Summer 2014 | No. 96

MOLDING VIEWS

Brought to you by the Injection Molding Division of the Society of Plastics Engineers

Chair's Message

Dear Members,

This April, SPE held its annual technical conference (ANTEC) in Las Vegas, NV. The Injection Molding Division (IMD) organized nine sessions over the three-day conference that highlighted new technologies in the areas of materials, emerging technologies, and processing. It also included a joint session with the Mold Making and Mold Design Division. The sessions had great attendance, and I was impressed with the quality of the presentations. Similar to ANTEC 2013, the IMD also held a tutorial session, aimed at providing a fundamental background in the areas of screw design, failure analysis, and process setup and optimization. These tutorial sessions were highly successful and the IMD is looking forward to continuing this format in the coming years.

As SPE rolled out its newly designed website this year (http://www.4spe.org/), the IMD followed suit

In This Issue:

This Month's Features:

Chair's Message Continued

with a new website of its own. Check it out here (http://injectionmolding.org/). The goal of the website is to maintain a calendar of important events in injection molding such as training opportunities and conferences, as well as provide links to current and past IMD newsletters. It also provides information regarding the history of injection molding, scholarship opportunities, and much more. If you have any input regarding valuable information for the IMD website, please feel free to contact me at imdchair@gmail.com. We hope this type of communication will help you find value in the Injection Molding Division and help maintain our status as a Communications Leader, as recognized by SPE the past two years.

I would like to extend a great amount of gratitude to our out-going chair, Erik Foltz. Erik spearheaded many initiatives, including the tutorial sessions at ANTEC 2013 and our first China TOPCON. I am honored to serve as the IMD Chair for 2014-2015 and look forward to carrying on the tradition of excellence that our divisional leaders have achieved since our inception. If you would like to become more involved, or have ideas on how the division can better meet our industries needs please feel free to e-mail me at imdchair@gmail.com. I look forward to working with you.

Thank you for your participation in SPE and your continued support of the IMD.

Best Regards,
Adam Kramschuster
Chair, IMD Board of Directors

Industry Events Calendar

Click the show links for more information on these events!

September 2014

8-11:
FOAMS® 2014
12th International Conference on Foam Materials & Technology
Iselin, NJ USA
www.4spe.org

8-13: IMTS 2014
Chicago, IL
www.imts.com

9-11:
Automotive Composites Conference & Exhibition 2014

The Diamond Center-Novi, MI
www.4spe.org

9-10:
Bio-based Global Summit 2014
Thon EU Hotel Rue de la Loi/Wetstraat 75 B-1040 Brussels
www.biobased-global-summit.com

14 — 16:
CAD RETEC 2014 What a Colorful World
New Orleans, LA
www.4spe.org

15-18:
Thermoforming Conference
Schaumburg, IL
thermoformingdivision.com/conference/

16-19:
Thermoplastic Elastomers Conference
Hilton Fairlawn Hotel
www.4spe.org

30-October 2:
Bioplastic Materials Conference

Schaumburg, IL
www.4spe.org

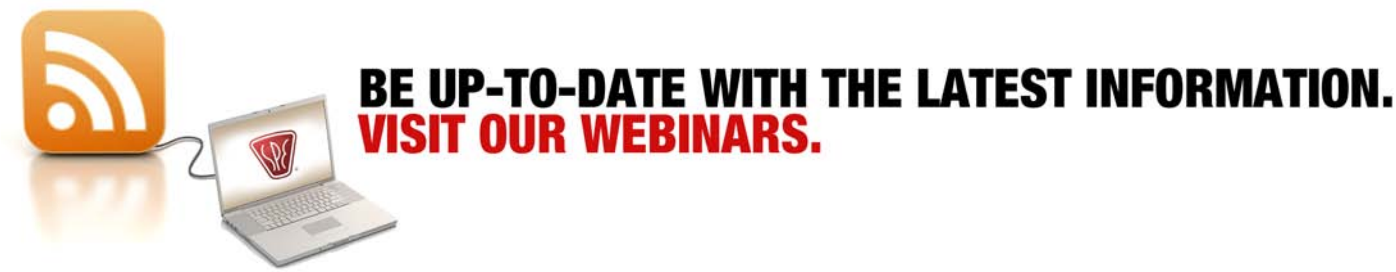
IMD ANTEC 2014
Reception

On April 28th, 2014, the Injection Molding Division (IMD) and Mold Making and Mold Design Division co-hosted a reception at the ANTEC in Las Vegas. The event was attended by more than 200 professionals in the plastics industry and academia. At the reception, the IMD presented several awards including; Best Paper and Engineer of the Year. The reception would not have been possible without the overwhelming support of our sponsors.

Sponsored by:

Thank you to IQMS, Alcoa, Moldex3D, Autodesk, Master Precision Mold Technology, and HASCO. We look forward to having another great reception at the 2015 ANTEC in Orlando, FL that is being co-located with NPE.

Webinars



How to Avoid Common Injection Molding Problems Before They Start Dyna-Purge Proper Planning in Screw/Barrel Design Will Improve Profits

Plastic Part Design for Reducing Cycle Time

Prop 65 & DINP - Estimating Exposure from Consumer Products

High Performance Plastics for Pumps and Fluid Handling

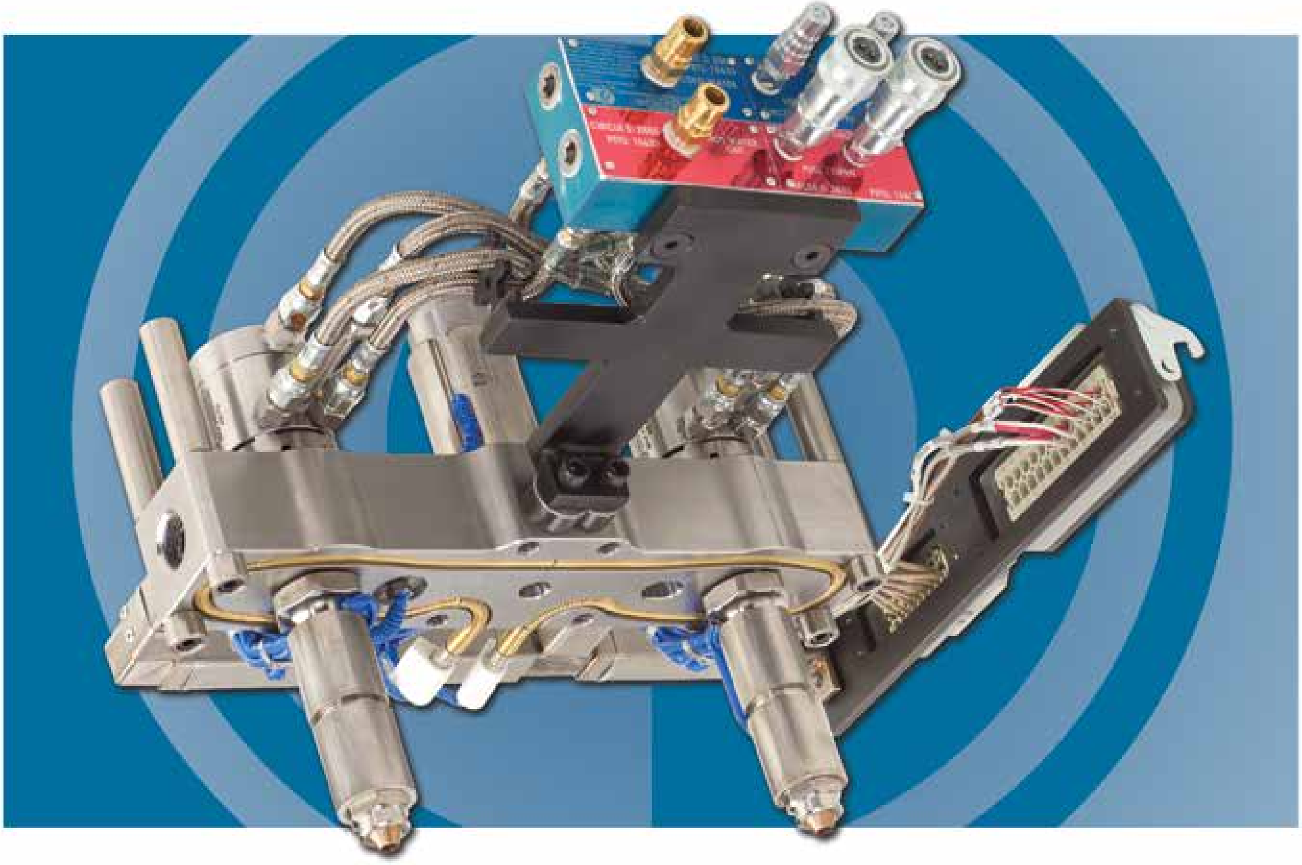
5 Things You Must Know to Optimize Any Injection Molding Machine or Extruder.

Global Market Opportunities for U.S. Moldmakers: BRIC Countries

Tuesday, August 26, 2014 2:00 PM - 3:00 PM EDT

Better Mold Designs and Shorter Cycle Times with Simulation

Mold Cooling Design Made Easy



Intensification Ratio

Bob Dealey, owner and president of Dealey's Mold Engineering, Inc. answers your questions about injection molding.

Bob has over 30 years of experience in plastics injection-molding design, tooling, and processing.

You can reach Bob by e-mailing molddoctor@ dealeyme.com

Q: I'm somewhat new to injection molding and struggle with some of the terms and lingo being used by the more experienced members of the team. When they speak of "intensification ratio", what area of the process are they referring to, what is it and why is it a ratio?

A: Injection molding vernacular can be specific to an operation, industry or area of the country. Often a particular function can and will be defined or referenced by different terms. Generally speaking, intensification ratio, in injection molding refers to injection pressure and the injection cylinder of the molding machine. However, the term could also apply to other areas where a mechanical or hydraulic advantage is gained.

Considering then the injection unit; Intensification ratio is the advantage gained by applying a hydraulic force on a large surface area that creates a pressure multiplier.

The basic for this is the formula: **Force = Pressure x Area.**

A typical hydraulic injection molding machine has an injection unit hydraulic line pressure of 2,000 psi available (although this can vary by machine and/or supplier). This pressure, which can be adjusted by the molding technician, acts on a surface at the back of the injection screw (or ram). The force developed at the front end of the screw then is dependent on the hydraulic force applied to that total surface area.

The intensification ratio can also be described as **IP x SA = HP x UA**.

Ask the Experts: Bob Dealey Continued

Where:

IP = Injection pressure at nozzle
SA = Area of the screw at nozzle end
HP = Hydraulic pressure at rear of screw
UA = Area of cylinder at rear of screw

The intensification ratio is how we get from the typical 2,000 psi of the machine hydraulic pressure to the 20,000 psi (or greater) injection pressures that we speak of when filling an injection mold. In the before mentioned example, the machine would have an intensification ratio of 10 to 1. A ratio of 10 to 15 to 1 is most common; however this could vary and be as much as 30 to 1.

Having said all of that, it might be easier to remember that:
Intensification ration = Injection pressure / Hydraulic pressure.

Bob Dealey

Ask the Experts: Steve Johnson

Training a Toolroom

Please submit any questions or comments to maintenance expert **Steve Johnson**, *Operations Manager for ToolingDocs LLC, and owner of MoldTrax.*

Steve has worked in this industry for more than 32 years. E-mail Steve at steve.johnson@toolingdocs.com or call (419) 281-0790.

Q: How does a mold maintenance manager "develop" a workforce that is historically OJT trained by its "best guy" who is in the final phase of his working life? How does a company know that its "best guy" is performing at a standard industry "best practice" level?

A: They know by starting at the beginning.

At a recent industry conference the results of a poll were presented where 115 molders of various products were asked to identify the top challenges their management teams will face over the next twelve months. More than 300 responses to this question revealed that

Ask the Experts: Steve Johnson Continued

81% of those polled need to have higher skilled help and more efficient systems in which to cultivate these skills.

