SPE Thermoforming Quarterly®

First Quarter 2018 | Volume 37 | Number 1

A Journal of the Thermoforming Division of SPE

The Art of Convenience

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Zero Emissions Program

Postcard from Japan

Modeling & Optimization Using Neural Networks

Melting Efficiency for Various Polylactide Resins

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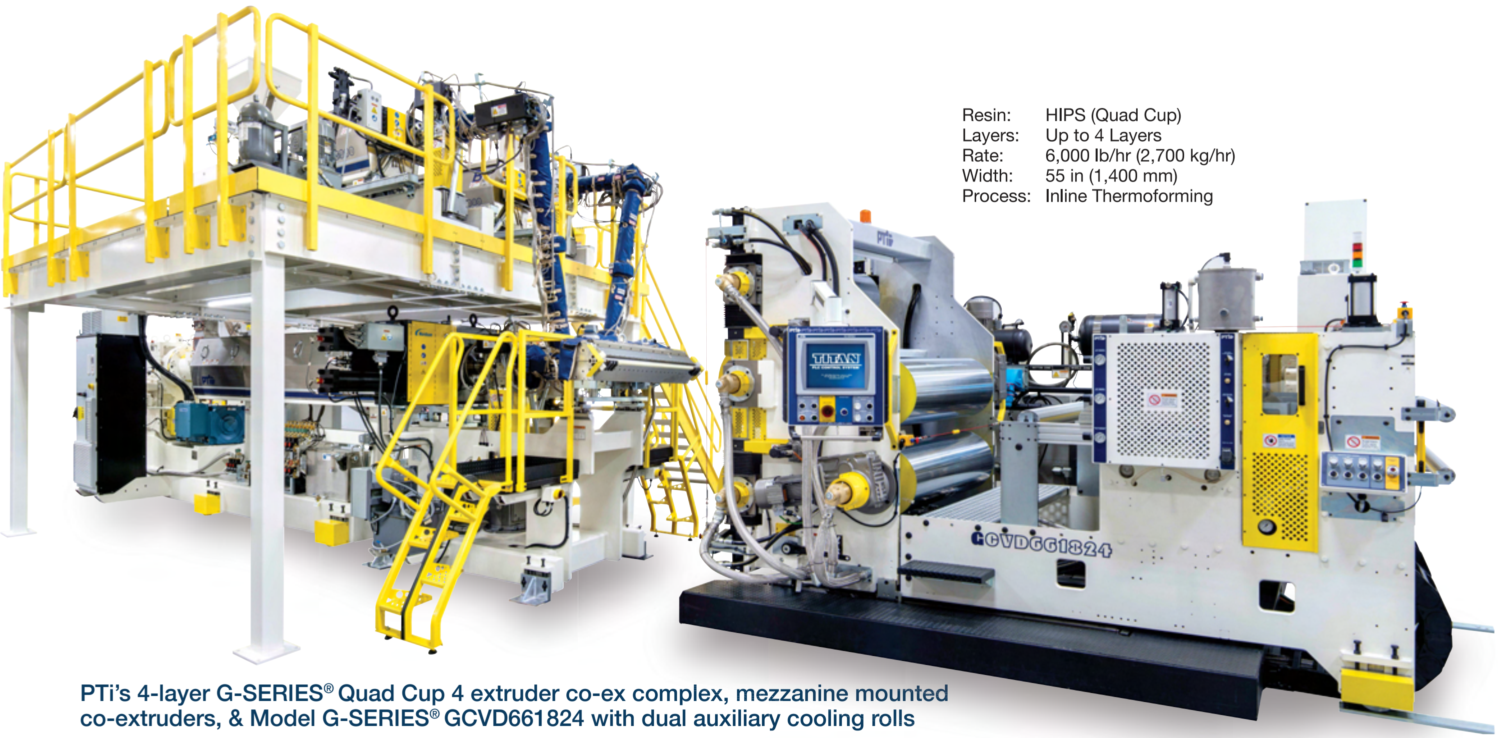

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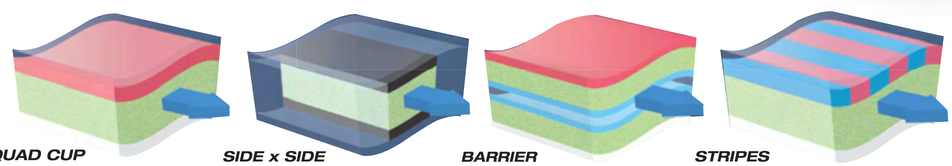

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Cover image of plastic packaging in Japanese convenience store. Courtesy of Conor Carlin

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Bret Joslyn

New Year, New Records

2018 is off to a terrific start! Many companies reported a record year in 2017 and the momentum shows no signs of letting up. With NPE on the horizon in just a few months, we can expect to see many buyers in the exhibition halls with the proverbial checkbook in hand as demand remains strong for plastic products. Bill Wood, who writes "Numbers that Matter" for Plastics News, thinks we'll see an increase in M&A activity as cash piles continue to accumulate at private equity firms and strategic industry buyers. Companies have underinvested in recent years due to uncertainty about growth and returns, but now they are looking to invest and grow, both to keep up with labor market demands and to boost productivity.

What does all this mean for thermoforming? If we review the two broad categories of thermoforming, packaging and industrial (or thin-gauge and heavy-gauge), we see growth in both areas. Global consumption drives a lot of packaging design, innovation and production. With increasing wealth in developing economies, especially in Asia, migration to urban areas drives the demand for more convenience, which usually results in something being packaged for sale. In this issue of TQ, our editor offers a peek into the plastics industry in Japan, a dynamic country known for technological prowess (see article on pp.18-20).

In the heavy-gauge sector, we continue to have success converting metal parts to plastic in many industries. In January, our friends at Ray Products released the results from their 4th annual survey on plastics manufacturing and found very positive responses. Lighter weight parts, built-in color options, environmental benefits and design flexibility offer engineers and manufacturers advantages that they might not have fully explored. Pressure forming, in particular, appears to be more popular than before. While PLASTICS offers data on plastics machinery shipments, they do not always drill down into the thermoforming sector. To address this gap, at our most recent meeting in February, the board has decided to commission our own North American Thermoforming Industry Survey in partnership with a leading independent research firm. More details will be forthcoming as this project evolves.

SPE's annual technical conference, ANTEC, takes place with NPE in Orlando in May. On the topic of technical papers, we are pleased to offer a paper on melting efficiency of PLA from our friends at the Extrusion Division (see pp. 28-34) as well as an interesting finding from Europe. A group of researchers approached the technology of vacuum forming with the idea of "developing models of prediction and optimization using artificial neural networks (ANN)" (see article on pp. 22-27). Simulation remains a contentious area in thermoforming. With so much variability inherent in the process, converters are challenged with cost-benefit ratios that don't clearly favor investment in complex software. Yet fortune favors the brave, and market demands for quality are relentless. With competition driving innovation and corporate cash looking for deployment, could we see a breakthrough in the black art…?

This will be my final letter as the gavel is passed to the next Chairman of the Board, Eric Short. It has been my great privilege to serve as Chair for the past two years and I'd like to thank my colleagues on the board, as well as many of the members, who have supported me during my tenure. In keeping with precedent, I will remain on the board as Prior Chair. I hope you will join me as we welcome Eric to the hot seat and get fired up for Texas!

Keep in touch.


NPE2018
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New Members

Adam DeBoskey
Superior Trim
Findlay, OH

Rishabh Jain
Bemis Company
Neenah, WI

Xian Wu Jinyoung (Xiamen)
Advanced Materials
Technology Co., Ltd.
Xiamen

Aleesha Pruett
Capitola, CA

Steven Raiman
Charles Industries, Ltd.
Schaumburg, IL

Roderick Reber
Arkema
King of Prussia, PA

Kiley Sluis
KLO Acqusition, LLC
Muskegon, MI

Dan Tall
Lane Company
Minneapolis, MN

John Whitaker
Illig
Cincinnati, OH

Jinying Zhang
Atra Plastics Inc.
Plymouth, MI

Why Join?

It has never been more important to be a member of your professional society than now, in the current climate of change and global growth in the plastics industry. Now, more than ever, the information you access and the personal networks you create can and will directly impact your future and your career. Active membership in SPE – keeps you current, keeps you informed, and keeps you connected. Visit www.4spe.org for details.

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

Why Not?

Brown Machine Group Acquires Thermoform Tooling Company

January 23, 2018 – Plastics Technology Staff

Brown Machine Group, Beaverton, Mich. has purchased Freeman Co., a leading manufacturer of thermoform tooling used predominantly in the high-volume food packaging industry. The transaction was effective Jan.5, 2018. Terms were not disclosed.

Brown makes highly-engineered thermoforming and automated material handling equipment under the Brown, Lyle, Nalle Automation Systems, and EPCO brand names.

Freeman was founded in 1892 as the Louis G. Freeman Company, and is located in Fremont, Ohio.

"Brown's customers enjoy a complete package of process engineering, tooling, productivity enhancement kits, spare parts, 24/7 customer service and access to our state-of-the-art prototyping laboratory for thermoforming processes." says CEO Bryan Redman. "We are the only thermoforming manufacturer in the U.S. that offers a full range of products, and the corresponding support services, that ensure our customers success. The addition of Freeman provides a more complete tooling solution, further establishing Brown's position as a comprehensive solutions provider in thermoforming."

Adds Mike Mullholand, Freeman COO, "(We) have been looking for the right partner for some time now, and we are very happy to be joining the Brown Machine Group family. We are all thrilled about the enhanced product offering for our collective customers, and the re-investment into the business we are all making to ultimately benefit the thermoforming industry."

Recycled-Content Thermoforms Maker Shrinks Workforce

January 24, 2018 - by Jared Paben, Plastics Recycling

Facing falling customer demand, an end user of recycled PET will lay off 100 employees at its North Carolina factory.

Absolute Plastics, which makes recycled-content thermoformed packaging, notified state government on Jan. 11 it will let go employees at its Wilson, N.C. plant. Absolute Plastics is owned by rePlanet Holdings, an integrated recycling-packaging company. The company's collection arm, called rePlanet, runs beverage container redemption centers in California. The processing arm, called ECO2 Plastics, shreds and washes the bottles.

Absolute Plastics, the company's plastics end user, makes thermoforms with a range of recycled PET and PP content, including product lines with 70 percent RPET. In June, the U.S. Food and Drug Administration issued a letter of no objection to rePlanet Holdings to create 100 percent RPET thermoforms for food and drink.

The Triangle Business Journal reported Absolute Plastics will reduce its manufacturing footprint in Wilson. Company CEO Paul Cobb stated in the disclosure to the state the decision was made because of the loss of significant customer volume and the desire to consolidate operations and eliminate excess manufacturing capacity, the paper reported.

In early 2016, rePlanet made headlines when it closed nearly 200 of its California container redemption locations. The closures were the result of low commodity values and the formula California state government uses to calculate subsidy payments for collection centers.

Plastics Improve Quality of Life—and Figs!

Plastics empower safer passage for fresh figs from California to New York—much to this editor's delight.

Blog Post: 1/31/2018, Matthew H. Naitove, Executive Editor, *Plastics Technology Magazine*

If you are a fan of fresh figs (as I am) then you may have resigned yourself (as I have) to the fact that when you buy figs in a plastic mesh-style box, the fruit on top may look great, but the figs on the bottom will be mashed, mis-shapen, and quite possibly moldy as a result.

Well, I am resigned to such disappointment no longer, thanks to a more imaginative use of plastics. For the first time since I have been living in New York City (which is all of my adult life), I found a supermarket that stocks fresh figs in thermoformed PET clamshells where each piece of fruit (six to eight) is held snugly in its own separate pocket. No bouncing around, no mashing, no squishing, no leaking of juice to promote mold growth.

