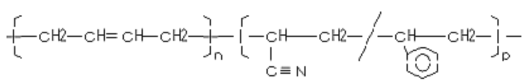
Figure 1 shows the variables that were chosen for the DOE. It also shows the parameters that were chosen for these variables.

The purpose of the DOE was to gain valuable data that would show which cycle parameters created the best part while also creating the least amount of dimensional change. The variables were cooling time, circulator temperature, and I.R. eye temperature.

After completing all the forming, ASTM D638 Type 1 tensile specimens were die cut out of each side of the first, fourth, seventh, and tenth part on both production style runs. These were used to evaluate and compare the tensile strength in both the machine and transverse direction through the cycles. The gauge length for the samples was set to two inches. The ASTM method D638 – 10 was followed during the tensile testing. The load cell used was 25 KN and the extension rate was 0.2 in/minute. A laser extensometer was placed opposed to the test specimens which had reflective tape placed two inches apart; the purpose of the laser extensometer was to more accurately measure the elongation and modulus values.

Materials

The material that was used to conduct this experiment was Acrylonitrile Butadiene Styrene (ABS). The ABS is a 1/8-inch thick premium grade, natural polish, and was supplied by Spartech Plastics.



The molds that were used are an aluminum mold supplied by McClarin Plastics Inc. and a Ren Shape 472 Medium-Density high temperature Polyurethane Fixture Board mold supplied by Tooling Technology.

The machine used was a custom manufactured MAAC thermoformer, model number 43SPT. The circulator that was used is a Sterlco VISION 4410-C with a maximum temperature of 250° F. Tensile testing was performed on a Tinius Olsen H25KS.

Results

This was a very successful project in terms of my project objectives. The data shows that the samples collected from the aluminum mold exhibit much more stable dimensions than samples collected from the non temperature controlled Ren Shape mold; this can be seen in Figure 2, Figure 3, Figure 4, and Figure 5 (shown on the next page).

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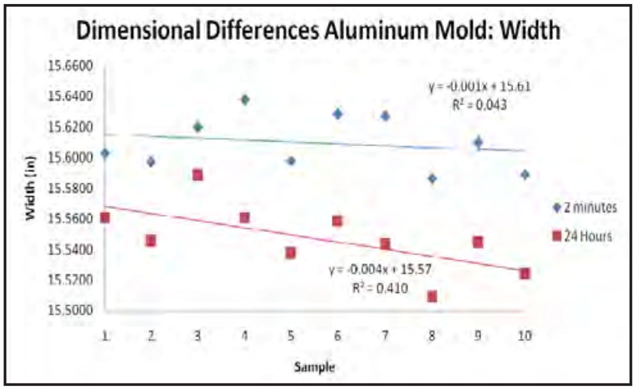

Figure 2 shows the difference in width between the aluminum mold at 2 minutes after forming and then 24 hours after forming.

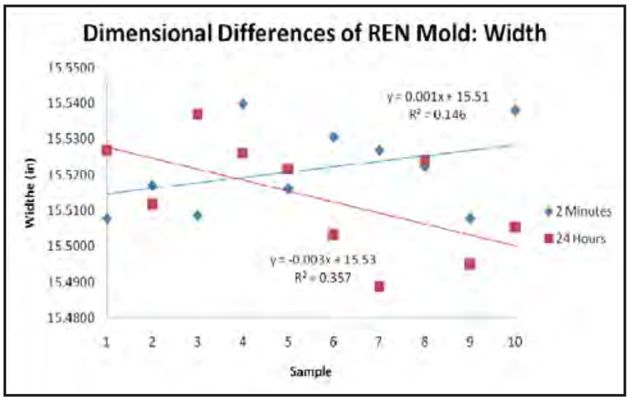

Figure 3 shows the difference in width between the Ren shape mold at 2 minutes after forming and then 24 hours after forming.

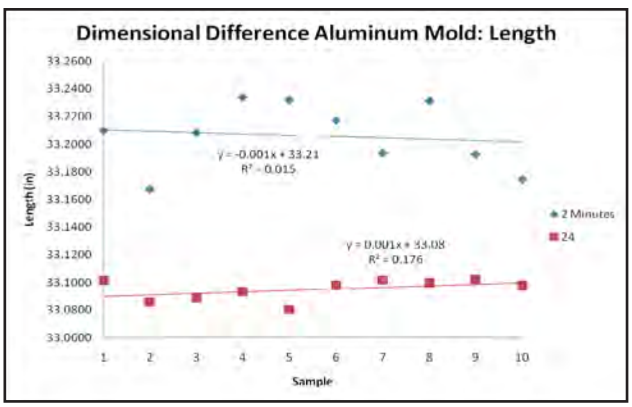

Figure 4 shows the difference in length between the aluminum mold at 2 minutes after forming and then 24 hours after forming.

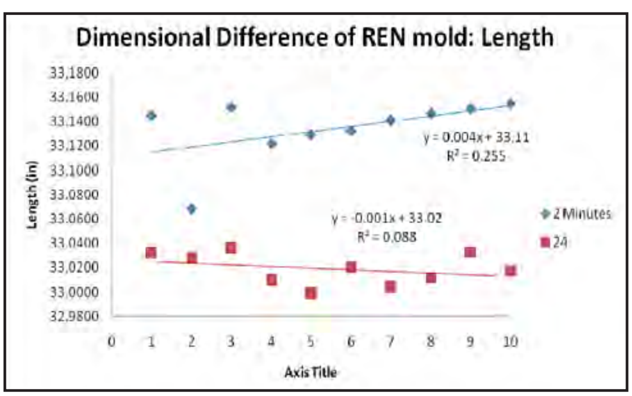

Figure 5 shows the difference in length between the Ren shape mold at 2 minutes after forming and then 24 hours after forming.

Thickness differed an extreme amount between the Ren shape mold and the aluminum mold. The thicknesses from the top of the sheets that were removed from the Ren shape mold were much greater than the thicknesses of the sides of the same sheet. This may be due to the differences in thermal conductivity between aluminum and Ren material. The thermal conductivity of aluminum is 144.447 Btu (IT) foot/hour/square foot/° F. and for Ren material or Polyurethane it is only 0.011556-Btu (IT) foot/hour/square foot/° F.

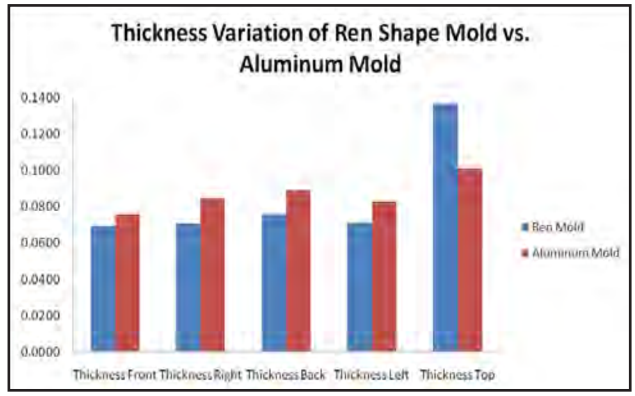

Figure 6 shows the difference in the thickness throughout the parts on both the aluminum mold and the Ren shape mold.

Another variable that was noticed is an increase in mold temperature and sheet temperature at de-molding. The increase in temperature explains why the dimensions of the parts on the Ren shape mold vary so much more than the dimensions of the parts from the aluminum mold; this can be noticed in Figure 7 (below) and Figure 8 (shown on the next page). As the mold temperature increased, bumps around the edges of the sheets began to form especially on the back of the sheet, towards the ovens. The bumps were actually blisters or bubbles that were caused by either uneven heating or too rapid heating.

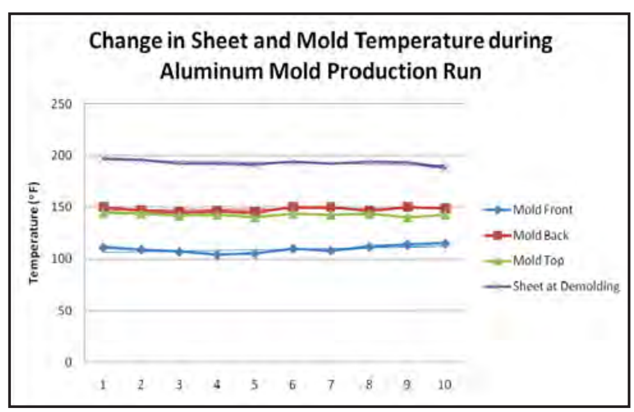

Figure 7 shows the temperature of the front, back, and top of the aluminum temperature controlled mold. It also shows the temperature of the sheet temperature at de-molding.