This is not news to anyone associated with maintaining molds. In our classes here at our maintenance center, we always have someone asking if we "know anyone" skilled in mold repair, or at least someone who has some kind of tooling repair experience. As baby boomers fade into the sunset, their skills and knowledge are not being replaced nearly fast enough by a new generation of maintenance personnel coming into this challenging field.

Skill Training Techniques

With skills training in anything mechanical, some specifics must be understood. We must know what our job is – from a 30,000 foot business perspective down to the type, location, amount and frequency of the grease we apply to our molds. Knowing this effectively encompasses a trainee's learning of mold character nuisances involving hundreds of variables. Historically, understanding these variables happens through OJT and informal repair "stories" that are scribbled onto typical W/O forms. This won't work in today's maintenance environment where the above noted focus is on Operational Excellence. OE is not attained by following the most senior technician around the shop to learn what they know. OE is attained by working in a structured system with standardized and documented techniques that are measureable to verify if they provide real value or just smoke and mirrors.

Take, for example, the maintenance job description. What does the mold repair department do? What is the reason for its existence? In a nutshell the toolroom supports molding and other departments to "efficiently produce quality parts on time". Success lies in a toolroom's ability to:

Create proactive tasks and standardized corrective actions to reduce or eliminate mold and part defects. This is the only logical path to make continuous improvements in mold performance and shop efficiency.

Historical Job Duties

The term "proactive" is a bit of a stretch from the historical job description of "just fix it", which refers to the proverbial maintenance band aid of "making it run".

Moving away from this means we need to work smarter. It's not a new concept, but it's one that's difficult to implement when we work in a world of maintenance "stories" versus real, measureable data. Specifically, this means we need to understand everything we possibly can about the variables that contribute to part defects, poor mold performance and tedious/laborious maintenance procedures.

In order to better understand and measure what we do all day as repair technicians, it is important – no, it's absolutely necessary – to resist the temptation to speak or document in broad terms when it comes to the language of mold maintenance. Identification is step one.

Use Terms, Not OJT Stories

Moving away from maintenance stories starts with using terms to shorten documentation time and improve clarification. Using terms can sometimes be difficult when there are so many that mean the same thing. Standardization of our maintenance language is more important than the "industry correctness" of the term. For example: "A" side versus Hot Half versus Stationary Side or Top Half, etc. These are all terms for the same thing. Is it a Leader Pin or Guide Pin? Well, that depends on who you ask. This fact makes it difficult to find a term that will paint the right picture of what someone needs to convey.

Ask the Experts: Steve Johnson Continued

The important aspect is using the same term vs. knowing the exact, proper definition of a term. Sure, it would be great if all repair techs used the same handbook to learn terms but don't let the correctness of the term bog down the process of using it. What are needed are publicized lists hanging by your PC that can be used in daily communication with a maintenance program.

In a world of maintenance subjectivity, here are few terms that you should use routinely in daily data entries when describing defects that molds suffer:

- Mechanical / Tooling Issues
- Bent
- Broken
- Worn
- Hobbed
- Galled
- Missing
- Pitted

All of the above terms point to potential root causes when troubleshooting molds. When these descriptive terms are used consistently (the software used should offer drop-down menus that offer these choices), there is now a means by which to count them for a clearer understanding of where targets and goals should be set.

By including these basic adjectives in one's tooling defect descriptions tooling issues will be more easily recognized for more accurate troubleshooting and root cause analysis. It will also help one to more quickly identify areas of weakness that are high cost (tooling and labor) or high frequency (efficiency reduction).

***Steve Johnson** is Operations Manager at ToolingDocs LLC in Ashland, OH. Visit www.toolingdocs.com for information about certification training and other services offered.*

Cold Runner Design – Attention to Details, Part 1

We previously talked about Flow Group ID's and how they relate to the pressure drop equation (**Figure 1**) to help identify root cause of mold filling and part quality variations. Using Flow Groups help separate out the root causes into either steel or viscosity variations.

$$\Delta P = \frac{8Ql\eta}{4}$$

Figure 1

The term "steel variation" is a catch-all phrase used to describe any source of variation not related to viscosity variations. Below are a few common sources of steel variations:

Gate land	Venting
Gate diameter	Cold slugs
Machining of the runner	Hot runner temperature distribution
Wall thickness (core/cavity dimensions)	Hot runner manufacturing

This tech tip will focus on one particular source of steel variation that shows up in both two-plate and three-plate molds, and is actually designed into the mold! We are talking about "puller pins (sucker pins), sprue picker stems, and vacuum pads". These features aid in removing the runner system from the mold, and/or the gate from the part. **Figure 2** is an illustration of a gate puller pin used in a three-plate mold design.

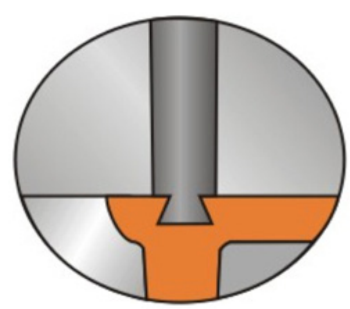


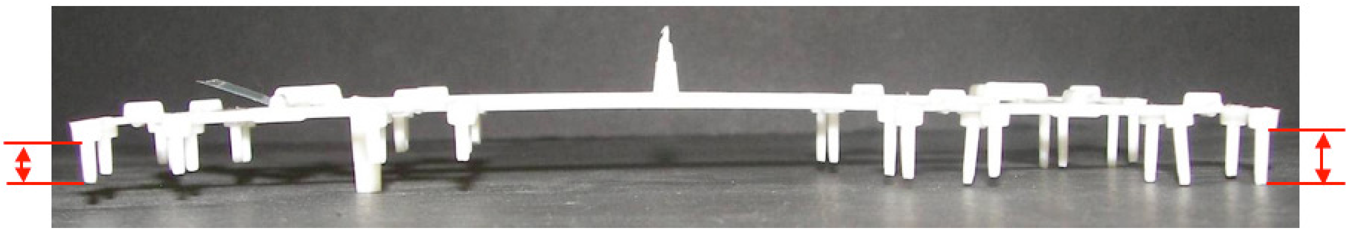
Figure 2

Technology Tips Continued

The placement and overall design of these features will impact the mold performance, flow balance, process window, and overall part quality. Our recommendations when designing these features into your molds are as follows:

1. Design puller pins such that they do not restrict the main flow path
2. Where appropriate, add the particular feature to both sides of the sprue and at each side of the preceding intersection

Figure 3 below shows a short shot of a runner from small 32-cavity, three-plate mold. As indicated by the red lines/arrows, one half of the mold is filling before the other half. Can you figure out why (no, the root cause is not gravity in this case)? How would you fix it? What other design improvements can be made?



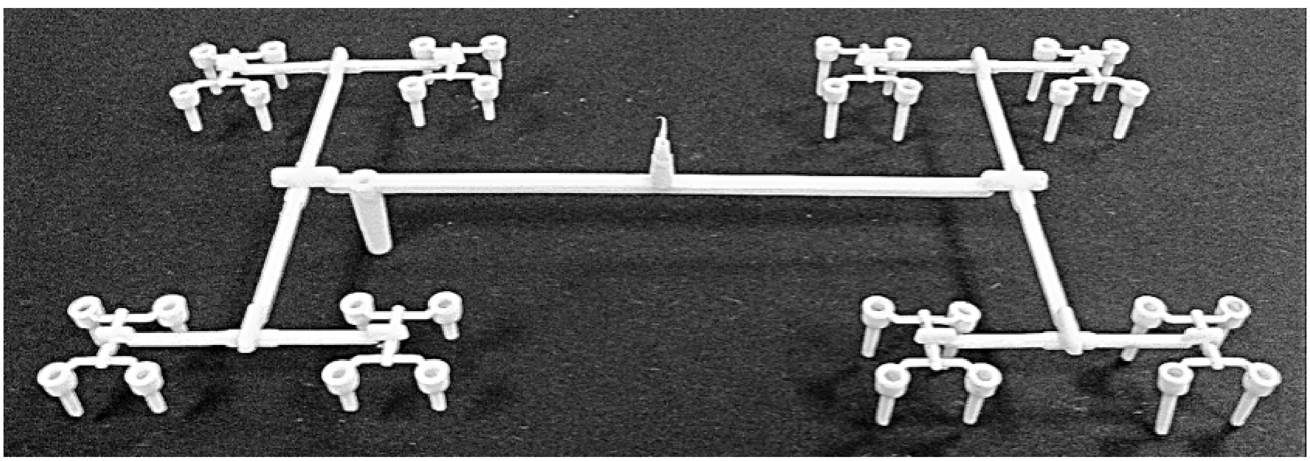


Figure 3

The general perception is "it's only the runner, so who cares?" But as with anything, the devil is in the details. And those details are often overlooked and misunderstood. A runner design that has been engineered for plastic flow needs to consider these details and a long list of others.

As you begin to understand plastic flow and the variables in the pressure drop equation you will begin to understand how small differences can have a big impact on the molding process and part quality. After all, the plastic that makes up the parts has to travel through the runner system. And what the plastic experiences along that trip will influence the final destination…the molded part!

Beaumont Technologies, Inc.
beaumontinc.com

Feature: Cellulose-Reinforced Polypropylene

By Mark Rosen
Corex Design Group Inc.
www.corexdg.com

Cellulose-Reinforced Polypropylene: A Processing Study

Composites made with wood-based cellulose were found to offer advantages in terms of molding cycle times, part weight, and more

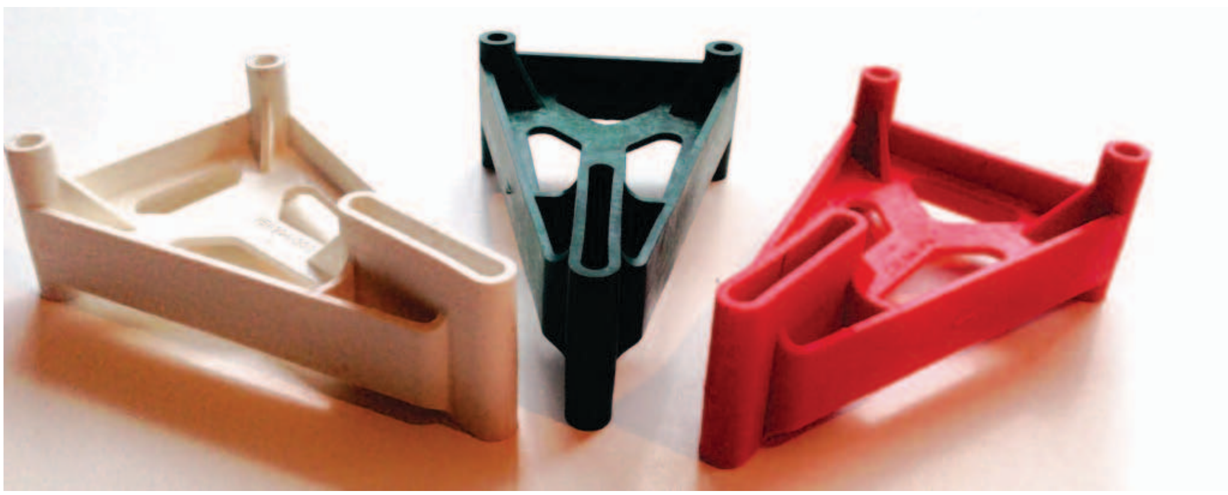
In the past few years, wood-fiber reinforced plastics, sometimes called "thermoplastic biocomposites," have generated considerable interest due to their renewable features and potential for reducing dependency on petroleum- based feedstock. This article discusses the initial results of an experimental study of Weyerhaeuser Thrive™ composites, a nearly lignin-free, cellulose-filled polypropylene (PP). (Weyerhaeuser is a global leader in sustainable forestry, wood products, and cellulose fiber technologies; it owns or manages more than 20 million acres of forestland in North America.)

Feature: Cellulose-Reinforced Polypropylene Continued

These findings showed that this material, at loads of 20% and 30% cellulose, is a cost-effective choice for applications requiring stiffness, faster cycle times, and lower part mass. In fact, this material has passed stringent automotive standards and will be included in Ford Motor Company's 2014 Lincoln MKX crossover vehicle.