I write about plastics every day, but I felt a renewed sense of awe at the many ways plastics make our lives better.

I went looking for the source of the package. The figs I bought were packed by Western Fresh marketing in Madera, Calif. Although I had never seen them before in the New York area, Western Fresh has been shipping figs in pocketed clamshells for many years. They get their fig clamshells from Mid Valley Packaging & Supply Co. (MVP) in Fowler, Calif. MVP is a distributor of packaging manufactured domestically and in countries such as China and Chile. The fig clamshells were made in Thailand. MVP, however, owns the tooling for the clamshells.

Since I separate my household's kitchen trash for recycling, I can't help noticing that the fig packs are just one more sign of the greatly enlarged presence of crystal-clear PET packaging in my home life. I like buying berries in PET clamshells instead of boxes, from which the berries tend to spill. I like salad greens in recloseable, rigid PET boxes instead of soft bags. And I particularly like my breakfast orange juice in a PET bottle instead of a coated paperboard carton or milky translucent HDPE jug. Lately, I've even begun buying iced tea in a PET bottle, rather than brewing my own (and never having enough on hand).

Silgan Unveils More Details for New Thermoforming Plant

February 1, 2018 - By Jim Johnson, Plastics News

Efforts to turn around Silgan Holdings Inc.'s plastics container business in recent years are now starting to pay off, company officials said.

Word about the progress comes as the Stamford, Conn.-based company released its latest financial results and discussed plans for a new plastics packaging manufacturing facility.

"We're expecting the plastic container business to benefit from continued manufacturing efficiencies and volume growth," Chief Financial Officer Robert Lewis said on a conference call to discuss financial results. "These benefits will be partially offset by costs associated with the start up of the new Fort Smith, Ark., facility."

News just recently broke about the new Arkansas location. Company officials, on a Jan. 31 conference call with stock analysts, provided more details about that project.

"That is a plastic thermoform business. As I think you know, we had acquired the Rexam [thermoformed food container] business several years ago and have been very happy with the free cash generation of that business and have been seeing some growth as it filled up its capacity in a single plant," CEO Tony Allott said.

"Really, our hope all along was that it would be able to grow out into a second plant. And, essentially, what's happened here is it has had that opportunity with some really interesting growth opportunities coming forward where we are now building a second plant," he said.

The CEO estimated the new plant will cost about $30 million to construct this year, with work expected to be completed in the third quarter.

The company then will qualify the plant and expects commercialization of production in 2019.

Creation of the new plant comes at a time when Silgan has been working to lower costs and improve production in the plastic container portion of its business.

"We're obviously very pleased with the progress the business made on the cost side this year, which was our key focus," the CEO said.

"This all started for us with an effort to get the competitive cost position of the business in a better spot. That took a little longer than we though, was a bit more challenging as we went through it. I would say we have come through that process, feel very good about the cost position of that business," he said.

While the company has made strides to turn around plastics container operations, Silgan also touted its 2017 acquisition of WestRock Co.'s specialty closures and dispensing business. That deal added 13 plants.

Allott also called Silgan a "poster child for a company that benefits" from the recent federal tax changes.

"We've been a highly profitable, high tax payer for a long period of time, heavily in the U.S., competing with a lot of companies that are in different jurisdictions that get the benefit of global tax structures, treaties that we didn't have," the CEO said.

The tax reform gives Silgan new advantages and permanently improves the free cash flow of the business, he said.

Silgan had a profit of $269.7 million, or $2.42 per diluted share, on sales of $4.09 billion for 2017. That compares with a profit of $153.4 million, or $1.27 per diluted share, on sales of $3.61 billion for 2016.

Profit was $146.1 million, or $1.31 per diluted share, on sales of $995.7 million during the fourth quarter of 2017. That compares with a profit of $23.7 million, or 20 cents per diluted share, on sales of $805.9 million for the fourth quarter of 2016. Full-year earnings per diluted share in 2017 are a company record.

"Each of our operating businesses improved solidly over the prior year, for the quarter and the full year," Allott said. "Perhaps, more importantly, we've increased the growth opportunities for the company both organically and through potential future acquisitions."

Metal containers accounted for $2.28 billion of sales in 2017.

Disney Design Team Selects Associated Thermoforming, Inc.

February 2, 2018 - Geeks News Desk (www.broadwayworld.com)

Disney design team selected Associated Thermoforming, Inc. (ATI) to create panels for their new Avatar Flight of Passage ride based on their expertise, experience, and capabilities. This huge thermoforming project consisted of almost 50 different thermoformed items, each with individual molds and CNC trim fixtures. ATI chose vacuum forming as the specific thermoforming process due to the design of the parts and the large variety of panels that needed to be manufactured.

"Coping with the large number of molds and part numbers was a unique challenge," said John Nix, owner of ATI.

"The logistics of such a large project with frequent changes challenged our ERP system a bit and capacity management – but all in all, this was a really fun, unique project for our team that we all really enjoyed, and learned from."

Additionally, the Disney designers spec'd a specifically formulated KYDEX® plastic that had to remain at a very low gloss level. Due to this, ATI used a glossmeter to determine the amount of reflected light, as the intensity of the gloss is dependent upon the material and angle of illumination. While this sounds like a small detail, many thermoforming companies find it difficult to achieve this low level of gloss and ATI was able to execute it perfectly.

Investment Partner Acquires Visual Packaging

February 19, 2018 - Plastics in Packaging (UK), Sayers Publishing

UK-based investment partner Tower Growth Management (TGM) has acquired Nottingham-based thermoformed packaging solutions provider Visual Packaging (VP).

The acquisition partners will aim to advance the business, which offers bespoke packaging solutions for industries such as food, medical and cosmetics, by working with the packaging firm to develop biodegradable plastics packaging in a bid to increase VP's turnover from £2.6 million ($3.6m) to £3.3m ($4.6m) over the next year.

Additionally, TGM is targeting expansion of VP's client base and team, with the recruitment of a designer, business development team and the introduction of an apprenticeship programme.

The acquisition guaranteed the job security of the firm's current ten employees, as well as offering promotions to the company's production manager Dave Norton, who will become the general manager, and Zoe Allen, who has been promoted to head of sales.

Simon Ashcroft, regional partner of TGM and VP board member, commented: "We are delighted to welcome VP into the TGM family and I'm really looking forward to seeing where we can take the company."

Next Generation Plastics Workforce

From *Plastics Technology,* Feb 2018

[Editor's Note: In this issue, we offer excerpts from some recent articles and research reports that provide insight into the plastics industry. Through macroeconomic data and trends in workforce development, we see a paradox: buoyant industry growth figures and healthy company profits, but continued difficulties with recruiting and training the next generation of plastics industry workers.]

After years of closely monitoring an increasingly worrisome labor shortage, the Plastics Industry Association's (PLASTICS) warnings about the widening gap between the sector's need for skilled workers and the supply of such employees have shifted to full alarm. As stated in PLASTICS' 2017 Size & Impact Study, "While the skills gap and the decline of a qualified manufacturing workforce have been discussed for many years now, the nation has reached the point where their impacts will begin to be felt more acutely."

In that report, released in December, PLASTICS forecasts that employment in plastics manufacturing will expand 0.9 percent, 0.7 percent and 0.6 percent from 2017 to 2019—rates slower than in the three prior years and in five of the last six going back to 2011. Total employment in 2019 is forecast to reach 735,000, not including captive operations. It stands at 719,000 today. "Employment growth slows as the supply of labor starts to dry up," is how PLASTICS describes the impending scenario in the report.

The plastics industry has responded at the university level with shifting curricula and new learning formats, including online education; and at the processor level with unique programs that target everyone from engineers who had no introduction to plastics while in school, to people who've had no introduction to engineering or plastics, period.

The Long View

Robert Malloy has been helping train plastics industry workers at the university level for more than 30 years. Malloy joined the faculty of the University of Massachusetts–Lowell's plastics engineering program in 1985, eventually becoming program chair, before transitioning to a professor emeritus at the school. Malloy first came on campus at Lowell 40 years ago as an undergraduate student, and in the intervening years he's seen both change and stasis in how students are readied to work in plastics. However, the demand for trained people, while it has ebbed and flowed somewhat, has remained constant.

"Education is like a pipeline," Malloy says, "and it takes four or five years for a student to pass through our program. So while the demand is there today, the student that's coming here today isn't going to graduate for four or five years. So there's this lag time where the work force just takes a while to generate."

UMass Lowell has some company in offering a plastics engineering program, but compared with other disciplines, the number of plastics options in academia is disproportionately small relative to the number of people who eventually have to work with these materials.

Online university database Cappex lists 13 schools with a polymer/plastics engineering major (although its list omits some well-known programs, including Ferris State and Pittsburg State). Across the U.S., only four of those have ABET (Accreditation Board for Engineering Technology) accreditation: UMass Lowell, University of Wisconsin Stout, Penn State Behrend, and Pittsburg State University.

The good news for the industry is that at the university level, interest in plastics engineering is extremely strong. The bad news: Schools are starving for qualified instructors, particularly those with knowledge of processing. "Finding faculty that have that blend of theory and practice is really a limiting factor," Kazmer says.

"Finding teachers is a very significant challenge," Malloy agrees. "Getting students these days, with the demand for graduates, is not a problem, but getting qualified faculty is a problem and it's not just a matter of salary." Here again, the lack of plastics-specific coursework in U.S. engineering programs poses a challenge.

"Education doesn't come quick—it's not a magic pill," Hoffman says. "It's not something where you're going to go to a course for a week or whatever and know everything. It takes time, and I think that's one of the biggest challenges for this industry. Everyone wants a quick fix for education—well, there isn't one."

Committee on Equipment Statistics (CES) Fourth Quarter 2017 Economic Update and Machinery Statistics Overview

Excerpts from PLASTICS Committee on Equipment Statistics, published by PLASTICS

2018 Macroeconomic Outlook: Forecast still solid, but excessive optimism now a threat.

This Spring marks the ninth anniversary of the economic expansion, and though it is already one of the longest expansions in US history, it shows no signs of abating. In fact, growth is expected to accelerate in 2018 due to the federal tax cuts that were signed into law at the end of last year.

The US economy is not showing signs of overconfidence yet, but there is cause for concern if the growth rate in real GDP gets too high and stays there for a sustained period. There has been a lot of political rhetoric coming out of Washington in recent weeks regarding a national economic growth rate in excess of 3% per year. Much of this talk is fueled by the fact that the recent tax cuts will result in a significant increase in the federal budget deficit that will only be offset if economic growth exceeds 3% per year.

But there is a potential problem with this scenario, and it stems from the fact that an economic growth rate in excess of 3% is higher than the long-term potential for the US economy at the present time. It is impossible to accurately assess what this country's long-term potential rate of growth truly is at any given moment, but roughly speaking it is the rate of population growth added to the rate of productivity growth.

Now maybe the official data underestimate productivity gains in the digital age; nevertheless, it is difficult to get to a long-term potential rate of growth much higher than 2% per year in the US. Simply put, there just has not been enough investment during the past decade to push productivity rates up much higher. Whether it is investment in infrastructure, investment in capital equipment, or investment in workforce development, all these areas have suffered in recent years from underinvestment. And the current low rates of productivity growth are what we get to show for it now.

Manufacturing and Industrial Indicators

The ISM Manufacturing Index averaged a strong 58.6 in Q4 of 2017, and this index should stay above the 55-level for the first half of 2018. This means that manufacturing activity will steadily rise, but not at a pace that will cause overheating anywhere in the supply chain. New orders for durable goods expanded 7.3% in Q4 of 2017 when compared with the same period a year earlier. For all of 2017, new orders for durable goods were up 5.9%. The GDP data continues to show that consumer spending is gradually accelerating, and this will continue to drive demand for durable goods in 2018. The forecast for durable goods orders calls for another gain in the range of 5% in 2018. Growth in the durable goods data still correlates closely with growth in production of plastics parts.

