



Thermoforming

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Stand **Out** from the Crowd

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Thermoforming of Low Viscosity Polymers

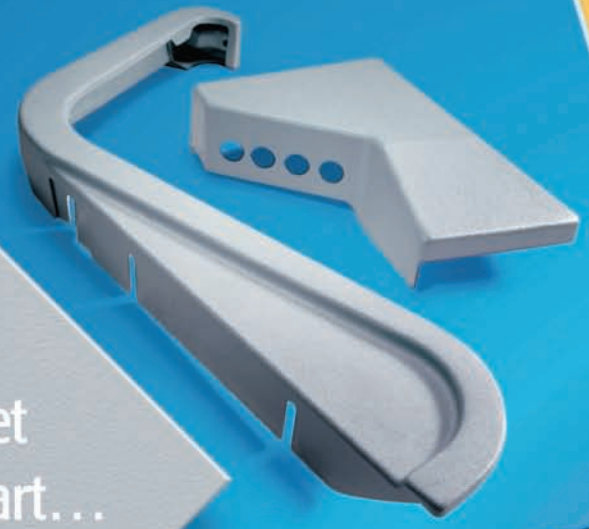

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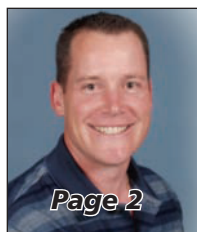
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My two-year term as Chairman of the Thermoforming Division is coming to a close. As I sit back and reflect on the past 24 months, I am amazed at what flashes through my mind. As a division, as manufacturers and as Americans, we have endured one of the toughest economic periods in the history of the world. The recent global recession is something that will be remembered for generations to come. In the same way that older generations talk of the Great Depression, the oil embargo in the 1970s, and the dot-com crash of the 1990s, I too will tell my children about the economic crisis that gripped this country in the late 2000s.

Despite the turbulence of the past two years, we were still able to accomplish a fair amount of work. We held a successful thermoforming conference in

2008 in Minneapolis and made a tough decision regarding 2009. Preparations for 2010 in Milwaukee are now ramping up. We continued to provide scholarships for students and matching grants for equipment by universities. We maintained our leadership position as the go-to organization for all things thermoforming. In addition, we provided seed money for the development of a technical center at Penn College. Successful collaboration with SPI, *Plastics News* and the European Thermoforming Division resulted in a sharper focus for the industry in a period when the effects of globalization continue to be felt. 2009 was also the year that we hosted a thermoforming pavilion at NPE for the first time.

These tangible activities, and numerous others, have kept the thermoforming process relevant and important to U.S. manufacturing during difficult times. However, perhaps most critical to our success are the individual efforts of our members who continue to showcase the process to ensure that thermoforming can expand into new markets in the years to come.

Although the last two years were filled with some difficult decisions, they are also filled with some very memorable moments. I enjoyed a higher level of interaction with fellow board members. I am always impressed with our volunteers; to say that our board members are selfless is an understatement. With that said, I would like to thank all the companies that support board members and allow them to attend meetings and volunteer their time away from the office and factories. This employer support is pivotal in ensuring a dynamic board that both drives and supports this industry.

I look forward to continuing my involvement over the next several years. I am excited about the goals and objectives that our new chairman – Ken Griep – will bring to the organization. I encourage everyone to mark their calendars for the 2010 Conference: September 18th - 21st, 2010 in Milwaukee.

Thank you for your continued support and I look forward to seeing you in Milwaukee if not sooner. |

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

Why Join?



Why Not?

Thermoforming of Low Viscosity Polymers

Dr. Majid Tabrizi, Chianeng Kong, Center for Plastics Processing Technology,
University of Wisconsin-Platteville

Introduction

Plastics processing is commonly classified on the bases of processing techniques. The six most common plastic processing techniques are: injection molding, thermoforming, blow forming, extrusion, compression and transfer molding. The development and the selection of these processes, however, is greatly affected by material condition, including material viscosity.

An example of such consideration can be seen during the thermoforming process when the sheet at the time of processing must have sufficient viscosity to be held and transferred to oven and into the forming press by the clamp system. Materials with low viscosity including liquids and low melting wax are historically considered non-thermoformable. Hence, the selection of materials that are highly affected by resin viscosity is limited to material with sufficient viscosity at room temperature as well as during the processing condition.

Viscosity is defined as the resistance to flow. Liquids have minimal viscosity. Waxes, solid materials at room temperature do not exhibit sufficient viscosity and melt strength during the heating cycle hence they are considered non-thermoformable.

The goal of this investigation was to study the possibilities of thermoforming low viscosity materials. This study emphasized thermosetting liquid resin mixed with reinforcing materials to produce a high strength thermosetting composite.

Procedure

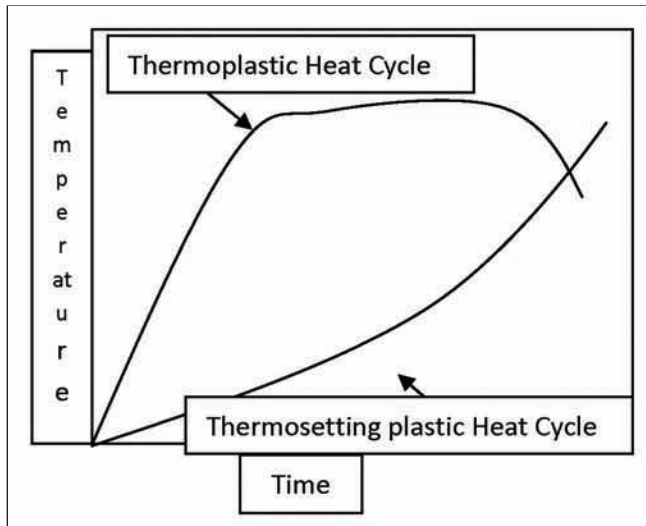
Thermoforming is a process of converting a thermo-plastic sheet in to the configuration of mold. The thermoforming process can include several configurations. Each has different arrangements to accommodate the variation in material thickness, processing condition, rate of output, and part size. A common denominator for all of these processes, however, is the heating of the plastic sheet and the configuration of a cold mold.

The heating and cooling cycle of a chosen material is a decisive factor in quality of the final product. This factor is particularly crucial when the thermoforming material is the combination of thermoplastics and thermosetting. In processing the thermoplastic material, the plastic sheet undergoes heating to the processing temperature. The processing temperature is some way above the glass transition temperature (T_g). The thermoformed part must cool to the temperature below the Heat Distortion Temperature (HDT).

During the processing of thermosetting materials, the plastic must be heated to the processing temperature and has been placed against or into the heated mold. The heated plastic material will increase further in temperature once it comes in contact with the heated mold, and the exothermic chemical reaction occurs. The plastic product is then removed from the mold when sufficient cross linking takes place. The part can be removed from the mold regardless of the part's temperature.

The following diagram on page 7 offers a comparison of the thermoplastics and thermosetting materials heat cycle.

Figure 1. Heat cycle for thermoplastic and thermosetting materials.



Material Selection

The goal of the investigation was to study the possibility of thermoforming low viscosity plastic materials. Specifically, the intention was to study the possibility of thermoforming composite materials with polyester, a liquid thermosetting resin with no noticeable viscosity. The process utilized the cotton fiber as a reinforcing material and PET to facilitate the process.

The polyester resin of different mixture and the reinforcement were placed between two sheets of 0.020" PET and placed in the clamp for thermoforming. A thermoplastic sheet was selected due to the processing condition. The process was affected by the curing time,

Table 1. Sample descriptions

Samples	Polyester resins (oz)	Catalyst drop
1	1	6
2	1	7
3	1	8
4	1	9
5	1	9.5
6	1	10
7	1	10.5
8	1	11
9	1	11.5
10	1	12

a process of converting the liquid resin into the solid state by creating cross linking. The curing time was effected by the ratio of catalyst to the matrix.