These initial tests demonstrate that thrive composites:

- are rigid materials with a flexural modulus as high as 422,000 psi (2.91GPa) at 30% fiber loading;
- can reduce cycle time by up to 50%, or more, compared to other resins and compounds with a similar modulus;
- can reduce part weight up to 30%, compared to other reinforced plastics;
- minimize surface sink and internal voids;
- reduce sink and warpage, compared to other filled crystalline materials;
- can lower energy costs due to lower molding processing temperatures and faster cycle times;
- produce a more scratch-resistant surface than the base polypropylene homopolymer material itself;
- are not abrasive to tool steel; and
- demonstrate excellent bonding strength for TPE overmolding and wood and plastic inlays.



Industrial bracket made from 20% cellulose-filled PP

Based on these results and market acceptance, Weyerhaeuser is currently working to expand this proprietary technology to polymeric families beyond polypropylene.

Cellulose Fiber-Reinforced PP: What is it?

Cellulose fiber is a natural polymer which gives trees, in part, their remarkable strength. It is one of the most abundant renewable materials in nature. The same purified cellulose fiber, used as a reinforcement for plastics, is also used in applications including baby diapers, absorbents, and food thickeners.

Some key benefits of cellulose fibers as reinforcement in plastics are that it is sustainable, strong, flexible, and nonabrasive to tooling, and it has a considerably (~40%) lower density than glass fiber. One of the key challenges of using cellulose as a reinforcement in plastics has been the difficulty in achieving a strong bond of the hydrophilic fibers to the hydrophobic PP resin.

Feature: Cellulose-Reinforced Polypropylene Continued

Testing Process

The study's goal was to better understand the molding characteristics of Weyerhaeuser Thrive composites. The material grades were 20DXMV235B4 (20% cellulose-filled PP) and 30DXMV235B4 (30% cellulose-filled PP).

Several parallel study paths were taken. Structured tests, using ASTM molds, established quantitative data for processing windows. A variety of actual injection molds were sampled to understand the molding behavior in real-world parts and tool designs. Material characterization for moldfilling analysis was verified using actual molded parts. Alternate molding technologies were tested, including foaming, overmolding, insert molding, and co-injection molding, as well as various postmold assembly processes.

Collection of industrial fluid housings, brackets, end caps, and a large tray—all molded of cellulose-filled polypropylene.

Test Results

Melt Temperature

As with many bio-filled plastics, this material needs to be run at lower temperatures to prevent browning of the organic fiber. Recommended processing at melt temperatures between 350° and 370°F (177°-188°C) resulted in low levels of color shifting and low odor. (Melt temperatures were taken from air shots using a preheated temperature probe.)

At a typical screw RPM for molding, the thermocouples on the heater bands on the barrel indicated a shear heating of 20-30°F (11-17°C) higher than the set points. After several minutes of running, almost all the heating was generated by the friction effects of the screw. The heater bands essentially stopped drawing electrical power.

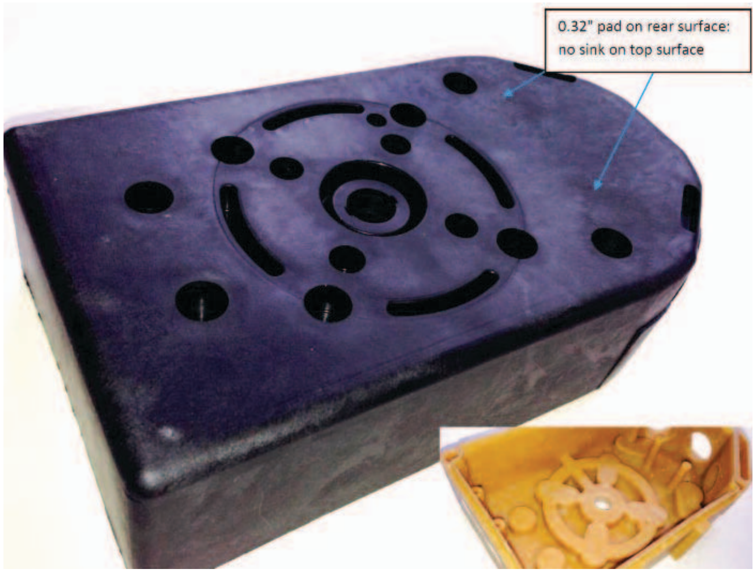
Flow Length and Fill Pressure

The results of 0.12-inch (3-mm) thick spiral melt-flow testing, ASTM D3123, showed that the material flows fairly well, as long as adequate pressure is applied. These tests were run with a peak injection pressure of 10,000 psi (69 MPa) and screw injection velocity of 2.5 inches/second (6.4 cm/sec). For the 20%-filled grade run at 350°F (177°C), the flow distance was 18 inches (46 cm). this resulted in an L/D ratio of 150:1. at 18,000 psi (124 MPa), the flow distance increased to 24 inches (61 cm) (L/D=200:1). For the 30%-filled grade, the flow distance at 350°F was 14 inches (36 cm) (L/D=116:1). At 19,000 psi (131 MPa), the flow distance increased to 19.5 inches (49.5 cm) Ll/D=158).

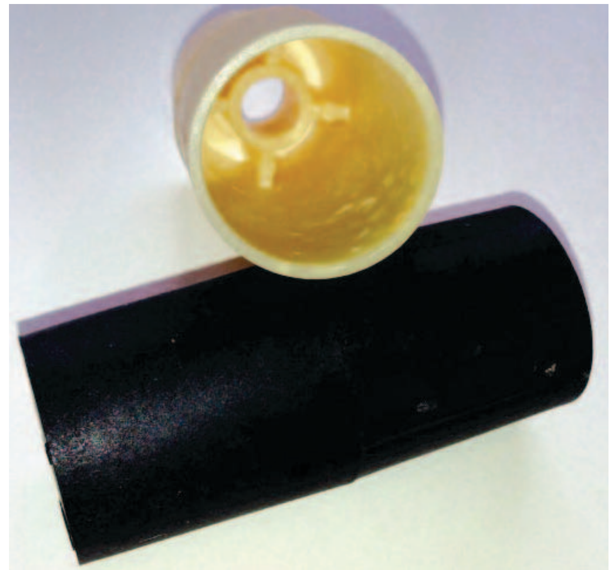
As a result, generally thicker walls (greater than 0.10 inches (2.5 mm)) are recommended for thrive composites. In smaller parts less than approximately 8 inches (20 cm) in length, however, walls as thin as 0.060 inches (1.5 mm) can be used. In all cases, it was important that parts were designed to minimize flow hesitation. This was due to the rapid solidification rates of the material.

It should be noted that larger gates (about 60% to 75% of wall thickness) and less restrictive runners are recommended to reduce pressure loss in the runner. This allows for maximum flow length and also reduces shearing of the fiber. However, smaller parts were molded with gates as small as 0.050 inches (1.3 mm) in diameter.

Feature: Cellulose-Reinforced Polypropylene Continued



Industrial fluid housing made from 30% cellulose-filled Thrive: no sink on surfaces adjacent to thick inner features (inset)



Leg end cap made from 20% cellulose-filled PP, shown in natural and black

Mold-filling analysis is recommended for all new molds to verify fill pressures and to optimize gating. (Verification of the material characterization data for thrive composites was tested with both SIMPOE and Moldflow software.)

Packing/Hold and Cooling Requirements

The molding tests showed that Thrive composites require short packing/hold and cooling times. This is contradictory to most fiber-filled resins, since these materials typically require higher melt and mold temperatures than the neat resin, resulting in longer packing and cooling times.

Parts with thick internal ribs and bosses were molded with almost no internal voids or sink on the visible surface. The reason was not clear. it may be due to a stiffening effect of the filler, or perhaps some outgassing occurs as the cellulose heats up.

The testing also showed that lower pack pressures were required, typically around 4,000 psi (28 MPa). Again, this is contradictory to most glass-filled crystalline materials, which typically require longer pack times and higher pressures to reduce warpage of the molded parts.

Table 1 compares estimated packing/hold and cooling times required for various materials to mold a part 0.200- inches thick.

Table 1: Comparison of estimated packing/hold and cooling times* for 0.200-inch (5.1-mm) thick part for various materials (modulus shown for comparison)

	Thrive 20DXV235B4	Thrive 30DXV235B4	PP Homo-polymer	PP 20% Glass	ABS General Purpose	HIPS	PPE Noryl Unfilled
Tensile Modulus (psi)	370,000	490,000	195,000	479,000	310,000	270,000	282,000
Pack/Hold & Cool Time (sec)	28	30	57	65	82	62	52

*Cooling times for Thrive composites based on actual mold samplings; other materials calculated using SIMPOE mold filling analysis software.

Cosmetics and 0dor

The Thrive material has a natural beige color with a light speckling from small amounts of non-dispersed white cellulose fiber. The 30% cellulose-filled grade is slightly darker than the 20% grade in its natural color.

Color was added with masterbatches of 3% white, 2% black, 2% blue, 3% red, and 2% green. The molded parts showed good consistent color. There was some white speckling due occasional non-dispersed fiber particles; however, this was less evident than with the natural colored parts.

The surface of the part ranged from glossy to slightly textured, similar to that of glass-filled PP, but with a significantly different surface feel.

There was a little odor (burnt wood smell) at molding, but this almost disappeared after a few days. This low odor is unusual for bioplastics and other natural fiber-filled polymers (for example, Ford Motor Co. tested more than forty materials for odor before they selected thrive composites for an application).

Examples of Good Candidate Parts

The composites are ideal for generally thicker parts (0.100 inches (2.54 mm) or greater) in applications requiring strength, stiffness, fast molding cycle times, low sink/warpage, and good chemical resistance. In fact, in thicker and/or larger parts, substantial cost saving can be achieved via lower cycle-time costs due to faster cooling times.

Parts designed for materials such as pure PP or HDPE can be downgauged with Thrive composites due to higher part rigidity. Both small and large parts can be molded; to minimize cycle time, however, the press needs to be able to generate shot volume fast enough to keep up with rapid cooling rates.

Molds should be designed with larger gates and runners with minimum gate depth between 60% and 70% of wall thickness. Minimum gate diameters of 0.050 inches (1.3 mm) can be used for smaller parts. The nozzle ID should be as large as possible for the sprue or hot manifold bore diameter.

While hot runners are acceptable, larger flow-through tips or valve gates are preferred, and the lower processing temperatures of cellulose composites should be accounted for when using manifolds designed for materials with high melt temperatures. and to ensure good mold ejection, large ejector pins and stripper plates are preferred.

For the part example shown in **Table 2**, the mold-closed time was reduced from 137 seconds to 46.2 seconds, and part weight was reduced from 379g to 280g. The Thrive materials demonstrated almost no surface sink at thick sections (versus significant sink with 30% nylon 6), and parts molded with them were easier to

Table 2: Industrial fluid housing example (wall thickness ranging from 0.236 to 0.560 inches (6-14 mm); single-cavity mold with cold sprue; molded in black and natural; mold runs on 200-ton press with several hand-loaded inserts)

	Thrive 30DXV235B4	Production Part Zytel 30% Glass-filled Nylon 6	Comparison
Melt Temperature **Mold Temperature**	355°F 90°F	530°F 190°F	
Molding Closed Time Fill Pack/Hold Cool	**46.2 seconds** 1.2 seconds 15 seconds at 4000 psi 30 seconds	**137 seconds** 2 seconds 20 seconds at 5400 psi 115 seconds	**90.8-second (66%) reduction in total cycle time**
Part Weight	**280 grams**	**379 grams**	**99 grams (26%) lighter**

Feature: Cellulose-Reinforced Polypropylene Continued

	Thrive 20DXV235B4	Production Part (2 Cavity) General Purpose ABS	Comparison
Melt Temperature **Mold Temperature**	350°F 70°F	500°F 125°F	
Molding Closed Time Fill Pack/Hold Cool	**29.3 seconds** 2.3 seconds 2.0 seconds at 4000 psi 25 seconds	**51.3 seconds** 2.8 seconds 3.5 seconds at 4000 psi 42 seconds	**22-second (43%) reduction in cycle time**
Part Weight	272 g	321 g	**49 g (15%) lighter**

Table 3: Industrial bracket example (nominal wall thickness of 0.156 inches (4.0 mm); two-cavity mold with cold runner and side tab gates (0.080 inches by 0.50 inches (2 by 12.7 mm); molded in red, white, and green on a 300-ton press)

handle postmolding due to lower ejection temperatures. It should be noted that 30% glass-filled nylon 6 is stiffer than the 30% cellulose fiber-filled composite, with a flexural modulus of 1,200,000 psi (8.3 GPa) versus 422,000 psi (2.91 GPa). For many structural components, however, Thrive represents a cost-effective reinforced engineering resin with mechanical properties similar to those of 20% glass-filled PP. Tests also showed that the composites exhibited low moisture absorption rates.