The long-term incentives for investment in capital equipment remain intact (prospects for further US economic growth, accelerating global economic growth, and low interest rates). Spending for plastics equipment could accelerate in 2018 if demand for plastics products registers a more rapid acceleration in the pace of expansion in the coming quarters. At the present time, the data on output of plastics products is accelerating, but it is not yet up to the rate of 3%-4% per year that is necessary to spark a large jump in demand for plastics machinery.

Total production of plastics products posted a gain of 2.9% in Q4 of 2017 when compared with the previous year. For all of 2017, total US output of plastics products increased 1.7% when compared with 2016. This is better than the annual gain of 0.5% in 2016. After a couple of years of sluggish growth, the rate of change curve has finally started to curl upward. The rate of change curve is forecast to continue to rise gradually rise throughout 2018. The forecast calls for a gain of 3.5% in 2018. If this forecast holds, then the pace of growth in the production of plastics products should be sufficient to sustain continued gains in the data for new equipment.

The trend in the shipments value of plastics products (a measure of the total dollar value received) perked up at the end of 2017. Total shipments increased 1% in Q4 of 2017 when compared with the same period in 2016. For all of 2017, the value of shipments was up a modest 0.3% when compared with 2016. The forecast for the value of shipments in 2018 calls for a gain of 3%.

Resin prices were firmer in Q4 of 2017, and they look poised to go higher. The forecast calls for a gradual rise in resins prices in 2018. As always, the trend in this data will follow the trend in the crude oil data.

End Markets

After two consecutive record years, total motor vehicle sales cooled in 2017. This pushed the US assemblies total lower. In Q4 of 2017, motor vehicle assemblies dropped 8% when compared with Q4 of 2016. For the year, assemblies were down by 8% in 2017. The downtrend in the date will hit bottom in the next quarter or two, and then stay flat. The forecast for total assemblies in 2018 calls for a total of 10.8 million units. This is a decrease of at least 4% from 2017. Total output of medical supplies and equipment is still trending lower, but the rate of decline is decelerating. Production dropped by 6% in Q4 of 2017 when compared with the previous year, and for the year output was down 5.5%. The 2018 forecast for this sector calls for the downtrend in output levels to reverse this year, but the total annual gain will be flat when compared with 2017. The plastics segment of this industry will continue to perform better than the overall decline in the data. Market conditions for plastics packaging products experienced gradually accelerating gains in Q4 of 2017 that corresponded to the pace of growth in the consumer spending. In terms of optimism amongst machinery suppliers, this was still one of the strongest end-markets in Q4.

Plastics Machinery Shipments Up 9.7% Y/Y in Q4 of 2017

Thanks to a very strong performance by the injection molding segment, North American shipments of primary plastics machinery posted another strong year-over-year increase in Q4 of 2017 according to statistics compiled and reported by the Plastics Industry Association's (PLASTICS) Committee on Equipment Statistics (CES). This marked the third consecutive quarterly Y/Y increase in this data.

The preliminary estimate for shipments of primary plastics equipment (injection molding, extrusion, and blow molding equipment) for reporting companies totaled $396.7 million in the fourth quarter. This was 9.7 percent higher than the total of $361.7 million in Q4 of 2016, and it was 14.6 percent stronger than the revised $346.1 million from Q3 of 2017. This Y/Y gain in Q4 followed a revised 18.8 percent Y/Y increase in the quarterly total from Q3.

The shipments value of injection molding machinery jumped 20 percent in Q4 when compared with last year. The shipments value of single-screw extruders declined by 15 percent. The shipments value of twinscrew extruders (which includes both co-rotating and counter-rotating machines) slipped 1 percent.

The shipments value of blow molding machines in Q4 declined by 41 percent. Demand for auxiliary equipment also appeared to be solid in the fourth quarter according to the latest estimate for total bookings. Actual comparisons in this year's quarterly auxiliary data to last year's quarterly totals are unavailable due to a change in the number of reporting companies.

Global market conditions in 2018 are expected to improve. Expectations for North America improved significantly. Expectations for the major international regions—Latin America, Mexico, Asia, and Europe— call for steady-to-better market conditions in the coming year. The respondents to the Q4 survey expect that automotive, packaging, and medical/pharmaceutical will be the strongest end-markets in the coming year. The outlook for all other major end-markets calls for steady-to-better conditions.

Pennsylvania College of Technology Students Compete in SPE Thermoforming RC Car Competition

[Editor's note: Even though the 2017 Thermoforming Conference in Orlando was cancelled due to Hurricane Irma, several students at Penn College continued their work on their RC Car construction projects. We are glad to present their results here, and we wish them success in the next competition.]

Team members Heather Fennell, Luke Orzechowski and Jack Walsh with their entry for the SPE RC Car Competition.

In the spring semester of 2017, our student group consisting of Jack Walsh, Heather Fennell, and Luke Orzechowski (all seniors in the Plastics and Polymer Engineering Technology program at Pennsylvania College of Technology), was given the opportunity to submit an entry into the SPE Thermoforming RC Car Competition.

We had completed a semester learning about the thermoforming process and theory and have since moved into a new course in part design. We thought this was a good opportunity to learn more about thermoforming and part design. Our group, along with guidance from Christopher Gagliano (PIRC Program & Technical Service Manager) and Dr. Kirk Cantor (professor of Plastics & Polymer program), began working on the project.

There were many different ways of approaching the task of designing an RC car body. First, our group looked at the existing car body that came with the RC car that we received from our sponsor, Wilbert Plastics. We then looked at pictures of famous cars to draw inspiration for what we wanted our car body to look like. In parallel, the original RC car body was being 3D scanned to pinpoint where the mounting holes were located so that we knew where to add them into our design. Dr. Eric Albert, a professor at Pennsylvania College of Technology, and his class assisted with this task.

We used Inventor software to begin designing our own RC car bodies. Ideas bounced around from using a classic car body all the way to a modern sports car. Formability was at the forefront of our minds when designing. It was important to make sure to avoid sharp edges as to not rip the sheet when being formed and that the thermoformed car body could be removed from the mold easily without damage to either the RC body or mold. That was the most difficult for us because we wanted to have a complex part to challenge ourselves by showing detail in the part while avoiding severe undercuts and any issues with the corners.

We decided on a recycling truck body as our final design to keep in theme with plastics as well as to show complex designs in our finished body. We showed complexity by embossing three R's on the back of the RC body (representing the three R's of sustainability: reduce, reuse, recycle) as well as importing a picture of a leaf and the recycling logo on the side. We sketched them and used the "extrude" feature in Inventor to add them to the design.

Thank you to our 2017 SPE Thermoforming Division RC Car Race Sponsors:

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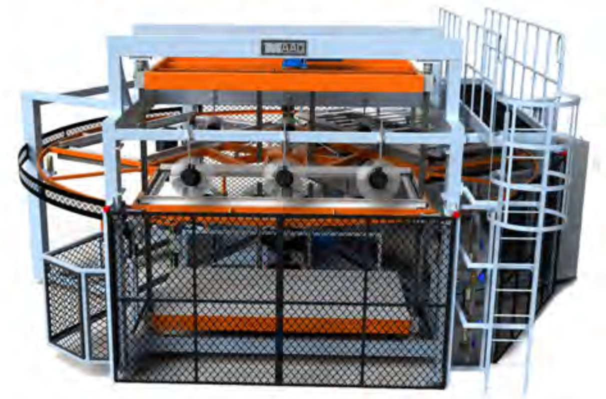

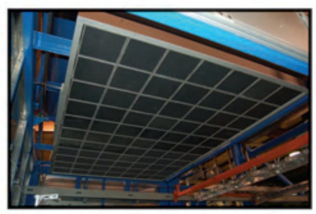

Postcard from Tokyo

By Conor Carlin, Editor

[Editor's Note: this article is adapted from a longer report published in Plastics Engineering (Wiley), January 2018]

The 9th International Plastic Fair Japan (IPF) took place in Tokyo from October 24-28, 2017. Event organizers reported almost 800 exhibitors and 43,000 attendees, an increase of 2% from the previous event in 2014. In this sense, the plastics industry in Japan is aligned with other regions of the world in terms of growth. The IPF is very much a regional show, however, with 90% of exhibitors and attendees from Japan[i]. Injection molding and robotics dominated the machinery sectors, with thermoforming not well-represented. Thin-gauge parts, however, were very much in evidence with interesting implications for thermoformers.

Japan Plastics Industry

According to domestic and international sources, the plastics industry in Japan is stable and balanced in terms of the proportion of production to demand. The country's strength in this sector is highlighted by the fact that total export volume significantly outweighs that of imports. International trade is primarily with other Asian countries, which is not surprising given the size of these markets and their rates of growth[ii]. Machine tools, injection molding machines and robotics are three of the primary areas where Japanese companies excel in the global market. Fanuc controls 65% of global market share in CNC controls and 6 of the top 11 machine tool manufacturers are from Japan[iii]. (By contrast, in the year 2015, the US had a trade deficit of $1.7bn for plastics machinery, up from $900MM in 2005[iv, v]) Official statistics from the Association of Japan Plastics Machinery, however, show a more varied picture across specific categories of plastics processing equipment. Injection molding machinery is holding steady after recovering from the financial crash, though the number of shipments and total value are both below their pre-financial crash levels.

Blow molding machinery has also shown a steady increase since 2009, but this sector is reaching new heights in terms of both units shipped and total value. The extrusion sector shows a mixed picture, with units shipped declining for the past 3 years though the overall value of shipments has increased.

The majority of plastics processing machinery on display at IPF was injection molding systems that integrated in-mold labeling systems, vision systems with new, powerful cameras, and lots of automation both for take-out systems and downstream packing or palletizing operations. Robotics specialists such as Yushin, Sailor and Fanuc showed their strength both in their own right and as integrated solutions for other molding machine manufacturers such as Sodick, Sumitomo Demag and Toshiba. Many companies highlighted machine to machine (M2M) and increased factory connectivity (via IoT and Industry 4.0 principles) in the pursuit of real-time decision making, granular reporting and reduced downtime.

Packaging Trends

Though IPF is not the primary show for plastic packaging in Japan (that would be Tokyo Pack, coming in October 2018), trends in consumer packaging were reflected in some of the technology at the show. IML parts are very visible at convenience stores and supermarkets along with thermoformed containers that have been decorated via offset printing methods. Only Illig (Heilbronn, Germany) displayed a thermoforming machine at IPF while the local market leader, Japan-based Asano Labs, stated that their order backlog precluded them from bringing a machine to the event. Thermoformed parts tend to be heavier in Japan than in other regions of the world due to a perceived link between the weight of the part and its inherent quality. Downgauging, therefore, is not a major driver in the thermoforming sector. In one unique cultural twist, convenience stored sell pre-packaged ice in sealed thermoformed containers that are then used for iced coffee. From a logistics perspective, this is less than optimal since parts must be stacked full instead of nested empty during (refrigerated) shipping.

Light-weighting was very much in evidence in the injection booths, however. Sumitomo and Toshiba (Shizuoka, Japan) displayed similar PP dessert cups. The Sumitomo system was 300T all-electric servo drive with an 8-cavity mold producing a 4.28g cup on a 3.2 second cycle time. Japan Steel Works (Tokyo, Japan) displayed several all-electric models including a 300T unit producing a 0.4mm PP cup with a 3.07 second cycle time. Sodick (Yokohama, Japan) introduced a new, modular injection molding cell


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factory with their proprietary two-stage V-Line method for plasticizing and injection functions. According to company literature, The MR30 automated manufacturing system integrates auxiliary devices like dryers, extractors and temperature control units. Keeping with Industry 4.0 trends, the system incorporates M2M for all elements that allows for traceability all the way through to the completion of the final molded product.