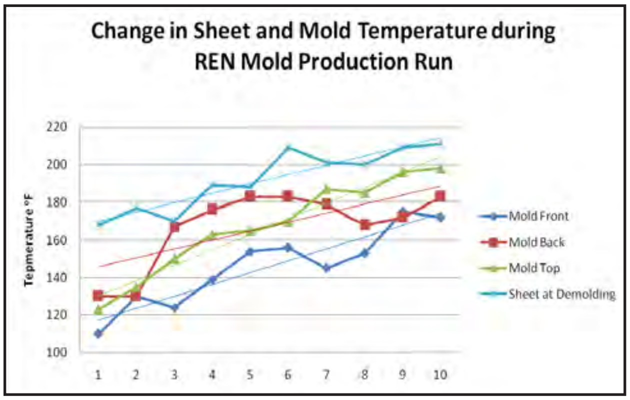

Figure 8 shows the temperature of the front, back, and top of the Ren shape mold. It also shows the temperature of the sheet temperature at de-molding.

The DOE showed which settings were the correct settings, it also showed which settings yielded the most consistent dimensions. For the best settings, the I.R. eye should be set to 400° F., the circulator temperature should be set to 170° F., and the cooling time should be set to 100 seconds. Run 5 actually had better dimensions then run 7 which contained the optimum settings, but there were issues with run 5, in particular, the material cooled too much and stuck to the mold causing stress marks and cracks in the corners of the sample.

Other issues that were noticed were the combination of high I.R. temperature and low cooling time that didn't cool the part enough leaving it pliable. The result was once they were formed, they dropped out of the clamps.

Conclusion

In conclusion this project was a successful project in terms of having achieved each of my four senior project objectives, the first three of which were:

- To determine how a temperature controlled aluminum mold and non temperature controlled Ren Shape mold of the same dimensions will affect shrinkage of a thermoformed ABS part.
- To gain experience on the set up and operation of the industrial scale MAAC thermoformer
- To develop a thermoforming lab experiment on the MAAC thermoformer for student education in Pennsylvania College of Technology's BPS program.

Finally my fourth and major object was achieved which demonstrated and proved that using a temperature controlled aluminum mold is essential in the case of ABS at the very least, to producing thermoformed parts with predictable and consistent dimensions.

This project outcome portrays vital information to the thermoforming industry and should be greatly considered when designing and purchasing molds for the production of thermoformed parts.

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Acknowledgements

1. Mr. Roger Kipp, McClarin Plastics Inc.
2. Mr. John Bartolomucci, Pennsylvania College of Technology
3. Mr. Gary McQuay, Pennsylvania College of Technology
4. Brett Braker, Pennsylvania College of Technology

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Thermoforming High Density Polyethylene Sheet Using Temperature-Controlled Aluminum Tooling

Brett K. Braker, Pennsylvania College of Technology

Abstract

Previous research has shown that thermoforming high density polyethylene (HDPE) is something that has been shied away from in the plastics industry. This paper will show the differences of thermoforming HDPE using temperature-controlled and non temperature-controlled tooling. In doing that, it will aim to prove that HDPE can be used with success in the thermoforming industry, as long as temperature controlled aluminum tooling is used.

Individual Performance Objectives

1. Show the importance of temperature-controlled molding in thermoforming.

2. Prove that HDPE can be a relevant material to use in thermoforming, instead of just amorphous materials.

Introduction

High density polyethylene isn't usually thought of as a usable material when thermoforming is talked about. It is not a material that seems like it would work with that type of process. Companies in industry have shied away from HDPE, because of its crystallinity and shrinkage rate. The thermoforming industry almost always uses amorphous materials, because they are a lot easier to control than crystalline materials.

Also, a lot of companies use wooden or urethane tooling to run their parts, because it is a lot cheaper to do that than to get aluminum or steel tooling. Instead of heating up their mold with water or oil, and keeping it at a constant temperature, they will just let the heat of the machine and material heat up the mold over time, but will run into problems at the start and end of their runs. The mold will either be too cold for the material and cool it too quickly, or be too hot, which will lengthen cycle time, and increase the chances of part defects.

Increased cycle times and part defects will cost the company a lot of money in the long run, when they could've just used a temperature-controlled aluminum mold. A temperature-controlled mold will stabilize mold temperature from the start, and will not have the variation a non temperature-controlled mold will. This will give the company much needed control of the tooling to help give them a chance at producing better quality parts for their customers. With better quality parts coming off of the temperature-controlled mold, there will be much less scrap sheet, stabilized cycle times and oven temperatures, and the company will be paying the cost of the tooling off with material savings.

Temperature-controlled tooling opens the doors to numerous materials that were once thought to never have a place in the thermoforming industry. It minimizes the increase in percent crystallinity that a material goes through when it is heated up and let to relax.

Material

Black HDPE sheet was used for this project. The sheet was 40 inches wide (machine direction), 22.5 inches long (transverse direction), and 0.125 inches thick. The material has a levant finish on one side and a smooth finish on the other, which would be the side used to touch the mold. The HDPE should be formed in between 285 and 385 degrees Fahrenheit, with the optimum forming temperature being 330 degrees Fahrenheit. The optimum temperature to take the sheet out of the mold is 170 degrees Fahrenheit.

Thermoformable high density polyethylene sheet has an average density of 0.0345 pounds per inch cubed (0.955 grams per cubic centimeter). It also has a 66.3 average Shore D Hardness, an average ultimate tensile strength of 3,800 pounds per square inch (psi), and an average tensile yield stress of 3,829 psi. The average deflection temperature with 66 psi is 166.5 degrees Fahrenheit.

Procedure

This project started when the material was received from the manufacturer. The first step after receiving the material was to put a grid system on the smooth side of the sheet, so that it could be measured to show the stretching that the material goes through when it

(continued on next page)

is formed. With help from the Printing Department at Penn College, the sheet was screen printed with an inch by inch silver grid system (shown in Figure 1). After the gridding was complete on the 50 HDPE sheets that were available for the project, they were ready to be thermoformed. The first mold that was to be used on the project was a replica mold of the main aluminum mold for the project, and it was made out of Renshape 472 medium-density Polyurethane Modeling Board. The mold has a wooden base, and then the machined polyurethane is made to be exactly the same dimensionally as the aluminum mold, which in relation to the material, is 15.25 inches long, 33.125 inches wide, and 4.2 inches high.

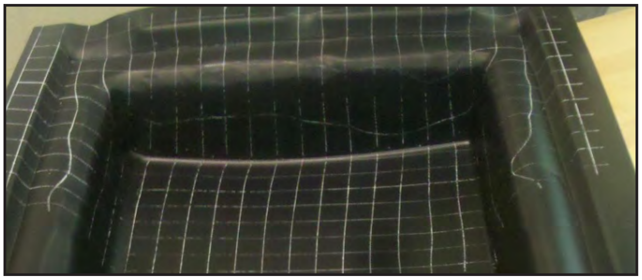

Figure 1. Gridding system on sheet after being formed.

The mold was first set on the lower platen (shown in Figure 2) of the MAAC Thermoformer that was used on the project. The first set of parts that were made on the machine was to try and help set up a process that would produce a quality part, so that a production-style run could be started. After a few parts were formed, it was easily determined that the mold should be hung from the top platen rather than the bottom platen.

Figure 2. Renshape mold on bottom platen.

The mold was switched from being set on the bottom platen to being hung from the top platen, because the sag in the pliable material coming from the oven coinciding with the top of the cool mold would cause a build-up of material in the four corners where the material would drape over the side of the mold. Switching to the top platen (shown in Figure 3) would eliminate the build-up of material in the corners, and create a better quality part.

Figure 3. Renshape mold on top platen.

Also by switching to the top platen, counter material sag stretching was eliminated. When a material is run in a thermoforming machine with the mold set on the bottom platen, the sag of the material as it comes out of the oven is met by the mold coming up into the pliable sheet and going through it to help create a seal to be able to vacuum the sheet around the dimensions of the mold. This phenomenon stretches the material twice, which could lessen some of the material's important physical properties. If the properties are compromised, the part has a possibility of failing once it gets out to its customer and starts being used. Hanging the mold from the top platen eliminates this from happening to the material. With the mold coming from the top of the sagging material, there is only one stretch on the material, which is in the same direction of the sag, and then the vacuum created by the seal between material and mold sucks the material back to the shape of the mold. This type of molding minimizes the stress on the material and theoretically eliminates the extra physical property damage done by double stretching with molds set on the bottom platen.

After the urethane mold was hung from the top platen, the machine settings were altered so that they were the exact same as the bottom platen settings and it was time again to try and find the correct settings and cycle to produce quality parts repeatedly. Once they were found, a production-style run could be performed.