In the **Table 3** example, the flexural moduli of ABS and the 20% cellulose fiber-filled composite were almost identical, at 320,000 psi versus 307,000 psi (2.2 vs. 2.1 GPa). The composite produces a lighter part with faster cycle time at equivalent stiffness. In addition, there was no surface sink at rib intersections for the thrive part, versus noticeable sink with the ABS component.

Feature: Cellulose-Reinforced Polypropylene Continued

	Thrive 20DXV235B4	Production Part 4 Cavity HIPS	Comparison
Melt Temperature **Mold Temperature**	350°F 70°F	395°F 110°F	
Molding Closed Time Fill Pack/Hold Cool	**15.0 seconds** 1.4 seconds 1.6 seconds at 4000 psi 12 seconds	**32.1 seconds** 2.8 seconds 1.3 seconds at 6000 psi 28 seconds	**17.1-second (53%) reduction in cycle time**
Part Weight	109.2 grams	125.2 grams	**16 grams (13%) lighter**

Table 4: Leg end cap example (wall thickness ranging from 0.070 to 0.135 inches (1.8-3.4 mm); four-cavity mold with cold runner and 0.050-inch (1.3-mm) diameter pin gates; molded in black and natural on a 90-ton press)

In the **Table 4** example, the mold-closed time was reduced from 32.1 seconds to 15 seconds. There were no ejection issues with the cylindrical core, and a small gate resulted in more dispersed fibers on the surface of the part.

Summary

The results of this testing showed that Thrive composites composed of cellulose fiber-reinforced PPs have a structural engineering-level stiffness equivalent to 20% glass-filled PP. The composites reduced cycle times by one-half or more, and parts molded with the composites were as much as 30% lighter than glass-filled materials. in addition, parts with thick internal features that were molded with the composites demonstrated little or no surface sink. Not only does the composite reduce the molded costs for many plastic parts, but this sustainably-produced material also replaces as much as 30% of the petroleum-based feedstock of plastic with renewable organic fibers.

About the Author:

Mark Rosen is principal of Corex Design Group Inc., of Franklin Lakes, New Jersey. If you would like additional information on the test results in this article, or for more details about Thrive composites, Mark Rosen, can be reached at 201-891-1650, e-mail mrosen@corexdg.com or visit www.corexdg.com.

Reprinted from Plastics Engineering, March 2014
www.plasticsengineering.org.

By Mark Yeager
Principal Engineer/Engineering Consultant
Bayer MaterialScience LLC

Variothermal Temperature Control More Gloss, Less Weld Lines

In the filling phase, a higher contact temperature is required in order to achieve high-gloss surfaces or perfectly replicated microstructures and nanostructures. This is economically contra-productive, however, since only a low mold temperature enhances the cooling of the molding. Variothermal process control helps achieve both goals.

Obstructions in the part represent a weld barrier during the injection molding process. The polymer melt is forced to split up during filling of the cavity. Behind the barrier the flows try to merge again, but this is made more difficult by a low temperature of the mold surface and a low melt pressure. Notched weld lines then remain near the cavity walls. Even though these notches may be very small, their steep flanks are clearly visible, particularly in black and glossy "piano-black" surfaces. It is a well-known fact that higher surface temperatures of the cavity during the injection process can reduce this notching. The goal of a joint scientific project organized by the injection molding machine was to validate this effect and to eliminate weld lines through appropriate process control.

The influence of dynamic mold temperature control on the surface quality of amorphous polycarbonate blends and semi-crystalline polypropylene grades was investigated, with the latter differing in filler content and modification (**Table 1)**. The gloss of a surface is greatly influenced by its roughness, which is why the replication of the mold surface on the molding surface is of great interest.

Grade	Color	Fillers	Modifiction
PC-ABS Bayblend T80XG	black	none	none
PC-ASA Bayblend W85XF	black	none	none
PP Daplen EE188HP	black	15 % talcum	elastomer
PP Daplen EE065AI	opaque	none	elastomer
PP Borclear RJ370MO	transparent	none	nucleated, demolding aid
PP Borclear RF366MO	transparent	none	nucleated, antistatih

Table 1: The surface quality of amorphous PC blends and semi-crystalline PP grades serves as an indicator for the influence of dynamic mold temperature control

Feature: Variothermal Temperature Control Continued

During variothermal mold heating, either the whole mold, a mold insert or just the mold cavity surface is heated. The energy source can thereby be either inside or outside the mold. Popular sources are hot steam or hot gas, induction, infrared (IR) and laser radiation, near-contour temperature control using alternating hot and cold liquid, electric heater cartridges, and contact between the mold insert and a heated block by thermal conductivity.

During the course of this study, the cavity insert was heated by IR radiation. The temperature of the cavity insert was increased from the normal mold temperatures of 40 °C for PP and 90 °C for PC+ABS and PC+ASA to 120 °C for PP and 170 °C for the PC grades. An average volumetric injection flow rate of 43.3 cm^3/s was selected. Additional tests with volumetric injection flow rates of 33.3 and 53.3 cm^3/s were carried out with PC+ABS.

Figure1: A specimen part with ribs, wall thickness variations and holes was used for the analysis of weld lines and surface roughness (view: rear side). The red triangle marks the gate. Photos courtesy of ENGEL.

Heating and Injection Parallel to the Cycle

The weld lines and surface roughness were analyzed using an approx. 80 x 80 mm large part (**Figure 1**). While the rear side has ribs and wall thickness variations as well as circular and rectangular holes, the visible side is smooth. The cavity is filled via a hot runner and a short tunnel gate on the underside of the molding.

The parts were produced using a new process using a variothermal injection mold (**Figure 2**) with two identical cavities [1]. This allows heating and injection parallel to the cycle. While the cavity is being filled in the lower position, a second mold insert is preheated in the upper position by IR radiation from the rear. The lower insert is then cooled and when the mold has been opened, the index plate is turned so that the preheated mold insert moves to the lower position for filling and the finished part can be removed in the upper position.

In view of the low mass of the cavity insert and the use of IR-absorbing coatings on the rear side, heating rates of up to 13 K/s were achieved. As soon as the hot insert is turned to the lower position, its rear side contacts the cold mold (20°C). This creates a higher temperature gradient which, despite the significantly improved surface quality of the parts, shortens the total cycle time by comparison with a conventional strategy with constant mold temperature [2].

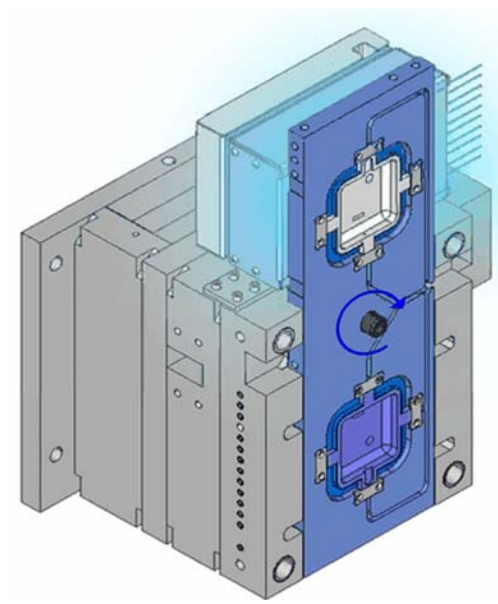


Figure 2: The mold with two cavity inserts and rotating index plate allows heating and injection in parallel with the cycle

Instrumental Simulation of Human Perception

When looking at surfaces, the reflected light creates the impression of color and contrast shading. Following the idiosyncrasies of the human perception of contrast, surface defects disturb the im-

Figure 3: The variothermal processing prevents visible weld lines. The PC+ABS part was manufactured with a cavity insert temperature of 90 °C (left, without variothermal control) and 170 °C (right, with variothermal control).
Photos courtesy of Polymer Competence Center Leoben.

pression of contrast of an otherwise uniform surface. The visual perceptibility of defects can now be determined using a new and patented measuring method [3]. The results displayed come remarkably close to the human perception and permit rapid and objective inline testing of the parts.

For the measurements, specimens were fixed in a holder and photometric pictures were taken using CCD-cameras. The image processing using mathematical models allows the perceptibility of weld lines to be evaluated on the basis of a machine examination. Calculated intensity matrices thereby contain the information on the threshold values for the perceptibility of the respective weld lines.

One of the main principles here is the relative contrast perception which is similar to that of humans. A practically perfect surface without visible structures shows no distortion. By contrast, the light reflected from surface structures with faults or scatters exhibits a certain loss of clarity.

Materials Behave Differently

In order to obtain more conclusive information about the quality of the replication, a roughness profiles with a measuring distance L of 0.56 mm were measured, starting 10 mm after the gate, every millimeter along a relative flow path of 40 mm and at right-angles to the flow path. The profiles were acquired using a contact-free optical sensor. Rq . is the root mean square of the magnitude of the deviation of the roughness profile z(x) from the mean line. L is the sampling length [4].

The investigations show that the formation of weld lines can be significantly reduced with increasing temperature of the cavity insert. This is already recognizable from visual assessment of the visible side of the molding surface (**Figure 3**). The part on the left that was produced at a cavity temperature of 90°C exhibits very fine, light-colored weld lines after the circular and rectangular holes. A cavity temperature of 170°C, on the other hand, makes the weld lines almost invisible.

In the summary of the test results with PC+ABS (**Figure 4**), a visually perceivable intensity of approx. 0.2 means that over 90% of the human observers do not perceive this defect. The graph shows clearly how an increasing cavity temperature correlates with a reduction in the weld lines. At a low volumetric injection flow rate of 33.3 cm^3/s, the weld lines decrease up to 150°C, while at higher volumetric injection flow rates of 43.3 and 53.3 cm^3/s the weld lines are no longer perceivable above 130°C. As expected, the injection rate also has a positive influence on the reduction in the weld line notches due to the steeper and faster pressure increase after the initial formation of the weld line.

Feature: Variothermal Temperature Control Continued

The replication of a mirror-finish cavity surface with an Rq value of 0.013 µm on several polymer grades was also investigated. The Rq values measured as a function of the cavity temperature and the relative flow path for PP EE188HP show that the flow path length has no significant influence on the replication (**Figure 5**). The increasing cavity temperature, however, reduces the roughness from approx. 0.2 µm to 0.05 µm, corresponding to an increase in the gloss. Furthermore, the surface gloss is more uniform at higher temperatures, as the Rq values exhibit a smaller spread.