Automotive Drivers

Beyond food packaging, weight reduction for automotive components was a central theme throughout the event. Advances in composites material and technology continue to be rich grounds for innovation. The National Composites Center, part of Nagoya University, presented results of new technology development in the areas of structural materials, long-fiber thermoplastics (LFT) and carbon fiber reinforced polymers (CFRP).

Sekisui Plastics (Osaka, Japan) introduced multiple new developments (some of which are not yet commercially released), expanding its line of thermoplastic elastomeric bead foam materials with several PS and PA-based foam sheets. High heat-resistance, flame-retardance and chemical resistance continue to be sought-after attributes in the automotive supply chain. Several exhibitors demonstrated MuCell technology in moldings with rapid heating and cooling systems for both weight reduction and surface decoration for applications in electrical appliances.

Japan is still the world's 3rd largest economy and an export powerhouse. It can be, however, a tricky place for foreign companies to tread if they are not prepared with a long-term vision and local assets. Cultural, social and linguistic differences can be stark and business negotiations are formal and drawn-out. Those who have succeeded suggest that a critical component of a company's strategy is to hire a dedicated country manager who will act as a bridge between corporate leaders and the local market. Even then, in the plastics industry at least, the competition will remain tough.

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An Approach to Modeling and Optimization Using Artificial Neural Networks

By Wanderson de Oliveira Leite[1,*], Juan Carlos Campos Rubio[2], Francisco Mata Cabrera[3], Angeles Carrasco[4] and Issam Hanafi[5]

Abstract
Many existing extruders running polyethylene (PE) resins can be optimized to operate at higher production rates and also with higher qualities by the mitigation of gels. This paper provides an assessment process where the extruder is studied for potential rate increases and quality improvements. It is recommended that such an assessment be made prior to purchasing new screws or when a line is close to becoming fully utilized and more product is required.

Abstract
In the vacuum thermoforming process, the group effects of the processing parameters, when related to the minimizing of the product deviations set, have conflicting and non-linear values which make their mathematical modelling complex and multi-objective. Therefore, this work developed models of prediction and optimization using artificial neural networks (ANN), having the processing parameters set as the networks' inputs and the deviations group as the outputs and, furthermore, an objective function of deviation minimization. For the ANN data, samples were produced in experimental tests of a product standard in polystyrene, through a fractional factorial design (2^{k-p}). Preliminary computational studies were carried out with various ANN structures and configurations with the test data until reaching satisfactory models and, afterwards, multi-criteria optimization models were developed. The validation tests were developed with the models' predictions and solutions showed that the estimates for them have prediction errors within the limit of values found in the samples produced. Thus, it was demonstrated that, within certain limits, the ANN models are valid to model the vacuum thermoforming process using multiple parameters for the input and objective, by means of reduced data quantity.

Keywords
vacuum thermoforming process; modeling and optimization; artificial neural networks; deviations and process parameters; multi-criteria optimization

Introduction
Thermoforming of polymers is a generic term for a group of processes that involves the forming or stretching of a preheated polymer sheet on a mold producing the specific shape. It is considered to be one of the oldest methods of processing plastic materials [1]. The process which uses the vacuum negative pressure force to stretch this heated polymer sheet on a mold is called vacuum forming or vacuum thermoforming [2]. Specifically, this is the forming technique and/or stretching where a sheet of thermoplastic material is preheated by a heating system (Figure 1a,b), and forced against the mold surface (positive or negative) by means of the negative vacuum pressure produced in the space between the mold and sheet (Figure 1c), by mold suction holes and a vacuum pump which "sucks" the air from the space and "pulls" the sheet against the surface of the mold, transferring it, after cooling and removing excess material to shape it (Figure 1d) [3,4]. The typical sequence of this technique by Ghobadnam et al. [5] is presented in Figure 1.

However, what is observed, in practice, is that incorporating prior knowledge or a trial-and-error

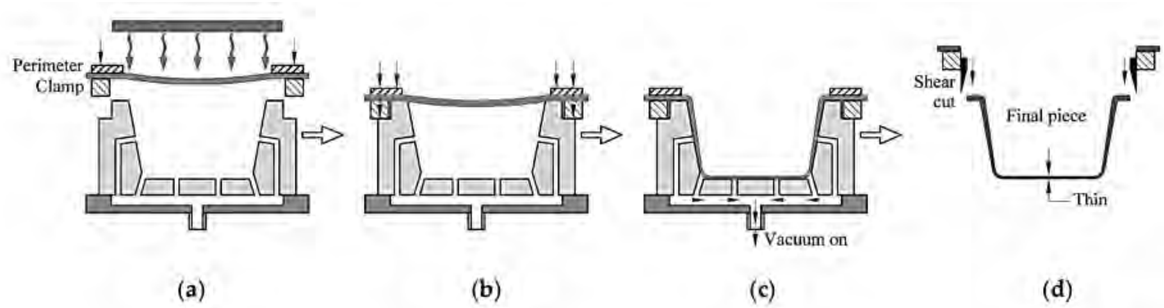

Figure 1. Schematic of basic vacuum thermoforming. (a) Heating; (b) sealing or pre-stretch; (c) forming and cooling; and (d) demolding and trimming.

methods to predict the final result of the process and the quality of the product can be far more difficult. Thus, the evaluation of the final performance of the system is sometimes complex, due to various factors, such as the raw material of the mold, the equipment characteristics, the type and raw material of the sheet, and other factors [6–8]. In addition, the process often highlights the conflicts between aspects of quality and adjustments of process control variables [9,10]. In recent years, several authors have developed work with the objective of modelling and predicting the quality of the final product of the vacuum thermoforming process.

Thus, Engelmann and Salmang [6] presented a computational statistics model and data analysis, and Sala et al [11] and Warby et al [12] in a complementary focus, worked on the development of an elastic-plastic model for thickness analysis. Many studies concentrated on aspects of mold geometry and process parameters to verify their influence on the wall thickness distribution [5,13–15]. A hierarchically-ordered multi-stage optimization strategy for solving complex engineering problems was developed, [3,16]. Martin et al [17] presented the study of the instrumentation and control of thermoforming equipment and its analysis and control in real-time of multiple variables. The accuracy of the developed controller and its prospective real-time application is evidenced by the results. Some studies focused on modeling, simulation, and optimization of the heating system by different methods and techniques [18–20].

However, in complex manufacturing processes such as this, Meziane et al [21], Tadeusiewicz [22] and Pham [23] suggest that the traditional approaches to process control fail to understand all aspects of process control or existing subsystems. Sometimes the amount and type of variables involved make the computational and mathematical modelling of the system a multi-variate, multiobjective, complex process with non-linear and conflicting objectives [9,10,24]. Thus, according to them, in the last few years, several studies have been presented, using computational intelligence (CI) techniques aimed at the modeling of the non-linear characteristics and conflicting objectives of these processes. The research was carried out using a series of computational tools for the resolution of problems that require human intelligence abilities for their resolution or computational modeling, with artificial neural networks (ANNs) being more intensively investigated and studied [25,26].

ANNs are mathematical computational models inspired by biological neural structures or biological neurons [27,28]. The artificial neurons, or perceptron, is constituted of three elements. One input, "X", one weight "W", and a combination of sum function (ϕ) which may be linear or not, and in some cases, a $bias$, θj, is included [29]. The "Y" response of the ANN is obtained by applying the activation function on the output of the combiner or sum function matrix $Y = \phi\ (W \times X + \theta)$ [30].

One algorithm model, called a basic ANN, is the multi-layer perceptron (MLP), which is typically composed of combinations of artificial neurons that are interconnected, usually by a node system or mesh. The MLP generally consists of "n" neurons interconnected in a system of meshes of nodes and divided into: an input layer, an output layer, and one or more hidden layers, and, between layers, the neurons are connected with their respective weights (biological synapses), which learn or record knowledge (by adjustable weights) between the input and output layers of the network. Furthermore, the network of layers is interconnected externally with their supervised training or learning algorithms [26,27].

In the MLP network, through the input and output data of the network or patterns, the network is trained in a cyclical process by its algorithms and a performance index is calculated for the network in each training round or epoch. These supervised training and learning MLP processes can be continuous until the ANN model "learns" to produce desired outputs for input from its pattern [27] or a performance index of the network, such as the mean square error (MSE), which achieves an error equal to or less than specified, or when the network reaches any other stop criteria specified during model programming. For this, the networks are implemented with training algorithms, the most commonly used being the back propagation (BP) and Levenberg-Marquardt (LM) algorithms. The BP algorithm is a method of supervised learning (batch) that seeks to minimize a global error function or Sum Squared Error (SSE) for the j neurons of the layer(s) at each epoch [31,32]. The LM algorithm, developed by Hagan and Menhaj [33] and implemented in MATLAB® software (MathWorks Inc., Natick, MA, USA) by Demuth and Beale [34], is a method that provides a solution to the minimization problem of a non-linear function based on the Gauss-Newton method and gradient descent algorithm via calculation of Jacobian matrices [35].

The ability to work with complex or multi-dimensional and multi-criteria problems makes ANNs one of the main methods used in engineering for computational modeling [22]. A model with multi-criteria optimization is defined when it is desired simultaneously to optimize several objective functions and, in some cases, these functions are in conflict, or compete with, each other and, thus, the possible optimal solutions do not allow, for example, the maximization of all the objectives in a joint manner [36].

In this context, some authors have developed computational models based on Computational Intelligence (IC) techniques associated, or otherwise, with statistical optimization for the analysis of quality characteristics of the piece produced by vacuum thermoforming, some of them described by Chang et al. [24]. Likewise, Yang and Hung [9,10] proposed an "inverse" neural network model which was used to predict the optimum processing conditions. The network inputs in this work included the thickness distribution at different positions various parts, and the output or optimal process parameters were obtained by ANNs. Additionally, Küttneret et al. [3] and Martin et al. [17] presented the development of a methodology that uses an ANN to optimize the production technologies together with the product design. Finally, Chang et al. [24] tested an inverse model of ANN on a laboratory scale machine, where it used the desired local thicknesses as inputs and the processing parameters as outputs, with the aim being process optimization.

Thus, first of all, the current work studied both the values of manufacturing parameters and the quality of samples produced by the vacuum thermoforming process on a laboratory scale. Additionally, these initial experimental results were used to investigate the computational modeling of the process through several ANN models that aimed to correctly present the deviation values given a set of manufacturing parameters. These study sequences allowed the study of multivariable and multi-objective optimization algorithms using ANN models to obtain optimum values of the manufacturing parameters simultaneously with the group predictions of product deviations. Finally, validation tests and confirmation are carried out with the objective of evaluating the ability of each model to simulate the process under new experimental conditions and, also, estimate deviations, verify the efficiency of the approach, and validate the proposed methodology.

2. Experimental Work

2.1. Material, Equipment, and System

For the three-dimensional (3D) design of the model and mold, aspects inherent to the manufacturing process and contraction of 0.5% were considered [8,37] and computer-aided design (CAD) software, integrated with computer-aided manufacturing (CAM), was used. The mold was machined in a computer numeric control (CNC) using plates of medium density fiberboard (MDF) as a raw material. This has dimensional and geometric characteristics of a product standard and, also, a 3D coordinate measuring machine (3D CMM) was used to determine the dimensional and geometric deviations present in the mold.

