



# Thermoforming Quarterly®

Second Quarter 2016 | Volume 35 | Number 2

A Journal of the Thermoforming Division of the Society of Plastics Engineers



## Fresh Style, Fresh Packaging



### IN THIS ISSUE:

European Conference  
Parts Competition  
Winners

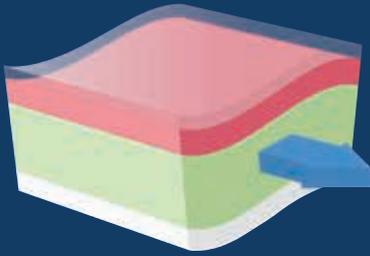
Giving Away the Store

Interview with James  
Naughton of TSL

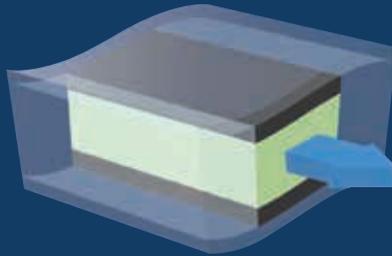
Troubleshooting  
Gear Pump Assisted  
Single-Screw Extrusion  
Processes

# AMERICA'S TECHNOLOGY LEADER

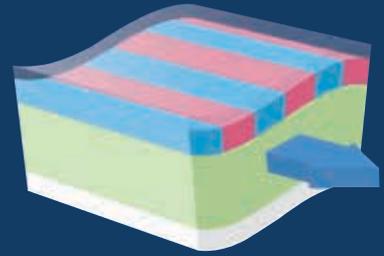
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## ■ Departments

Chairman's Corner | 4

Thermoforming in the News | 6-7

University News | 8

## ■ Features

Giving Away the Store | 10-12

Troubleshooting Gear Pump Assisted Single-Screw Extrusion Processes | 14-21

Commodore SX-28S Thermoformer Flexibility of a Narrow Web with Output of a Wide Web | 22-23

2016 European Thermoforming Conference | 24-26

Interview with James Naughton of TSL | 28-29

## ■ In This Issue

In Memoriam - Tom Mohs | 7

ETD Parts Competition Awards | 27

SPE Council Report | 30



Cover photograph courtesy of RPC Bebo Plastik, Germany.

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

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A stylized, handwritten signature in black ink, appearing to read 'Bret Joslyn'.

## Taking The Gavel

As the incoming Chairman of the Thermoforming Division Board of Directors, I would like to open my maiden article by thanking the outgoing chair, Mark Strachan. Mark has been tireless in his promotion of all things thermoforming, from technological innovations to student programs to stewardship of the Division's mandate. I am looking forward to taking the gavel and progressing into the next two years with the support of the board.

Over the past few years, we have seen the continued evolution of thermoforming. Our industry is competing in many markets, providing value-added solutions for companies operating in the automotive, medical and food sectors, to name just three. We have developed better and more sophisticated marketing tools to promote the benefits of thermoforming over competing processes. As Chairman, I am committed to making sure this trend continues at a high level, primarily through the creation of expert technical content at our annual conference. This year marks our 25th annual event, a true anniversary that I know will be a great success.

Speaking of anniversaries, our colleagues in Europe celebrated their 10th annual conference in Spain last

month (see pp. 24-27 for commentary and photos). By all accounts, it was a great success with the largest attendance ever. Several of our US colleagues presented papers on heavy gauge thermoforming, focusing on process control and manufacturing excellence. Differences still remain across the Atlantic in terms of preferred technologies and market demands, but the need for higher quality parts is a common driver.

As we look forward to our 25th gathering, what are the big questions that we, as an industry, should be asking (and answering) in the coming years? Will market demands 'pull' new innovations from formers? Will new designs and technologies from the supplier base 'push' new capital investments that allow formers to leapfrog competition? Will there be more consolidation through strategic and financial investments? One thing is for sure: the division will continue to serve as a platform for all members of the industry. Join the conversation and let us know what you think. |

Bret Joslyn

## Have an idea for an article?

### Submission Guidelines

- We are a technical journal. We strive for objective, technical articles that help advance our readers' understanding of thermoforming (process, tooling, machinery, ancillary services); in other words, no commercials.

- Article length: 1,000 - 2,000 words. Look to past articles for guidance.
- Format: .doc or .docx Artwork: hi-res images are encouraged (300 dpi) with appropriate credits.

Send all submissions to Conor Carlin, Editor, at [cpcarlin@gmail.com](mailto:cpcarlin@gmail.com)

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## Linpac Addresses Rising PET Demand

by Paul Hill, *Plastics in Packaging*

MARCH 16, 2016 – UK fresh food packaging business Linpac has invested more than €8 million (\$8.8m) in extrusion and thermoforming capacity in Spain in order to deal with the growing demand for PET and rPET.

The installation of a fourth extruder at its Pravia site will allow the food packaging manufacturing site to increase its capacity by 25 per cent in order to meet demand from retailers and packers across Europe, which are making the transition from EPS and PP to PET packaging.

Ricardo Cabeza, managing director of Linpac Southern Europe, said: "The new extruder will extend our capabilities and enable us to offer a wider variety of products to customers, ensuring they receive the best packaging for their application."

The installation of thermoforming capacity will enable the site to increase annual production to 630 million trays, an increase of 80m.

The investment is part of a three-year plan with an estimated total of €14.3m (\$15.8m) going into Linpac Spain; €3.8m (\$4.2m) is allocated for 2017 and a further €2.5m (\$2.7m) in 2018. The thermoformer is an Irwin and the extruder comes from Bandera.

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## RPC Bebo Plastik Unveils Thermoformed Cup for Coffee Packaging

by Staff Writer, *Packaging Business Review (PKBR)*



MARCH 28, 2016 – RPC Bebo Plastik, a producer of thermoformed containers, has unveiled a new thermoformed cup for Café Coffee Day's new ready-to-drink iced coffee, Frappe Chill.

Developed in multilayer polypropylene with an EVOH layer to prevent oxygen ingress, the new on-the-go cup is designed to provide the necessary strength to allow hot filling.

Capable of extending shelf life and maintaining the quality of coffee, the cup can withstand retort for 30 minutes at 118°C, the company said.

Café Coffee Day official Senthil Murugan said: "Our new cup is ideal for busy consumers and commuters, and its multilayer construction ensures the quality of the coffee is not compromised throughout its long shelf life.

"We are delighted with RPC's contribution to this important project."

Featuring an integrated telescopic straw in the lid that can be expanded and contracted, the RPC Bebo's cup allows consumers to easily drink Café Coffee Day's Frappe Chill while travelling.

Frappe Chill is Café Coffee Day's take on the original frothy Greek beverage with a unique flavor and an iced coffee blend, RPC said.

In February, RPC Bebo Plastik has expanded its In-Mould Label Thermoforming (IML-T) technology. It also developed a concept which includes the production of lids with the enhanced quality decoration which In-Mould Labeling offers.

RPC Bebo Plastik currently manufactures thermoformed containers and lids in polypropylene, polystyrene and PET. Available in different sizes ranging between 100ml and

1000ml, the company's products target the margarine and spreads, delicatessen, salads, conserves, ready meals, coffee capsules, baby foods and pet foods markets.

## Private Equity Firm Buys Parent Company of Brown Machine and Lyle Industries

by Michael Lauzon, *Plastics News*

MARCH 29, 2016 – A heavyweight in thermoforming machinery, Thermoforming Technologies Group LLC, has been bought by private equity Tenex Capital Management. The previous owner was private equity Spell Capital.

TTG of Beaverton, Mich., owns Brown Machine LLC and

Lyle Industries Inc. Both are thermoforming equipment producers; TTG bought Lyle in summer 2014. Spell acquired Brown in 2008.

"We believe TTG is a high quality business, with a strong leadership and solid end markets," noted Tenex Capital CEO Michael Green in a news release.

Tenex invests in middle-market companies. Its portfolio doesn't contain any other plastics industry companies but it does have stakes in two medical devices firms that would rely on plastic components.

"As a result of this transaction, we become even better positioned to bring our market leading technology and service to the next level," stated TTG CEO Bryan Redman in a March 14 news release. |

## In Memoriam: Tom Mohs, Founder of Placon Corp.

by Judy Newman, *Wisconsin State Journal*

Tom Mohs, founder and chairman of Placon Corp., one of the Madison area's biggest plastics manufacturers, died Friday of complications from pneumonia, just two weeks before the company's planned 50th anniversary celebration. Mohs was 77.

Mohs always liked building things, his son, Dan, said. As a teenager, Tom built a 16-foot wooden motorboat, powered by a Ford engine, in his parents' garage. It took him two years.

"They parked outside for two years," Dan Mohs said.

A graduate of West High School and UW-Madison, Tom Mohs was a student of Ronald Daggett, a UW professor who was a pioneer in the study of plastics engineering.

"That was the beginning of his love affair with the plastics industry," Dan said, of his father.

In 1966, a year before "The Graduate" gave the plastics industry a Hollywood boost, Tom Mohs started Placon when he built a thermoforming machine — which heats a sheet of plastic and shapes it in a mold — in his home workshop. His first products included plastic jewelry boxes. Within three years, local cheese companies were ordering packaging from him.

Over the years, Placon has added innovations and acquisitions. In 1980, Placon patented the design for the first retail clamshell package in the U.S. — still a core product line

for the company. It has since added food trays and medical packaging to its products. The company also built a plastic extrusion plant, recycling plastic bottles into packaging material.

In the past five years, Placon has acquired plastic packaging plants in Elkhart, Indiana, and West Springfield, Massachusetts. A family-owned company, Placon now has more than 500 employees, including a combined 360 at its Fitchburg buildings and at a warehouse in DeForest, and annual revenue topping \$160 million.

A May 12 celebration of Placon's 50th anniversary will be a celebration of Tom Mohs, as well, his son said.

"When I think of my heroes in life, he was certainly one of them," said Dan Mohs, Placon CEO and now also chairman. "His greatest source of pride was always seeing people here succeed and improve as a result of what we do."

As Tom Mohs said in a 2004 interview with the Wisconsin State Journal, "The bottom line is treating employees with respect, caring about them and wanting to see them succeed."