Insufficient amounts of catalysts do not cure the resin. Too much of the catalyst leads to process difficulties as well as excess heating causing the part deformation and the reduction of certain properties.

The rationale for the selection of the mixing ratio of resin and catalyst was based on manufacturer suggestion. The manufacturers suggested 10 drops of catalyst for each flow ounce of resin. The amount of resin was changed from 1 oz. to 4 oz.

Process Preparation

A hydro-trim thermoformer equipped with a matched mold was selected as a press. A set of aluminum prototyping molds in the form of a 10" diameter frisbee (1" deep). The processing parameters of PET had been implemented, and the thermoformed samples had been stored for 24 hours to achieve the completed curing.

Testing

Dynatup impact testing has been used to examine the quality of test samples. The test parameters and the results are shown in Table 2.

Table 2. Test result of impact testing.

Sam ple	DATA				
	Impact Velocity	Impact energy	Max. load	Energy Max.Ld	Total Energy
	ft/sec	ft/lb	lb	ft-lb	Ft-Lb
1	10.72	89.21	23.32	0.08	0.18
2	10.71	89.15	14.58	0.09	0.09
3	10.73	89.39	17.5	0.05	0.05
4	10.73	89.37	19.69	0.03	0.03
5	10.72	89.36	12.4	0	0.01
6	10.74	89.66	13.12	-0.01	-0.01
7	10.68	88.59	11.66	0.01	0.03
8	10.57	86.8	14.57	0.12	0.15
9	10.65	88.13	15.3	0.22	0.22
10	10.54	86.35	32.06	0.49	1.55

(continued on next page)

The Result

The visual inspection of the thermoformed test sample has shown an acceptable level of physical and adhesion properties. The sample showed the pleasant appearance associated with the thermoplastics outer layer combined with the rigidity of the inner thermosetting plastics and an improvement in strength associated with the reinforcing materials.

The impact strength of the samples has shown the contribution of the PET layer in improving the shutter resistance of the sample. The following graph depicts the result of the impact strength for the test samples.

Figure 2. Photograph of samples after impact testing.

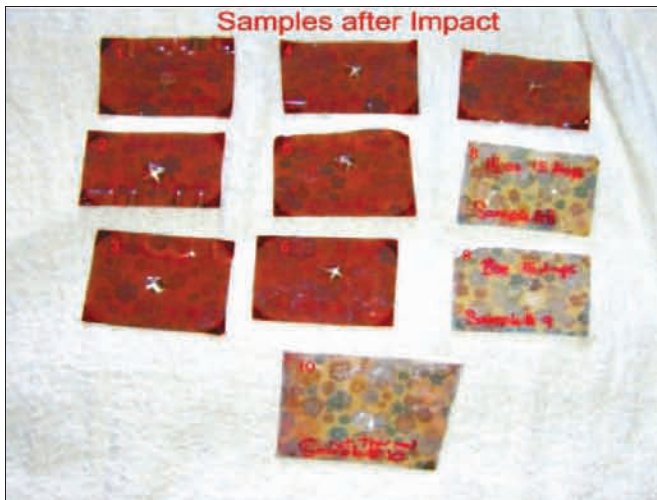


Figure 3. Graphic representation of the impact energy for the test sample.

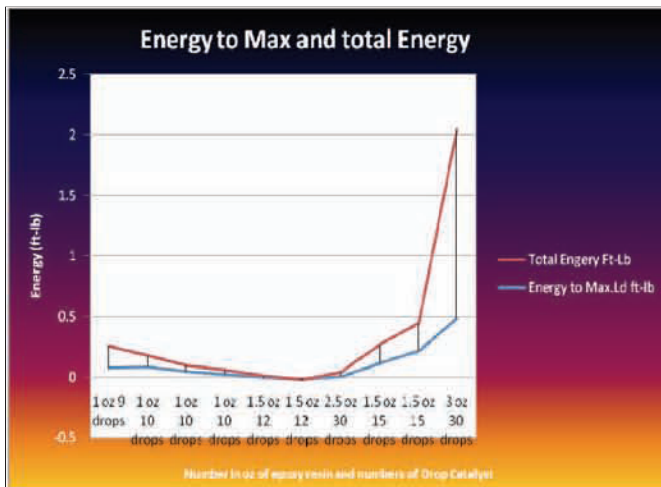


Figure 3 represents the “energy to maximum,” total energy (ft.-lb.) to the amount of epoxy resin used (oz.), and the total number of catalyst drops for a sample.

Figure 4. Graphic representation of sample deflection at the time of impact for test sample.

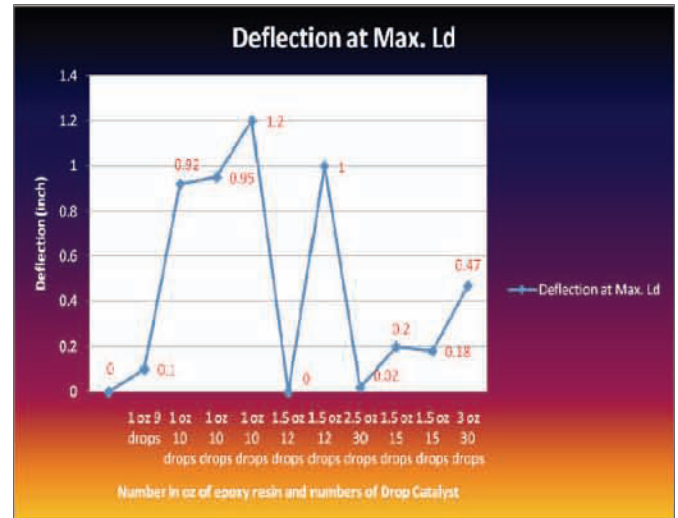


Figure 4 represents the deflection at maximum: LD (inches) with the amount of polyester resin and the total number of catalyst drops for a sample.

Figure 5. Maximum load for the samples.

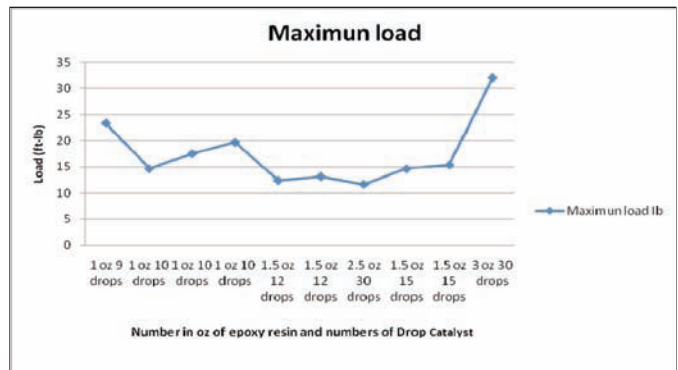
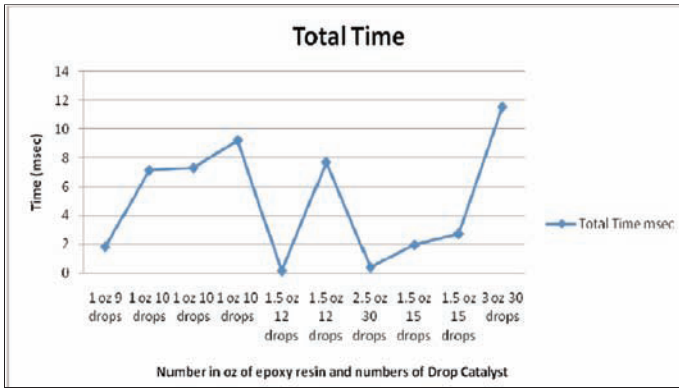


Figure 5 represents the maximum load (ft.-lb.) of the thermoformed test sample. The graph shows an increase in impact strength for the sample with maximum amounts of catalyst.