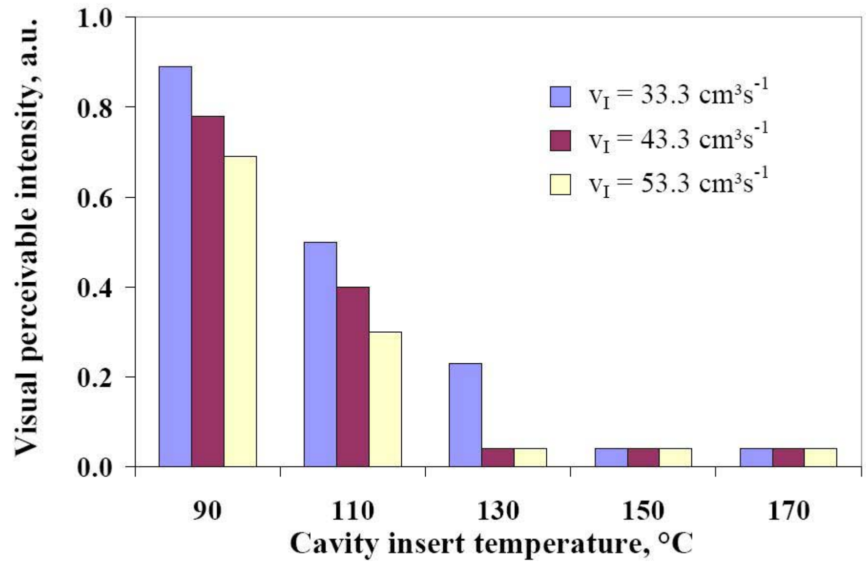


Figure 4: The visual perceptibility of the weld line, here for PC+ABS, depends on the temperature of the cavity insert and the volumetric injection flow rate v_e.
Figures courtesy ofPolymer Competence Center Leoben.

Influence on the Roughness

The trials also show clearly how the cavity temperature influences the surface roughness of all the polymers used **(Table 2)**. With most of the polymers, a higher temperature led to a reduction in the surface roughness and to an increase in the gloss.

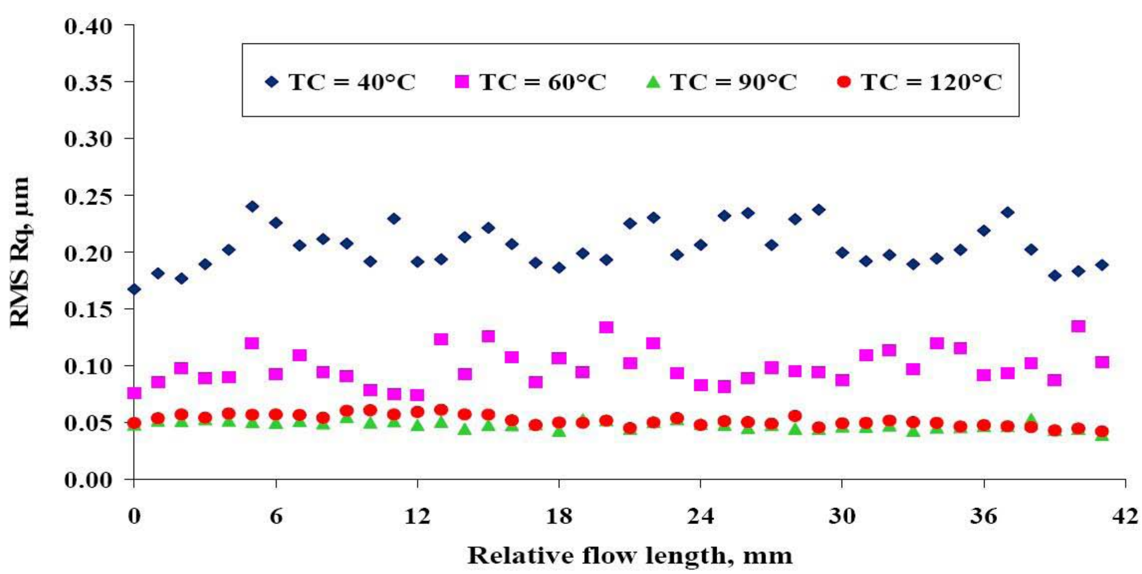


Figure 5: The roughness of the PP surface (Type: EE188HP) remains practically unaffected by the relative flow path, but decreases sharply with increasing temperature TE of the cavity insert.

Feature: Variothermal Temperature Control Continued

Grade	40 °C	120 °C	Remarks
PP Daplen EE188HP	0,200	0,050	90 °C und 120 °C produce the same R_q value
PP Daplen EE065AI	0,300	0,055	90 °C und 120 °C produce the same R_q value
PP Borclear RF366MO	0,030 – 0,035	0,030 – 0,035	No influence of the variothermal temperature control
PP Borclear RJ370MO	0,040	0,070	Increased near-surface cristallinity?
	90 °C	**170 °C**	
PC-ABS Bayblend T80XG	0,035	0,028	Positive influence of the variothermal temperature control
PC-ASA Bayblend W85XF	0,065	0,044	Positive influence of the variothermal temperature control

Table 2: The temperature of the mold insert significantly influences the roughness of polymer surfaces (figures for RMS roughness Rq in µm)

The surface quality of the elastomer-modified PP grades EE188HP and EE065AI increased significantly up to 90°C; a further raising of the temperature, on the other hand, had no major impact. No high gloss was achieved even with mold temperatures of up to 120°C. A further highly nucleated transparent PP grade (RJ-370MO) had a lower Rq value of 0.040 µm at 40°C, but when the mold temperature was increased to 120°C the roughness deteriorated to 0.070 µm. This effect can possibly be explained by the temperature-related increase in microscopic sink marks, or localized delaminations of the skin layer close to the part surface frozen after the mold filling caused by local differences in shrinkage [5-7]. Although a smooth polymer surface is obtained, it is covered with a large number of pit marks several hundred nanometers deep which increase the overall roughness.

The variothermal processing had no influence on the surface quality of PP RF366MO that was developed as a high-gloss grade.

Even at the conventional cavity insert temperature of 90°C, the PC blends exhibited a low surface roughness; furthermore, the surface quality was further improved by an increase in temperature. PC+ABS achieved a better Rq value of 0.028 than PC+ASA. Although this is still twice as high as for the mirror-finish mold surface, it is overall the best result achieved during the investigation.

Grained Surfaces, Microstructures and Nanostructures

Variothermal temperature control also offers significant benefits when it comes to the replication of structures. If grained surfaces show an undesirable greasy gloss with conventional temperature control, variothermal temperature control allows a uniform dullness to be achieved over the whole part surface. The enlarged detail of a mold insert and of the replication result at the corresponding point on the molding with and without variothermal temperature control [8] shows that the superimposed fine structure can be better replicated at the higher mold temperature **(Figure 6**).

Acknowledgment

The authors wish to thank Borealis Polyolefine GmbH, Linz, Austria, Camo Formen- und Werkzeugbau GmbH, Schwanenstadt, Austria, Johnson Controls GmbH, Burscheid, Germany, Alicona Imaging GmbH, Grambach, Austria.

This article is based on the conference paper "Improving the polymer surface quality by infrared radiation driven dynamic mold temperature control" by G.R. Berger and W. Friesenbichler for the 27th Annual Conference of the Polymer Processing Society in May 2011 in Marrakesh, Morocco. The underlying research work was funded as part of the Austrian COMET program.

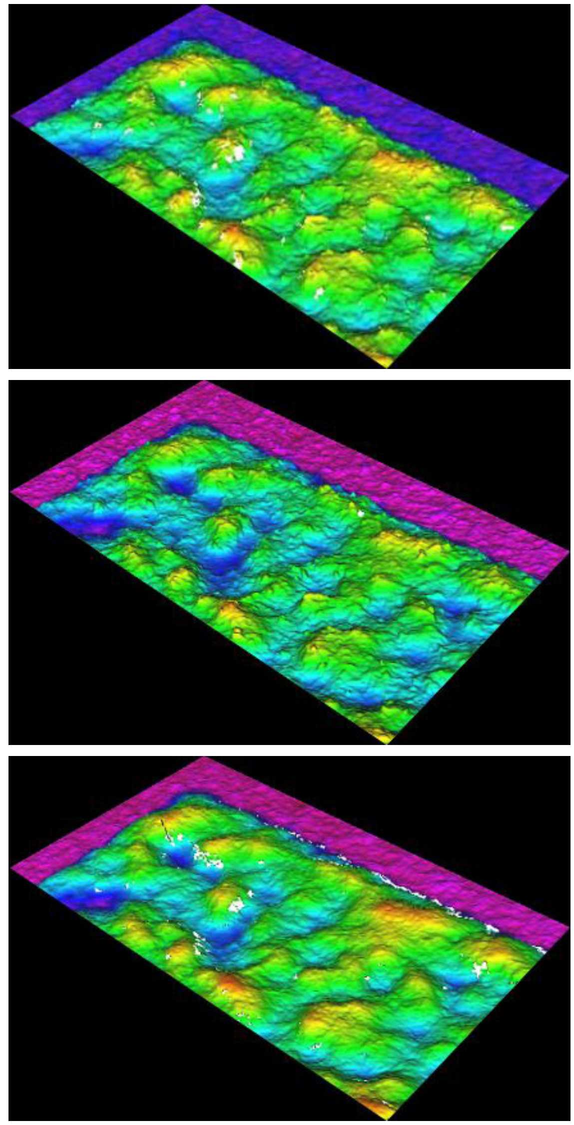


Figure 6: Fine details of the grained structure on the mold insert (top) are replicated better with variothermal temperature control (middle) than with conventional temperature control (bottom). Figure courtesy ofAlicona Imaging.

References

1 Giessauf, J.: Heizvorrichtung für ein Formwerkzeug. Patent AT 506 097 B1

2 Roock, S.: Untersuchungen zur Verbesserung der Formteiloberflächenqualität durch IR-variotherme Prozessführung beim Spritzgießen. Diploma thesis, Technical University of Clausthal, Institute for Polymer Materials and Plastics Technology 2010

3 Gruber, D. P.: Verfahren zum automatisierten Nachweis eines Defektes an der Oberfläche eines Formteils. Patent A384, 2009

4 Whitehouse, D.: Surfaces and their Measurement. 1st Edition, Kogan Page Science, London 2004

5 Berger, G.R.: Replication of geometric and stochastic surface microstructures by injection molding. Dissertation, Montanuniversität Leoben 2006

6 Berger, G.R.; Friesenbichler, W.; Reitter, M.; Jutz, S.: Hochglanzoberflächen beim Spritzgießen. MP Materials Testing 5 (2010), pp. 211–221

7 Berger, G.R.; Gruber, D.P.; Friesenbichler, W.; Teichert, C.; Burgsteiner, M.: Replication of Stochastic and Geometric Micro Structures – Aspects of Visual Appearance. International Polymer Processing XXVL (2011) 3, pp. 1–10

8 Pillwein, G.: Verfahren und Anlagen zur Herstellung hochwertiger Optikkomponenten. IKV Conference: Optische Komponenten aus Kunststoff – Die gesamte Prozesskette im Blick, Aachen 2011

About the Authors

Dipl.-Ing. Dr. Gerald R. Berger, Post Doc and Project Leader at the Chair of Injection Molding of Polymers at the Montanuniversität Leoben, Austria; gerald.berger@unileoben.ac.at DI Susanne Roock, R&D at ifw Manfred Otte GmbH, Micheldorf, Austria; s.roock@ifw.at Prof. Dr.-Ing. Georg Steinbichler, Head of Research and Development Technologies at Engel Austria GmbH, Schwertberg, Austria, and Chairman of the Institute for Polymer Injection Molding Technology and Process Automation at the Johannes Kepler University, Linz, Austria, georg.steinbichler@jku.at DI Josef Giessauf, Head of Development Process Technology at Engel Austria GmbH, Schwertberg, Austria; josef.giessauf@engel.at Dipl.-Ing. Dr. Dieter P. Gruber, Senior Researcher and Project Leader at the Polymer Competence Center Leoben in Austria; dieter.gruber@pccl.at Prof. Dipl.-Ing. Dr. mont. Walter Friesenbichler, Head of the Chair of Injection Molding of Polymers at the Montanuniversität Leoben, Austria; walter.friesenbichler@unileoben.ac.at

IMD Best Paper

Xiaofei Sun[1,2],Hrishikesh Kharbas[1,2], and Lih-Sheng Turng[*1,2]
[1]Department of Mechanical Engineering,
University of Wisconsin-Madison, WI, 53706, USA.
[2]Wisconsin Institute for Discovery,
University of Wisconsin-Madison, WI, 53715, USA.
*Corresponding Author:turng@engr.wisc.edu

Enhancing Cell Nucleation for a Novel Microcellular Injection Molding Process Using Gas-Laden-Pellets

A novel and cost-effective method of microcellular injection molding using gas-laden pellets has been developed. In this study, several methods,as well as their combinationsto en-hance the gas-laden pellets'foamability,have been attempted including (a) enhancing homogeneous nucleation by blending N_2-and CO_2-laden pellets to create an N_2/CO_2 synergetic effect, (b) enhancing heterogeneous nucleation by incorporating talc as a nucleating agent, and (c) enhancing heterogeneous nucleation by compounding PP (polypropylene)/HDPE (high-density polyethylene)immiscible blends. The results show that these methods effectively improvedthe cell nucleation rate and cell morphology. Moreover, it was found that these methods could also be superimposed on one another without conflict, thus leading to further improvements.