Mohs was the son of Mary Ellen and Frederic Mohs. His father was a renowned UW cancer surgeon. His wife, Nancy, and children, Dan (Ellyn), Linda (Tony) Granato, and Andrea (Jim) Klauk, and nine grandchildren survive him, as well as his brother, businessman Fred (Mary) Mohs. |

# Update on Free Student Memberships by SPI/SPE

The results are in on the free student memberships in SPE which have been 100% underwritten by the SPE and SPI starting after the 2015 ANTEC. As of January 31st, 2016 there are now 3,107 student members in SPE. This is a 30% increase from the start of the offer.

According to Plastics News: SPI will cover a portion of the dues for student members of SPE and package their SPE membership with an SPI electronic membership that plugs plastics students and future industry leaders into the biggest industry trade associations, right at the start of their careers. Student membership dues will be waived and SPI and SPE would share the membership cost for each student taking advantage of this offer. Note: This is a promotional program only open to US Citizens currently residing in the USA.

## **Thermoforming Scholarship Winners— Where Are They Now?**

### *Travis Kiefer – 2009 Thermoforming Scholarship*

After graduating from Iowa State University with an Industrial Engineering Degree Travis started working at Plastics Unlimited utilizing his degree and working with the R&D Department. During this time Plastics Unlimited was invited to speak at the 2012 SPE Thermoforming Conference on their patented Toolless Engineered Composite process. Travis represented Plastics Unlimited as one of the chosen speakers for this presentation. Since then Travis was promoted to the COO Position at

Plastics Unlimited and today he manages the day-to-day operations of the company, as well as Plastics Unlimited's R&D Department. He continually uses his training from Iowa State University to help improve production speed and capabilities at the facility. He has also attended multiple SPE thermoforming board meetings as a guest and is looking forward to getting more involved with the SPE Thermoforming Board in the future.

He is grateful for the Scholarship from the Thermoforming Division and strongly believes it is a program that should continue into the future. The students that receive these scholarships will be the next generation to continue the path forward for the industry.

## **An Invitation for Students (w/Instructors!) to attend the 2016 Thermoforming Conference**

The SPE Thermoforming Division would like to invite students and their instructors to attend this year's Thermoforming Conference being held September 26-28 in Schaumburg, IL just outside of Chicago. The Division helps subsidize travel costs in most cases. In addition to attending the full conference the students will have an opportunity to participate in other activities including a parts competition, a class on interviewing, and networking with industry leaders. Please contact Lesley Kyle at 914-671-9524 or thermoformingdivision@gmail.com for more information. |



**Did you know** the SPE Foundation offers numerous scholarships to students who have demonstrated or expressed an interest in the plastics industry? Start by completing the application forms at [www.thermoformingdivision.com](http://www.thermoformingdivision.com) or at [www.4spe.org](http://www.4spe.org).

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## Thermoforming Technical Problems I Wish I Could Solve Giving Away the Store

By Jim Throne, Dunedin, FL

### Prologue

A long time ago, when the earth was cooler and spun more slowly, I was Technical Editor of TFO. With nothing better to do than chase after writers who seemingly had become ghostly, I wrote a series of now long-gone and forgotten articles called Thermoforming 101. If I recall, in one of those articles, I mused about the grievous sin of wall thickness variation. Recently, while penning of a vignette on, of all things, differential pressure issues during plugging, it occurred to me that just perhaps this sin needs to be revisited. If for no other reason than to reinforce my concerns about differential pressure.

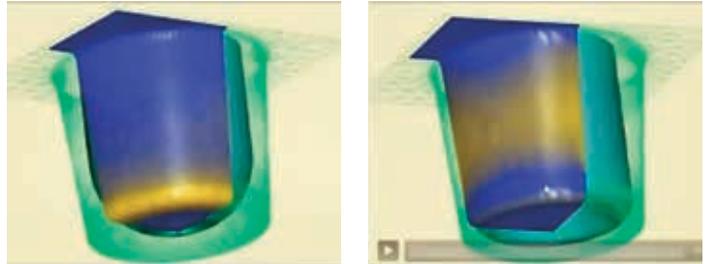
### So why are we reconsidering this topic?

First off, let's be practical about thermoforming. It suffers from two afflictions. Unlike the injection molding process with its pellet-to-product procedure, we gotta make sheet first. And unlike that same process, a whole bunch of our hot sheet winds up as non-product. Meaning, of course, that we need to reprocess the non-product into more sheet. One of my earliest childhood memories is watching my German grandmother make her legendary cookies—rolling out the dough and cutting the *pfeffernusse* disks from it with a water glass. She'd remold and reroll the skeleton before repeating the cutting process. Eventually, to we kids' delight, she'd give us the tiny left-over cookie dough. Sounds familiar, right? So we spend a lot of time and money redoing and redoing and redoing.

But that's for another time. The second affliction is that we don't have very good control over the instant wall thickness of our final product. Gramma had the same problem. Some of her cookies were thin. Others were kinda chubby. But for us kids, size didn't matter. But it does to us thermoformers, doesn't it?

### So where are we going with this?

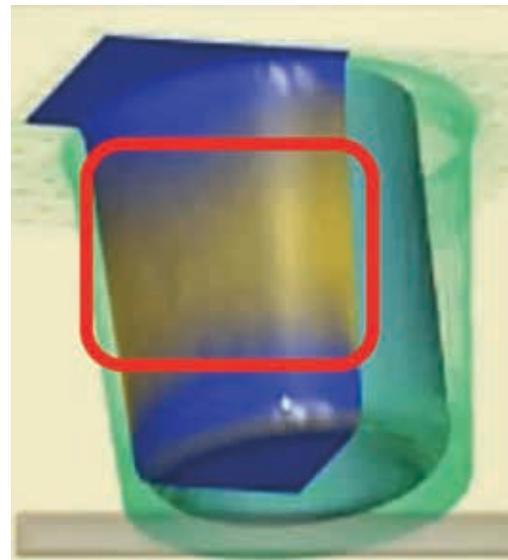
The second affliction is wall thickness variation. Consider this, from a classic T-Sim simulation:



Yeah, I know this is about plug shape. But consider instead wall thickness across the cup. Notice something significant, like substantial variation in wall thickness? Injection molders don't have this problem. Wall thickness accuracy to within 1% or better. Even rotational molders can hold to within 5%. We, along with blowmolders, are saddled with much greater wall thickness variation. How much? Maybe 10% if we have everything working 'just right' (whatever that means).

### Why is this so important?

Remember grandma and her cookies? A glass of milk always was there. What about now? How about a 16 oz. red cup filled with grape juice in the hands of a four-year old? How squeezable is the side wall of that plastic cup?



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In that long-ago article, I expounded on what effect wall thickness variation has on the flexural strength of a plastic product. Let me touch on this again, for just a moment.

Stiffness is the product of plastic modulus and something called moment of inertia. Plastic modulus is an intrinsic physical property of the plastic. Moment of inertia is related to the wall thickness. Actually it is proportional to the wall thickness cubed. Let's write this like this:

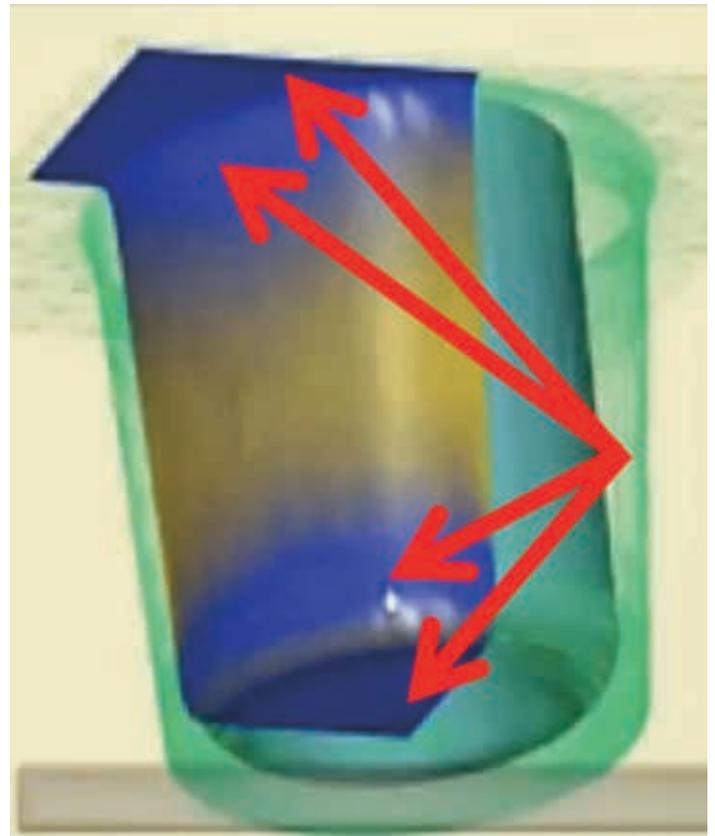
$$\text{Stiffness} = \text{Modulus} * G\text{-}tk^3$$

G is a proportionality factor and tk is the wall thickness. Now let's state that we need a wall stiffness of at least S to keep the little kid from squeezing his grape juice all over grandma's expensive white carpet. Knowing what plastic we're using and assuming that G is well-known (the shape of the cup wall, for instance), we only need to calculate the desired wall thickness, right?

$$tk = (S/M*G)^{1/3}$$

Right? Wrong! We forgot about the wall thickness variation of, say, 10%. Oh, and the stiffness that we need is the absolute minimum stiffness. Meaning, of course, that our wall thickness variation must be minus zero plus about 20%. Everybody following? In short, folks, at the very least, we need to give away 20% more plastic to ensure that no grape juice will ever leave the cup.

But wait. There's more! Take another look at the earlier figure. While we are giving away all that extra plastic to satisfy the stiffness requirement, we are giving away *beaucoup* more in non-critical areas away from the squeeze point.



Injection molders don't do that! Their motto – waste not, want not.

### So where are we going with all this?

I have often thought that the thermoforming process is a series of vagaries and vexations. And I have often heard really professional formers say 'it is what it is' or mutter about silk purses and sow's ears. Besides, someone will always muse, 'The customers like our product and sometimes we even make money at it.'