Figure 6, shown on page 7, represents the total time (m.-sec.) necessary to fracture the samples. The graph shows a noticeable increase in time for the sample with the maximum level of catalyst.

Figure 6. Graphic representation of fracture time for the samples.



Conclusion

Thermoforming of low viscosity resin, such as polyester resin, is possible when the thermoplastic sheets are used as supporting materials. The additional reinforcing materials allowed for the production of a thermoforming structure with physical appearance of thermoplastics, rigidity of thermosetting, and the strength attributed to the reinforcing materials. |



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Plastics Technologies in Motion.

Summary Report of the Plastics Processing Industry

Jeff Mengel, Plante & Moran

Thoughts on Becoming a Highly Successful Company

Get back to basics – the best companies have exquisite alignment of their strategy, organizational structure, compensation and systems (SOCS). Yet only 66 percent of our respondents prepare strategic plans. Now is a unique time to re-invent your company as you rebuild it from the aftermath of the “Great Recession.”

Strategy is the heart of any reinvention. Designing a value proposition that is intriguing (resonates with the customer, has growth potential) and unique (not easily imitated by competitors) creates margin and demand. With a strong value proposition you have the ability to select who you want as a customer. Unfortunately, most companies are pack rats that collect customers without regard to fit with the value proposition.

Organizational structure is how you are designed to fulfill your strategy. Companies with weak or no strategies tend to

(Editor's Note: The following article is an edited version of the recent comprehensive “Summary Report of the Plastics Processing Industry” prepared by Plante & Moran, PLLC. This abbreviated version is designed to provide thermoforming companies with a snapshot of the overall plastics industry in which they operate. As with most industry-wide reports, injection molding provides the basis for the majority of the data. However, the strategic and operational insights offered are not unique to injection molders as the key performance indicators used by the authors are also applicable to thermoformers. For further reading or to request a copy of the complete report, contact Jeff Mengel at jeff.mengel@plantemoran.com.)

be designed for any contingency, which sounds reasonable, but creates unnecessary costs.

Companies organized around their strategy will be leaner and more streamlined. The company design is also streamlined with consistent equipment standards.

During this recession:

- Strong companies used their retained talent to work at positions below their former responsibility to redesign more productive processes.
- Strong companies acquired talent that enhanced their strategy.
- Strong companies embraced flexible automation for further headcount reductions and improved quality.
- Strong companies acquired equipment at auctions to upgrade existing equipment.

Compensation of the workforce has undergone a substantial change with reduced wages and benefits as companies battled reduced demand. An economic recovery will create pressure to restore the lost wages and benefits. Increased use of variable pay is one method to meet the compensation expectations of the employees while matching pay with progress. Beware: you get what you pay for. Variable pay must be carefully crafted to align with the strategy to avoid gamesmanship and inconsistent behavior.

Business operating systems used to monitor performance must be real-time and action-oriented. However, too many business operating systems are historical in nature and do not provide actionable information. Strong companies have identified key performance indicators that align with the strategy and are monitored regularly. Furthermore, strong companies managed manufacturing complexity

through properly aligned systems versus through the efforts of labor. Complexity creates traffic jams that can be reduced with coordinated and controlled deployment.

Other observations of note:

- Highly successful companies are not large. The technical niche they exploit may be better suited to a narrower market. But rest assured they are not thriving on volume.
- Highly successful companies have more working capital availability – more cushion to address capital investments and daily operations.
- Highly successful companies are two times more likely to be component specialists than the average molder/processor.
- Highly successful companies may invest heavily in new equipment, but net equipment is still a smaller percentage of total assets than the average. More of the successful companies' assets are in receivables and inventory.
- The highly successful companies have average utilization, but also above-average manufacturing complexity, primarily due to the number of active molds required to match their higher degree of

customer diversification.

It is necessary to have available capacity to manage complexity and the vagaries of the customers' demands.

- Highly successful companies use predominately intermediate and engineered resins, but also purchase a higher percentage of resins under the customers' P.O.s, meaning they are not rewarded/punished for commodity risk.

Key Performance Indicators

Value Added Per Employee

The concept of value-added addresses what you convert within your four walls, not what you buy from the outside. It is difficult to compare sales activity between different organizations due to the varying material content. Value added per employee eliminates this variable and makes comparisons between organizations more meaningful. Companies with low value added per employee should look to how they are organized, as it typically means you have too many people.

Lean Savings Percentage

The industry, by and large, has poor acceptance of lean manufacturing techniques (a median inventory turnover of just 7.4 times). This allows companies with the discipline and skills to reap significant cost, capacity and responsiveness advantages

over their competition. Larger companies tend to adopt lean principles more extensively and also have higher savings as a percentage of earnings.

Training Per Employee

You would never know that labor is the most significant cost beyond material based on how little is invested in training and retaining our workforce. The appropriate level of training per employee should be considered as a strategic initiative, even though there is no correlation between higher training and higher profits.

Delivery Percentage

While higher delivery performance does not guarantee you higher profits, lower delivery performance guarantees you higher costs and more upset customers. A lower delivery level generally means you incur additional costs to expedite jobs, are less responsive to schedule changes and also have lower inventory turns. |

THERMOFORMING QUARTERLY invites thermoformers to comment and contribute their business perspective to the magazine. If you would like to submit a letter to the editor or if you would like to write a business article, contact [Conor Carlin, Editor, at cpcarlin@gmail.com.](mailto:cpcarlin@gmail.com)

Plug Materials for Thermoforming: The Effects of Non-Isothermal Plug Contact

Peter J. Martin, Hui Leng Choo, Chin Yong Cheong, & Eileen Harkin-Jones, Thermoforming Research Group, Queen's University Belfast, Northern Ireland

Abstract

The plug-assisted thermoforming process is the largest and most important industrial thermoforming process. The main aim of this study was to investigate the interaction between the properties of the plug and the polymer sheet in thermoforming. Non-isothermal plug only thermoforming tests were carried out using identical plug designs for various combinations of plug and sheet materials. It was hoped that this study would help to improve the understanding of friction and heat transfer effects during the thermoforming process. The plug materials used included: Hytac-B1X (thermoplastic syntactic foam), Hytac-WFT (epoxy syntactic foam with added Teflon), Blue Nylon, and POM (polyoxymethylene). The sheet materials included aPET and polystyrene (HIPS). It was found that the magnitude of slip during plug contact was much higher with aPET than with HIPS and that this reduced as the temperature of the plug was increased. Different plug materials produced significantly different wall thickness distributions in the preforms. It was concluded that friction was the dominant effect during contact.

Introduction

In most thermoforming processes the most important practical operating consideration is the ability to control the wall thickness distribution since this will largely determine the physical properties of the final product. In the case of an uneven thickness distribution the thinnest regions will tend to dictate the maximum achievable mechanical strength of the formed part. Considerable effort in industry is therefore expended in trying to balance the wall thickness of thermoformed parts. Most often this simply involves trial and error changes whilst in production. However, it is clear that for most companies there is little in-depth understanding of the physical phenomena that lead to the particular wall thickness distributions in parts.

For many years various studies had been carried on plug-assist thermoforming in order to gain a deeper understanding and better control of the process. As a result of these it is known that different process parameters such as sheet temperature, plug temperature, and plug material have a significant effect on the wall

thickness distribution and properties of the thermoformed part. Various researchers have studied the influence of factors such as plug material, temperature, speed and geometry, and sheet material and temperature [1-5]. These have highlighted in particular the important roles that heat transfer and contact friction play in the thermoforming process.