A few problems were run into when trying to find the "perfect" cycle. The first problem was that the rails that hold the sheet in place were set too close to the mold and the mold was going too far through the rails. This caused the back of the sheet to rip out completely. After this, the rails were moved out to about one-half inch from the mold and the mold was programmed so that it didn't go through the rails as far. The top of the mold was then set to go down 5.5 inches from the sheet in the rails. The sheet didn't rip completely when the mold came down through it, but it did leave a few small tear spots, which were a sign of the side of the sheet closest to the oven being too hot when it came out to be formed (shown in Figure 4). This problem was fixed by lowering the oven percentages in the back of the oven so that part of the sheet wouldn't be as hot as it exited the oven. After the cycle was finalized, the production-style run was ready to be started. A production-style run is basically just a certain number of sheets run one right after another. This production run was set for 10 sheets, and there were a number of variables that were measured related to the machine during the production run. They were: temperature of the front of the mold, the top of the mold, and the back of the mold (all of which were taken right before the next sheet in the run was loaded in the rails), sheet temperature as it came out of the oven right before forming, and temperature of the sheet after the rails opened after cooling and the formed part was ready to be taken out of the machine. Room temperature and humidity were also measured before every sheet was loaded.

Figure 4. Tears in back of formed sheet.

After the formed sheet came out of the mold, it was set into the measuring jig that was made for the dimensions of what the sheet should be as it comes off the mold. The aluminum jig (shown in Figure 5) is 33.500 inches wide and 15.875 inches long. The sheet was placed in the jig the exact same way every time, and measured in 10 different places along the lengths and widths of the part (shown in Figure 6) using dial calipers set at the edge of the jig and being extended into the formed sheet.

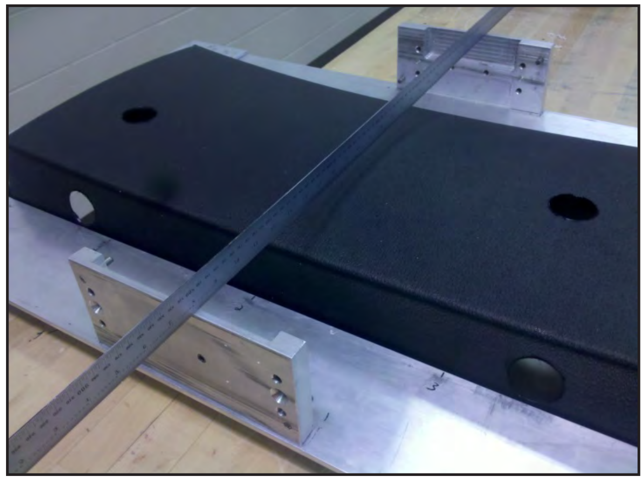

Figure 5. HDPE sheet in aluminum jig.

Also shown in Figure 5 is how thickness measurements were taken on each of the sheets after they had been measured using the jig. A drill and hole saw attachment were used to cut one-inch holes in the top, front, left, back, and right sides of the sheet. The discs that were produced were then measured for thickness. Figure 5 also shows that the holes were drilled in the left side of each side immediately after the sheet was taken out of the machine. Measurements taken 24 or more hours later were drilled out of the right side of each side.

Also shown in Figure 5 is how the height measurement was taken for each part after the 10 jig measurements were taken. Two aluminum blocks were placed on the long sides of the aluminum jig, and an aluminum meter stick was placed on top of the blocks. The dial calipers were then extended from the top of the meter stick to the top of the formed sheet. That number was then plugged into a formula (5.5625 – x = height) to obtain the actual height of the part. The number 5.5625 comes from the jig thickness, aluminum block height, and meter stick height.

After all of the measurements were taken, they could be plugged into formulas that would give

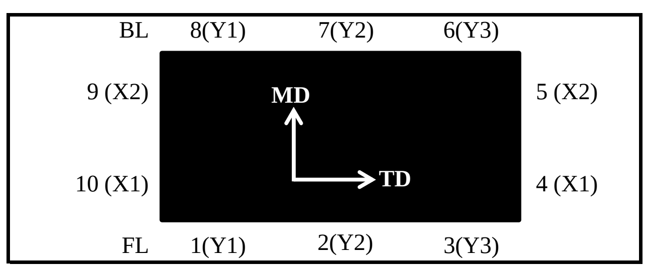

Figure 6. Measurement points and formula labels.

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the formed sheet lengths and widths at the given measurement points. The original measurement points and their corresponding formula labels are shown in Figure 6.

The formulas were calculated by taking the original jig Y (machine) direction (15.875 inches) or the original jig X (transverse) direction (33.500 inches) and subtracting the two measurement points that go together (1-8, 3-6, 5-9, etc.). An example for the Y1 measurement would be 15.875 inches minus the combination of measurements 1 and 8 (0.1025 and 0.4865), measured with the dial calipers, which would equal out to a Y1 length of 15.2860 inches. The caliper measurements help show the warpage of the formed part and the formulas for the length and width help show the overall shrinkage.

After the production style run was completed with the Renshape urethane mold, the aluminum mold needed to be prepared so that it too could be hung in the machine and used for a production-style run to compare with the production run performed with the Renshape mold. The aluminum mold was sealed and then was switched out with the Renshape mold so that a production-style run could be performed. The aluminum mold has water lines inside of it, so a circulator was used to send hot water into the mold to control the temperature of the sheets, so that there wouldn't be an increase in mold temperature as there was in the Renshape production run. All of the same measurements were performed during the aluminum production-style run, with the only additions being the circulator temperature and the inlet and outlet temperatures to and from the mold and circulator.

A Design of Experiment (DOE) was also performed for the project using the temperature-controlled aluminum mold. The main purpose of the DOE was to show if extreme high and low values were mixed and used in a cycle could produce quality parts like the production-style run. The three factors used in the DOE were cooling time, circulator temperature, and infrared (I.R.) eye temperature. The infrared eye is a laser that measures the temperature of the sheet in the oven. Figure 7 shows all the different set-ups ran for the DOE. The MAAC thermoforming machine allows for either a time or temperature-based oven time. The cycle that was used in this project was temperature-based. The high and low values for cooling time were 150 and 90 seconds, respectively. The high and low values for circulator temperature were 205 and 170 degrees Fahrenheit, respectively, and the high and low values for I.R. eye temperature were 330 and 400 degrees Fahrenheit, respectively.

Run	Cooling Time	Circulator Temp	I.R. Eye Temp
1	-	-	-
2	-	-	+
3	-	+	-
4	-	+	+
5	+	-	-
6	+	+	-
7	+	-	+
8	+	+	+

Figure 7. DOE Table.

Results and Discussion

The first results that were obtained were from the production-style run of the Renshape (REN) mold. When the machine was first heated up, five parts were run to solidify the cycle so there wouldn't be a lot of variation during the production run. Since the five parts were ran, the mold already started to heat up. Appendix A shows the temperatures measured during the production style run. The graph shows that every measured mold temperature increased by at least 10 percent and up to 25 percent, and the forming temperature increased by 6 percent without any parameters being changed. The ejection temperature also increased by 12 percent in 7 runs until cooling time was increased to help make the parts easier to handle out of the mold.

The measurements that were taken on the REN mold parts right after forming and 72 hours after forming are shown in Figure 8. The most noticeable thing about the REN mold measurements was how much the part shrank in only three days. The length of the formed sheet shrank about one-half inch in three days and the width shrank

REN	2 mins	72 hrs	2 mins	72 hrs
Dimensions	**Average**	**Average**	**St. Dev.**	**St. Dev.**
Y1	15.2772	14.7679	0.0737	0.0817
Y2	15.2703	14.6292	0.0916	0.1319
Y3	15.2146	14.6189	0.1027	0.1786
X1	32.8077	32.5823	0.0680	0.0540
X2	32.7825	32.5545	0.0604	0.0547
Z	3.6531	3.5861	0.1874	0.0854
Thickness	**Average**	**Average**	**St. Dev.**	**St. Dev.**
Front	0.0728	0.0640	0.0066	0.0063
Right	0.0699	0.0541	0.0072	0.0036
Back	0.0693	0.0590	0.0086	0.0056
Left	0.0733	0.0536	0.0105	0.0034
Top	0.1280	0.1207	0.0068	0.0037

Figure 8. REN mold measurements.

about one-quarter inch in three days. The standard deviation of the length averages about 80 thousandths of an inch and the width's standard deviation averages 64 thousandths of an inch. The height shrank about one-sixteenth of an inch in three days.

The thickness of the sheet also shrank dramatically after three days. The front thickness shrank about 12 percent, the right shrank 23 percent, the back shrank 15 percent, the left shrank 27 percent, and the top shrank 6 percent. The standard deviation for the thicknesses averages around 8 thousandths of an inch right after forming, but only around 5 thousandths of an inch after 72 hours. This shows that the thicknesses vary a lot right off of the mold, but get to a more stable state after they shrink.

After all of the data was collected and measured for the urethane mold, the temperature-controlled aluminum mold was ready to be switched out. Appendix B shows the forming temperatures during the production-style run using the aluminum mold. This mold required a few more measurements: rail temperature, circulator temperature, and inlet and outlet temperature of the circulator.