There are many reasons why we give away plastic. Some are intrinsic to the very nature of the process, viz, differential stretching of an elastic membrane. But some are simply because 'we' have yet to focus on what variables need more careful observation and control. I started this vignette by contemplating the issue of differential pressure during plugging. Of course, it's not just controlling differential pressure throughout the stretching, now is it? It's assuring that the sheet is properly thermally conditioned, that cavity air temperature and pressure is known, and so on.

This has run long. I'll need another vignette to propose ways of getting our arms around this part of the process. Keep in touch. |

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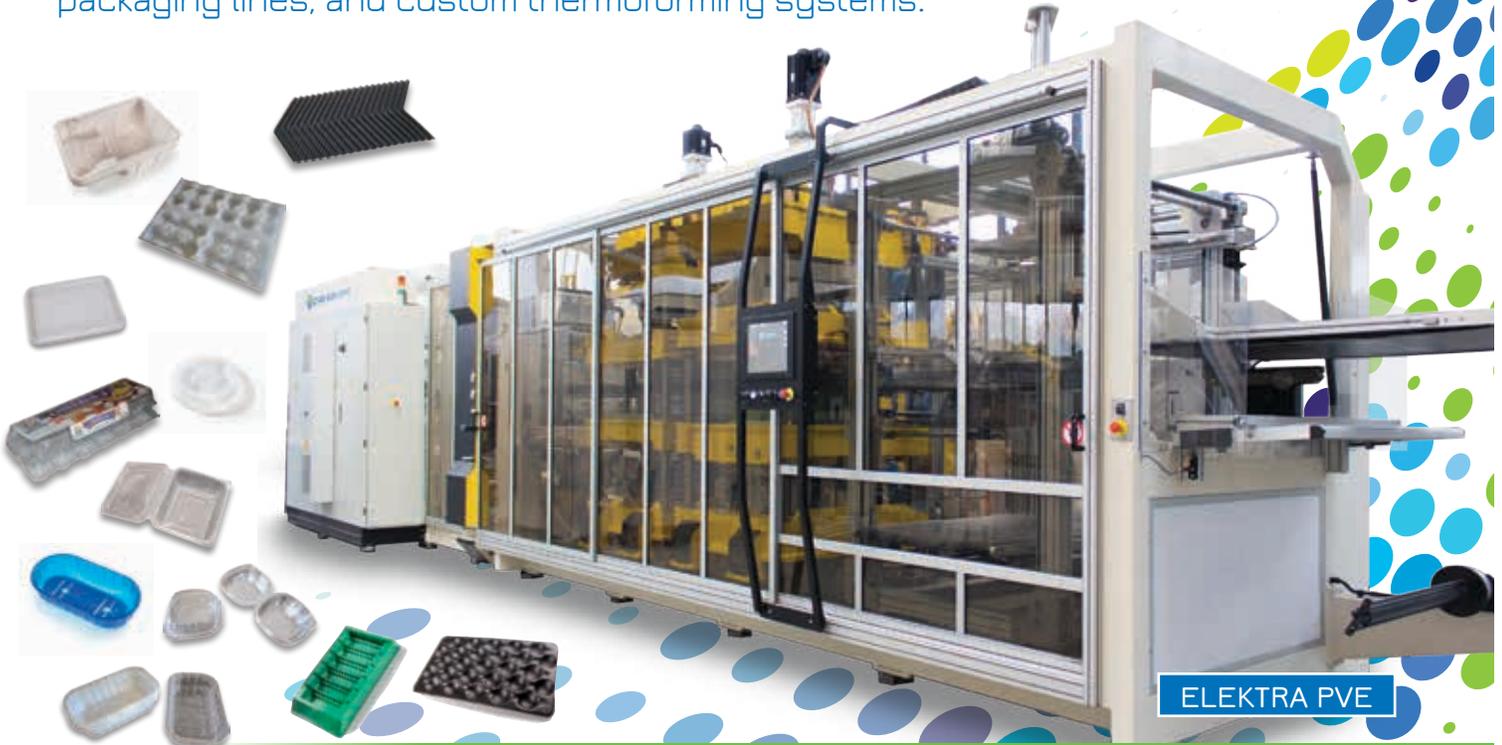
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# Troubleshooting Gear Pump Assisted Single-Screw Extrusion Processes

By Mark A. Spalding and Wenyi Huang, The Dow Chemical Company, Midland, MI; Daniel Smith, Maag Automatik, Inc., Charlotte, NC; Gregory A. Campbell, Clarkson University/Castle Associates, Jonesport, ME

*This paper was first presented at ANTEC 2014. It is reproduced here by kind permission of the SPE Extrusion Division.*

## Abstract

Gear pumps are often used in tandem with singlescrew extruders to increase rate, decrease resin consumption, improve process stability, decrease extruder discharge pressure, and decrease the extrudate temperature. When a process is unstable, it is often not obvious if the extruder is unstable and the gear pump is operating well, or the extruder is operating well and the gear pump operation is unstable. This paper will describe a few operations where gear pumps improved a process, how they are used in unstable processes, and approaches to troubleshooting lines using gear pumps.

## Introduction

Gear pumps are often positioned between smoothbore, single-screw extruders and dies, providing several processing advantages. These advantages include the mitigation of pressure surges and thus flow surges from the extruder, a decrease in the discharge temperature by generating part of the pressure required for the die by the pump instead of by the extruder, reducing resin consumption, and for rate increases [1-5]. For example, if the extruder is operating with a low frequency and small pressure oscillation with time (or pressure surge) to the inlet of a gear pump, the gear pump and control algorithm will provide a nearly constant outlet pressure and flow rate to the downstream equipment such as a die. Stable operations with a gear pump will allow plant personnel to operate at the lower specification limits for sheet or film and thus reduce the resin consumption per unit of product. If a gear pump is contributing to the generation of the discharge pressure for the downstream equipment, the metering section of the screw will operate with a higher specific rate as compared to a process without a pump. Extruders that operate at a higher specific rate will generally operate at a lower discharge temperature [6]. A

gear pump used with a two-stage, vented screw can allow higher operating rates while not causing material to flow out the vent port.

Gear pumps operate by metering molten resin from the low-pressure inlet side of the pump, and then discharging at a higher pressure to the downstream equipment. The inlet pressure is high enough to force resin in between the gear teeth. As the gears are rotated, the material between the teeth is trapped between the teeth and the body of the pump. At the discharge side of the pump, the intermeshing gears displace the resin and force it through the discharge opening. The theoretical volumetric rate for the pump can be calculated based on the rotation rate and the volume between the gear teeth [4]. Leakage flows, however, reduce the volumetric rate to that observed on the line. Leakage flows occur because of flow over the gear lands, flow between the sides of the gears and the pump body, flow through the pump bearings, and flow past the gears in the intermeshing zone [3]. Leakage flow depends on many factors including pump design, differential pressure, and resin viscosity. Differential pressure is defined as the outlet pressure minus the inlet pressure. Leakage flows were measured at up to 30% of the theoretical volumetric rate for specific conditions [3]. For a constant pump rotation rate and a constant inlet pressure, the outlet rate will be constant. If a small change in pressure occurs at the inlet, a rate change will occur in the outlet due to the change in the differential pressure and leakage flow.

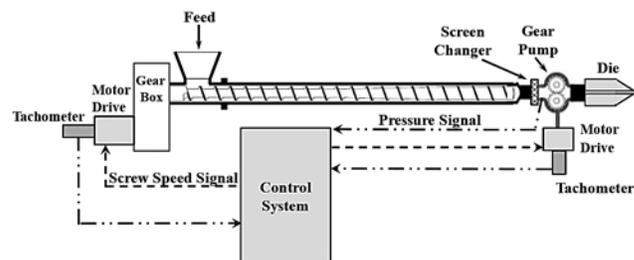


Figure 1. Diagram of a typical gear pump installation for a single-stage extruder and a screen filtering system. The control schematic for extruder screw speed is included.

For gear pump assisted extrusion, the control algorithms are set to maintain a constant pressure to the inlet side of the pump by controlling the screw speed. The pump is

operated at a constant rotational speed and thus it delivers molten polymer at a very steady and controlled rate. A schematic of a gear pump assisted extrusion process is shown in Figure 1 for a single-stage extruder. If the pressure to the inlet of the pump is less than the set point value, then the control algorithm will increase the screw speed of the extruder. Conversely, if the inlet pressure is too high the control system will decrease the screw speed. For properly designed systems, the screw speed will only have relatively small changes to compensate for slight changes in the pump inlet pressure. But for extrusion processes that are not operating properly and show severe flow surging, the screw speed will have large variations.

The goal of the controller is to maintain a constant pressure at the inlet of the pump. If the inlet pressure is constant, then the outlet pressure and rate will also be constant [3].

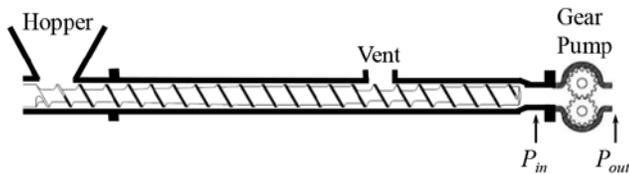


Figure 2. Schematic of a two-stage, vented extruder with a downstream gear pump.

Gear pumps allow higher rates for two-stage, vented extruders by decreasing the discharge pressure of the extruder. A schematic of this process is shown in Figure 2. Since the vent is at atmospheric pressure or under vacuum, all pressure required to operate the die for a system without a gear pump must be generated in the second-stage metering section of the screw. If the pressure required to operate the die is higher than what the second-stage metering channel can develop, then molten resin will flow into the vent port. A gear pump, however, can allow higher rates while eliminating vent flow by decreasing the discharge pressure of the extruder. For this case, the metering section only needs to generate enough pressure to operate the pump safely, a pressure typically about 2 to 8 MPa. This pressure level is high enough to keep the pump channels completely full of resin and maintain lubrication in the bearings. The pump will then increase the pressure to a higher level as required by the downstream equipment. Moreover, if the gear pump is generating most of the pressure required for the downstream equipment, then the screw and extrusion process can be optimized to a lower discharge temperature [6].