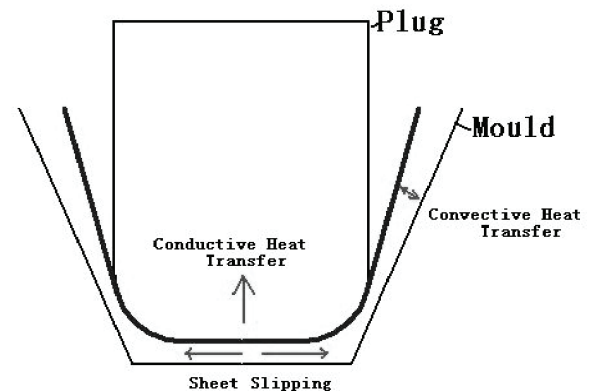


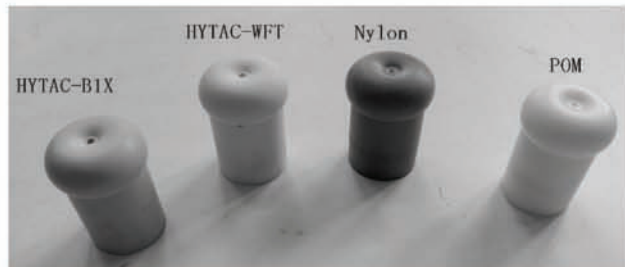
Figure 1. Stretching of polymer sheet during thermoforming.

Figure 1 illustrates the key elements that determine the stretching behavior of the sheet during plug contact. As can be seen from the figure, during the process heat is primarily lost from the sheet through conduction into the plug and convection into the surrounding air. The sheet may slide across the contacting surface of the plug as it moves downwards, but the magnitude of this effect is modified by frictional resistance that is determined by the coefficient of friction between sheet and plug. Locally the stretching behavior of the sheet material is therefore modified by its change in temperature and the contact friction. It has been observed that coefficients of friction for most polymers increase with temperature, and so on plug contact it is likely that the resistance to sliding will fall because of heat loss into the plug by conduction [2]. However, the ability of the polymer to stretch, and thereby slide, is also temperature dependent. Lower temperatures will stiffen the sheet and make it harder to deform, and this may actually reduce the magnitude of sliding despite the lower coefficient of friction. Conversely, higher temperatures should make the sheet easier to stretch but stretching may actually be less due to much higher coefficients of friction.

The main objective of this study was to investigate how different combinations of plug and sheet materials change the wall thickness distribution produced by thermoforming, and thereby gain an insight into the interacting effects of friction and heat transfer. Rather than study the entire process, tests were carried out in which perform shapes were produced by pushing a plug of pre-determined shape into a heated sheet, and then freezing the resulting wall thickness distribution with cooling air.

The sheet materials used in this study included commercial thermoforming grades of high impact polystyrene (HIPS) and amorphous PET. The thicknesses of the sheets used were 0.8 mm for HIPS and 0.5 mm for aPET and all of the sheets used were sourced from industry and were extruded under the normal extrusion conditions typical for thermoforming applications.

The plug materials used were Hytac-B1X (thermoplastic syntactic foam, Manufacturer: CMT Materials), Hytac-WFT (epoxy syntactic foam with added Teflon, Manufacture: CMT Materials), HS Blue Nylon (Quadrant EPP Nylatron® MC® 901), and POM-C (polyoxymethylene, Quadrant EPP Acetron® GP Acetal). A specially designed plug with a doughnut-shaped end was used for these tests as shown in Figure 2.



Three factors were investigated in this study: plug temperature, sheet material, and plug material. Sheet temperature was fixed near to the maximum forming temperature, plug forming depth was fixed at 96 mm and plugging speed was set to 200 mm/s. aPET was formed at 100°C and HIPS was formed at 150°C. For aPET sheet, the effects of different plug temperatures were tested at three different plug temperature settings: room temperature (25°C), 62.5°C, and 100°C. HIPS was tested with plugs at room temperature (25 °C) and 87.5 °C. The test settings used are summarized in Table 1.

Thermoforming of the polymer sheets was performed using a laboratory plug-assisted thermoforming machine. For these tests the normal mold cavity assembly

was replaced by an open ring, which allowed the heated sheet sample to be deformed into a preform shape (Figure 3a). Firstly, sheets were cut to fit a 230mm diameter clamping frame and then placed onto a tray and heated in an oven to the required temperature. Sheet temperatures were monitored using a non-contact infrared sensor and after the required heating period, the tray was removed from the oven. The bottom platen holding the open ring mold was then moved up such that the ring mold came up and sealed against the sheet clamped on the frame. Then forming simply involved the displacement of the plug into the sheet surface and the shapes formed were frozen at the end of plugging by the application of cooling air from below.

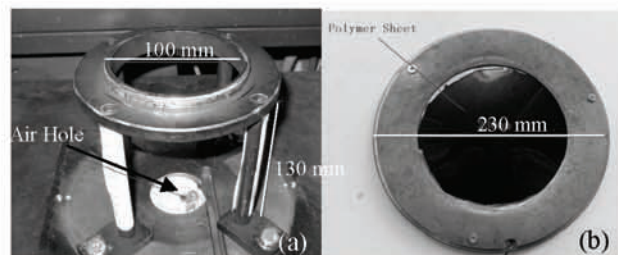


Figure 3. (a) Open ring mold. (b) Polymer sheet frame.

Table 1. Table showing plug temperature used for the different plug-sheet combinations.

	PS (150°C)	APET (100°C)
Hytac-B1X	RT, 87.5 °C	RT, 62.5 °C, 100 °C
Hytac-WFT	RT, 87.5 °C	RT, 62.5 °C, 100 °C
HS Blue Nylon	RT, 87.5 °C	RT, 62.5 °C, 100 °C
POM-C	RT, 87.5 °C	RT, 62.5 °C, 100 °C

RT = Room Temperature = 25 °C

The wall thickness distribution of the formed parts was measured using a handheld ultrasonic thickness gauge at the points indicated in Figure 4. Each formed part was measured at 3 different sections located at 120 degree intervals around its periphery. The results presented in this paper show the average measured thickness.

Results and Discussion

Figure 5 shows a typical part formed using the doughnut plugs shown in Figure 2. It was formed to a depth of 96 mm and like most of the specimens it is clear that the material has wrapped itself around the doughnut shaped end.

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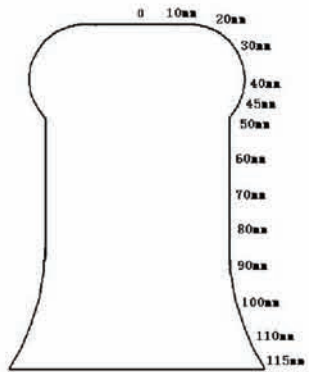
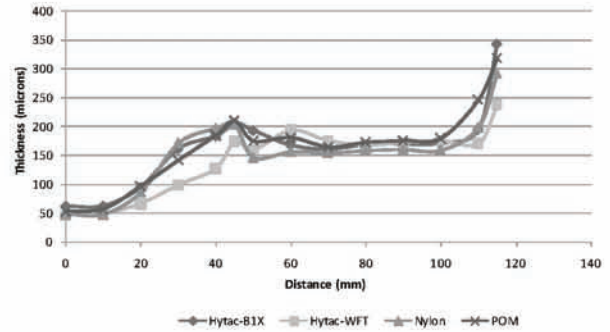


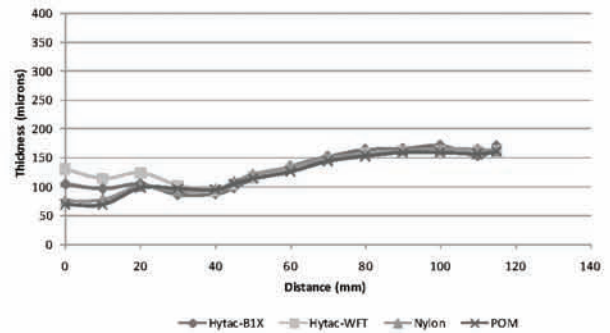
Figure 6 shows the effect of different plug materials at room temperature on the wall thickness distribution of aPET. As can be seen from the graph, the finished parts formed have relatively thin bases and their sidewall thickness increases gradually from the base up to a distance of 55 mm. There is little difference between the four plug materials, although WFT gives the thinnest base suggesting that it is best at enabling slip at this temperature. Overall the thin bases in these specimens show that the lower temperature plug is promoting slip across the contacting surface and the expected cooling effect due to heat transfer is less significant in altering the sheet deformation.