The production-style run was started with a 100 second cooling time and a 370 degree Fahrenheit I.R. eye. Before sheet 4 was loaded, the cooling time was extended to 120 seconds, because the sheet was consistently coming out at around 200 degrees. It came down to about 190 degrees, and then before sheet 5 was loaded, the cooling was increased to 150 seconds and the I.R. eye was changed to 360 degrees Fahrenheit, because at 370 degrees the sheet was coming out in a consistent pattern of 343 and 330 degrees Fahrenheit. Before sheets 7, 8, and 9 were loaded, the cooling time was decreased to 130 seconds, 120 seconds, and 110 seconds respectively to see what kind of effect it would have on the ejection temperature. This can also be seen in Appendix B. As seen on Appendix B, the top of the mold barely changed at all during the production run, while the front and back of the mold increased slightly, with the back increasing the most, because it is closest to the oven (which reaches upwards of 700 degrees Fahrenheit). The rails, circulator, and inlet and outlet temperatures all stayed virtually the same throughout the production run.

Appendix C-1 shows the part lengths after 72 hours over the course of the production run. The REN mold parts have a downward sloping trend for the lengths. The temperature-controlled aluminum mold parts basically stayed the same overall, but have a slight upwards undulation in the middle of the run.

Appendix C-2 shows the part widths after 72 hours over the course of the production run. The REN mold part widths both have downward sloping trends, while the temperature-controlled aluminum mold part widths have one upward and one slightly downward sloping trend. This shows that even though the aluminum has differing trends, it is still closer to staying the same than the REN mold part widths.

The measurements of the formed sheets (shown in Figure 9) showed much better results than the REN mold. While the REN mold widths shrank an average of one-half inch in 3days, the aluminum mold widths only shrank about one-tenth of an inch. The REN mold and aluminum mold lengths both shrank about one-quarter inch. The REN mold height shrank about one-sixteenth of an inch and the aluminum mold shrank less than one-thirty second.

Aluminum	Al 2 mins	Al 72 hrs	Al 2 mins	Al 72 hrs
Dimensions	**Average**	**Average**	**St. Dev.**	**St. Dev.**
Y1	15.1864	15.0772	0.0532	0.0629
Y2	15.3429	15.2224	0.0556	0.0498
Y3	15.2405	15.1412	0.0387	0.0494
X1	32.7307	32.4864	0.0815	0.0799
X2	32.6969	32.5176	0.0234	0.0627
Z	3.5513	3.5266	0.0566	0.0451
Thickness	**Average**	**Average**	**St. Dev.**	**St. Dev.**
Front	0.0939	0.0903	0.0021	0.0047
Right	0.0838	0.0807	0.0064	0.0054
Back	0.0846	0.0918	0.0028	0.0055
Left	0.0810	0.0835	0.0021	0.0044
Top	0.1029	0.1083	0.0017	0.0055

Figure 9. Aluminum mold measurements.

The aluminum thicknesses only changed at most 8.5 percent, and averaged about 3.5 percent, while the REN mold thicknesses changed up to 27 percent and averaged 16.5 percent.

Figure 10 (shown on the next page) shows the overall shrinkage percentages for the REN and aluminum mold. The REN mold widths shrank over 5 times more than the aluminum, the lengths shrank only one-half percent more, and the heights shrank over 3 times more than the aluminum.

Warpage was also a key factor in the REN mold parts after 72 hours (shown in Figure 11 on the next page). These measurements come directly from the aluminum jig, and show the difference from the edge of the jig to the edge of the part. Each formed sheet that was brought off of the thermoformer and placed

(continued on next page)

OVERALL SHRINKAGE			
REN	72 hrs	***Aluminum***	72 hrs
Width	3.816%	Width	0.719%
Length	0.691%	Length	0.647%
Height	1.836%	Height	0.696%

Figure 10. Overall Shrinkage.

Warpage	**REN 72hrs**	**Al 72hrs**	**REN 72hrs**	**Al 72hrs**
Measurement Pt.	**Average**	**Average**	**St. Dev.**	**St. Dev.**
1	0.2195	0.2134	0.0551	0.0687
2	0.2342	0.1188	0.0719	0.0131
3	0.2000	0.1339	0.0481	0.0192
4	0.2427	0.1639	0.0281	0.0686
5	0.2485	0.1583	0.0394	0.0278
6	1.0562	0.5999	0.1765	0.0538
7	1.0117	0.5339	0.1038	0.0514
8	0.8877	0.5845	0.0681	0.0609
9	0.6971	0.8242	0.0510	0.0454
10	0.6751	0.8498	0.0659	0.0605

Figure 11. Warpage measurements.

in the jig was pushed in the bottom right hand corner (in between measurement point 3 and 4 as seen in Figure 6. Points 1, 2, and 3 made up the front of the part. The REN mold seems to be better on the front as it only changed about 34 thousandths while the aluminum changed 100 thousandths from point 1 to 2, but that is the only instance of the REN being slightly better than the aluminum. Points 4 and 5 make up the right side of the part, and the warpage was about six thousandths for both the REN and aluminum mold.

The back is where the REN mold really warped. It varied about 75 thousandths where the aluminum mold only varied about 65 thousandths. The left sides of the parts both varied about 20 thousandths. The standard deviation for the REN mold show how much the warpage varied on any one part. The front varied an average of 60 thousandths on the REN mold and only about 40 thousandths on the aluminum. The right sides were about the same, with the aluminum having a slightly higher standard deviation. The back of the REN mold parts varied an average of 110 thousandths of an inch, while the aluminum only varied an average of 53 thousandths of an inch. The left sides of the REN mold parts varied an average of 58 thousandths, while the aluminum only varied an average of 52 thousandths. All these averages show that the REN mold was much more unpredictable when it was measured in the jig, because every part shrank and warped differently, while the aluminum mold was much more consistent.

The grid that was placed on the bottom of the sheets was to show stretching in the machine and transverse direction. The grid on the Renshape mold expanded an average of 10 thousandths of an inch on the top of the mold in the machine direction and shrank an average of 20 thousandths in the transverse direction. On the drawn part of the sheet, the material expanded an average of 1.500 inches over the original inch in the machine direction and shrank an average of 25 thousandths in the transverse direction. The aluminum mold expanded an average of 100 thousandths in the machine direction and 120 thousandths in the transverse direction on the top of the part. On the drawn section of the part, the material expanded an additional inch in the machine direction and shrank an average of 20 thousandths in the transverse direction. All grid measurements were taken after 72 hours. These measurements show that the temperature-controlled aluminum mold parts held their dimensions a lot more than the Renshape mold parts, as the Renshape mold parts stretched and then shrank back down below the original grid measurements after 72 hours.

The Design of Experiment results showed that only a couple parts off of the aluminum temperature-controlled mold would be deemed quality. Run 1 with all the low settings, Run 3 with just a high circulator temperature, Run 5 especially with just a high cooling time, and Run 6 with high cooling time and circulator temperature, all produced a part that was too cold when it was ejected. The top of the part stuck to the top of the mold, and permanently deformed the part by stretching it (shown in Figure 1). Run 2 with just a high I.R. eye temperature and Run 7 with a high I.R. eye and high cooling time, produced full parts that ended up with a lot of warpage. Run 4 with a high circulator temperature and high I.R. eye temperature produced a full part that only exhibited a small amount of warpage, and Run 8, which had all high settings, produced the best part of the DOE. This shows that the cycle that was set up for the production run is the best for this material.

Tensile tests were run on a number of the parts, with samples being cut out of the front, back, left, and right portions of the formed sheet. The results are shown in Appendix D. Unfortunately, the data that was collected from the temperature-controlled aluminum tool parts was too random to determine whether one mold produced tougher parts than the other. Overall, the results look similar. The yield and maximum stresses, yield and maximum elongation percentages, and maximum energy were all similar. The modulus measurements from the parts of the temperature-controlled aluminum mold were very random and ranged from 3410 to 1.2 million, so it was deemed irrelevant for the comparison.