The goal of this paper is to show the attributes of positioning a gear pump in tandem with a single-screw extruder, and provide troubleshooting methods for tandem operation.

### Extrudate Temperature Reduction

A gear pump is a common method to decrease the discharge pressure from the extruder, especially if the discharge pressure required by the die is relatively high. Decreasing the discharge pressure from the extruder will cause the specific rate to increase and the discharge temperature to decrease. A schematic for the axial pressure and temperature for a single-stage process is shown in Figure 3. Here the pump is generating the pressure rather than the metering section of the screw, allowing the discharge temperature to decrease. For example, a process and die required a pressure of 21 MPa for operation at a rate of 400 kg/h for a high density polyethylene (HDPE) resin with a melt index of 0.08 dg/min (190°C, 2.16 kg). If all of the pressure is provided by a single-stage 114.3 mm diameter extruder (screw design fixed), the discharge temperature will be about 242°C, as shown by the operating curve in Figure 4. Here the specific rate for operation is 4.7 kg/(h rpm). But if a gear pump is positioned between the extruder and the die such that a portion of the required pressure is generated by the pump, then the specific rate for the operation of the screw will increase (causing the screw speed to decrease at a fixed rate) and the discharge temperature will decrease. For example, if the inlet pressure to the gear pump (discharge pressure from the extruder) in this case was 8 MPa, the

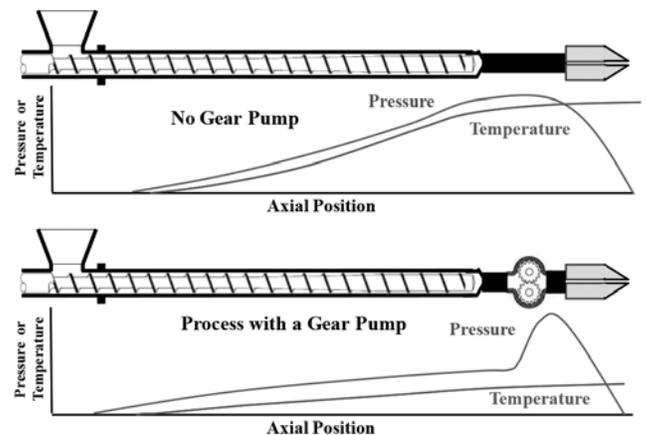


Figure 3. A schematic of the axial pressure and temperature for processes with and without a gear pump. The rates for both processes are the same, but the discharge temperature for the process with the gear pump is less than that for the standard process.

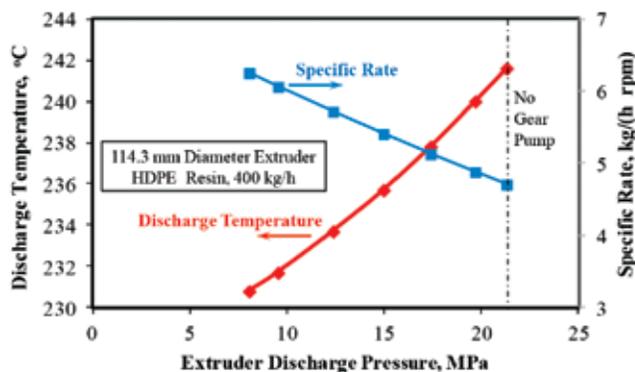


Figure 4. Operation of a 114.3 mm diameter extruder running a HDPE resin at 400 kg/h as a function of discharge pressure.

extruder would discharge at 231°C and operate at a specific rate of 6.3 kg/(h rpm). Thus, the discharge temperature could be decreased by 11°C and the specific rate increased by 1.6 kg/(h rpm), as shown in Figure 4.

Some temperature increase will occur as the resin passes through the gear pump. This temperature increase is small compared to the decrease in temperature due to using the pump to increase the line pressure. The actual extrudate temperature will depend on the design and operation of the screw, the shear viscosity of the resin, the pressure contribution from the pump (differential pressure), and the design of the pump.

## Surge Suppression

Flow surging is defined as the oscillatory change in the rate of the extruder while maintaining constant set point conditions. Flow surging can originate from many different sources including improper solids conveying, melting instabilities, flow restrictions, and improper control algorithms [5,6]. The control algorithms on gear pumps are very effective at mitigating low frequency pressure surges originating from the extruder. Thus they have the capability of minimizing resin consumption in the final product for a process with a mild flow surge to maintaining a level of production for processes with severe flow surging.

A severe and random flow surging problem limited the production rate for a large-diameter, two-stage, vented extruder [7]. If it were not for a gear pump positioned between the extruder and die, this extrusion line would not have been operable. The surging did, however, limit the rate of the line to about 70% of its potential rate. The maximum potential rate is the rate that the extruder can

run at high screw speeds and with stable operation. The extruder was 203.2 mm in diameter and had a 40 length-to-diameter (L/D) barrel. A schematic for the extruder and gear pump arrangement are shown in Figure 2. The extrusion system was used to make a sheet product. Steady-state operation of the extruder is shown by the first 400 minutes in Figures 5 and 6. The data for these figures were from the same production run. The extruder was running a high-impact polystyrene (HIPS) resin at 2250 kg/h and a screw speed of 99 rpm for a specific rate of 22.7 kg/(h rpm). This specific rate was about 14% higher than the specific rotational flow rate calculated for the first-stage metering section, indicating that a negative pressure profile exists in the section. The negative pressure gradient is expected for a first-stage metering section of a vented screw that is operating properly; i.e., the first-stage metering section was full of resin. To maintain the stability, the extruder screw speed was reduced such that extruder was operating at about 70% of its potential maximum rate. That is, at screw speeds higher than 99 rpm the extruder was more likely to transition from a stable to an unstable operation.

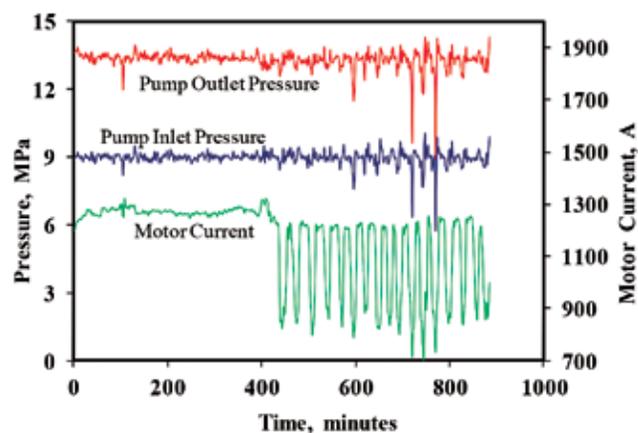


Figure 5. Pump inlet (extruder discharge) and outlet pressures and motor current for stable and unstable extrusion for a large-diameter extruder running HIPS resin.

During this first 400 minutes, the inlet pressure to the pump was relatively stable, and the outlet pressure to the die was also acceptable, producing prime product. At about 410 minutes into the run, the extruder started to operate unstably, as indicated in Figures 5 and 6. The processing change that caused the extruder to go from a stable operation to an unstable one was not known, but it could have been due to minor changes in the bulk density of the feedstock or cooling water fluctuations to the screw. The root cause for the event and technical solution were

provided earlier [5,7] and they are beyond the scope of this writing. As shown in Figure 6, the extruder screw speed was oscillating between 100 and 180 rpm during the period of the instability. During this unstable period, however, the gear pump control allowed the pump inlet pressure to oscillate at only a low level. The outlet pressure from the pump (pressure to the die) had a similar level of oscillation as in the inlet pressure, as shown in Figure 5. This result was expected since the specific rate of a pump depends on the differential pressure between the inlet and outlet sides [3]. Thus, if the pressure surge is too fast for the control algorithm to compensate, then a pressure surge will be observed in the outlet of the pump. Here, the oscillation in the outlet pressure, however, was acceptable for making prime product. Resin consumption was higher than normal during unsteady operation because the product was varying widely between the upper and lower control limits for sheet thickness rather than operating close to the lower control limit. If the pump would not have been on this line, prime product could not have been produced when the extruder was unstable. Although the pressure oscillation observed here was unacceptable, the pump and control algorithm were able to allow production during the time required to make the process modification to mitigate the surge.

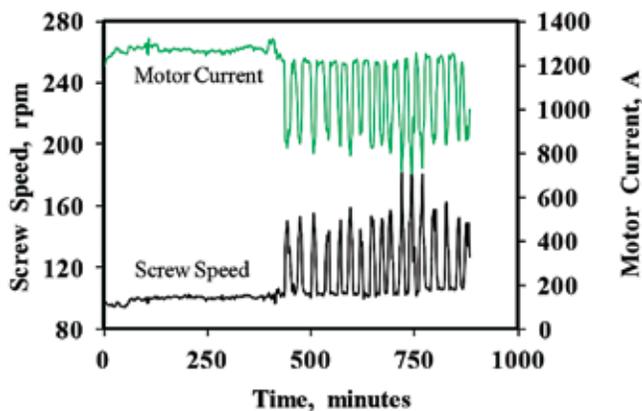


Figure 6. Screw speed and motor current for a large diameter extruder running stable and unstable.

### Gear Pump Pressure Control

A poor control algorithm for the pump can cause some variation in the extruder screw speed, causing large variations in the inlet and outlet pressures to the pump. This type of control-induced surging can occur even though the process as designed is stable. To determine if the control algorithm is inducing the surging, the screw speed of the extruder should be operated in a manual

mode and at a constant speed. If the controller is inducing the surging, placing the process in manual control mode will stabilize the process.

Transient process data were collected for an extruder with a downstream gear pump, as shown in Figure 1. For this case, the control algorithm was controlling the speed of the screw such that the inlet pressure to the pump was maintained at 8 MPa for a polycarbonate (PC) resin. Although the variation in screw speed was not excessive at  $67 \pm 1.5$  rpm, the variation in motor current seemed quite high at  $690 \pm 50$  A. At about 16 minutes into the run, the extruder was switched from automatic to manual screw control; i.e., the screw speed was held constant at 67 rpm. As shown by the data in Figure 7, the motor current variation was unchanged, indicating that the screw speed control algorithm was not inducing the variation in the motor current. During the period that the screw speed was held constant, the pressure to the inlet of the pump slowly increased, as shown in Figure 8. This pressure was increasing because the screw was operating at a speed that delivered a rate slightly higher than that needed by the pump. When the control was placed back into automatic mode, the screw speed was decreased initially to compensate for the higher than desired pump inlet pressure.