When plug temperature was increased to 62.5 °C (Figure 7), the average base thicknesses of the formed aPET parts were thicker than those formed at room temperature. There were also clearer differences between the different plug materials. Parts formed by Hytac-WFT showed the thickest base whereas parts formed by Hytac-BIX showed the thinnest base. These results suggest that frictional resistance is higher due to the higher contact temperature and this again highlights the important role that friction plays in the process.

Comparison of different plug materials at room temperature



Comparison of different plug materials at 62.5 °C



As can be seen from Figure 7, cups formed with Hytac-BIX and Hytac-WFT tends to pull more material to the base whereas cups formed with nylon and POM show a thinner base. It can also be observed that most of this change in stretching occurs up to 40 mm from the middle of the tip of the plug, which is the end of the corner radius of the doughnut shape. The material that slides from the base is then redistributed relatively evenly over the sidewalls of the preform beyond the 40mm mark.

Figure 8 shows the wall thickness distribution of the aPET parts formed when the plug temperature was increased to 100°C, the same temperature as the sheet. Once the plug temperature was increased to the temperature of the sheet, more material was drawn downwards by the plug forming a very thick base. This suggests that as the plug temperature is increased from room temperature to 100°C, the coefficient of friction between plug and sheet increases significantly. Effectively these tests were isothermal as the sheet and plug were approximately the same temperature. Again significant differences in behaviour may be observed for the four different plug materials. The sheet seems to have great difficulty in sliding across the plug surface at high

temperature and this causes excessive material to remain in the base of the part. The thinnest section lies between 30 mm and 45 mm, before the thickness increases again in the sidewall. Hytac-WFT formed the thickest base whereas POM formed the thinnest part.

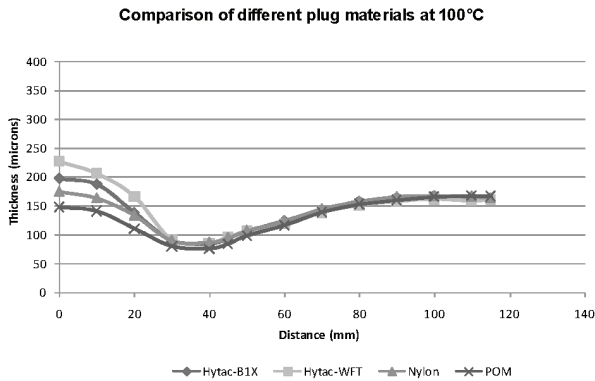


Figure 8. Wall thickness distribution of aPET sheets formed by different plug materials at 100°C.

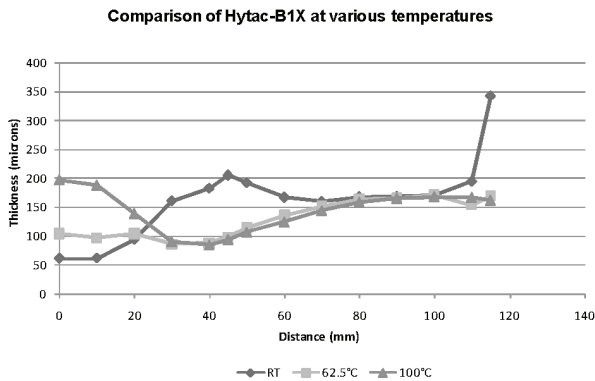


Figure 9. Comparison of the wall thickness distribution of aPET sheets formed by Hytac-B1X at various plug temperatures.

In order to highlight the effect of plug temperature on the results, Figure 9 shows a comparison of the wall thickness distribution of aPET sheets formed by Hytac-B1X at various plug temperatures. It can be seen that the base is thickest when the plug temperature is at 100°C followed by 62.5°C and then room temperature. This suggests that contact friction, rather than heat transfer dominates the stretching behavior with the frictional resistance to sliding increasing with increasing contact temperature. The most even wall thickness in the preform is produced by the plug at 62.5°C. All the other plug materials followed similar trends.

Figure 10 shows the wall thickness distribution of HIPS parts formed by different plug materials at room temperature. The stretching behavior of the HIPS sheet is markedly different from that observed for the aPET sheet.

During thermoforming HIPS sheet formed a very thick base section, with the result that the sidewalls of the perform were substantially thinner. From the figure, it may be observed that the bases of the preforms are more than twice the thickness of their sidewalls. The results for the four plug materials are similar, although the syntactic foam plugs create slightly thinner bases than the other materials.

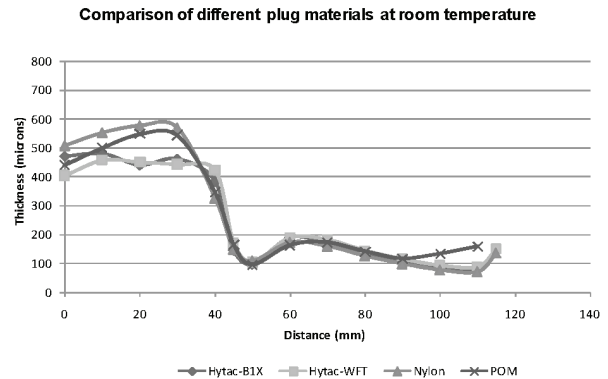


Figure 10. Wall thickness distribution of HIPS sheets formed by different plug materials at room temperature.

When parts were formed with the plug at 87.5°C, the stretching behavior of the sheet (shown in Figure 11) was largely similar to that for the room temperature plug. Again the base region of the preform was substantially thicker than the sidewall, although this time the middle part of the preform base was even thicker with the 87.5°C plug, suggesting an increase in frictional resistance. The preform thickness fell rapidly from 40-50 mm and then remained relatively stable across the sidewall. Differences between the four plug materials remained small, although with the rise in temperature it is the syntactic foam plugs that now create the thickest base.

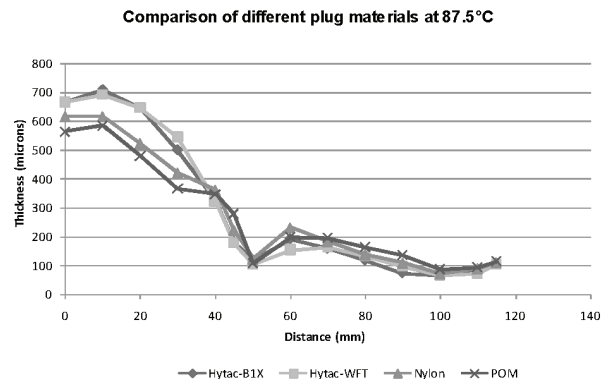


Figure 11. Wall thickness distribution of HIPS sheets formed by different plug materials at 87.5°C.

Figure 12 shows a comparison of the wall thickness distribution of HIPS sheets formed by Hytac-B1X at various plug temperatures. It can be seen clearly that the

(continued on next page)

HIPS performs have very similar wall thickness distributions with very thick bases and comparatively thin sidewalls. The main effect of the increase in plug temperature is to increase the base thickness even further, suggesting that the already relatively high frictional resistance increases even further with temperature. All the other plug materials behave in a similar manner.

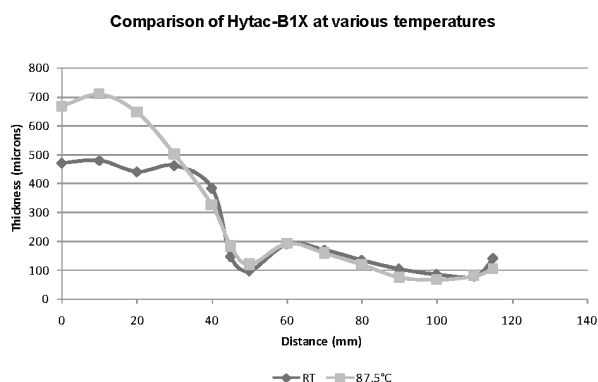


Figure 12. Comparison of the wall thickness distribution of HIPS sheets formed by Hytac-B1X at various temperatures.