Conclusion

Overall, the temperature-controlled aluminum mold showed a much more consistent process than the Renshape mold did. It shrank less, warped less, and had a much higher dimensional stability. With that, this project proves that there is a huge importance in temperature-controlled aluminum tooling in the thermoforming industry. This also shows that HDPE can be a relevant material in the thermoforming industry, instead of just amorphous polymers. In conclusion, if a company wants to run a crystalline material that has a high shrinkage rate, then they need to use a temperature-controlled aluminum tool if they want to continuously make quality parts. ❙

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Acknowledgements

John Bartolomucci, Pennsylvania College of Technology

Patrick Bundra, Pennsylvania College of Technology

Todd Chrismer, McClarin Plastics

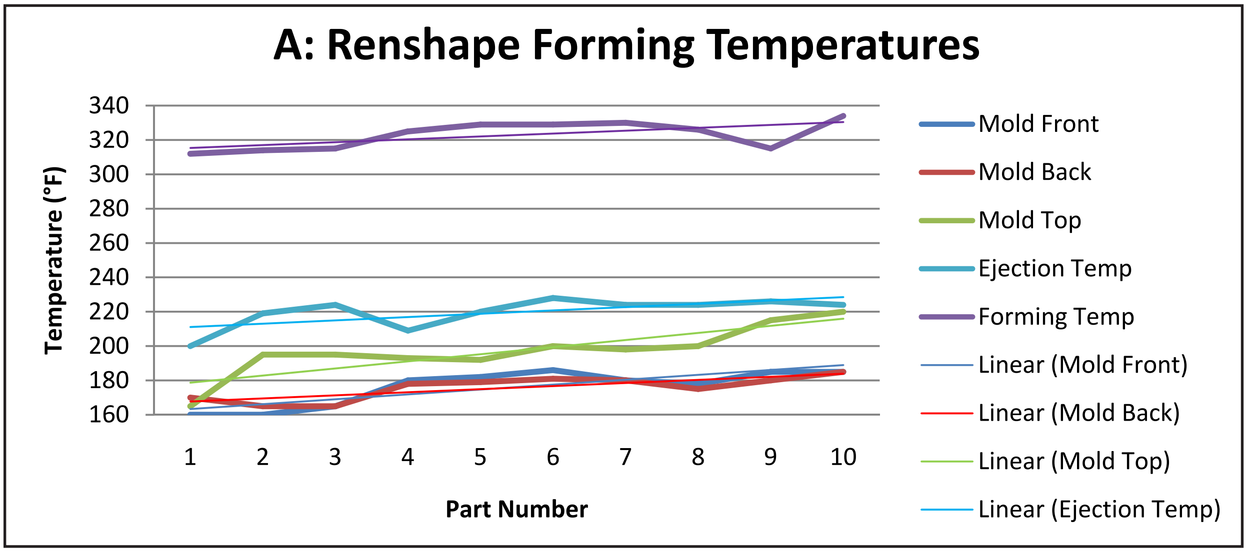
Todd Kennedy, McClarin Plastics

Roger Kipp, McClarin Plastics

Aaron Lapinski, Pennsylvania College of Technology

Gary McQuay, Plastics Manufacturing Center

Appendices



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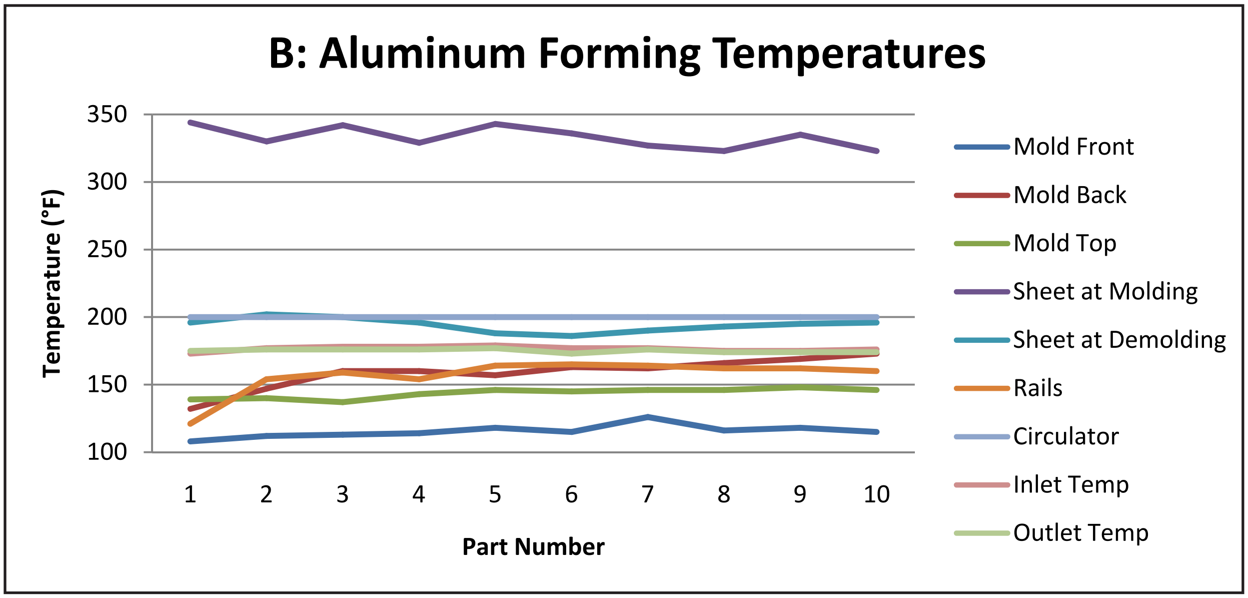
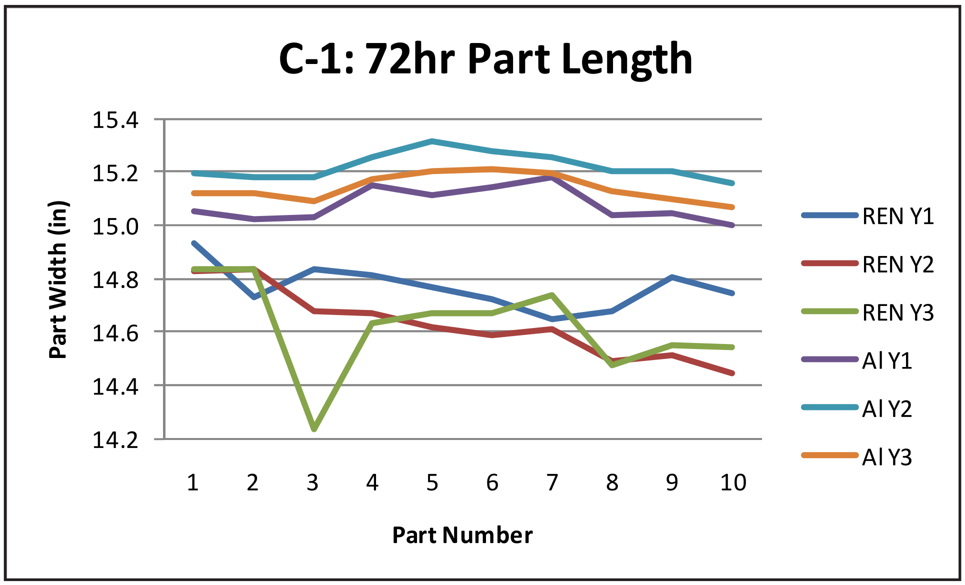
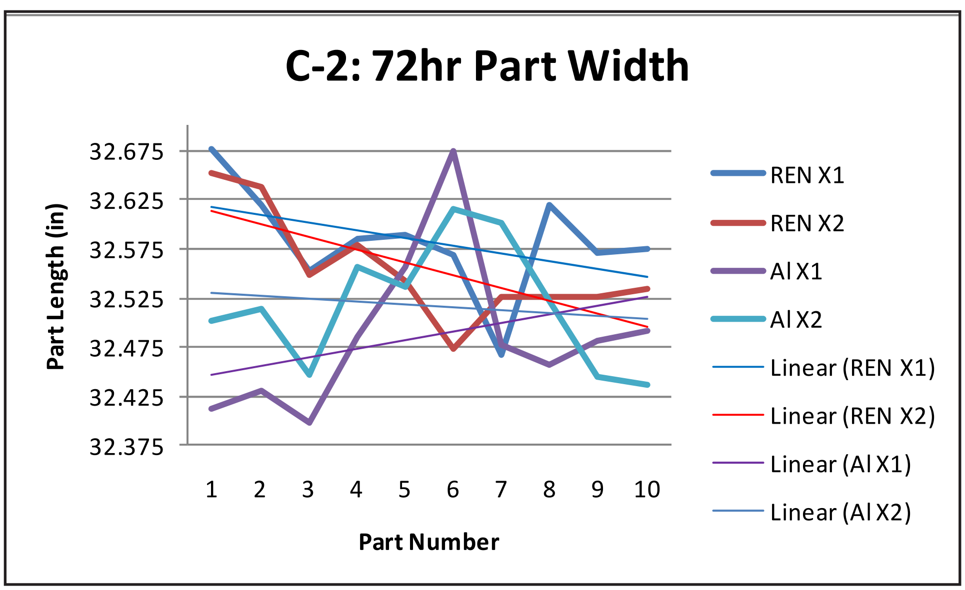

B: Aluminum Forming Temperatures
Temperature (°F)
350
300
250
200
150
100
1
2
3
4
5
6
7
8
9
10
Part Number
Mold Front
Mold Back
Mold Top
Sheet at Molding
Sheet at Demolding
Rails
Circulator
Inlet Temp
Outlet Temp


C-1: 72hr Part Length
Part Width (in)
15.4
15.2
15.0
14.8
14.6
14.4
14.2
1
2
3
4
5
6
7
8
9
10
Part Number
REN Y1
REN Y2
REN Y3
Al Y1
Al Y2
Al Y3