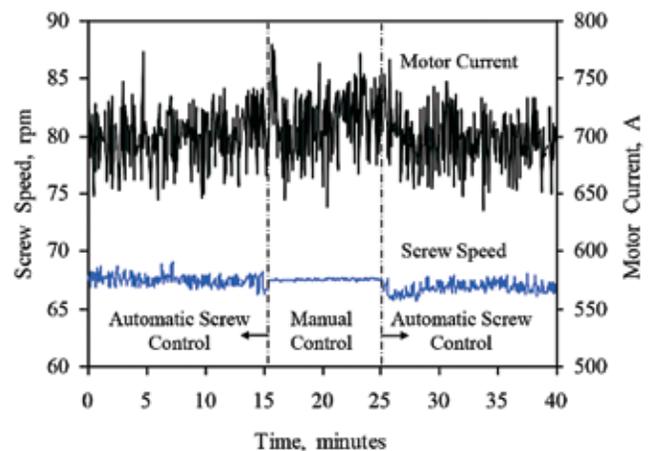


Figure 7. An extrusion process with a downstream gear pump with the screw operating using inlet pressure control and followed by the screw in manual operation (constant screw speed).

The large level of variation in the motor current during constant screw speed control suggests that the extrusion process was unstable, and the control algorithm was not the root cause for the variation in the motor current. The root cause and technical solution for mitigating the surge

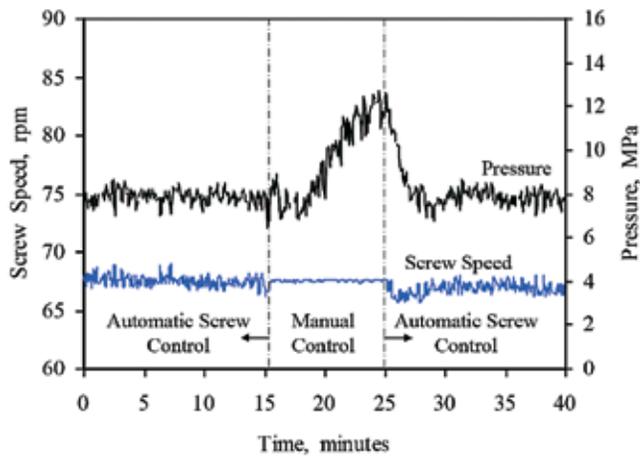


Figure 8. Pressure at the inlet to the gear pump for the data presented in Figure 7. The pressure increased during manual control because the flow rate of the extruder was slightly higher than the rate of the pump. as provided elsewhere [5].

In another case, a single-stage extruder with a gear pump running a low density polyethylene (LDPE) resin was operating with a pressure oscillation at the discharge of the extruder. Like the previous case, it was not known if the extruder or the control algorithm for the gear pump was causing the instability. The pressure oscillation during the unstable period is shown in Figure 9 for the first 7 minutes of data collection. Like before, the gear pump controller was placed into manual mode such that the extruder screw speed was held constant. As shown in Figure 9, the pressure at the inlet to the gear pump was relatively stable when the screw speed was in manual control. When the control was turned back on, the pressure variations resumed. These data indicate that the control algorithm was causing the pressure surges to the inlet of the gear pump. In this case the proportional gain of the controller was set too high for the process. Here, the

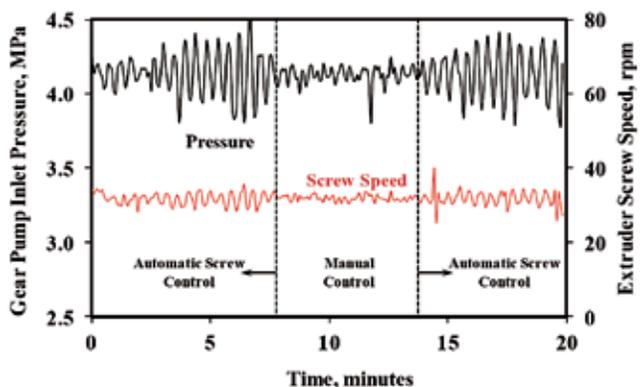


Figure 9. Process dynamics for a gear pump with a poorly designed control system running LDPE resin.

proportional gain is the amount of screw speed adjustment used based on the deviation of the inlet pressure from the set point pressure of 4.2 MPa. When the gain was reduced, the process became very stable with the pump in automatic control mode. In this case the proportional gain was reduced from about 1000 to 1.

Placing the screw speed controller in manual mode is recommended when minor levels of low frequency flow surging are observed with a process where the screw speed is controlled from the inlet pressure of a gear pump. This procedure will correctly guide the troubleshooting process to focus on the extruder or the gear pump controller.

### Gear Pump Seizing

A polystyrene (PS) sheet line was constructed using a two-stage, vented extruder and a gear pump. On several occasions the bearings on a gear pump would seize. In both cases, the gear pump was identified as the root cause of the failure, and claims were placed against the manufacturer. After the third pump seized, a full evaluation of the line was performed. The analysis indicated that the first-stage metering section of the extruder screw was not controlling the specific rate of the process as designed. Instead the specific rate was about 90% of the flow due just to rotation; i.e., historically known as the drag flow rate. Here the rate was controlled by a poorly designed solids conveying section. During typical operation, the extruder would operate with the first-stage metering channel at essentially zero pressure, and the second stage metering section would use only two diameters of filled length to supply an inlet pressure of 6 MPa to the pump. On very rare occasions, the solids conveying section would deliver a large amount of material such that first-stage metering section was operating at 120% of the specific rotation rate. This event would completely fill the second-stage metering section such that a very high and nearly instantaneous discharge pressure would occur. This pressure was estimated at about 30 MPa. This high pressure coupled with a low pump discharge pressure of 15 MPa created enough differential force to deflect the rotors and overload the gear pump bearings, leading to the seizing of the pump.

For a normal control scheme, the controller for the screw speed would have decreased the screw speed to match the 6 MPa inlet pump pressure set point. But because the pressure surge happened extremely quickly, the controller could not respond fast enough when the



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high pressure surge occurred, causing the catastrophic failure of the pump.

The solids conveying section of the screw was modified through screw design and process temperatures such that the first-stage metering channel was always operating full and under pressure at a specific rate of 110% of the calculated rate due just to screw rotation. The pump never seized again.

## Improperly Designed Metering Section for a Two-Stage Screw

A gear pump system was added to an existing 114.3 mm diameter, two-stage, vented extruder on a PS sheet line as detailed in Figure 2. The extruder discharge pressure before the addition of the pump was about 20 MPa, and the process was fairly stable and operated well. The screw channels were previously optimized to a pre-specified rate and a discharge pressure of 20 MPa. After the addition of the pump, the extruder discharge pressure was reduced to about 10 MPa. The line could not be operated at more than 70% of the potential rate due to the excessive oscillation in the inlet pump pressure and consequently the fluctuation in screw speed and outlet pressure. The problem was analyzed and found that solids conveying in the first stage of the screw was performing as expected and that the flights were full and pressurized in the first stage of the screw. Since the discharge pressure of the second stage was decreased by half, the length in the second stage that was required to generate the discharge pressure was decreased significantly, moving the position downstream where the second-stage meter becomes first

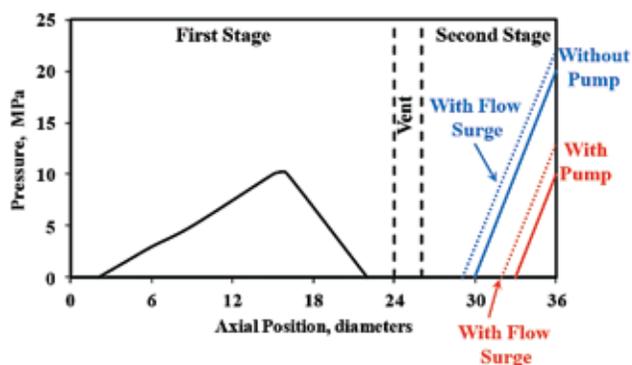


Figure 10. Axial pressure profile for the PS sheet line with and without a gear pump. The blue dotted line is the expected screw pressure profile for a high pressure surge without the pump, and the red dotted line is the same surge with the pump.

filled with resin.

A schematic of the axial pressure profile with and without the pump is shown in Figure 10. For the line without the pump, a typical pressure surge will cause the fill position to start 1 diameter earlier and would cause the discharge pressure to increase to 22 MPa or 10% as indicated by the dotted blue line. When the process was configured with the gear pump, the same surge would increase the extruder discharge pressure to 12 MPa, or an increase of 20% as indicated by the dotted red line. The higher percentage of pressure increase caused the higher pressure oscillations at the inlet and outlet of the gear pump, and caused the controller to oscillate the screw speed. When the pump was not installed, the pressure fluctuation was about 10%. Although this level of fluctuation was not acceptable, it did allow the line to produce acceptable sheet.

With the gear pump installed, additional screen packs were added to increase extruder discharge pressure to the original 20 MPa. With these conditions, the screw speed could be increased to full rate with the pressure relatively stable at the inlet to the pump. Long term solutions were found to be an adjustable melt restrictor valve installed directly after the extruder to induce resistance and cause a higher extruder discharge pressure, or the redesign of the second stage of the screw for the expectation of reduced extruder discharge pressure.

Although either solution will work, the preferable course of action is to redesign the second-stage metering section for the reduction in extruder discharge pressure, allowing the processor to take advantage of lower energy and discharge temperature afforded by the pump. For this case, the second-stage metering channel was too deep relative to the depth of the first-stage metering channel. As expected, a similar problem occurs when the second stage is not optimized with the first-stage metering section for processes without gear pumps [8].