Conclusions

From the aPET thermoforming tests, it was observed that the base of the preform is relatively thin for all of the plug materials at room temperature, indicating that the resistance to slip is relatively low. This suggests that friction is the dominant effect in determining the wall thickness distribution. Heat transfer does not appear to be significant. As plug temperature is increased the base thickness is increased, indicating that frictional resistance increases with temperature. Hytac-WFT created the thinnest base and POM the thickest base at room temperature but these effects were reversed at higher plug temperatures. The performance of the different plug materials was therefore found to be very temperature sensitive. The tests on HIPS produced very different results to those for aPET sheet. HIPS parts had much thicker bases, indicating much higher frictional resistance for all of the plug materials. Higher plug temperatures increased base thickness further, which again confirmed rises in frictional resistance with temperature. The syntactic foam plugs enabled more slip at room temperature but these effects were reversed at higher plug temperature.

More experiments will be carried out on different sheet materials in future tests. In addition it is proposed to create preforms at different plug depths to investigate the progression of slip during contact. |

Acknowledgements

The authors would like to thank the members of the PlugIn project consortium for their help with these experiments and the European Commission for funding this work.

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Key Words

Thermoforming, Plug, Friction, Heat Transfer.

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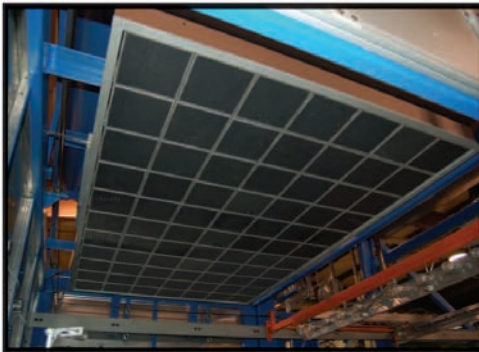
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COUNCIL SUMMARY



Roger Kipp
Councilor

Council Communications

The Fall Council Meeting was held in Southbury, CT on October 24, 2009. The following are highlights of that meeting and prior Committee meetings I attended while representing the Thermoforming Division

Communications Committee

- The Communications Committee has completed the criteria and format of the Communications Excellence Award. This award will replace the newsletter award and is designed to encourage creative communications beyond a newsletter and even traditional websites. These could involve two-way communication tools such as surveys, or other web presence. The value of the award will be the opportunity for sharing successful communication tools among all Divisions and Sections. A letter of introduction and application has been distributed.
- As Councilor, I encourage all Division members to share your suggestions for Communications success with our Chairman or any Board member.
- Communications within our Division, within SPE, within the industry and throughout the business community are all important to the growth and success of thermoforming.

Divisions Committee

- There was discussion on a proposal to provide support from the SPE Divisions and Sections to fund a National College Student Competition. Greg Campbell reported that the Extrusion Division Board has agreed in principle to take the lead and provide initial seed money. The goal of the competition is to get more recognition of polymers, plastics processing and SPE at the student and faculty level to a broad base of U.S. and Canadian universities. I have a Power Point presentation of the initial concept and will be pleased to forward at your request.
- A new Division in formation – the European Medical Polymer Division – was approved.

Council Notes

- The option of remote participation continued at this meeting allowing Sections and Divisions to be present from all corners of the world.
- The Treasurer, Jim Griffing, provided the financials reporting that through August, SPE is posting a loss of just under \$236,000.00. This compares to the loss of \$277,000.00 in 2008. However, the final revenue from ANTEC is not included as SPI has a balance due to SPE of \$125,000.00. While expenses have been reduced by \$800,000.00 – revenue is down one million dollars primarily due to lost membership. The sale of the SPE Headquarters was completed at \$1,275,000.00 less fees. A million dollars has been put in securities.

- The budget was reviewed and approved with the following highlights:
 - Spending to be focused on revenue generation.
 - Plastics Engineering will break-even in 2010 thanks to the Wiley agreement.
 - The budget revenue assumes membership of 15,000.
 - The new Corporate Outreach Program is budgeted for \$100,000.00 in revenue and already has \$30,000.00 committed.
 - The rebate to Sections and Divisions will be the same as 2009.
- There was a presentation recommending the downsizing of Council. The objective was to streamline the Council format and increase efficiency.
- The plan would reduce the Council members from 145 to 45. This would be accomplished by creating Sections in regions and “grouping” Divisions based on Division membership. There would still be regional meetings and group meetings. Larger Divisions would have a greater Council voice. The

presentation proposed that structure would establish equity for Council representation through Division and Section size. The proposal failed to win support for further consideration.

Staff Report

- SPE must proceed with an aggressive membership campaign. Halt decline, stabilize at 16,000 and stimulate new growth with a goal at 25,000 for 2011 year end.
- There is a new pricing strategy for new members at \$79.00 through a direct mail campaign – new programs for young professionals, retired past members and the unemployed are in planning.
- Target markets outside of the U.S.
- Reaching out through campaigns with Sections and Divisions and the acquisition of the PlastiVan Program are continuing action items.

These are highlights of many hours of meetings. If you have any questions or comments, I will be pleased to discuss with you in detail.

Roger Kipp
rkipp@



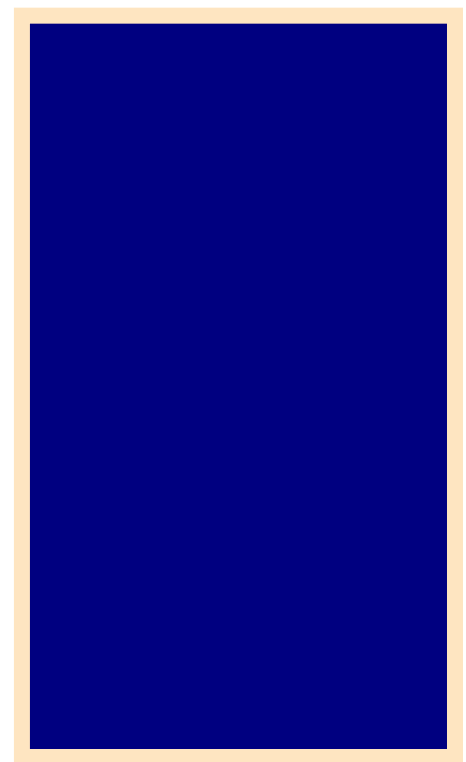
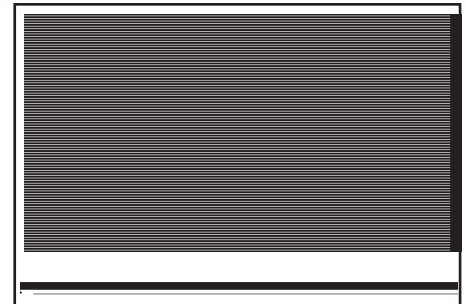
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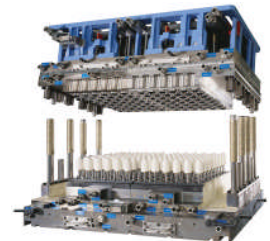
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18.00-20.00 Conference Registration
20.00-22.00 Welcome Reception – *A warm welcome to new and old friends and colleagues*

Friday 23 April 2010

General Session

08.45-09.00 **Introduction – Conference Introductions & Welcome**
Ken Darby, Chair ETD

Michel Py, Conference Chair

09.00-09.45 **Plastics and the World in 2030 – One man's vision or a fascinating & intuitive insight of which we should all take note?**

Dr. Wilfried Haensel / Plastics Europe,

09.45-10.15 **Handling the Development Process – With increasing demands from clients made on thermoformers to help develop product and project-manage, we gain guidance from 'front-line' consultants.**

Soren X. Frahm / Artlinc, Denmark

10.15-11.00 **Thermoforming: The American Way**
A fascinating opportunity to learn firsthand how our thermoforming colleagues from the USA are coping during difficult economic conditions.