Introduction

Microcellular injection molding is one of the special injection molding processes. The idea of microcellular foaming was first conceived at MIT in the 1980s. Later, Trexel,Inc. combined the idea of microcellular foaming with the injection molding process and commercialized it as the MuCell process[1]. It continues to attract attention because it saves on material costs and energy consumption while improving dimensional stability and production efficiency as compared to conventional solid injection molding[2, 3].

In spite of the benefits, the up-front capital investment on machine modification or system purchase is onemajor barrier to adopting microcellular injection moldingfor mass production. Recently,a more cost-effective alternative method for producing microcellular injection moldedparts was proposed by Lee et al.[4], and is known as Supercritical fluid-laden pellet Injection molding Foaming Technology (SIFT). This method can be realized in two-steps. First, a physical blowing agent(such as CO_2or N_2) is injected and mixed into the polymer during the extrusion process using either a single-or twin-screw extruder. Once the material is extrudedout of the die, a strong cooling action—typically an ice water bath and/or cold spray guns—is performed on the extruded strand(s) to freeze the plastic and lock the gas in the polymer. After being dried, the strand(s) ispelletized into gas-laden pellets.Then these gas-laden pellets can be used in one or multiple conventional injection molding machines for injection molding. A schematic of this method is shown in **Figure 1**.

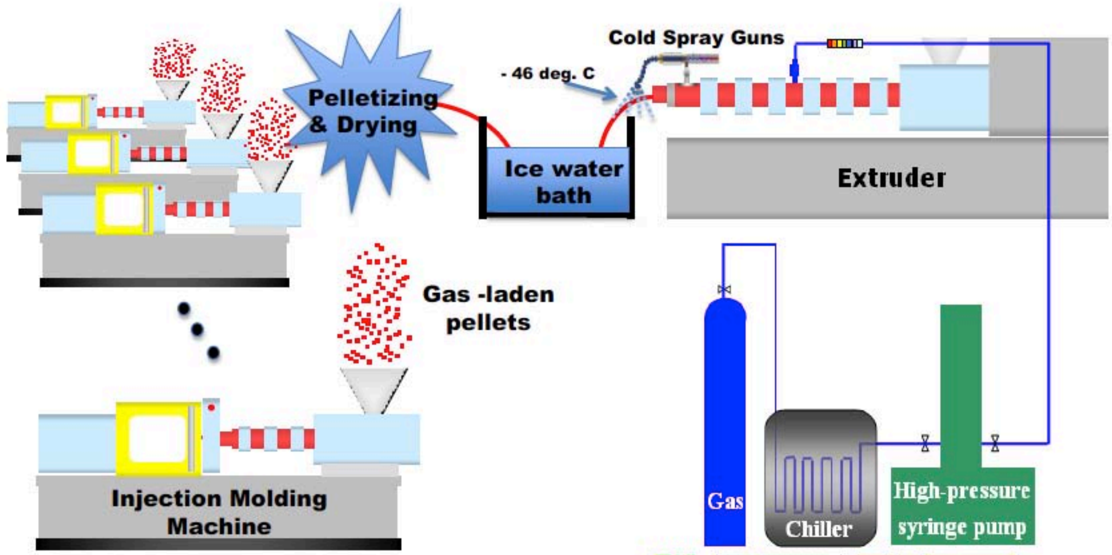


Figure 1: Schematic of the SIFT Process.

Using this method, gas-laden pellets canbe produced by an extruder equipped with a gas dosing device. Minor modifi-cations and device additions are only needed for one extruder, while the gas-laden pellets produced can be used by multiple conventional injection molding machines to produce light-weight micro-cellular parts without any modification or addi-tional equipment required. In this way, the equipment cost, as well as the amount of work needed to modify the machines, can be significantly reduced. Since extrusion is a continuous process, the production efficiency of gas-laden pellets can be ensured. This new foaming technology enables the ease of processing of the chemical blowing agent method with the foaming characteristics of a physical blowing agent, but in a cost-effective and sustainable fashion.

During the extrusion process of gas-laden pellets, partial foaming will occur and the gas will escape if the gas content is high and cell nucleation is strong. Consequently, there is an inherent gas limit in the extrud-ed gas-laden pellets. Itimposes challenge to applications where significant weight reduction and fine cell morphologies are required, due to a low cell nucleation rate. Tobroaden the range of applications for the SIFTprocess, twodifferent approaches to boost the cell nucleation rate were investigatedin this study. Their theoretical backgroundsandexperimental outcomes are discussed in detail in the following.

Nucleation Enhancing Methods

The cell nucleation process is dominatedby a homo-geneous nucleation mechanism in a single-phase poly-mer matrixor by a heterogeneous nucleation mechanism if the cellsareemerging from a multi-phase matrix with immiscible inter-faces. Enhancing either mechanism will lead to a higher nucleation rate and finer cell morphology.

Enhancing Homogeneous Nucleation by Using $N_2 + CO_2$ as Co-Blowing Agents

According to classic and subsequently modified nucleation theories [5, 6], the homogeneous nucleation rate of the microcellular injection molding foaming process can be expressed as:

$$N = fC\exp\left(-\Delta G^{**}/kT\right) \qquad \text{(Eq. 1)}$$

where *N* is the nucleation rate, *f* is the frequency of atomic molecular lattice vibrations, *C* is the concentration of gas molecules, *ΔG*** is the activation energy barrier for nucleation, k is the Boltzmann's constant, and *T* is the absolute temperature. The activation energy barrier can be estimated by:

$$\Delta G^{**} = \frac{16\pi\gamma^3 M^2}{3\left(RT\rho\ln S\right)^2} \qquad \text{(Eq. 2)}$$

where *γ* is the surface energy of the bubble interface, *M* is the molecular weight, *R* is the universal gas constant, *ρ* is the density, and S is the degree of super-saturation.

A low *ΔG*** is favorable for foaming because it increases the nucleation rate, N, exponentially. *ΔG*** can be significantly reduced by using $N_2 + CO_2$ as co-blowing agents. N_2 and CO_2 are the two most commonly used physical blowing agents in foaming processes today. While both are widely used, they have distinct physical properties, which lead to significant differences in the process as well as in the final part quality. Generally speaking, given the same gas content, N_2 tends to provoke a stronger nucleation reaction as compared to CO_2 [7-10] due to its lower solubility in the polymer, therefore yielding a higher degree of super-saturation, *S*. Carbon dioxide, on theother hand, can be dissolved in the polymer more readily [7], and substantially reduce the melt strength and the surface energy, γ, due to its plasticizing effect [7, 11]. When CO2 and N_2 are combined in the same foaming process, both will contribute to a lower *ΔG*** value and thus a higher nucleation rate. The end result will be to create a finer morphology. This methodology has been proven to work on microcellular injection molding in our previous study[12]. By using a combined SIFT/MuCell process with N_2 and CO_2 as co-blowing agents, a much finer cell structure was obtained as compared to using either blowing agent alone, as can be seen in **Figure 2**.

The implementation of the SIFT/MuCell combined process requires the equipment of both SIFT and MuCell. To take advantage of the effects of N_2/CO_2 co-blowing agents with reduced process complexity and cost, one feasible alternative is to use blends of N_2-laden and CO_2-laden pellets, such that only the SIFT process

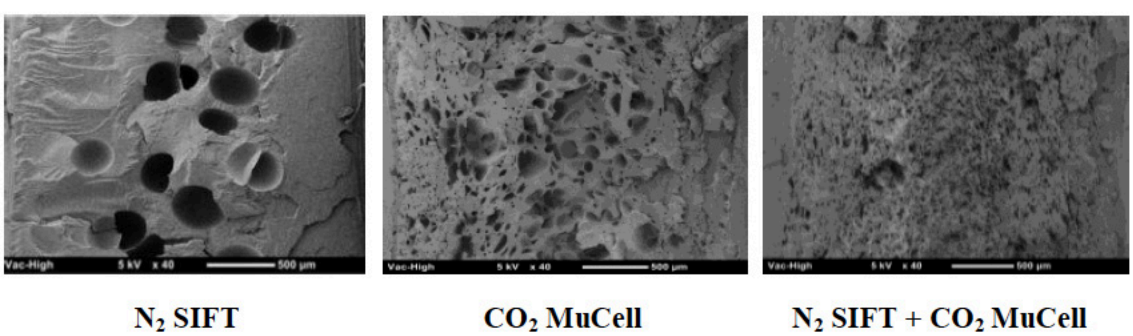


Figure 2: Comparison of N_2, CO_2, and $N_2 + CO_2$ foam injection molding. Scale bars are 500 μm.

IMD Best Paper Continued

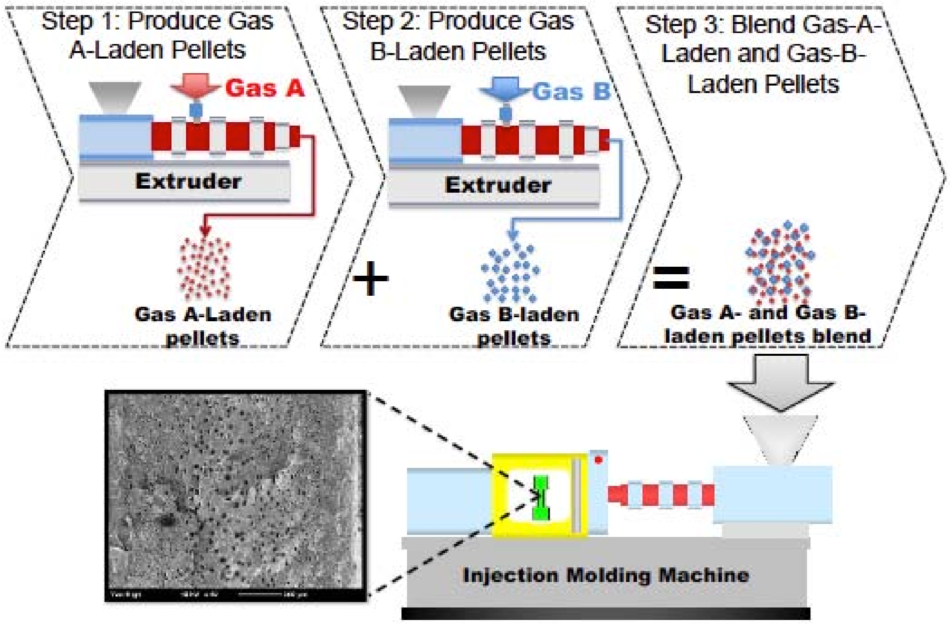


Figure 3: SIFT process with N_2 + CO_2 as co-blowing agents by blending N_2-laden and CO_2-laden pellets.

is needed. N_2-laden and CO_2-laden pellets can be produced respectively in two batches by the SIFT process. These two batches of pellets can then be dry blended at a precise mass ratio to yield the designated N_2/CO_2composition. A schematic of this method is shown in **Figure 3**.