## Discussion

Using a gear pump to control rate and to generate a portion of the pressure required for the die is an excellent method to allow a process to operate near the lower control limit of the product thickness, reducing the consumption of resin per unit area for a sheet line. For new installations, the design of the extruder screw should be optimized for the inlet pressure required by the pump. For

the addition of a gear pump to an existing extrusion line, the processor should consider the process changes that will occur when the discharge pressure from the extruder is reduced, especially for two-stage, vented machines. Gear pumps with well-tuned control algorithms are excellent at mitigating low frequency flow surges. For these cases, the control algorithm has time to adjust the screw speed to maintain a constant pressure to the inlet of the pump. If the pressure surge is at a high frequency, the control algorithm may not be able to respond. For mild, high frequency pressure surges, the surge may be observed downstream from the pump, consistent with previous data and observations [3]. If the surge is large and high frequency, then catastrophic damage to the pump can occur.

Gear pump rotors are positioned in the pump body using specially designed bearings. These bearings and the rotor shafts are lubricated with molten resin from the extruder. That is, a very small portion of the resin flow from the high pressure outlet side of the pump is flowed into the bearing annulus and then into the low pressure inlet side of the pump. The design of the bearing depends on several factors including resin rheology, differential pressure, and rate. If the differential pressure becomes too low, resin flow to the bearings will be reduced or interrupted, shortening the life of the bearings or causing the pump bearings to seize.

### Summary

Gear pumps positioned between single-screw extruders and dies can provide advantages including reducing the

discharge temperature, reducing the discharge pressure from extruder, reducing instabilities from the extruder, and reducing the resin consumption to make the final product. Reductions in extruder discharge pressure can also extend the operation life of screws, barrels, and thrust bearings while reducing energy consumption. However, while applying this technology processors must be aware of the change in dynamics of the extrusion line for normal troubleshooting principles. Troubleshooting process problems associated with this type of process were presented.

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## 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:

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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 Conor Carlin, Editor, at [cpccarlin@gmail.com](mailto:cpccarlin@gmail.com) or 617-771-3321.

## Commodore SX-28S Thermoformer Flexibility of a Narrow Web with Output of a Wide Web

In foam tray thermoforming equipment is a large component of having fast cycle times, along with quality sheet and tooling. Reaching high volume cycles per minute is important, but the effort will be lost if trim accuracy and the quality of the mold impression is not held. Through decades of knowledge running our own foam plant, Commodore can provide a proven complete solution from extrusion to thermoforming, grinders, auxiliary equipment and a complete range of tooling solutions.

Commodore has improved its SX-28S thermoformer to reach speeds of 190 CPM. The technology allows users to increase output without significantly increasing cost. Due to the narrow width of the 28" sheet, the machine is best suited for low to mid-range volume applications. Narrow molds and trim tools can be exchanged quickly. Since there are fewer units per mold, set up time is decreased and scrap is minimized. Capital costs for narrow molds and trim tools are much lower than a wide-bed application. With the increased speed, production output is similar to larger, wider thermoformers but with the benefits of a flexible narrow line.

### Trim Station Improvements

The trim station was the performance constraint within the narrow thermoforming system. The challenge was to increase CPM without impacting trim accuracy. The reciprocating motion of the trim treadle created vibration when the cycles increased thus causing trim accuracy issues. Utilizing accelerometers and FEA (finite element analysis) modeling tools, Commodore was able to analyze localized vibrations within the trim press. Several actions were taken to eliminate these vibrations. The tubular frame was stiffened in strategic areas to compensate for flexing. Eventually the frame was replaced with solid boiler plate sides which not only improved the machine's stiffness, it also improved the manufacturability of the machine by eliminating several welding steps. A variable counterbalance was incorporated to compensate for the inertia generated when the reciprocating motion ended its stroke. The balance keeps the machine from vibrating excessively and helps to increase output through better machine stability. Utilizing a servo motor, the speed of the trim press remains consistent throughout the entire trim



cycle. Furthermore, a power canopy is utilized to present the formed sheet to the trim tool feeder rather than attempting to pull the entire sheet from the form station over the canopy to the trim tool. Having an intermediate step to stage the sheet reduces tension on the material which improves trim accuracy.

### Form Station Improvements

Along with the trim station, the form station has also been updated to work at speeds up to 50 forming cycles per minute by utilizing servo technology. Replacing the hydraulic cylinders in the form station with servo driven



linear actuators has increased speed and precision. In the spirit of lean manufacturing, the need for hydraulics is completely eliminated from the machine thus reducing maintenance, improving cleanliness and making it quieter. Since the hydraulic actuator has been essentially replaced with a powerful servo driven linear actuator, the need for toggles on each corner of the platens is not required. This keeps the cost of the equipment down while also eliminating the need to maintain 8 toggles per machine.

### **Continuous Improvement**

Further improvements to the series SX-28S includes an

extended oven which increase the number of heat indexes before the forming station which allows a more gradual build-up of heat. The oven length can also be adjusted to ensure uniform shots during heating. Increased vacuum capacity helps to improve forming. These items combine to improve the forming accuracy while ensuring success to form open cell absorbent trays.

### **Necessity is the Mother of Invention**

The need to update Commodore's thermoforming machinery originally came from the demand within our own foam plant to increase production without increasing our footprint. Many of our customers are small- to medium-sized businesses facing the same situation. Our machine makes it affordable to increase production by doubling output with a cost increase of just 10% while maximizing existing floor space. Some of the performance improvements have been retrofitted to Commodore's existing thermoformers allowing output gains of 20%. We also found that while maximizing efficiency in our narrow web machine, our results were coming close to the same output as our large web machine with the added benefits of reduced set up time, lower scrap rate, less maintenance, lower cost molds and trim tools. |

## 2016 European Thermoforming Conference

By Conor Carlin, Editor, *Thermoforming Quarterly*

A record number of delegates descended on Sitges, Spain for the 10th European Thermoforming Conference held on March 9-11. With 245 attendees from 27 countries, it was a true international celebration of thermoforming technology and processes.

In keeping with tradition, the event kicked off with a 1-day workshop led by Peter Lichtherte and Mark Strachan. A cornucopia of information was presented and a lively discussion among the 35 participants ensured that both heavy- and thin-gauge concepts were covered. The instructors stressed the importance of polymer science, upstream sheet extrusion and material handling as critical to getting consistent and repeatable thermoformed parts.

On Day 1 of the main conference, Jeff Pitt of the Program(me) Committee reviewed the origins of the European Thermoforming Division and recognized early pioneers on both sides of the Atlantic. The high level of cooperation is clearly still evident today with a large contingent of US formers and industry consultants at the proceedings. Marek Nikiforov of GN Europe (and outgoing ETD chair) introduced the conference chairman, Gabriel Bernar of Walter Pack (Spain). A gracious host in his native country, Mr. Bernar warmly welcomed attendees and ensured that no one missed the gastronomical pleasures of Spain. In addition to a solid technical program, the ETD will certainly receive high marks for choice of venue.

The sessions began in earnest with a presentation on plastics pollution from Thomas Drustrup of the Danish Plastics Federation (DPF). As in 2014, the Danes brought a sizable contingent to the event, highlighting their strength in food packaging and 3D printing technologies. Mr. Drustrup, however, discussed the topic of marine litter. While most people in the plastics industry are now very aware of the issue, perhaps not everyone is as forward-thinking as the DPF when it comes to creating a media and communications strategy. Despite data showing that the overwhelming majority of plastic marine litter comes from Asia, the DPF is at the vanguard of the effort to build coalitions with NGOs and others in Europe. By expanding the conversation to include the benefits of plastics vis-à-vis other materials such as glass, paper and aluminum, trade groups can engage a wider audience and actually get out in front of the headlines instead of having to react

to negative press. Drustrup presented encouraging case studies illustrating how his group has helped to raise funds for projects that recover waste plastics.

### **A Brave New World**

SPE CEO Wim de Vos delivered a bold and slightly terrifying vision of the future where plastics and polymers play new and daring roles. Intelligent, app-driven flower pots, color-changing pigments, conductive polymers, foldable phones and self-healing materials were just a few of the mind-bending projects presented by de Vos. The nexus of information technology and novel polymers will result in entirely new categories of products such as artificial blood and polymer-based thought-controlled exoskeletons that have the potential to revolutionize healthcare. Of course, more mundane benefits such as light-weighting continue to ensure that plastics is still a 'wonder' material in today's market. Two examples from the automotive sector showed how new polymer-based materials are being used to reduce weight in new car construction. Glass-fiber reinforced polyamide wheels from BASF can eliminate 3kg (6.6lbs) each of weight. India-based Mahindra is using ABS-PMMA and ABS-PC-PMMA thermoformed outer body panels for the Reva electric car. As SPE approaches its 75th anniversary next year, the organization is clearly going to spend more time looking forward than backward.

### **Updates on 3D Printing**

If you've been keeping up with your threads on SPE's "The Chain," you might have seen a conversation about whether 'additive manufacturing' is the most appropriate term to describe what is commonly called 3D printing. Multiple techniques are now being used for many different materials including fused deposition modeling (FDM), laser sintering, fused filament and polyjet printing. Presentations from Voxeled Materials (Spain) and Materialise (Belgium) on the technology suggested big savings are possible for companies who are able to print prototype parts, prototype tooling (instead of using wood, for example), fixtures and jigs. 3D printed parts can also serve as virtual inventory which saves space and frees up cash flow. Light-weighting opportunities also exist for elements that can be integrated into value-added items such as hinges on large, multi-component parts.

Linked to 3D printing is design thinking, and one of the more noteworthy presentations was delivered by Elena Kopola of Trendworks (UK) illustrated how CMF (color, material, finish), especially in the aviation industry, is integral to production. Design thinking stresses truly understanding the user's needs. Early supplier coordination and good communication across the supply chain (which is easier said than done, especially in polyglot Europe) will lead to better collaboration across multiple disciplines including design, manufacturing, marketing and sales.

### Thin Gauge Developments

The thin-gauge sessions included papers on thermoforming in-mold labeling (T-IML) and the continued influence of the coffee capsule market on thermoforming innovation. There was still 22% growth in coffee pods in 2012-13. Since the Nespresso and Green Mountain patents both expired in 2012, the number of capsule manufacturers has almost doubled. Multilayer films, faster machines, more sophisticated tools are all tied into the growth of this convenient little package. Plug-assisted thermoforming is proving to be the most efficient process for producing the pods. Competitive benefits include pods that are lighter than aluminum and injection-molded versions; large cavitation tools for high-volume production; optional oxygen and/or light barrier films for long shelf life; different weight containers from one tool through the use of inserts.