Phil Driskill / Berry Plastics, USA,
Steve Murrill/Profile Plastics, USA

11.00-11.45 **Coffee Break**

11.45-12.30 **'Create Value, Not Waste' – The food and retail industry is under pressure to reduce use of resources and to generate less waste! How does the packaging industry answer that call? A critical look at ourselves and the options of the plastics converting industry.**

Paul Scheers / Reynolds Packaging, UK
and Marek Nikiforov / GN, Czech Rep.

12.30-14.00 **Lunch**

Thin Gauge Session (Parallel)

14.00-14.30 **In-line Stacking Solution – An overview on robotic stacking systems and a chance to compare with your own bespoke solution?**

Erwin Wabnig / Kiefel, Germany

14.30-15.00 **US Equipment for European Thermoformers – Does an American plant have a place in European manufacturing facilities? You may be surprised!**
Roger Moore / TSL, USA

15.00-15.45 **Coffee Break**

15.45-16.15 **Thermoforming Going East - Is it a case of the students becoming the masters?**
Henning Sandahl / Faerch, Denmark

16.15-16.45 **Ultrasonic Sealing & Cutting**
Expert advice in the 'minefield' of highly automated, high volume manufacture
Sven Engelmann / Gerhard Schubert, Germany

16.45-17.15 **Downgauging & Productivity - A timely and useful presentation on process control by implementing effective plug assist systems**
Michel Py, CGP, France and Jacob Plastics, Germany

Heavy Gauge Session (Parallel)		15.00-15.45	Coffee break
14.00-14.30	How to optimize the Product and Process to Design, Prototyping & Mouldmaking? Mauro Faè / Self, Italy	15.45-16.45	'How to re-enforce a Thermoformed Part? <i>In an increasingly dynamic market requiring light weight but immensely strong thermoformed parts, what are the options available?</i> Senoplast, Austria and John Watkins
14.30-15.00	Thermoforming Surfaces made economically – 'In at the deep end', bespoke thermoforming systems for industry Manfred Rudholzer / FRIMO, Germany	16.45-17.15	From Development to the Part Daniele Versolato / Solera Thermoform Group, Italy
		19.00	Conference Dinner and Sponsors presentations
 Saturday, 24 April 2010			
08.30-08.45	Welcome		
08.45-09.15	Industrial Design <i>An increasingly vital element in the business of thermoforming, we are introduced to a unique approach - a market driven innovation process</i> Liesbeth Longueville / Flanders in Shape, Belgium	12.15-12.45	Foaming Technology for thermoformed articles – <i>an insight into the technology we live with daily but perhaps never appreciated.</i> Luc Bosiers / Dow Benelux, Netherlands
09.15-10.00	How to survive in Thermoforming? – <i>expect an explosive account from a man that's been there and done it – survived and thrived!</i> Frank Nelissen, former Managing Director Sealed Air Nelipak, Netherlands	12.45-14.00	Lunch and Parts Presentations
10.00-10.45	Coffee break	14.00-14.30	Get Thermoforming out of the Black Box – <i>The quest for the 'dream machine' and associated technologies continues - innovative built-in data logging system for your thermoforming tools.</i> Peter Schöberl / Toolvision
10.45-11.15	The Thermoformers response to the Environmental Challenge – <i>In an ever changing market fuelled by environmental concerns, some would argue that it is one of the most important materials to ensure future survival for certain sectors of the thermoforming industry?</i> Andrew Copson / Sharp Interpack Europe, UK	14.30-15.00	Simulation – the vehicle to improve Designs and Technology David Russell / DRA, UK
11.15-11.45	The Influence of the Design of the Product – <i>one of Europe's leading manufacturers of thermoformed packaging informs conference of the importance of innovative design</i> Bent Eckehardt / PlusPack, Denmark	15.00-15.30	3rd Generation Thermoformers RDK-Series: <i>Increased cycle speeds, improved product quality and sustainability with 3rd generation thermoformers – a fascinating update on the new technologies T-IML and Thermo-Bottle-Former</i> Reiner Albrecht / Illig, Germany
11.45-12.15	Thermoforming of Biomedical Film-based Microdevices – <i>An insight into the latest film developments within the medical industry</i> Roman Truckenmüller, University of Twente, Netherlands	15.30-16.00	Study on Sales in Thermoforming – <i>Recent patterns of growth & Technological change in our industry – do you recognize the trends?</i> Peter J Mooney / PlasRes, USA
		16.00-16.15	Closing remarks
		16.15	Drinks and Champagne bottle raffle
			Sponsor Commercial presentations (parallel)

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Full exhibits will be offered. Our machinery section continues to grow each year. If you are not yet participating in our machinery section, you are encouraged to do so. Each 10' x 10' booth is fully piped, draped, carpeted and a sign will be provided. As an extra value, one comp full registration is included with every booth sold. This gives your attendees access to all **Technical Sessions, Workshops, Special Events, Expert Panel Discussions and all meals. A great bargain at \$2,250.00.**

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Should you have questions, please call (706) 235-9298, fax (706) 295-4276
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4th European Bioplastics Conference

10/11 November 2009, Berlin, Germany

The 4th industry conference on bioplastics took place in Berlin on the 10th and 11th of November 2009. Despite the difficult financial situation, the event set a new visitor record: 380 visitors and 27 exhibitors attended the conference hosted by the European Bioplastics Association. Experts still expect continued growth in the field of compostable and biobased materials. “Where will the industry be in five years’ time?,” “What are the trends?,” “Which materials will dominate the market?,” “How can we communicate the advantages for the environment and what are the optimum utilization fields for bioplastics?” Twenty-eight speakers and 380 participants dealt with these and other questions during the two-day bioplastics conference in Berlin. Altogether 237 companies from 27 countries attended the event. Approximately 78 percent came from Europe, 16 percent from Asia, and over five percent from North and South America. The European Bioplastics Conference is now in its fourth year and has become an established industry event. “To have broken attendance records, in spite of the difficult economic background, is extremely heartening. Market interest and uptake is very real and

(Editor’s Note: The production capacity of bio-based plastics is projected to increase from 360,000 tons in 2007 to approximately 2.3 million tons by 2013, representing 37% annual growth. A recently published European study shows that up to 90% of the current global consumption of polymers can technically be converted from oil and gas to renewable raw materials. This conference report is an abbreviated version of a longer version provided by the communications department of European Bioplastics. It appears in THERMOFORMING QUARTERLY thanks to the kind permission of European Bioplastics.)

bioplastics producers continue to increase both capacity and the technical capability of their materials,” cheers Andy Sweetman, Chairman of the Board of European Bioplastics.

The boundaries between ‘bio’ and ‘fossil’ are blurred

Those who think that the plastics industry will split into a “bio” and a “fossil camp” will probably be quite wrong. On the other hand, those who think that plastics could become much more sustainable by reverting more and more to renewable resources are right indeed. A significant example of the possibilities in this context is currently provided by one of the most famous brands in the world, Coca-Cola. Its “Plant Bottle,” of which two billion pieces are supposed to be produced next year for beverages, has a sugar share of up to 30%. The principle: take a polymer component – in this case PET – which can be derived from renewable resources, to replace a fossil component. The multi-million ton chemical compo-

nent ethylene can be obtained from bio-ethanol. This can be added to very different polymers as “bio-based element.” Using the example of Coca-Cola, bio-based ethylene is chemically modified to ethylene glycol, a monomer and component of PET. Coca-Cola has already defined a future strategy for itself: increasing the share of renewable resources step by step. 100% is the ultimate goal, just like increased utilization of non-food biomass and recycled materials. Making the first step and keeping a clear focus on your goal – that’s the way to work in the world of bioplastics.