C-2: 72hr Part Width
Part Length (in)
32.675
32.625
32.575
32.525
32.475
32.425
32.375
1
2
3
4
5
6
7
8
9
10
Part Number
REN X1
REN X2
Al X1
Al X2
Linear (REN X1)
Linear (REN X2)
Linear (Al X1)
Linear (Al X2)

Appendices (continued)

D: TENSILE TESTING								
Type	Yield Stress (psi)	Max Stress (psi)	Yield Elongation (%)	Break Stress (psi)	Modulus (psi)	Max Energy (in*lb/in^3)	Max Elongation (%)	TE Auto (%)
REN front	2830.00	2830.00	14.23	1157.23	53133.33	275.33	13.79	664.00
Al front	2610.00	2610.00	13.74	760.50	514600.00	276.50	13.47	270.60
REN back	2860.00	2860.00	13.72	1142.50	65250.00	278.75	12.88	486.25
Al back	3086.67	3086.67	14.78	806.20	456900.00	351.67	14.40	249.33
REN left	2835.00	2835.00	12.82	2169.67	42125.00	310.25	15.69	853.00
Al left	1809.67	1813.33	17.89	899.33	19570.00	198.00	16.83	1040.67
REN right	2765.00	2765.00	16.06	2109.25	31950.00	283.00	15.53	1032.50
Al right	2776.67	2783.33	17.43	2032.33	131100.00	313.67	16.73	1039.00

Placon Opens $14 Million Recycling Facility for Post-Consumer Bottles and Thermoforms

EcoStar - Recycle, Replastic, Results

FITCHBURG, WI (May 4, 2011) – Placon Corporation, a thermoformer and plastic sheet extruder, announces the opening of its EcoStar® closed-loop recycling facility.

Placon becomes one of the first thermoforming companies in the food and consumer packaging industry to implement its own in-house recycling to process post-consumer bottles as well as thermoforms. With this new 70,000 square foot facility, Placon accomplishes its plan to create a standalone manufacturing location with its own brand identity under the EcoStar name.

EcoStar purchases bales of curbside collected post-consumer PET bottles and mixed bales of post-consumer thermoform packaging, grinds them, washes them, and processes them into sheet and flake. EcoStar recycled PET products include flake, LNO (letter of non-object) flake for food packaging, and sheet products for the food and consumer products markets. At full capacity, EcoStar will process 36 million pounds of inbound material.

"We are excited about our new EcoStar facility as it enables us to produce consumer packaging from 100% post-consumer PET recyclate," said the company CEO Dan Mohs.

Along with the ability to wash and recycle PET, half of the new facility is engineered for sheet extrusion. This operational layout eliminates non-value-added activities and reduces the total carbon footprint by bringing the material supply chain closer to sheet production. Moreover, the supply of post-consumer plastics processed by the facility are collected primarily in the Midwest, streamlining local and regional operations at every step of the process.

"Our $14 million investment demonstrates our commitment to sustainable packaging and the reduction of solid waste. We believe that the best way to reduce energy consumption and conserve resources, from a cradle-to-grave perspective, is to recycle plastic packaging back into plastic packaging, thereby closing the loop," Mohs said.

For nearly two decades, Placon has pioneered the use of post-consumer recycled polyethylene terephthalate (RPET) in the consumer packaging industry. In the past seven years alone, it has diverted more than one billion discarded bottles from landfills. According to the Environmental Protection Agency, recycling one pound of PET instead of using virgin material saves approximately 12,000 BTUs of energy.

The new facility has created 44 new jobs. Currently, Placon employs more than 400 people worldwide.

Claiming Recyclability: Tips and Tricks for the Unwary

By Sheila A. Millar, Partner
J. C. Walker, Partner
Keller and Heckman LLC

In a much anticipated action, the Federal Trade Commission ("FTC" or "Commission"), released proposed revisions to its *Guides for the Use of Environmental Marketing Claims* (16 C.F.R. Part 260) ("Guides") last fall, soliciting additional public comments on the changes which will be evaluated before finalizing the updated Guides. In preparing for these revisions, the FTC conducted several workshops, sponsored consumer research, and reviewed extensive public comments submitted through several different proceedings to identify emerging issues in environmental claims. The proposed Guides offer guidance (sometimes limited) on new terms, including "renewable," "renewable energy" and "carbon offset" claims. The revisions, however, do not provide guidance for the increasing claims of "sustainability," "organic," or "natural." Guidance on terms already covered was largely left unchanged.

The proposed Guides reflect the FTC's current thinking on the adequacy of certain claims, the need for qualification, and the amount of substantiation needed to support such claims. Notably, the proposed Guides provide clarification on the Commission's current approach to recyclable and recycled content claims.

Recyclable Claims

Claims for recyclability and recycled content are addressed in both the current and proposed Guides. Despite criticism of the FTC's approach to recyclable claims from organizations seeking greater international harmonization, the FTC maintained its three-tiered distinction for qualifying recyclable claims depending on whether a "substantial majority," a "significant percentage," or fewer consumers or communities have access to recycling facilities. To make an unqualified claim about recyclability, recycling facilities must be available to a *substantial majority* of consumers or communities where the item is sold. The proposed Guides reference FTC's informal position that a "substantial majority" means 60%. Advertising for products that do not meet the "substantial majority" threshold, but are recyclable to a "significant percentage" of consumers must be qualified; products or packages with limited recyclability require added qualifiers to assure that consumers are aware of the limited recyclability. FTC also requested comments on whether it should quantify a "significant percentage."

The Commission's proposed 60% threshold received mixed review, with some in support, some suggesting it should be lowered, some urging adoption of the International Standards Organization's "reasonable proportion" standard, and one suggesting higher thresholds for each of the three levels. Most who support quantifying a "significant percentage" generally suggested 20% or 30% as the standard, but most suggested that the FTC avoid a percentage reference.

A longstanding criticism of the FTC's approach is the rather consumer-unfriendly qualifiers that it recommends. The FTC continues to maintain that, standing alone, "recyclable where facilities exist," "check to see if recycling facilities exist in your area" and "please recycle" do not adequately qualify recyclable claims. In essence, these statements are treated as unqualified claims which the FTC will view to be misleading if the product or package is not recyclable to a substantial majority (60%) of consumers. A number of commenters to the proposed Guides urged FTC to reconsider the use of positive disclosures, noting that with the increased use of the internet and mobile devices, it is likely consumers would interpret positive disclosures differently today.

Recycled Content Claims

Guidance on recycled content claims also remains relatively unchanged. These claims continue to remain subject to a critical prerequisite – the material claimed as recycled content must have actually been diverted from the solid waste stream, either during the manufacturing process (pre-consumer) or after consumer use (post-consumer).

The proposed Guides do address suggestions about expanding the definition of post-consumer material to include the ISO 14021 approach. In declining to adopt such an approach, the FTC noted that under ISO 14021, material returned from the distribution chain (*e.g.,* overstock) would qualify as post-consumer recycled material. Because this material never actually reaches the consumer, it is unlikely that consumers would interpret such material as "post-consumer."

Further, the FTC declined to prohibit pre-consumer recycled content claims, as suggested by some workshop commenters, noting that this information may be important to consumers. At the same time, however, the revised Guides do not require advertisers to specify whether the recycled content is pre- or post-consumer content. To the extent a pre-consumer content claim is made, the Guides continue to remind advertisers that they must be able to substantiate that the pre-consumer material would otherwise have entered the solid waste stream, the recycled material was required to undergo significant modifications, and the recycled material will not be reused in the original manufacturing process. So long as marketers can substantiate

(continued on next page)

these claims on a reasonable basis, the FTC continues to allow pre-consumer recycled content claims to be made.

In its proposed Guides, the Commission requested comments on what changes, if any, it should make to existing guidance on pre-consumer recycled content claims, and requested relevant consumer perception evidence. In reviewing the public comments submitted in response, only 10 out of 340 comments dealt directly with the definition of pre-consumer recycled content. Critically, the sole commenter opposing the use of pre-consumer recycled content did not provide consumer perception evidence. Based on FTC's past response to comments that failed to include consumer perception evidence, it is not expected that the Commission will change its position regarding recycled content claims for products manufactured with pre-consumer recycled materials.

Combined Recyclable and Recycled Content Claims

Marketers must remain mindful that, by itself, the use of the Möbius loop likely conveys that the product or packaging is both recyclable and made entirely from recycled material. Unless a marketer has substantiation for both messages, FTC requires this distinction to be conveyed. Such a claim may require further qualification, to the extent necessary, to disclose the limited availability of recycling programs and/or the percentage of recycled content used to make the product or package, if less than 100%. With regard to implied claims suggesting both recyclability and recycled content, the proposed Guides declined to advise marketers making an unqualified recycled content claims to affirmatively disclose if their product is not recyclable.