Enhancing Heterogeneous Nucleation by Using Talc as a Nucleating Agent or by Compounding HDPE/PP Blends

The governing equation of the heterogeneous nucleation is similar to that of the homogeneous one, and is written as[5]:

$$N_{het} = f C_{het} exp\left(-\frac{\Delta G^*_{het}}{kT}\right) \qquad \text{(Eq. 3)}$$

where Nhet is the heterogeneous nucleation rate, *Chet* is the concentration of heterogeneous nucleation sites, and *ΔG*het* is the activation energy barrier for heterogeneous nucleation, which can be estimated by:

$$\Delta G^*_{het} = \frac{16\pi\gamma^3 M^2}{3(RT\rho lnS)^2} F(\theta_w) \qquad \text{(Eq. 4)}$$

This equation is similar to Eq. 2, except for the additional term $F(\theta w)$, which is a function of the wetting angle θw between the polymer, the gas, and the secondary phase particle. The value of $F(\theta w)$ is far less than unity, and reduces the energy barrier dramatically. For this reason, creating interfaces in the matrix by either introducing a filler as a nucleating agent or by compounding immiscible polymeric blends are effective methods of boosting heterogeneous nucleation and enhancing the nucleation rate. In this study, multi-phase interfaces and heterogeneous nucleation was triggered by either incorporating talc as a nucleating agent, or by compounding high-density polyethylene (HDPE)/polypropylene (PP) immiscible blends.

IMD Best Paper Continued

Homogeneous nucleation and heterogeneous nucleation are not mutually exclusive. By enhancing both mechanisms, it is possible that the enhancement can be superimposed and have a synergetic effect, such that the nucleation rate can be further increased. In this study, two different homogenous + hetero-geneous nucleation enhancing methods were investigated: (1) N_2 + CO_2 as co-blowing agents with talc as a nucle-ating agent, and (2)N_2 + CO_2 as co-blowing agents in HDPE/PP immiscible blends. Experimental details are described in the next section.

Experimental

Materials

The HDPE used in this study was Dow DMDA6200NT7, with a MFI of 1.9 g/10 min at 230 ºC. The PP used was a random copolymer (LyondellBasell Pro-fax SR256M) with a MFI of 2.0 g/10 min at 230 ºC. Talc with an average size of 4.5 µm was used as the nucleating agent.

Processing

TheN2-laden and CO_2-laden pellets were produced using a twin screw extruder (LeistritzZSE-18). Gas was in-jected into the barrel using a TeledyneISCO 260D high precision syringe pump.The gas–polymer solution was then extruded through a 1.5 mm diameter filament die. Then the strand was pelletized and oven dried for 1 hour to remove moisture. Afterwards, the N_2-laden and CO_2-laden pellets were mixed in several defined mass ratios to yield different N_2/CO_2 ratios. A master batch of the same type of resin with 20% talc was compounded by using the same twin-screw extruder, and then was diluted by the blended N_2 and CO_2-laden pellets to yield a 2% talc content.

The blended gas-laden pellets with talc-containing pellets were then injection molded. The injection molding machine used in this study was an Arburg Allrounder 320S equipped with a Trexel MuCell system. A tensile test bar mold (ASTM 638 Type I) was used to mold the test parts. Some key process-ing conditions are listed in **Table 1**.

Table 1: Key Process Conditions.

Extrusion	
Screw Speed	150 rpm
Material Feed Rate	40 g/min
Temperature	190/200/210/210/210/200/190 °C (sequence from hopper to die)

Injection Molding	
Nozzle/Runner Temp.	210 °C
Injection Speed	40 cm_3/s
Packing	None
Screw Recovery Speed	15 m/min
Back Pressure	100 bar
Coolant Temperature	25 °C
Cooling Time	30 s

For the nucleation enhancing method using HDPE/PP immiscible blends, the equipment used was the same as in the previous one. HDPE gas-laden pellets and PP gas-laden pellets were prepared separately using the twin-screw extruder. After drying, the HDPE and PP gas-pellets were dry-blended at three different weight ratios: 25/75, 50/50, and 75/25. The blended gas-laden PP and HDPE pellets were then injection molded. The process conditions are listed in Table 1.

Characterization

Tensile tests were performed using a mechanical test bench (Instron 5967) following the ASTM D638 standard at a tensile strain rate of 50 mm/min. Differential scanning calorimetry measurements were conducted using a TA Instrument DSC Q20 at a heating and cooling rate of 10°C/min. The cell density was calculated using Eq. 5:

$$Cell\ Density = \left(\frac{N}{A}\right)^{\frac{3}{2}} \qquad \text{(Eq. 5)}$$

where *N* is the total number of cells included in the analyzed image, and A is the area covered by the image. The maximum weight reduction was measured by reducing the shot volume during the injection molding process until shrinkage or short shots occurs. The part weight produced by the lowest shot volume without causing a dimensional defect was used to calculate the maximum weight reduction.

Results and Discussions

$N_2 + CO_2$ as Co-Blowing Agents with Talc as a Nucleating Agent

The morphologies of the injection molded parts using blends of CO_2- and N_2-laden pellets with and without talc on HDPE and PP are shown in **Figures 4 and 6**. Their property statistics are shown in **Figures 5 and**

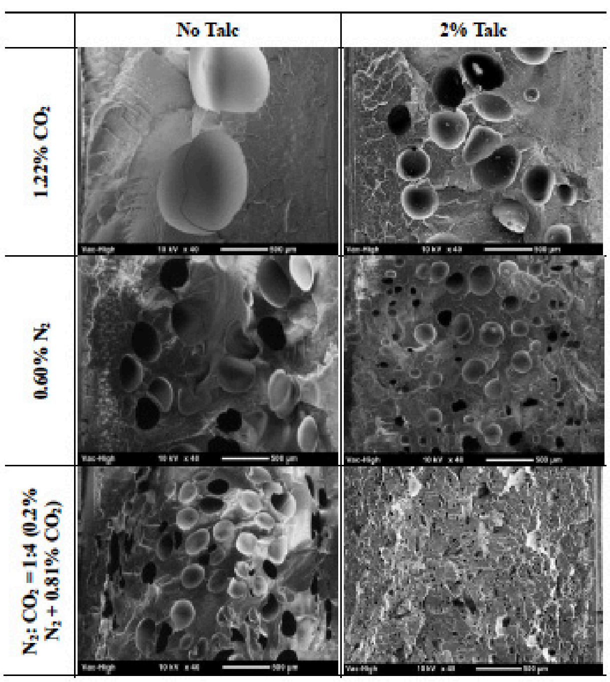


Figure 4: SEM images of injection molded HDPE using gasladen pellets with and without talc. The scale bars are 500 μm.

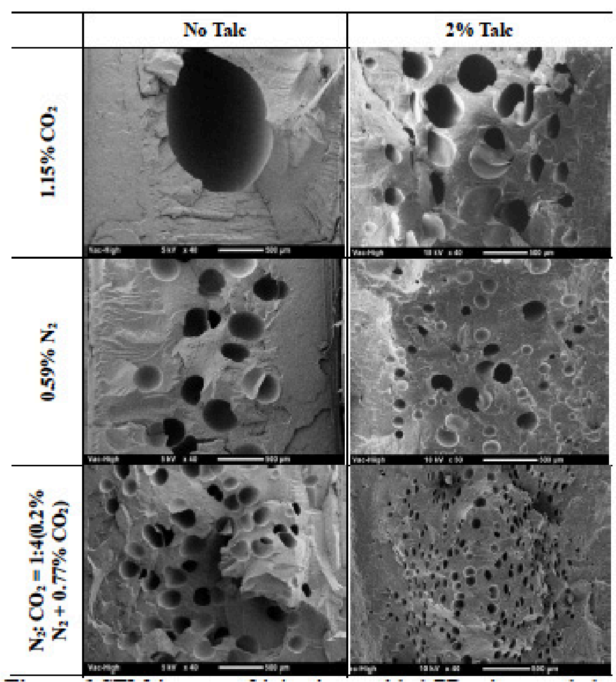


Figure 6:SEM images of injection molded PP using gas laden pellets with and without talc. The scale bars are 500 μm.

IMD Best Paper Continued

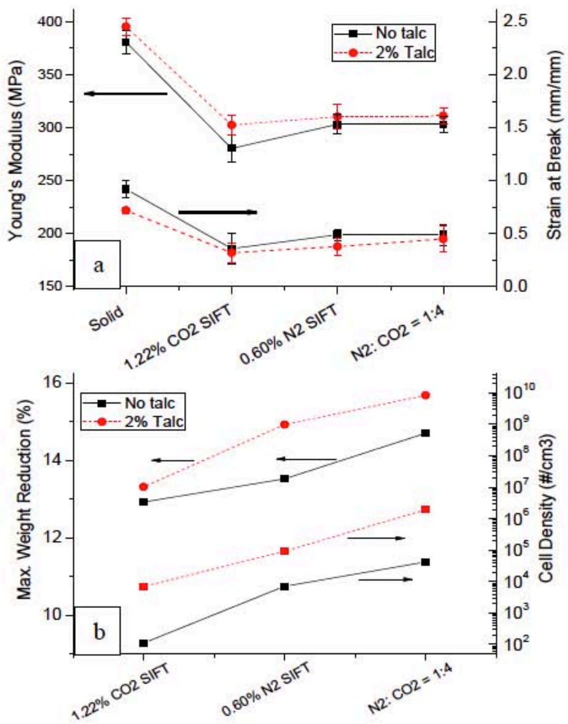


Figure 5: (a) Tensile properties and (b) maximum weight reduction and cell density of injection molded HDPE using gasladen pellets with and without talc.

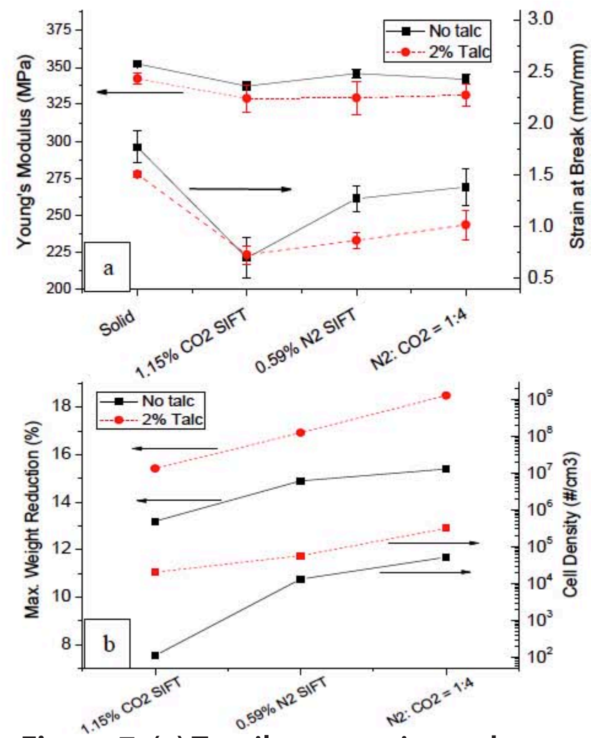


Figure 7: (a) Tensile properties and (b) maximum weightreduction and cell density of injection molded PP using gasladen pellets with and without talc.

7, correspondingly. From our earlier study [13], for PP and HDPE, a N_2/CO_2 ratio of 1:4 yielded the finest cell structure, and thus, this ratio was also used in this study. Cases using only N_2 or CO_2 as the blowing agent are also shown for comparison. Our results show that by using blends of N_2-laden and CO_2-laden pellets, the resulting cell density and weight reduction were significantly higher than when either blowing agent was used alone. By incorporating talc as a nucleating agent, the cell density and weight reduction improved even further, suggesting that these two nucleation enhancing mechanisms could be combined without confliction.

With regard to the tensile properties, by using N_2+CO_2 as co-blowing agents, both the Young's modulus and strain-at-break showed slight improvements compared with using either blowing agent alone thanks to the finer cell structure. After adding talc, HDPE showed a slight increase in Young's modulus and a minor reduction in ductility, while PP showed a more significant decrease in both the Young's modulus and ductility, possibly due to poor capability and weak interfacial adhesion between the talc and the PP that we used in this study.