A semi-automated vacuum-forming machine was developed and automated by the researchers. This equipment has the capacity to work with plates of thickness of 0.1 to 3.0 mm, a useful area of 280 x 340 mm, a displacement of the mold (z axis) of 150 mm, a vacuum pump of 160 mbar with a motor of 1.0 CV, an infrared heating system composed of two resistors of 750 and 1000 W, movement by pneumatic systems, and acquisition of temperature data by "K" thermocouples and non-contact infrared. The system is programmable and controlled by a commercial personal computer (PC) integrated with an Arduino microcontroller (Arduino Company Open Source Hardware, Somerville, MA, USA).

In this work, 2.0 x 2.5 m of white laminated polystyrene (PS) sheets with a thickness of 1.0 mm were used to manufacture the parts. The plates were cut into 300 x 360 (machine size) sheets, cleaned with water and liquid soap of neutral pH, and then dried and packaged in plastic film packages that had previously been heated at 50˚C for two hours.

The commercial equipment and software used in the development of this study are described below and included: a Micro-Hite 3D TESATM 3D coordinate measuring machine (3D CMM, Hexagon AB, Stockholm, Sweden), Discovery 560 ROMI TM Machining Center (CNC, INDÚSTRIAS ROMI S.A, São Paulo, Brazil), and Arduino UNO Revision 3 microcontroller board (ATmega328, Arduino Company). A commercial personal computer (PC) environment withWindows® 7 Home Premium 64-bit operating system (Microsoft Company, Redmond, WA, USA), Intel® CoreTM i3-2100 3.10 GHz

processor (Intel Corporation, Santa Clara, CA, USA.) and 6 GB of RAM to integrate the machine with the Arduino system's software and equipment. The software was chosen so that information could be shared, and the main packages used were: Arduino Software (IDE) Release 1.0.5 Revision 2 (Arduino Company) for Arduino microcontroller board, SolidWorks® 2008 (SOLIDWORKS Corp, Waltham, MA, USA), EdgeCAM® 2010 by SolidWorks® (Vero Software, Brockworth, Gloucester, UK), Reflex Software for Micro-Hite 3D TESATM (Hexagon AB, Stockholm, Sweden), MiniTab 16® (Minitab, Inc., State College, PA, USA), and MATLAB® 2011 version 7. 12. 0. 635 (R2011a) 64-bit (MathWorks Inc.).

2.2. Parameters and Measurement Procedure

There is no consensus among authors about the measurement parameters and procedures. According to Küttner et al. [3], Muralisrinivasan [4], Yang and Hung [9,10] and Chang et al. [24] in the vacuum thermoforming process several parameters of control and quality can be used, depending on the type of equipment, mold, and product geometry. Throne [2], Klein [7], Throne [8] and Chang [24] explain that there is no specific measurement procedure or equipment to be used. Thus, they were defined to control the deviations as described in the following paragraphs, with the scales, measurement procedures, and tolerances presented.

For measurement of the errors, 3D MMC was used carrying a 4mm diameter solid probe, calibrated with an error of 0.004 mm, which has an accuracy of 0.003 mm and CAI software. The reference values for dimensions were calculated, based on the final dimensions of the mold. Additionally, according to Throne [2] and Klein [7], a deviation of 1% for linear dimension and 50% for flatness on surfaces are acceptable and, as a reference, the values calculated for dimensions were adopted as the general criteria for acceptance of sample dimensions.

Figure 2 presents the geometry of the product standard, where dimensions and deviations to be measured in the samples are represented. The dimensional deviation height (*DDHi*) or *DEV 01* was defined as:

$$DDHi = (MHS_i - TSH) == DEV01_i = (MHS_i - 57.92) \quad (1)$$

where TSH is theoretical sample height and a negative (–) mean value indicates that the height is less than the ideal and a positive mean value (+) that it is greater than the ideal. For the calculation of *DEV 01*, eight (8) points were collected on each surface. Additionally, in all equations in this section, the index *i* represents the *i*-th analyzed sample.

The deviation of the diagonal length *(DDL,)* or *DEV 02* is calculated by the difference between the values of the $MLDS_i$ and the value of the *TDL*, being:

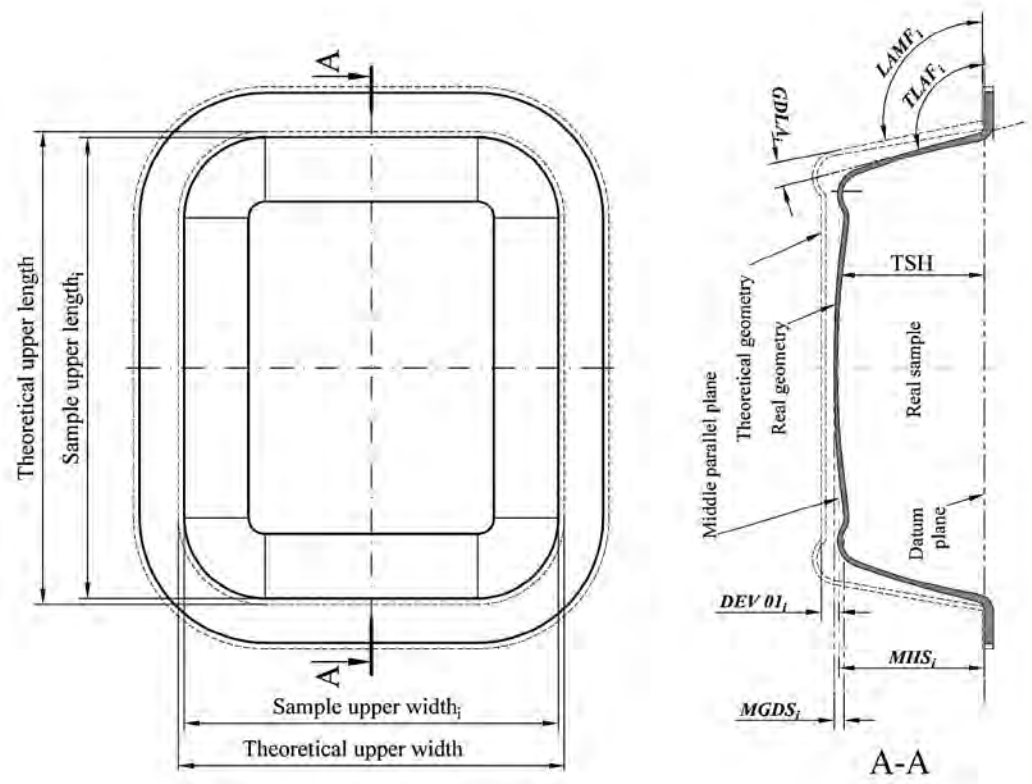

Figure 2. Product standard: dimensions on piece or dimensional deviations parameters.

$$DDL_i = (MLDS_i - TDL) \quad (2)$$

where $MLDS_i$ is the measured length of the diagonal in the sample, which in this work was defined as the quadratic relation of the lateral distances of the upper end of the sample (length and width) and *TDL* is theoretical diagonal length of the Sample = 207.97mm, so:

$$DDL_i = DEV02_i\left(\sqrt{(width_i)^2 + (length_i)^2 - 207.97}\right) \quad 3)$$

For the calculation of *DEV 02*, five points were collected along each lateral of the samples. A negative (−) mean value indicates that the length is smaller than the ideal and a positive mean value that it is greater than the ideal.

The geometric deviation of flatness (GD_i) or *DEV 03*, which will have a zero value (0) for an ideal surface or positive value, was calculated as:

$$GD_i = (MGDS_i - TGDS) == DEV03_i = (MGDS_i - 0.11) \quad (4)$$

where $MGDS_i$ is the measurement geometric deviation flatness in the sample and TGDS is the theoretical geometric deviation flatness of the sample, that is, the deviation calculated, which was 0.11 mm. For *DEV 03*, nine (9) points were collected on the lower/bottom surface of the samples.

The *DEV 04* or Geometric Deviation of Side Angles ($GDSA_i$), in this study, is expressed as:

$$GDSA_i = \frac{1}{z}\sum_{J-1}^{Z} GDLA_i == DEV04_i = \frac{1}{4}\sum_{J-1}^{4}(LAMF_S - TLAF_S) \quad (5)$$

where z is the number of sides and s the evaluated face. The GDLA is the difference between the Lateral Angle Measured on the Face of sample i (LAMFi) and the theoric lateral angle of the face (TLAF), for s = 1 ... 4, respectively, 95.93, 95.93, 96.02, and 96.06. For DEV 04, nine (9) points were collected on each surface analyzed.

2.3. Experimental Study

In this research, we used the manufacturing parameters (factors) described by Throne [2] and compatible with the geometry of sample and equipment, namely: A. heating time (in seconds—s); B. electric heating power (in percentage—%); C. mold actuator power (in Bar and cm/s); D. vacuum time (s); E. vacuum pressure (in millibar—mbar). Table 1 shows the levels/values for each parameter.

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Table 1. Factors and levels selected for the main experiments.

Level	Factors				
	A (s [a])	B (% [a])	C (bar and cm/s [a])	D (s [a])	E (mbar [a])
1 (−1)	80	90	3.4 and 18.4 (100%)	7.2	10
2 (+1)	90	100	4.0 and 21.6 (85%)	9.0	15

[a] Unit.

Melting Efficiency for Various Polylactide Resins in a Co-rotating Intermeshing Twin Screw Extruder

Nick Knowlton1, Augie Machado2, Brian Haight2
1NatureWorks LLC, Minnetonka, MN, USA
2Leistritz Extrusion, Somerville, NJ, USA

Abstract:

There are many grades of polylactide resins marketed by NatureWorks LLC under the Ingeo™ trade name. For commercial and technical reasons, Ingeo may be supplied as a neat resin or with the addition of external lubricant. The applied lubricant improves pellet flow through conveying systems, silos, and dryers with minimal influence on physical properties. Several studies have been performed comparing the differences in melting behavior, power load, and melt temperature in single screw extrusion, but to date no study has characterized the same parameters in twin screw extrusion.

Leistritz Extrusion and NatureWorks LLC have conducted experiments that examine the effect of externally applied lubricants on the melting performance in a twin screw extruder with multiple screw configurations and differing operating conditions (i.e. rotational screw speed), denoting the location of the onset of melting, power consumption, and melt temperature for lubricated and unlubricated high molecular weight, low melt flow rate (MFR), formulations.

Introduction:

NatureWorks LLC and Leistritz Extrusion have collaborated to conduct experiments examining the effects of externally applied ethylene-bis-stearamide (EBS) at levels less than two percent by weight on the melting performance of Ingeo polylactide (PLA) resins in a Leistritz 27-mm ZSE MAXX twin screw extruder. A naturally advanced materials company, NatureWorks offers a family of commercially available performance materials derived from locally abundant and sustainable natural resources.1 Some of NatureWorks Ingeo resins are provided with a surface lubricant to reduce the friction and prevent sticking in conveying systems, silos, and dryers.

Twin screw extruders (TSEs) such as the Leistritz 27-mm ZSE MAXX, shown in figure 1, are a preferred manufacturing method for compounding bioplastics, including PLA. TSEs utilize modular barrels and segmented screws assembled on splined shafts. TSE motors transmit power into the gearbox/shafts and rotating screws which impart shear energy into the materials being processed. The modularity of TSEs allows for a wide range and refinement of many processing applications.

Figure 1- Leistritz ZSE 27 MAXX twin screw extruder used for processing.