RIC

The FTC also did not change its position on the Resin Identification Code (RIC), now an ASTM International standard. Inconspicuous use of the RIC is not deemed to be a recyclable claim. ***Makers of plastic packaging, however, should be careful to use the appropriate code in reference to the material used.*** [Ed. emphasis]

Conclusion

The FTC's views on how to assure that recyclable and recycled content claims are truthful and not misleading in essence has changed little from the current Guides. One reason is that the FTC's views on false and deceptive advertising are driven by consumer perception. The FTC is still in the process of reviewing comments submitted to the proposed Guides, including input on how to quantify the substantial majority threshold. It will likely issue final guidance later in the year.

For more information on the revised Guides, or how your company can comply, please contact Sheila A. Millar at (202) 434-4143, or millar@khlaw.com, or J.C. Walker at (202) 434-4181, or walker@khlaw.com.

COUNCIL SUMMARY

Roger Kipp
Councilor

SPE Council continues to provide stable direction for the society. Our outgoing President Ken Braney brought further global recognition to SPE with significant membership stimulation, global corporate outreach, and a broader depth of technology growth. Ken is a "globalist thinker" with plans in place for worldwide technical conferences including EUROTEC 2011 (14-15 November in Barcelona, Spain) and two exciting new conferences in India and Japan (ANTEC ASIA). Incoming President Russell Broome will build on the solid foundation put in place by Ken. The two leaders are working to ensure continuity during the transition phase. Russell's vision is to maintain the global / corporate growth while focusing on the three key areas Ken outlined a year ago: **Membership, Revenue, Member Value**.

While Ken focused on global and corporate growth, Russell will put emphasis on expansion of the student, early career, and Generation Y groups. He has added an ad hoc student member to the Executive Committee, created the Next Generation Advisory Board and the Academic Outreach Committee that I am proud to chair.

I noted in the last *Quarterly* the importance of SPE regaining and retaining financial stability if we are to continue our mission. I am pleased to report that with the hard work and commitment from staff and Council the recent trend toward financial stability has continued. The 2010 fiscal year ended with revenues up and SPE in the black with a $134,000.00 net positive balance. These increased revenues are the result of increased membership, continued global expansion, further corporate sponsorship and increased technical product sales. The first quarter of 2011 is the best first quarter since 1999 with income up 28% and expenses down 2%. Webinar sales are up 33% and ANTEC income tracked ahead of budget with expenses at budget. A great start!

Membership has grown above 15,000 with 822 new members and membership retention rate of 77%. The source of new members includes conference registrations, Wiley Authors, website, and Section and Division growth. However, the primary recruitment tool has been New Member Campaigns where over 35% of new members were signed up. Members need to reach out to colleagues and promote membership in the society that is the "trusted technology information source" for the plastics industry. If you are interested in obtaining a discount in your membership you can do just that by bringing in new members.

Member value is paramount. The SPE Foundation is an excellent opportunity to find member value. Since 1997 the Foundation has awarded $1.6 million dollars in grants to educational and continuing education programs for plastics research and education. Scholarships totaling $107,000.00 were awarded in 2010 to 31 students. The new Association Management System software AVECTRA and accounting system, INTACCT, went live at the end of the first quarter and will begin to provide member value through service and billing options.

ANTEC 2011

ANTEC ran from May 1st-5th at the Hynes Convention Center in Boston, MA. This ANTEC was a huge success with attendance up by 31% from 2010. Exhibitors, sponsorship, and registration revenues are all above forecasts. Even more exciting is that there was a flurry of activity relating to our Division.

The Thermoforming Division was awarded the Gold Pinnacle Award for Outstanding Division performance as well as the Communications Excellence Award for providing unique and varied communications to members and the industry. These awards are the result of the leadership of Ken Griep (Division Chair) and Clarissa Schroeder (Communications Committee Chair) as well as the continuing support of our members.

On Monday May 2nd, I served as moderator for the Thermoforming Division's technical session. The five papers presented were excellent and featured outstanding attendance. The topics included:

- Thermoformability of Radiation Cross Linked Polyamide 12
- Syntactic Foams For Use As Plug Assists in Heavy Gage Thermoforming
- Multi-Layer Films for Thermoformed Food Container Applications
- Influence of Processing Conditions on the Thermoformability of PP Sheet Material
- Optimization of Molding Conditions of Plug Assisted Thermoformed Thin Containers

Each of these papers will be presented as technical articles in future Thermoforming Quarterly publications.

As in the past, our Division was pleased to be a sponsor for the Student Luncheon. The financial support was amazing this year with Divisions and Sections providing over $30,000 to cover the cost of student attendance and awards. One notable award for our Division was the Outstanding Student Chapter Award that went to the chapter at Penn College, the home of the Thermoforming Center of Excellence. With a standing room crowd of over 200, the students and guests were enlightened by a panel of entrepreneurs sharing advice on the challenges and rewards for start-up ventures.

There is still time to present technical papers for consideration at EUROTEC 2011. Please contact me for complete details.

Best regards,
Roger
rkipp@mcclarinplastics.com

Executive Committee
2010 - 2012

CHAIR

Ken Griep
Portage Casting & Mold
2901 Portage Road
Portage, WI 53901
(608) 742-7137
Fax (608) 742-2199
ken@pcmwi.com

CHAIR ELECT

Phil Barhouse
Spartech Packaging Technologies
100 Creative Way, PO Box 128
Ripon, WI 54971
(920) 748-1119
Fax (920) 748-9466
phil.barhouse@spartech.com

TREASURER

James Alongi
MAAC Machinery
590 Tower Blvd.
Carol Stream, IL 60188
(630) 665-1700
Fax (630) 665-7799
jalongi@maacmachinery.com

SECRETARY

Mike Sirotnak
Solar Products
228 Wanaque Avenue
Pompton Lakes, NJ 07442
(973) 248-9370
Fax (973) 835-7856
msirotnak@solarproducts.com

COUNCILOR WITH TERM ENDING ANTEC 2010

Roger Kipp
McClarin Plastics
P. O. Box 486, 15 Industrial Drive
Hanover, PA 17331
(717) 637-2241 x4003
Fax (717) 637-4811
rkipp@mcclarinplastics.com

PRIOR CHAIR

Brian Ray
Ray Products
1700 Chablis Avenue
Ontario, CA 91761
(909) 390-9906, Ext. 216
Fax (909) 390-9984
brianr@rayplastics.com

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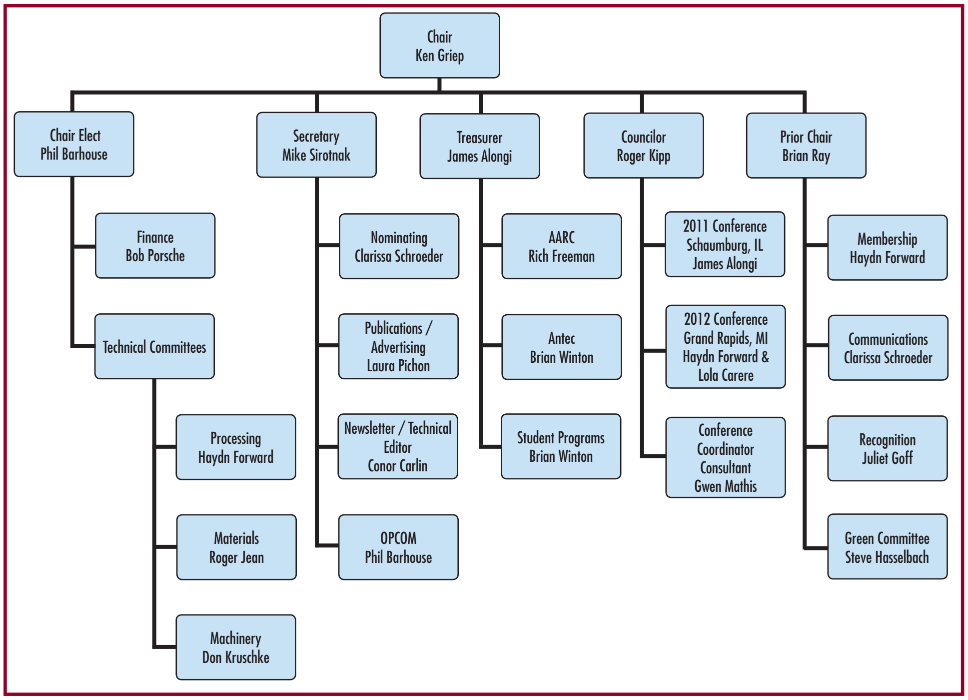

MACHINERY COMMITTEE

James Alongi
MAAC Machinery
590 Tower Blvd.
Carol Stream, IL 60188
T: 630.665.1700
F: 630.665.7799
jalongi@maacmachinery.com

Roger Fox
The Foxmor Group
373 S. Country Farm Road
Suite 202
Wheaton, IL 60187
T: 630.653.2200
F: 630.653.1474
rfox@foxmor.com