Speakers from RPC, a large Europe-based converter, and the equipment panel discussed the continued evolution of T-IML as a competitive decorative process. Higher output, lower product weight and lower capex - the advantages over injection molded parts are well-known, but the broader market has yet to fully embrace the technology. Illig and TSL, however, stated that they are building systems for both new and existing customers (RPC and others in Europe, Tech II in the US). For perspective, the panel reminded us that even though OMV first presented IML technology at K 1995, there are still only 5-10 T-IML lines in operation around the world.

Looking more closely at the drivers behind the continuing development of T-IML, RPC discussed how market segmentation allows for niche positioning for premium products on supermarket shelves. Decoration is required for entry into the premium category and T-IML appears to offer an "excellent investment to capacity ratio" for converters. As has been previously discussed at AMI's Thin Wall Packaging conferences in the US and Europe (see

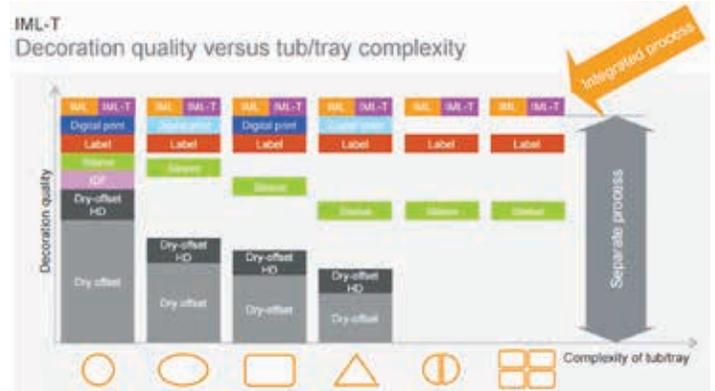


FIGURE 1 – matrix of decorating technologies used for various containers (source: RPC presentation SPE ETD 2016 Conference)

TQ1 2016, vol.35, no.1), changes in consumer preferences are a major influence on package design, especially as they relate to shelf-life. Thermoforming offers great flexibility in film choice and T-IML can exploit this while maximizing design elements. Thinner walls are reinforced by 5-sided wrap-around labels.

During the panel discussion, a question was asked about the ability to retrofit existing machines with IML technology. OEMs are usually loath to retrofit older machines with new tech, so it wasn't surprising to hear that it would be difficult in the case of T-IML. Label handling, slower speeds are two major concerns, not to mention the costs associated with custom-engineering a solution for different vintages of equipment and control systems.

Other topics in the thin gauge sessions included plasma-enhanced chemical vapor deposition (PECVD), a 3D coating system with inert barrier technology that is proposed as an alternative to traditional EVOH. Like barrier films, PECVD is designed to reduce oxygen permeability and water vapor transmission to increase the shelf life of products. The barrier is deposited in a very thin layer (100 nanometers – think semiconductor ranges). The presenter, Wolfgang Czizegg of Cavonic Industries, gamely proposed some project economics suggesting that the barrier costs are approximately €0.04 per 1000 parts (small PP cups in the example). But because the parts have to be introduced to a vacuum chamber in a separate step, skeptical audience members questioned the applicability of the technology to a continuous, inline thermoforming process.

Thomas Tang of Faerch Plast (Denmark) also discussed shelf-life as a key trend while presenting a macro-level

view of the packaging industry. Active packaging, CO2 absorbers, portion packaging and skin packs offer protection to many different foods, preserving taste and aroma, improving both pack security and integrity. The design of these new trays also leads to improved logistics and space optimization during transport because they are smaller and thinner. Saving space equals saving costs.

According to Tang, broad patterns suggest industry consolidation as food producers demand high quality, reliability and total cost management from their suppliers. Faerch, who have completed several acquisitions of their own recently, continue to develop new and innovative packaging concepts while incorporating sustainability as a core principle. They reported a 57% reduction in CO2 emissions, driven mainly by an increase in the amount of RPET used.

### **Heavy Gauge Developments**

The U.S. was well-represented in the heavy-gauge sessions with two presentations from Evan Gilham of Productive Plastics (Mount Laurel, NJ) and Steve Murrill of Profile Plastics (Lake Bluff, IL). Gilham presented results from two lean manufacturing case studies. In one study, results showed that after performing gembu walks (from Japanese gembutsu, or 'real thing', meaning to observe work in the place where it is actually done) the company moved to cell-based manufacturing and saw an average reduction from 55 steps per product to 25. Murrill presented a short evolution of pressure forming techniques over the past 30 years, highlighting the market and technical changes that have allowed thermoformers to increase their range to capture more business. He also highlighted a dilemma, well-known to thermoformers, about how standard part acceptance is driven by statistical process control (SPC) in a closed-loop, injection molding world. Because thermoforming is an open-loop process, the variations in sheet, forming, trim fixture fit, etc., processors are constantly tweaking trim programs at great cost. This leads to the eternal question: how to tighten the process to improve consistency? Better sheet, better forming process control through IT and data analysis and better trim programs will all help, but costs need to be understood and managed so that thermoforming doesn't lose its competitive edge. Getting better quality with lower costs is a real and difficult business challenge. As was pointed out in the presentation, it can take 10 years for a product to be accepted in a market.

### **European University Research in Thermoforming**

The final day of the conference ended with a series of academic papers from KU Leuven (Belgium), Institut für Kunststofftechnik (IKT) at the University of Stuttgart (Germany) and Technische Universität Dresden (Germany). At least one of the papers has been presented in the US at ANTEC (see TQ2, 2015, vol.34, no.2) while others were presented here for the first time. Generally speaking, all of the papers explored the ability to use mathematical models to predict material efficiency through optimized heating profiles and sheet thickness measurements. Even though thermoforming, as an industry, is moving toward greater scientific rigor in thermoforming, these results reinforced the difficulties that remain when trying to develop repeatable and consistent results. Beyond taking the extruder or resin supplier to task for inconsistent product, thermoformers must be able to develop criteria by which they can first define what they need so they can better control and contain the degree of variation in the final product. What these universities and technical institutes are attempting to do is find better modeling tools (including finite difference modeling and simulation software) in order to establish a stronger link between simulated results and actual process parameters. From there, they hope to compare theory and practice to reduce the gap between calculations and actual process outputs so that commercial tools can be developed by industry to increase efficiency and reduce variability.

### **Parts Competition**

This was the first year that conference organizers sought to initiate independent, sector-oriented awards. The prizes were given for first-class innovative achievements in originality, creativity, mold complexity and technical difficulty. There were 4 winning submissions at the 6th European Thermoforming Parts Competition (see story and photos on pp. xx)

### **Termoformado en los próximos 20 años**

The ETD celebrated 20 years in Sitges. What will the conference look like 20 years in 2036? If Wim de Vos's visions become reality, we'll all arrive in driverless cars made from advanced composite materials, dressed in polymer-based wearable tech suits with pre-programmed chips that will automatically download the conference proceedings to the iPhone 26 app inside our contact lenses. Let's just hope the food and drink retain their delicious, elemental nature |

## Winners of the 6th European Thermoforming Parts Competition 2016

By Conor Carlin, Editor, *Thermoforming Quarterly*

In 2006, the European Thermoforming Division of the Society of Plastics Engineers sought to initiate an independent, sector-oriented awards competition. These awards represent first-class innovative achievements in originality, creativity, mould complexity and technical ability in order to promote advanced design and developments of thermoformed parts.

Now, for the 6th time, the European Thermoforming Parts Awards once again highlighted applications selected by the jury at the recent European Thermoforming Conference in Sitges (Barcelona) from March 9-11.

And the winners are:

### 1st Prize Winner: Heavy Gauge Vehicle/Automotive Applications

"Engine Hood" produced by **Technoplast, France**.

Jury's comments: "A large cosmetic formed area forming but for use as an industrial application. Surface finish is good. Well-formed and trimmed. Both parts well-assembled, good integrity in bonding that result in a highly functional part."

### 1st Prize Winner: Heavy Gauge Non-Automotive

"VELUX Roof Dome" produced by **Formplast, Sweden**.

Jury's comments: "Excellent clarity using a fairly complex sheet material which requires a great deal of preparation. Good industrial application - high risk product."

### 1st Prize Winner: Thin gauge Food Packaging Application

"Veggiefresh" produced by **RPC Bebo Plastik, Germany**.

Jury's comments: "The way to beat injection moulding - nice volume thermoformed IML to create the product."

### 1st Prize Winner: Thin gauge Non-Food Packaging Application

"Back-lit Day-Night Effect Baguette" produced by **Walterpack, Spain**.

Jury's motivation: "Advanced high pressure forming – superbly done." |



"Engine Hood" produced by Technoplast, France.



"VELUX Roof Dome" produced by Formplast, Sweden.



"Veggiefresh" produced by RPC Bebo Plastik, Germany.



"Back-lit Day-Night Effect Baguette" produced by Walterpack, Spain.

## Interview with James Naughton, President of Thermoforming Systems Limited (TSL)

By Conor Carlin, Editor, *Thermoforming Quarterly*

*James Naughton has been with TSL for 30 years. Based in Yakima, WA, TSL designs and develops thermoforming systems and trim presses.*

*TQ spent time with Naughton at the 10th European Thermoforming Conference in Sitges, Spain where Naughton participated as a panelist on a machinery committee discussing the impact and growth of T-IML (in-mold labeling).*

**C. Carlin:** Let's first talk about machinery technology. You've been with TSL since 1985. How would you summarize the evolution of thermoforming machinery since you started with the company?