Optimal processing of PLA in a twin screw extruder requires properly addressing the heat and shear sensitivity of the neat PLA, as well as its torque requirements. Poor processing practices such as high pressure, high melt temperature, excessive moisture content, and increased residence time can result in hydrolytic degradation and reduced mechanical properties.3 Use of a surface lubricant provides many benefits in conveying and transportation, but also has implications on the melting performance of PLA in a twin screw extruder. Explicitly engineering a TSE to account for the differences in processing can increase the efficiency of melting, improve material properties, improve throughput, and reduce tool wear. A few key factors that influence the melting performance of PLA in a twin screw extruder include:

1.) Level of surface lubricant used

2.) Barrel temperature set points

3.) Length of the melting region

4.) Pellet to pellet and pellet to metal friction

5.) Screw rotation speed

6.) Screw element and pellet geometry

The factors that can be controlled through the design of a twin screw extruder are the temperature set points, length, and design of the melting region, screw speed, and screw element geometry. The influence of these various parameters in a TSE process can be observed in polylactide in the form of melt temperature, overall torque, energy input, onset of melting, and molecular weight degradation. These values can be measured in line or through analytical studies on the final product. Analysis of the specific energy is particularly useful when evaluating the mixing performance of a TSE and looking for drastic differences in processing. The specific energy can be calculated through combination of equations 1 and 2 below.

Co-rotating TSE Design

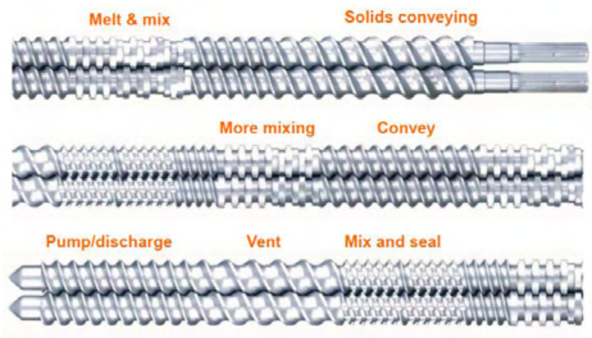

Figure 2- Co-rotating screws in a twin screw extruder split into various separate regions. These will be referred to as the melting, mixing/conveying, and pumping/discharge regions.[2]

$$kW\ (applied) = \frac{0.97\ (gearbox\ efficiency) * kW(motor\ rating) * \%\ torque * screw\ RPM\ running}{Screws\ Max\ RPM}$$

Eq. 1

$$Specific\ Energy = \frac{kW\ (applied)}{kg/hr}$$

Eq. 2

For the purpose of this study, a twin screw extruder can be viewed as various regions with unique tasks. As shown in the image below, these process sections include the melting region, the mixing and conveying region, and finally a vent and discharge region. In the melting region, the pellets must absorb heat from the barrels and energy of the screw. This will allow the pellets to soften and begin to form a viscous melt. As the polymer reaches the first set of mixing blocks, they should be soft enough to mechanically deform without cracking or crunching. Audible crunching present in the process is indicative of higher levels of mechanical energy, which lead to higher motor loads and in essence, wasted energy. The formation of a viscous melt in the melting region will also help mixing, which is essential for a homogenous polymer melt. After melting, additional conveying and mixing will occur and materials with viscosity mismatch such as fillers and liquids may be added through the use of a side stuffer or liquid pump. The latter region includes a melt seal, conveying and venting, and pump/discharge. After the polymer leaves the discharge region of the screws, downstream processes such as pelletization, sheet extrusion, melt pumps, etc. are performed.

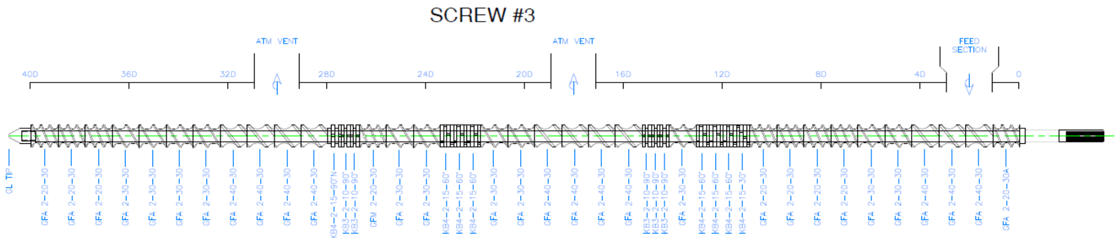

Figure 3- Three screw designs used over the course of this study.

Methods and Equipment:

Twin screw extrusion (TSE) experiments processing NatureWorks LLC Ingeo™ Biopolymer 4032D were performed using the three screw designs in figure 3 below. Neat Ingeo 4032D pellets as well as pellets with medium and high levels of externally applied surface lubricant were processed on a Leistritz ZSE 27 MAXX extruder with 28.3 mm diameter screws, 5.7 mm flight depth, 1.66 OD/ID, torque rating of 304 NM for both screws, and 1200 max rpm. Close attention was given to the melt temperature, melt pressure, specific energy, overall torque, residence time, and onset of melting. The parameters were measured and logged and the specific energy calculated using a state of the art twin screw extrusion control system. An image of the two melt temperature probes and two pressure transducers used in this study are shown in figure 4 below where the internal (deep) melt probe was fixed at 0.25" melt penetration.

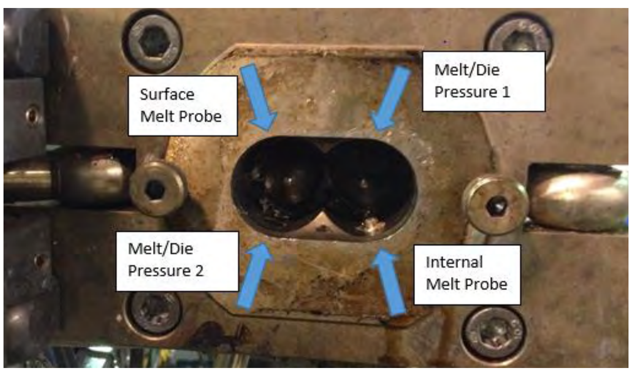

Figure 4- Locations of the two melt pressure transducers, the surface (shallow) melt probe, and internal (deep) melt probe at the end of the 27-mm TSE used.

The onset of melting of PLA was determined by removing the vent at zone 3, which immediately follows the kneading blocks present in zone 2. An image of the melt extrudate freely flowing out of the extruder can be observed below. After removal from the extruder, the collected polymer was immediately quenched in room temperature water to preserve the melt image.

Figure 5- Melt extrudate collected from highly lubricated PLA at zone 3 Figure 1- Image of melt extrudate removed from zone 3 on screw design #1.

Results and Discussion:

Figure 6- Melting region of screw design 1 using GFF screw elements and kneading blocks in zone 2.

Examining the Lubricant- Screw Designs 1 & 2:

Screw design 1 is typical of a screw optimized for melting and mixing of unlubricated polylactide. The melting region, as shown in the image above, consists of three GFF2-40-30 elements, three GFA2-40-30 elements, and four kneading blocks varying from 30° to 90° forward twist between each division. This is a relatively short melting zone for PLA that is advantageous when processing unlubricated polymer due to the high friction and shear energy absorbed by the polymer. The addition of the surface lubricant EBS altered the pellet-to-pellet and pellet-to-metal friction experienced in the extruder. The reduction of friction from surface lubricant in this design reduced the shear energy and frictional heat applied to pellets. As a result, the melting efficiency of the PLA pellets was reduced and the polymer was too solid as it approached the first set of kneading blocks. This was observed in the form of torque spikes and audible pellet crunching. Photos of the melt extrudate for various levels of surface lubricant can be found in figure 7. On the far left, neat Ingeo™ 4032D shows almost complete, uniform melting while the highly lubricated PLA on the right shows a high portion of unmelted pellets. The physical cracking of the pellets is not desired in a twin screw extrusion process as it is an indication of inefficient melting, excessive tool wear, lower throughput, torque overload, and increased probability of catastrophic events such as broken elements and shafts.

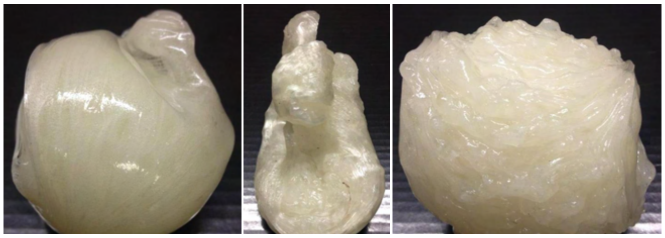

Figure 7- Images of melt extrudate removed from zone 3. From left to right: unlubricated Ingeo™ 4032D, medium level of surface lubricant, and high level of surface lubricant.

The learnings from screw design 1 were used to engineer a revised temperature profile and screw configuration, referred to here as screw design 2. In screw design 2, the melting region was extended by 30-mm to allow for increased heating and softening prior to the first set of kneading blocks. Also, the GFF screw elements used in the feed throat of design 1 were replaced with GFA elements of equivalent pitch and length. As shown in figure 8, GFF's are freely cut, non-self-wiping elements while GFAs are closely-meshing, self-wiping elements. The use of GFA elements reduced the free volume and increased the energy input into the polymer through additional pellet to screw surface contact, increased pellet to pellet friction, and additional contact with the heated barrel wall.4 The temperature profile early in the screw was also increased from 210°C to temperatures as high as 222°C in the melting region. The increased temperature in the melting region caused the polymer to melt faster and reduced the overall load on the screws.

A comparison of the specific energy input while operating at 350 RPM and 35 kg/hr with a medium level of surface lubricant in screw designs 1 and 2 is included in figure 9 below. It can be seen that an increase in temperature set points in the melting zone and extension of the melting zone reduced the load on the extruder. The audible crunching sounds that were experienced when processing lubricated PLA were eliminated using screw design 2. The temperature profile for screw design 2 also efficiently managed the final melt temperature. This provides additional benefits such as improved melt strength for downstream processes such as sheet extrusion, reduced degradation, and efficient mixing throughout the screw. One thing to note is the extension of the melting zone required the atmospheric vent to be moved one barrel downstream form zone 3 to zone 4. However, relocation of the mixing blocks and increased viscosity along the process length is still expected to provide quality dispersion of additives.

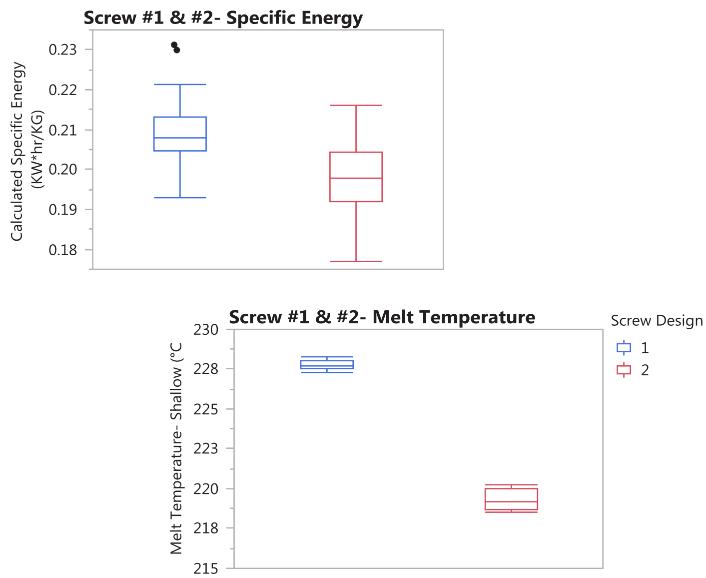

Figure 9- Specific energy and melt temperature while processing medium level of lubricant at 350 RPM and 35 kg/hr on a Leistritz 27-mm ZSE MAXX. Melt temperature measured with shallow, surface thermocouple.

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9	Zone 10
Screw Design 1	210°C	210°C	210°C	210°C	210°C	210°C	210°C	210°C	210°C	210°C
Screw Design 2	220°C	222°C	222°C	212°C	212°C	212°C	202°C	202°C	202°C	210°C

Figure 8- Schematic of GFF and GFA elements used in screw designs 1 and 2, respectively. Also included are the temperature profiles used for processing at 35 kg/hr and 350 RPM.