The plastics industry owes its success to an enormous degree of flexibility and the power of optimisation. No other material can even hope to keep up with the growth in the plastics market. One essential reason for this is that the components provided by chemistry are processed into an entire spectrum of polymers with the most varied functionality and optimum application properties. Now that fossil raw materials are becoming more and more

expensive, and the dreaded climate change can only be combated by saving fossil carbon, the building blocks required for polymers can increasingly be derived from renewable raw materials. Whether bioethanol/-ethylene, lactic acid or succinic acid, this approach will not remain an idea; it is becoming reality. No less than four companies – BASF-CSM, Bioamber, DSM-Roquette, and Mitsubishi Chemicals – announced plans to produce succinic acid from biomass using biotechnological fermentation methods. This C4 component is a suitable base product for numerous polymers and can be applied directly or chemically modified.

Mixing biobased with fossil monomers to yield “new” polymers is a trend. The goal is, as numerous speakers and participants agreed, greater sustainability. This is not about completely eliminating fossil polymers or polymer components, which would, after all, also be illusory in the medium term. A 20% biobased carbon share may represent a giant step in the right direction away from purely fossil materials. According to a recently published study by the University of Utrecht, it is theoretically possible to produce 90% of all polymers from renewable resources. The Brazilian company Braskem will write a new chapter in polymer history as the first world scale manufacturer of biobased PE from sugar cane. Despite enormous investments and the financial crisis, the company is on course to start production in the coming year, as communicated at the conference.

How to become more sustainable

Those who still think that they cannot afford more sustainability these days should have a closer look at the issue. Coca-Cola is not exactly known for wasting its resources on “green spleens,” and nor is ALDI. The discounter, who has perhaps changed the shopping world more than any other retail chain in many European countries, is now also opting for compostable and biobased carrier bags. No margin is sacrificed, and there are no subsidies. The supplier, Viktor Güthoff & Partner, now sees good chances that other retail chains will follow this example. The Italian company UNICOOP Firenze also reported good results with compostable carrier bags made of Mater-Bi this year at the conference. All innovators are familiar with the eternal discussion about costs and prices. However, it is still possible to “buy and sell” higher value materials if the product and the philosophy are coherent.

Coca-Cola spokesman Cees van Dongen answered the question of a participant as to what extent the company would be willing to pay a surcharge for the more expensive bioplastics by saying that Coca-Cola could NOT afford to NOT offer such products as they are desired by more and more consumers. Apparently there is not much difference between novel flat screens and bioplastics: those convinced of the success in the market will invest.

The development of bioplastics is still in the starting phase. The results of eco-balances may be strongly distorted by the low degree of optimisation and the often still very small number of producers. If questionable and partial results are taken out of their context and published, this may easily lead to a wrong image. Wrong handling may even turn eco-balances into innovation inhibitors. Despite all this: they are helpful to improve individual processes and help companies to focus on optimising their potential.

What about the political dimension?

While the use of agricultural feedstocks for energy or biofuel production benefits from a strong political and legal framework, the material use is still practically without any support these days. It is an undisputed strength of the bioplastics industry that it is successfully advancing the marketing of its products in Europe despite partially obstructive framework conditions. It is also clear that positive regulations do not only improve the difficult competitive position, but can also help to remove obstacles, e.g. in the field of waste management and utilisation. Peter Schintlmeister, Chairman of the ad-hoc Advisory Group for the EU Lead Market Initiative on Bio-based Products, also

(continued on next page)

confirmed in his speech: The European Commission sees great potential in the market for biobased products, which is still below its full performance at present. The lead markets initiative is designed to contribute to raising the potential and competitiveness of biobased materials.” Not just at a EU level, but also at member state level, innovative, biobased products like bioplastics are increasingly moving into central focus. In Germany, the Biomass Action Plan For Industrial Uses also pursues similar aims; in France the environmental protection law “Grenelle de l’Environnement.” Countries with a policy that is strongly focused on ecology like the Netherlands or Germany have already passed laws to this respect. There are discussions in the industry and in politics as to which measures would be desirable and which ones are not. “What helps us as an industry in the short term, and is undisputed, is the promotion of the transfer of information,” summarises Kaeb. “We have to communicate our standards and labels.” There is still a lack of knowledge on all levels when it comes to bioplastics.

Time for Change

Almost everything points to the fact that bioplastics will continue the difficult yet successful path of all innovations. Most participants at the conference agreed with that. The industry, which is still young after all, profits from growing competition, new ideas and more players. It orients itself

on sustainability aims, but should not be hindered by excessive short-term expectations during its strive for optimisation. Public funding and a suitable legal framework are desirable, but the measures should not trigger negative side effects. Uncertainty and unawareness slow down market development. This is why information transfer between all involved target groups is key to success. No one will deny to what extent the Internet has changed our

individual lives and the economy. Information, advertising, business communication, our leisure time and shopping behaviour – all this is shaped “online,” and increasingly lived or paid there as well. The process is more subdued as we might have thought at the beginning, but there is no stopping it anymore. Bioplastics will not revolutionize the world of materials in the short-term, but they have already started to change it. |



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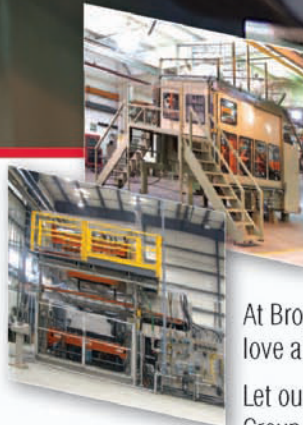
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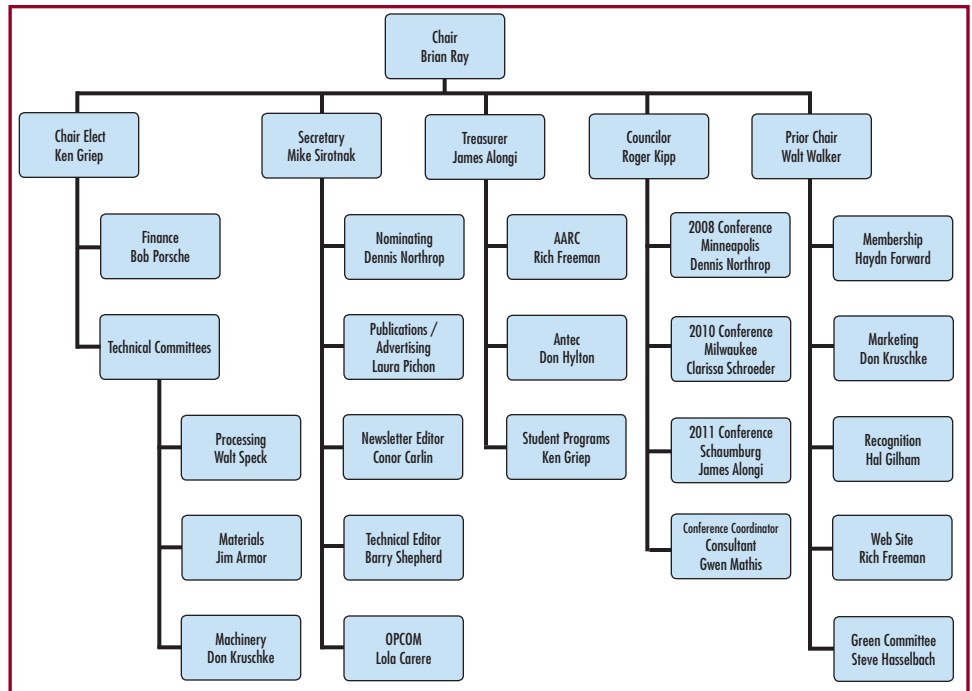
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