**J. Naughton:** Thirty years is a long time. I started in the foam polystyrene area when Mobil Chemical was expanding their footprint with meat trays and clamshells for McDonald's. Brown was the dominant player until Irwin Research came along with servo mechanical machines and faster trim presses. TSL focused on machines for rigid plastic products and introduced the third motion plug drive in 1995, which has become an essential feature for all deep draw thermoformers on the market today. In the US, the machinery designs evolved toward larger flat bed-and trim-in-place processes for higher production capacities. With each advancement, new features became important such as shorter tool change time, production management information software and process control. A significant driver for machine technology improvement has been the evolution of material changes and advances, from polystyrene to APET, PP and PLA.

**Carlin:** Thermoform in-mold labeling (T-IML) seems to be a major topic of conversation in Europe, perhaps less so in the US. Both here [at the European Thermoforming Conference] and at the recent AMI Thin Wall Packaging Conference, the subject is central to the agenda. What are your thoughts on the technology and the market

**Naughton:** T-IML or IML-T is a developmental niche market, both in Europe and in the US. There is keen

interest in its development because it results in high quality graphics, even for non-round parts. Tech II continues to lead the pack, with the most number of T-IML machines and product lines here in the US. As we learned [at the ETD Sitges conference], there are a number of machines in Europe being developed for higher capacities. For T-IML to succeed, there needs to be a clear business case that demonstrates its viability beyond what the injection molded IML process can achieve.

**Carlin:** How do changes in materials affect TSL's approach to machinery design? For example, with increased demands for tamper-evident packaging and increased shelf life for food products, do you see changing demands from customers?

**Naughton:** Resin suppliers have developed materials with higher performance characteristics, such as clarity, increased melt strength and barrier properties. These new resins require advances in heat control, plug speed, motorized rail adjustments, increased forming tonnage, faster form air fill times, and precise trim control. In addition, we often collaborate with key tool suppliers to incorporate critical features in the mold and trim tooling to meet expectations. Tamper-evident products have grown dramatically over the past 2-3 years. TSL approaches these type of developments from the customer's point of view: to maximize productivity and ease of operation while maintaining high reliability.

**Carlin:** TSL is active in the Asia-Pacific region through your Sunwell subsidiary. Do you see clear differences in different markets around the world? Give us some examples.

**Naughton:** Sunwell Global manufactures extrusion and thermoforming machinery, along with several other key accessories, such as tooling, granulators, material handling systems, etc. All of the equipment is manufactured in Taiwan and shipped to 58 different countries. An example of differences among world markets is that while foam was shrinking in Europe and the US, it was growing strong in places like Brazil, South America, Russia and India. Another major difference can be seen in the gram weight of products such as drink cups which can weigh as little as 1.2 grams in China or South America. These parts cannot (yet) be sold in the US market.

**Carlin:** Here in the US, workforce development is an important subject as companies seek to retain talent

and train the next generation of workers. How does TSL approach this subject given your location? Is there a solid ecosystem in Yakima?

**Naughton:** Yakima has a long history of strong manufacturing companies that came along with its agricultural developments and expansions throughout the state of Washington. We recruit engineers from the University of Washington, Central Washington, Gonzaga and Washington State, as well as Oregon schools. Also, we find very good service technicians from Perry Technical Institute right here in Yakima.

**Carlin:** What will the next 3-5 years look like from TSL's perspective?

**Naughton:** TSL will continue to develop new technology to best serve our existing customers, but will also seek new growth opportunities. As long as we continue to think innovatively and provide our customers with solutions and service, we expect to see positive results moving forward. The US market continues to be strong versus many global markets that have lagged in their recovery. We recognize that dual purpose machine designs are important, serving both APET and PP production due to the cost battle between these major resins. The trend to implement automation and parts handling has continued, as it is critical to the overall success of converters to reduce labor and other overhead costs. |

## 2016 SPE Thermoforming Quarterly Author Membership Program

The SPE Thermoforming Division invites prospective authors to contribute articles to its award-winning publication, *SPE Thermoforming Quarterly*. As part of our mission to facilitate the advancement of thermoforming, we seek to widen our audience and increase our knowledge base.

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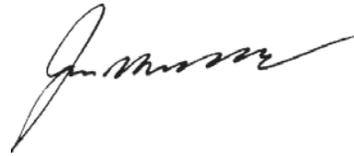
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The SPE Council held a telephonic meeting on February 5, 2016 with 64 people on the line at the same time! This was a first for SPE and hopefully the last. Telephone conference calls have their place and I understand the savings that you get by not having everyone gather at physical location, but you really lose some of the spirit of the meeting when doing it via conference call.

On the positive side, it was one of the fastest meetings on record: 80 minutes.

The Council reviewed the financial draft report. The good news is that the budget for 2016 is set to be a positive number. Some of that was achieved by reducing the rebates from 75% to 50%. 2015 was still in the red with an overall loss of \$7k but again, some this was due to the improvements that are being put in place and are beginning to show some results.

SPE is beginning to add back some positions that were cut. If the Society is to provide the services that are being advertised, then there has to be some additions to the staff. I believe this will improve some operations and assist the Division in both its conference and membership efforts. One of the most important actions was the report from the Governance Task Force (GTF). The Society has

been evaluating how to govern and make executive management more efficient. I would encourage you to go the Leadership Chain and lookup the GTF report on their recommendations. These recommendations will be voted on in May at ANTEC.

The Council also reviewed the new electronic voting procedures for President and Vice Presidents. Using the new Etouch system it was painless to vote quickly. The election results will be posted shortly.

Our Division has attempted to use electronic voting for board elections. The apathetic response has been very discouraging. Hopefully, we will be able to use this new system which will make it easier for you to participate in Division activities.

Congratulations to the Division for winning the Pinnacle Gold Award. Our incoming Chairman, Bret Joslyn, did a great job in getting the application together. The Division should be proud that we are one of the most active divisions in SPE and this award represents the efforts of many people participating and getting the job done. |

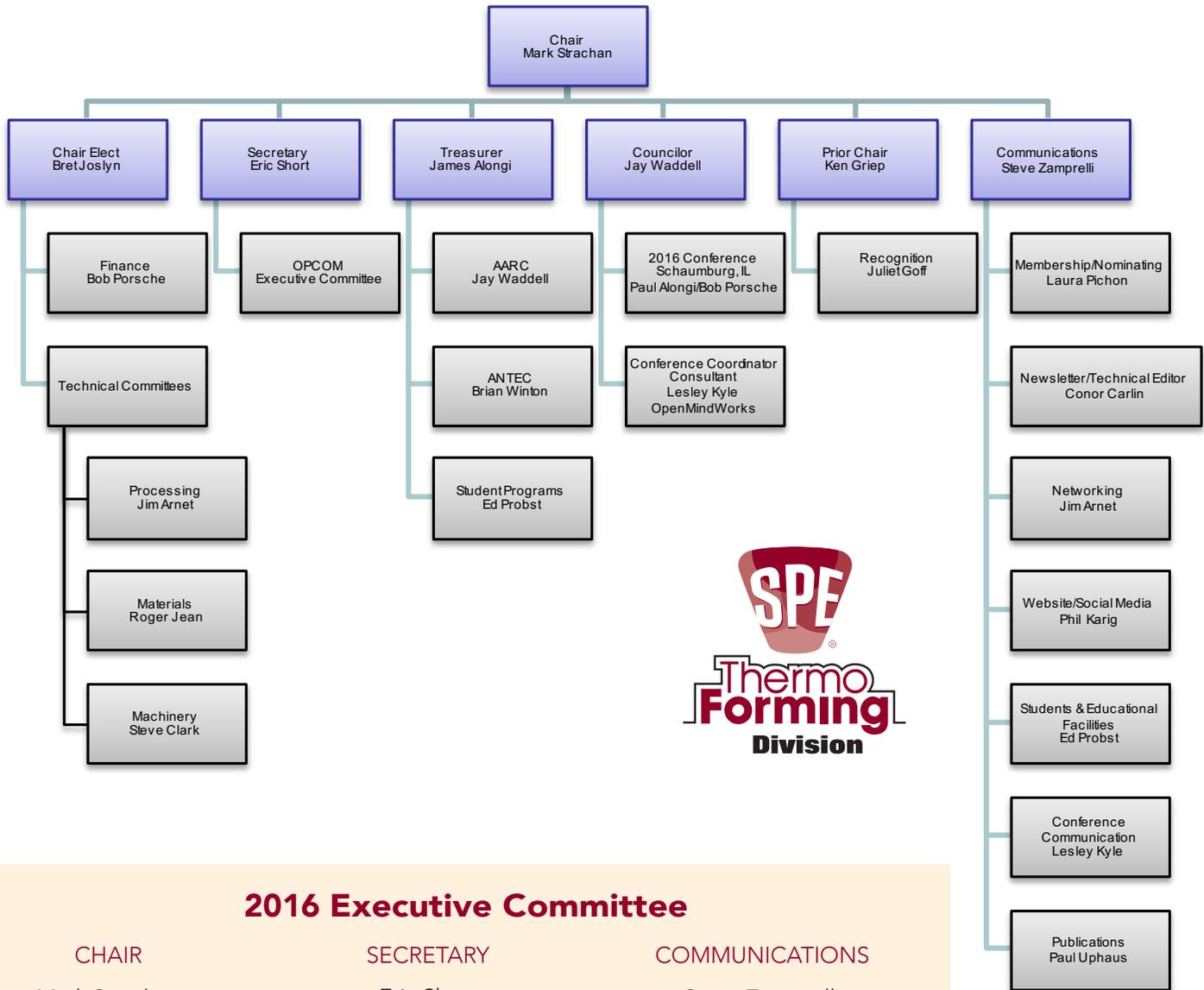
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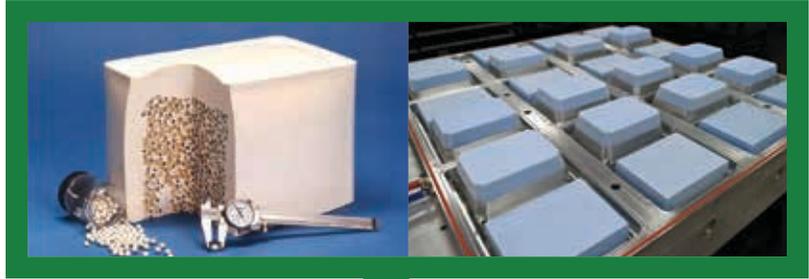
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