Hal Gilham
Productive Plastics, Inc.
103 West Park Drive
Mt. Laurel, NJ 08045
T: 856.778.4300
F: 856.234.3310
halg@productiveplastics.com

Don Kruschke (Chair)
Thermoforming Machinery & Equipment
31875 Solon Road
Solon, OH 44139
T: 440.498.4000
F: 440.498.4001
donk440@gmail.com

Mike Sirotnak
Solar Products
228 Wanaque Avenue
Pompton Lakes, NJ 07442
T: 973.248.9370
F: 973.835.7856
msirotnak@solarproducts.com

Brian Ray
Ray Products
1700 Chablis Drive
Ontario, CA 91761
T: 909.390.9906
F: 909.390.9984
brianr@rayplastics.com

Brian Winton
Lyle Industries, Inc.
4144 W. Lyle Road
Beaverton, MI 48612
T: 989-435-7714 x 32
F: 989-435-7250
bwinton@lyleindustries.com

MATERIALS COMMITTEE

Jim Armor
Armor & Associates
16181 Santa Barbara Lane
Huntington Beach, CA 92649
T: 714.846.7000
F: 714.846.7001
jimarmor@aol.com

Phil Barhouse
Spartech Packaging Technologies
100 Creative Way
PO Box 128
Ripon, WI 54971
T: 920.748.1119
F: 920.748.9466
phil.barhouse@spartech.com

Lola Carere
Premier Material Concepts
2715 Maple Park Drive
Cumming, GA 30041
T: 567.245.5253
F: 770.406.8217
lcarere@rowmark.com

Juliet Goff
Kal Plastics, Inc.
2050 East 48th Street
Vernon, CA 90058-2022
T: 323.581.6194
Juliet@kal-plastics.com

Donald Hylton
McConnell Company
646 Holyfield Highway
Fairburn, GA 30213
T: 678.772.5008
don@thermoformingmc.com

Roger P. Jean (Chair)
Rowmark/PMC
PO Box 1605
2040 Industrial Drive
Findlay, OH 45840
T: 567.208.9758
rjean@rowmark.com

Laura Pichon
Ex-Tech Plastics
PO Box 576
11413 Burlington Road
Richmond, IL 60071
T: 847.829.8124
F: 815.678.4248
lpichon@extechplastics.com

Robert G. Porsche
General Plastics
2609 West Mill Road
Milwaukee, WI 53209
T: 414-351-1000
F: 414-351-1284
bob@genplas.com

Clarissa Schroeder
Auriga Polymers, Inc.
Film & Sheet Division
1551 Sha Lane
Spartanburg, SC 29307
T: 864.579.5047
F: 864.579.5288
Clarissa.Schroeder@us.indorama.net

Eric Short
Mytex Polymers
1403 Port Road
Jeffersonville, IN 47130-8411
T: 248.705.2830
F: 248.328.8073
eric_short@mytexpolymers.com

PROCESSING COMMITTEE

Haydn Forward (Chair)
Specialty Manufacturing Co.
6790 Nancy Ridge Road
San Diego, CA 92121
T: 858.450.1591
F: 858.450.0400
hforward@smi-mfg.com

Richard Freeman
Freetech Plastics
2211 Warm Springs Court
Fremont, CA 94539
T: 510.651.9996
F: 510.651.9917
rfree@freetechplastics.com

Ken Griep
Portage Casting & Mold
2901 Portage Road
Portage, WI 53901
T: 608.742.7137
F: 608.742.2199
ken@pcmwi.com

Steve Hasselbach
CMI Plastics
222 Pepsi Way
Ayden, NC 28416
T: 252.746.2171
F: 252.746.2172
steve@cmiplastics.com

Roger Kipp
McClarin Plastics
15 Industrial Drive
PO Box 486
Hanover, PA 17331
T: 717.637.2241
F: 717.637.2091
rkipp@mcclarinplastics.com

Bret Joslyn
Joslyn Manufacturing
9400 Valley View Road
Macedonia, OH 44056
T: 330.467.8111
F: 330.467.6574
bret@joslyn-mfg.com

Stephen Murrill
Profile Plastics
65 S. Waukegan
Lake Bluff, IL 60044
T: 847.604.5100 x29
F: 847.604.8030
smurrill@thermoform.com

Dennis Northrop
Soliant LLC
1872 Highway 9 Bypass
Lancaster, NC 29720
T: 803.287.5535
dnorthrop@paintfilm.com

Mark Strachan
Global Thermoforming Technologies
1550 SW 24th Avenue
Ft. Lauderdale, FL 33312
T: 754.224.7513
mark@global-tti.com

Jay Waddell
Plastics Concepts & Innovations
1127 Queensborough Road
Suite 102
Mt. Pleasant, SC 29464
T: 843.971.7833
F: 843.216.6151
jwaddell@plasticoncepts.com

Director Emeritus
Art Buckel
McConnell Company
3452 Bayonne Drive
San Diego, CA 92109
T: 858.273.9620
artbuckel@thermoformingmc.com

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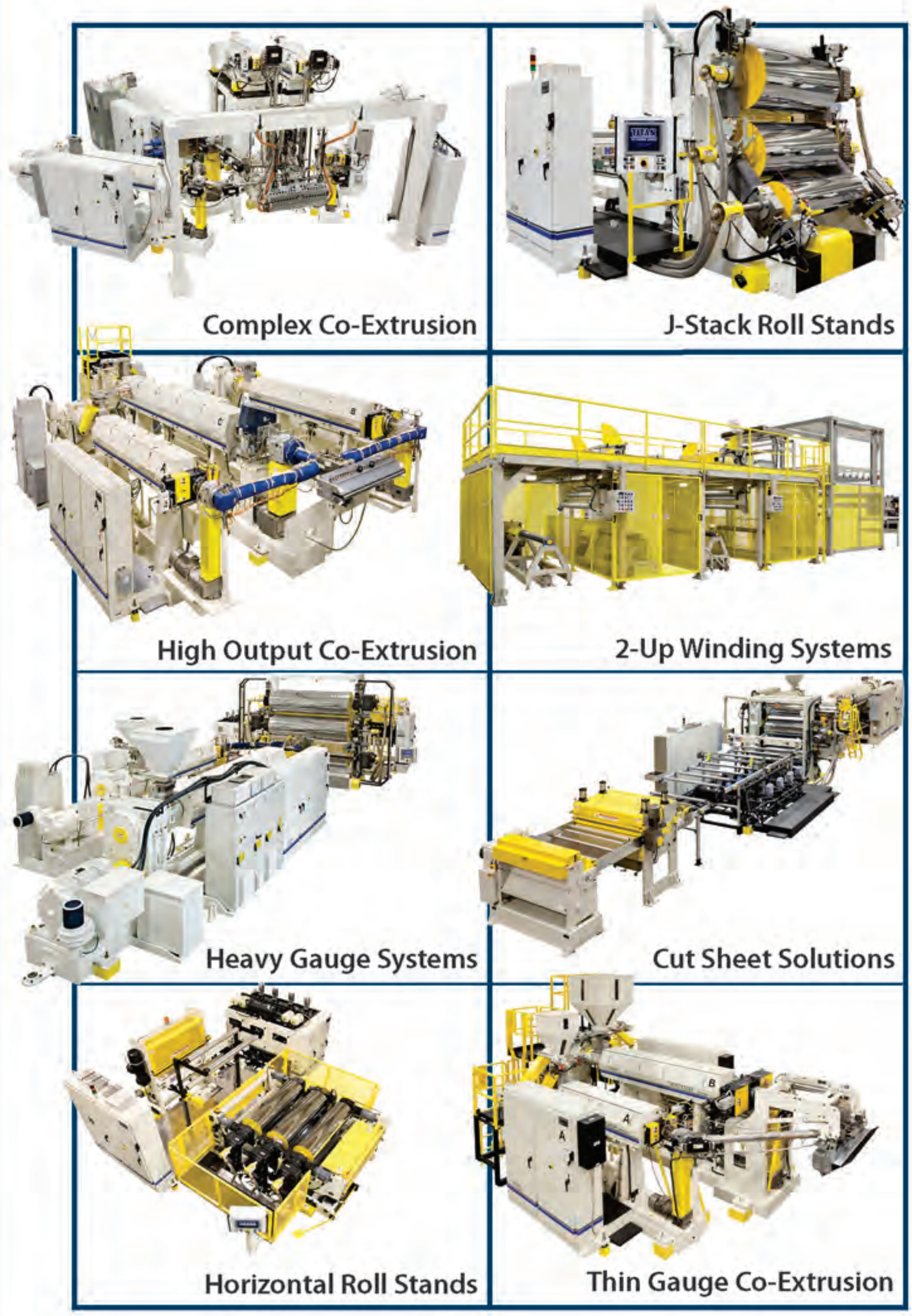

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