Optimizing the Process- Screw Designs 2 & 3

Further optimization of screw design 2 was targeted with varied screw speeds, temperature set points, lubricant levels, and a modification that resulted in screw design 3. In screw design 3, the melting region was extended by an additional 60 mm beyond that of screw design 2. The conveying elements in the melting region of design 3 were altered to include two fewer 30 mm, 40° pitched elements and instead used four additional 30-mm, 20° pitched elements. The ability to extend the screw an additional 60 mm will depend on the process being used. In some cases, this may not be an option due to additional feeders and/or mixing necessary in the mixing and conveying portion of the screw. However, this design further improved the melting prior to mixing by increased pellet to metal surface area and increased residence time in the heated barrel prior to the first set of kneading blocks.

The temperature profiles and feed rates for screws 2 and 3 were altered beyond the work performed in screws 1 and 2. The increased temperature is designed to increase melting early in the screw, manage melt temperature throughout the process, decrease the torque on the screw shafts, and increase the overall throughput. The feed rates for all materials was increased to 45 kg/hr due to improved melting performance of the screws.

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9	Zone 10
Screw Design 2	220°C	240°C	230°C	230°C	220°C	210°C	210°C	210°C	210°C	210°C
Screw Design 3	220°C	240°C	230°C	230°C	220°C	210°C	210°C	210°C	210°C	210°C

Figure 10- Temperature profiles used for a comparison and optimization of screw designs 2 and 3.

The final melt temperature of Ingeo 4032D was measured at the barrel surface as well as 0.25" (6.4 mm) into the melt with the use of a variable melt probe. The recorded temperatures from this process at screw speeds varying from 325 to 600 RPM can be observed in figures 11 and 12. As expected, the internal melt temperature is significantly higher than the surface temperature in both screw designs due to reduced influence of heat transfer from the barrel. The differences in melt temperature of lubricated and unlubricated feeds can be explained by decreased melting performance. The reduction of frictional heat early in the screw results in a cooler melt throughout the extruder. One thing to note is the maximum melt temperature observed in screw design 2 was 243°C while the maximum temperature in design 3 was 240°C. The difference of 3°C may seem marginal, however, it may have a significant influence on degradation in processes where regrind is incorporated and the polymer may be exposed to these temperatures 5-10 times. It is recommended that each process be optimized with close attention paid to the molecular weight, melt temperature, torque load, and mechanical properties for any process.

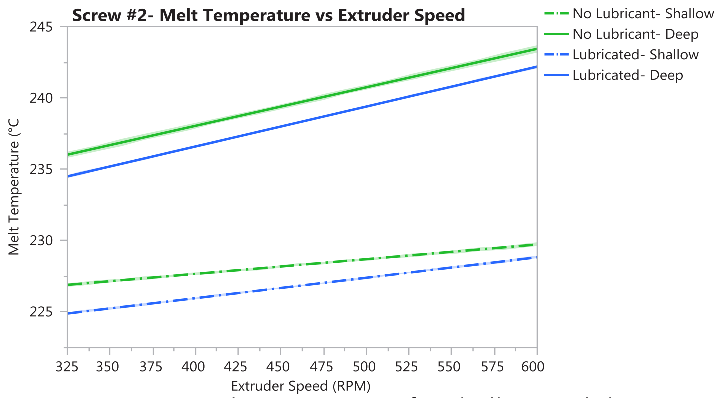

Figure 11- Melt temperature for shallow and deep thermocouple measured on lubricated and unlubricated PLA at the die prior to discharge in screw design 2.

In addition to monitoring the melt temperature, close attention was paid to the specific energy input in screw designs 2 and 3. In figure 13 it is clear that screw design 2 is adding more energy to the polymer melt. One would expect that design 2 is providing more efficient mixing while design 3 is a lower work screw. Each of these designs provides benefits for different applications. When compounding a performance enhancing material such as an impact modifier, screw design 2 may be preferred due to enhanced dispersive mixing. However, screw design 3 may be beneficial for compounding in a colorant powder or other highly hygroscopic material where low residence time, increased throughput, and low melt temperatures are desired.

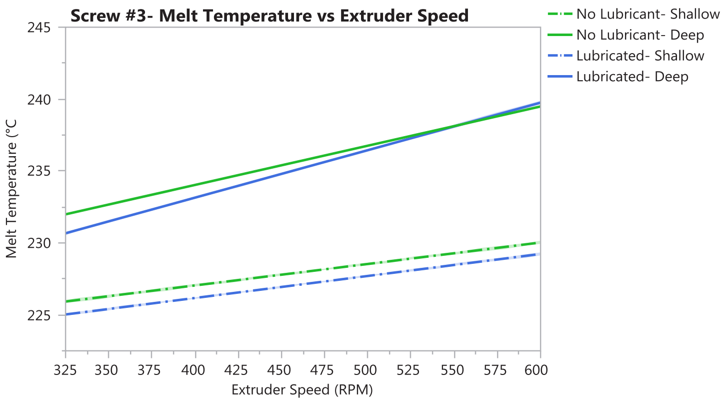

Figure 12- Melt temperature for shallow and deep thermocouple measured on lubricated and unlubricated PLA at the die prior to discharge in screw design 3.

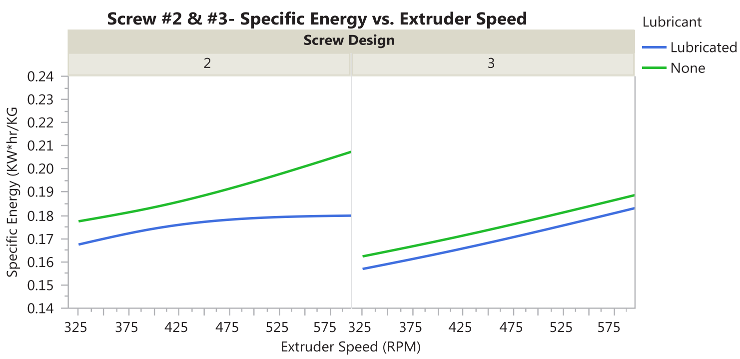

Figure 13- Specific energy vs extruder speed for designs 2 and 3 with lubricated and unlubricated PLA.

For each of the conditions applied to screw designs 2 and 3, the polymer extrudate was strand cut and analytical testing performed. It was concluded that each of the screw designs and process conditions resulted in greater than 92% molecular weight retention after a single pass, the surface lubricant level was maintained constant, the melt temperature did not exceed 245°C, pressure did not exceed 300 psig, and residence time was held maintained between 15 and 20 seconds. The surface lubricant used in the studies has been tested extensively and does not significantly influence the mechanical properties, rheology, or degradation of polylactide at the concentrations used. Screw designs 2 and 3 offer viable options for melting and processing lubricated PLA but should be further optimized based on desired throughput, mixing efficiency, and polymer mechanical properties.

Conclusions:

The processing of NatureWorks' Ingeo™ 4032D was observed with and without the application of EBS surface lubricant while processing with three different screw configurations in a Leistritz 27-mm ZSE MAXX. Key differences were noted in the melting behavior of lubricated PLA including delayed melting, reduced load on the extruder, and a reduction of melt temperature. In screw design 1, unlubricated PLA exhibited quality melting behavior while lubricated PLA caused torque spikes and unmelted pellets immediately following the first set of kneading blocks. In designs 2 and 3, optimized for processing lubricated PLA, quality product was observed under all processing conditions tested. This was determined as greater than 92% molecular weight retention, melt temperatures of less than 245°C, specific energy input of 0.15 to 0.21 kW-hr/kg, and sufficient melting/softening prior to further processing. For the general practitioner, this work suggests some practical guidelines for optimizing a twin screw compounding process when PLA makes up a major portion of the blend. If motor loads seem excessively high or there is audible cracking and grinding of pellets coming from the extruder, the process, and therefore product, would benefit from a change in the screw design. Increasing the heat transfer into the pellet bed prior to the first kneading section generally will lead to lower energy consumption, improved process stability and reduced melt temperature. This work performed by NatureWorks LLC and Leistritz Extrusion has identified multiple solutions to improve optimize the processing of lubricated Ingeo™ resin grades, such as extending the melting region of the screw, altering temperature profiles, improving the modes of heat transfer through increased surface area and frictional/shear heat.

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3.) Garlotta, Donald. "A Literature Review of Poly(Lactic Acid)." ResearchGate. Journal of

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One Company's Sustainability Journey to Zero Waste

SEKISUI SPI manufacturing campuses earned zero missions certifications as a part of their commitment to safety, health, and environmental protection worldwide.

By Keri Lebo, Marketing Manager, Sekisui Polymer Innovations, Bloomsburg, PA

SEKISUI Polymer Innovations, LLC, manufacturer of KYDEX® and ALLEN® Thermoplastics, is dedicated to producing materials with regard for environmental protection. Its parent company, Sekisui Chemical, was chosen as one of the "2018 Global 100 Most Sustainable Corporations in the World index" and SEKISUI SPI locations in Bloomsburg, PA and Holland, MI are designated as zero emissions facilities. This dedication is evident in Sekisui companies all over the world.

Sekisui Chemical's Zero Emissions Program

Zero emissions is a designation by Sekisui Chemical. This rigorous program was started in 1998 to make all Sekisui facilities "zero waste to landfill" within five years of becoming a Sekisui Chemical company. To date, 12 factories have earned the designation.

Being good stewards of the planet and community has always been a part of SEKISUI SPI's business philosophy, history, and culture, so achieving zero emissions was a natural step in their environmental efforts. In 2010, SEKISUI SPI began its journey towards zero emissions by creating a cross-departmental team tasked with conducting an in-depth audit of its processes and materials.

Sekisui Chemical's zero emission certification is awarded to candidates that refine processes so no waste products that pollute the environment or disrupt the climate are sent to the landfill. Other initiatives were redefining processes that were better for the environment even after KYDEX®

and ALLEN® sheet left the manufacturing facilities. These included educational programs to recognize employee waste reduction in all areas – from office supplies to food and packaging in the break rooms.

SEKISUI SPI's Holland, Michigan plant was first to receive its ero missions certification in October 2014. When asked how the journey began, Mike Angell, Holland Plant Manager, explained, "We assembled a cross-departmental 'Green Team' to attack the project. We started small with a recycling program for common materials such as cardboard, paper, and film. Then it expanded very quickly, mostly driven by suggestions from employees. The program immediately became a part of our culture."

non-recyclable items or find vendors who will; and convert non-recyclable materials to energy. SEKISUI SPI's north campus facility received its certification in March 2016. That year, 48 tons of waste were converted to 19,528 kilowatt hours of electricity, enough to power SEKISUI SPI's fleet of Nissan Leaf EVs for 65,000 miles.

SEKISUI SPI has also implemented programs that concentrate on recycling products after they leave the facility. KYDEX® and ALLEN® sheets are recyclable, providing end users with more environmentally sustainable alternatives than other commonly used materials. As designers take a more holistic approach to designing

Subsequently, Bloomsburg's ero missions team utilized the PDCA (Plan-Do-Check-Act) cycle in pursuit of eliminating facility landfill waste. The team, guided by Environmental Health and Safety Manager, Tom Kapelewski, evaluated over 25,000 purchase records to determine which items could be kept out of landfills. First, the team distributed new recycling and waste-to-energy containers in all office and production areas. Then, they developed plans to recycle all possible materials including cardboard, metals, paper, and magazines; reuse material that isn't traditionally recyclable including edge trim and PVC powder; repurpose

products that protect our planet for future generations, OEMs will transition from traditional materials like fiberglass and metal to thermoplastics that are safer, stronger, lighter, and recyclable.

2030, the global middle class will more than double in size, improved experiences in transportation and healthcare. Thermoplastics used in transit applications can reduce the weight of airplanes, trains, and buses. Weight savings from 2 billion people today to 4.9 billion. These people will be travel on planes and trains and will expect translate to reduced fuel consumption and emissions, less wear and tear on mechanical systems, and lower energy use, all of which reduce costs. For example, airplane seat shells using KYDEX® 6565 are approximately 26% lighter than traditional products, reducing the overall airplane weight. Between 2009 and 2013, KYDEX® 6565 used in airline interiors contributed to the reduction of CO2 emissions by 800,000 tons, which is the equivalent of planting 56 million trees.

products, reducing their burden on the environment, and preserving the natural environment.

SEKISUI SPI, in close collaboration with our sister companies and headquarters, is on a journey of continuous improvement to save energy, reduce waste, and create sustainable products throughout the supply chain. We continue to invest in our people, processes, and facilities

zero emissions team

ENVIRONMENTAL RESPONSIBILITY

ELIMINATING FACILITY LANDFILL WASTE

Environmental Week

Every August, SEKISUI employees around the world demonstrate their commitment to stewardship of the planet during the annual SEKISUI Environmental Week. SEKISUI SPI locations offer company-wide programs that encourage employees to give back to their communities by participating in local events that have included electronics and appliance recycling drives, park and beach cleanups, and Adopt a Highway programs. Many locations also use this opportunity to provide education about the importance of reducing, reusing, and recycling at home and work.

Environmental Week originated during SEKISUI Chemical Group’s “Global Children’s Eco Summit 2012.” During this event, 85 children of employees from around the world participated in environmental studies at the headquarters in Japan. Following this event, SEKISUI Chemical Group began working towards new goals including preserving biodiversity by contributing to natural capital through expanding and creating markets for environmentally-sound

to meet the growing industry demands in a responsible and meaningful way. “Patrick Long, Supply Chain Manager, and Lucas Allen, Technical Service Specialist, clean up a local highway as part of SEKISUI SPI’s Adopt a Highway program in Bloomsburg, PA.”]

Patrick Long, Supply Chain Manager, and Lucas Allen, Technical Service Specialist, clean up a local highway as part of SEKISUI SPI’s Adopt a Highway program in Bloomsburg, PA.

In Memoriam

John Nelson Grundy, of Carmel, California, passed away November 30th after a long battle with Parkinson's and Leukemia. John was under hospice care and passed peacefully at his home surrounded by family, who will miss him dearly.

Born on Christmas Day 1932 in Hackensack, NJ to Albert and Anne (Nelson) Grundy, John moved to the Chicago area as a youth and attended Nichols Junior High School where he met his wife of 61 years, Diane (Flick). Both attended Evanston Township High School and DePauw University (John - class of 1955), settling in Glenview, IL to raise their four children (John Jr., Cynthia, Steven, and Andrew). In 1989, John and Diane retired to Carmel, CA, their "little bit of heaven".

A Boy Scout since his early childhood days, John achieved the rank of Eagle Scout. He guided many young men, including his sons and grandson, and served as Scoutmaster in the Chicago suburbs. Their adventures included trips to Ma-Ka-Ja-Wan Scout Reservation in Wisconsin and Philmont Scout Ranch in New Mexico.

In the early 1960's, John acquired Profile Plastics, a vacuum forming plastics company. He and Diane grew Profile Plastics from a small, one-room operation to a large corporation of nearly one hundred employees. John's entrepreneurial spirit, dynamic personality, and principles of integrity and honest, hard work were inherent to the success of their business.

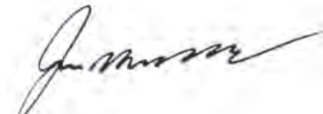
John was an avid antique car collector, who even wrote a book about early Packards. He also created the packardsonline.com website which to this day holds the largest collection of early Packard automobile information available online. The Grundy family enjoyed many months-long cross-country antique car reliability tours throughout the 1970's and early '80s. One of the pillars of the Monterey Cypress MG motor club, John was President in 1999 as the club took on a new direction. He remained a proud member and enthusiast until the very end.

Adored by his family, John was a gift to many who continue to model their lives after his examples of compassion, generosity, honesty and kindness. His smile lit up the room, and he had a warmth about him that made everyone feel welcome.

John is survived by his wife Diane; son John Grundy Jr. and children Morgan and Parker; daughter Cynthia (husband Edward) Laurance and children Alex, Anna, and Audrey; son Steven (wife Debbie) Grundy and children Katie, Kyle, Nikki, and Cole; son Andrew (wife Meg) Grundy and children Lily and Lucas; and brother Roy (wife Priscilla) Grundy and children John, Christopher, and William. John is also survived by his constant companion, Teddy the Golden Retriever.

The family is forever grateful for the loving care of John's personal caregivers and doctors.

SPE Council Meeting December 2017



James Waddell

SPE Council convened via conference call on December 15, 2017. President Al-Zubi called for a moment of silence to pay tribute to recently deceased SPE members E. Clark Broome and Dick Nunn. Al-Zubi stated that the onboarding of the new Chief Staff Executive, Pat Farrey, was complete and the EB continues to execute on strategic plans.

Financial Update

The 2017 fiscal results YTD were presented to Council. 4 major expenses items were highlighted: CSE search; membership; corporate sales; ANTEC '17. These items represent a loss of ($600k). A new project accounting approach will be used in 2018, including ways to increase revenues through a renewed focus on corporate sales, membership services, and ANTEC profitability. More in-depth details can be found on Leadership Lane where all EB presentations are posted.

Next Generation Advisory Board

Council reviewed 5 strategic objectives from the 2018 action plan for NGAB and an associated request for funding:

- Recruit 100 new Young Professional members
- Recruit and retain 10 new active NGAB members
- Identify / prepare chair-elect
- Retain 15 active, core NGAB members
- Take charge of Student Activities Chapter (SAC)

ANTEC Task Force Report

Council heard a summary of the task force's activities and noted that the new, proposed ANTEC format was presented in draft format to EB on 12/14. Several councilors asked questions about the nature of the changes including deadlines for major decisions. Vice President of Events, Jaime Gomez, stated that the task force had respected the fundamentals of ANTEC but will propose changes to the format to make it more exciting. The proposals will be available in January 2018. All councilors are requested to review the draft and provide feedback within 3-4 weeks with the March Council Meeting expected to be the date for a final decision to accept the changes with a formal announcement made at ANTEC 2018 in Orlando. The task force is targeting the 2019 event for implementation.

Affiliate Groups

The VP of Sections, Monica Verheij, recommended that Council place 6 sections in abandoned status:

- Gulf South Central
- Central Texas
- Portugal
- Hong Kong
- Taiwan
- Caribbean

There were 54 votes in favor with 2 abstentions. The plan to communicate with members from abandoned status will be managed by SPE HQ. All members have been offered the ability to switch sections.

Vice President of Divisions, Jason Lyons, presented a summary of activities by the Divisions Committee. The committee is establishing best practices for the Society. Quarterly updates reporting progress will be posted to Leadership Lane. Division-in-Formation (DIF) status was awarded to Bioplastics & Renewable Technologies. Council approved to move Electrical & Electronics Division to abandoned status. It was suggested by Councilor M. Baumann (Palisades - New Jersey Section) that Electrical & Electronics be presented as part of the New Technology Forum at ANTEC. VP Lyons reviewed feedback to date and noted areas where SPE does well and areas that need improvement. He encouraged councilors to participate more actively in their respective affiliate groups as well as in Council.

CSE Update

Chief Society Executive Pat Farrey reviewed several initiatives underway at SPE HQ. The IT infrastructure is being revamped to provide more flexibility for members including a potential variable pricing model. Stephanie Clark was hired on 10/23 as the new Director of Business Development. Ms. Clark has already overhauled marketing collateral and continues outreach to corporate sponsors.

The SPE Europe office was evaluated in the context of SPE global goals. CSE Farrey has decided that the office is an important base of operations for global activities. There remains some unfinished business in the discussions between HQ and affiliate groups on financial structures.

Councilor D. Cameron asked Farrey what had surprised him most during his tenure. Farrey stated that there were no major surprises and that he was humbled by the level of volunteer work that underpins SPE.

By-Laws & Policies

President-Elect Brian Grady offered changes to the following By-Laws and Policies. Councilor Bruce Mulholland presented 3 motions and requested votes:

- **Article 16-2 (12-15-17):** Puts line in to direct someone to policy 001 to describe how policies are changed.
- **Article 4-3-1-1 (12-15-17):** Defines member in good standing as someone who is current on their dues. E-members are NOT members in good standing which means they cannot vote or hold society office.
- **Article 7-6-4 (12-15-17):** Puts into words that in the case of an appointment of an EB member by the President, the only criteria is that the candidate is eligible (at the present time that means only a Member in Good Standing). The Nominating committee does not vet the appointee for his/her qualifications.

All changes and documentation were approved and are available for review on Leadership Lane.

Next Meeting

The next EB/FC meeting will be a teleconference on March 9, 2018. This will include a "Meet the Candidates" session as part of the 2018 elections.

2018 THERMOFORMING DIVISION ORGANIZATIONAL CHART

- Chair – Bret Joslyn
  - Chair Elect – Eric Short
    - Finance – James Alongi
    - Technical Committees
      - Processing – Jim Arnet
      - Materials – Roger Jean
      - Machinery – Steve Clark
  - Secretary – Steve Zamprelli
    - OPCOM – Executive Committee
  - Treasurer – Paul Uphaus
    - Assistant Treasurer – James Alongi
    - AARC – Jim Arnet
    - ANTEC – Brian Winton
    - Student Programs – Matt O’Hagan
  - Councilor – Jay Waddell
    - 2018 Conference – Fort Worth, TX – Jim Arnet
    - Conference Coordinator Consultant – Lesley Kyle – OpenMindWorks
  - Prior Chair – Mark Strachan
    - Recognition – Juliet Goff
  - Communications – Ed Probst
    - Membership/Nominating – Laura Pichon
    - Newsletter Editor – Conor Carlin
    - Networking – Jim Arnet
    - Website – Phil Karig
    - Students & Educational Facilities – Matt O’Hagan
    - Conference Communication – Lesley Kyle
    - Publications – Paul Uphaus

Upcoming SPE Thermoforming Division Board Meetings

May 4-6 • Orlando, Florida

September 23 • Ft. Worth, Texas

For more information, contact Lesley Kyle:

lesley@openmindworks.com or 914-671-9524

SPE PLASTIVAN™ SPONSORSHIP

With a national focus on STEM disciplines at all educational levels, both private and public resources are being marshalled to address a shortage of skilled employees across manufacturing industries. It is critical for plastics and related companies to be active in their communities, both to demonstrate career opportunities and to promote the benefits of plastics which are often misunderstood.

The PlastiVan™ Program is a great way to excite young people about the science and the vast opportunities the plastics industry has to offer. The program travels to schools and companies throughout North America, educating middle- and high-school students about plastics chemistry, history, processing, manufacturing, sustainability and applications. Corporate sponsors have a unique role to play in this community outreach program, linking the wonders of plastics to applications and jobs in the real world.

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COSTS OF SPONSORSHIP

The fee for the PlastiVan™ program is $1500 a day. Your sponsorship covers travel & expenses for educators as well as all materials. SPE coordinates all scheduling and communication with schools. This allows more students greater access to the wonders of plastics in their own communities. Sponsorship of the PlastiVan™ Outreach Education Program is a tax-deductible donation.

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As part of the sponsorship package, companies gain access to students, parents and educators in local communities. Sponsoring companies can choose to provide a list of local schools or SPE staff can work with you to select schools and arrange schedules. Many companies choose to send a representative to speak directly to the audience about products and career opportunities. In addition, SPE can help coordinate PR with local press to craft stories about the PlastiVan™ visit. These stories are then added to SPE's library of testimonials highlighting the success of the PlastiVan™ program.

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