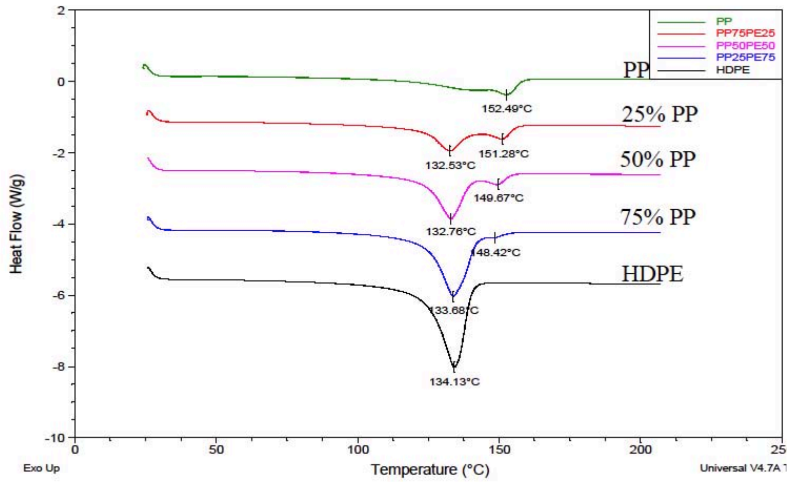
$N_2 + CO_2$ as Co-Blowing Agents in HDPE/PP Blends

Three different HDPE/PP blend ratios were tested in this study: 25/75, 50/50, and 75/25. The DSC results of the second heating cycle are shown in Fig. 8. With PP/HDPE ratios of 25/75 and 50/50, two distinct melting peaks can be seen in the curves, which indicates two crystalline phases in the blends and strong immiscibility, which is beneficial for cell nucleation. For PP/HDPE = 25/75, the PP peak was not as distinguished, thereby, implying that at this ratio, the HDPE and PP were more miscible. The SEM images at 10000× magnification shown in **Figure 8 (b)** agree with the DSC results. At PP/HDPE = 75/25, HDPE was dispersed in the PP matrix in a particle shape at a sub micron size. With PP/HDPE = 50/50, the morphology of the HDPE phase became

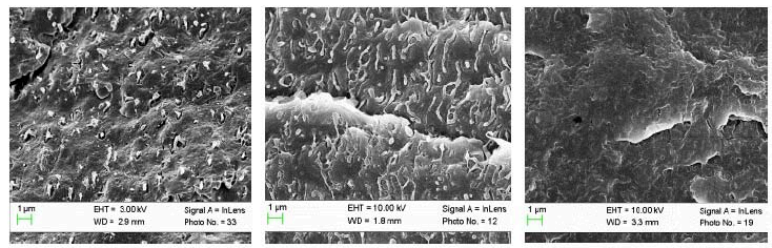
IMD Best Paper Continued

worm shaped. At PP/HDPE = 25/75, no clear boundary was observed between the PP and HDPE, which suggests that at this ratio, HDPE and PP were miscible.

The resulting cell morphology of the injection molded parts are shown in **Figure 9** and summarized in F**igure 10**. The 75/25 PP/HDPE ratio yielded the finest cell structure and highest cell density. This was due to the fine HDPE dispersion, which provided more nucleation sites, and the strong immiscibility, which lowered the energy barrier to overcome for cell nucleation. Yet for the 25/75 PP/HDPE ratio, at which the blend appears miscible, not much improvement in cell nucleation was observed compared with using either PP or HDPE alone, as shown in **Figure 9**. The 75/25 PP/HDPE ratio was selected as the optimal ratio for nucleation.



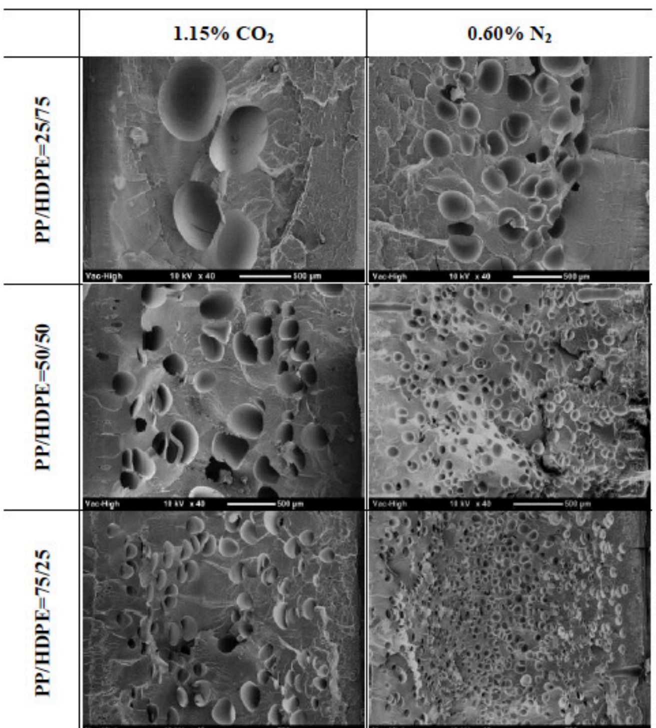
(a)



PP/HDPE = 75/25 PP/HDPE = 50/50 PP/HDPE = 25/75

(b)

Figure 8: (a) DSC results and (b) SEM images at 10000x magnification of HDPE/PP blends. The scale bar is 1µm.



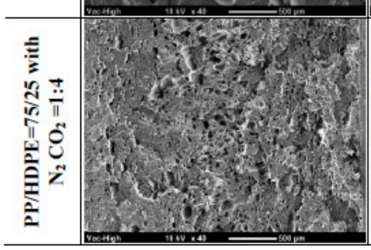


Figure 9: PP/HDPE blends using N_2, CO_2, and N_2 + CO_2 as blowing agent(s). The scale bar is 500 µm.

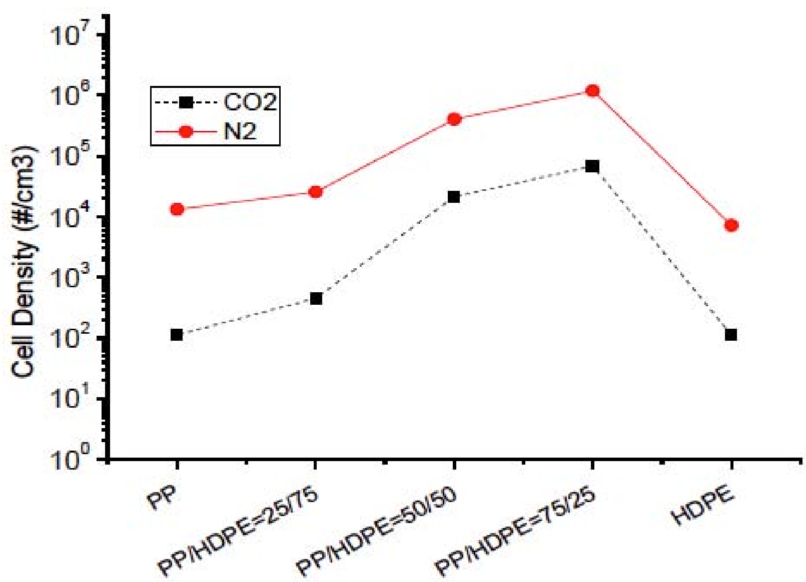


Figure 10: Cell density of PP/HDPE injection molded parts using N_2 or CO_2 laden-pellets at various blend ratios.

IMD Best Paper Continued

Conclusions

In this study, three different methods of enhancing the foamability of gas-laden pellets was investigated including: (a) enhancing homogeneous nucleation by blending N_2- and CO_2-laden pellets and creating an N_2/CO_2 synergetic effect, (b) enhancing heterogeneous nucleation by incorporating talc as a nucleating agent, and (c) enhancing heterogeneous nucleation by compounding PP/HDPE immiscible blends. All three methods effectively improved the cell nucleation rate and cell morphology. It was also found that method (a) could be superimposed with methods (b) or (c) without conflict, and lead to even finer and denser cell structures.

Acknowledgements This research was supported by the Wisconsin Alumni Research Foundation (WARF) Accelerator Program.

References

1. J. Lee, L.-S. Turng, SPE ANTEC Proceedings 2009, 3 (2009) 1662-1666.
2. A. Kramschuster, R. Cavitt, D. Ermer, Z.B. Chen, L.S. Turng, Plastics Rubber and Composites, 35 (2006) 198-209.
3. Trexel Inc. Website. www.trexel.com
4. J. Lee, L.S. Turng, E. Dougherty, P. Gorton, Polymer Engineering and Science, 51 (2011) 2295-2303.
5. J.S. Colton, N.P. Suh, Polymer Engineering and Science, 27 (1987) 485-492.
6. D.L. Tomasko, A. Burley, L. Feng, et. al., Journal of Supercritical Fluids, 47 (2009) 493-499.
7. E. Di Maio, G. Mensitieri, S. Iannace, L. Nicolais, et. al., Polymer Engineering and Science, 45 (2005) 432-441.
8. T. Ishikawa, K. Taki, M. Ohshima, Polymer Engineering and Science, 52 (2012) 875-883.
9. S.G. Kim, J.W.S. Lee, C.B. Park, M. Sain, Journal of Applied Polymer Science, 118 (2010) 1691-1703.
10. S.G. Kim, C.B. Park, B.S. Kang, A. Sain, Cellular Polymers, 25 (2006) 19-33.
11. A. Wong, L.H. Mark, M.M. Hasan, C.B. Park, SPE ANTEC Proceedings 2011, 3 (2011) 2688-2694.
12. X. Sun, L.-S. Turng, Polymer Engineering and Science, (2013). 13. X. Sun, L.-S. Turng, 10th Intl' Conference on Advanced Molding & Material Processing Tech Proceedings, (2013).

IMD Board of Directors Meeting

April 28, 2014

Las Vegas, NV

Submitted by Srikanth Pilla, Secretary

Welcome

The new Chair Adam Kramschuster called the meeting to order at 5:20pm PST. He welcomed all attendees to the meeting.

Roll Call

Present were: Adam Kramschuster (Chair), Susan Montgomery, Jim Wenskus, Peter Grelle, Hoa Pham, Jeremy Dworshak, Srikanth Pilla, Raymond McKee, Rick Puglielli, David Okonski, Jack Dispenza, Brad Johnson, Kishor Mehta, Mike Uhrain, Tom Turng.

Guests were: Kathy Schacht (SPE Staff)

Absent were: Erik Foltz, Lee Filbert, Nick Fountas, David Kusuma, Larry Schmidt, Mal Murthy, Ram Thanumoorthy

This constituted quorum.

Approval of January 31, 2014 Meeting Minutes

Motion:

Hoa moved that the January 31, 2014 meeting minutes be approved, as written and distributed. Kishor seconded the motion and carried.

Financial Report – Jim Wenskus, Treasurer

Jim presented the financials from July 1, 2013 to March 31, 2014. Balance sheets were distributed. China Topcon expense was $11K, we paid $15K, and so we should get back $4K. Overall, we have a positive balance.

The budget for fiscal year July 1, 2014 to June 30, 2015 was also presented. Kishor made the budget call and Pete seconded the motion and carried. The board discussed the reception @ ANTEC budget to be increased to $3,000 and it was approved and the budget was passed.

Communications Report – Adam Kramschuster

The IMD website was launched at http://injectionmolding.org/. Adam suggested to place a banner on the new SPE IMD website for the newsletter.

Upcoming newsletter deadlines:

Summer (July 2014)

• June 10 for content, ads, and payments

Fall (November 2014):

• October 10 for content, ads, and payments

Spring (March 2015):

• February 10 for content, ads, and payments

IMD Board of Directors Meeting Continued

Adam requested for a volunteer to take over the communications chair due to his overwhelming responsibilities as Chair, website content manager etc. Rick Puglielli volunteered. He will work with Adam for the first year to get up to speed.

IMD won the highest communications award from SPE

ANTEC Technical Program Committee Report – Adam Kramschuster

- Adam presented the final matrix and keynote and tutorial session schedule.
- As discussed earlier, the next year TPC will be running the IMD reception at ANTEC. This is a huge load-off the TPC. Ray championed this year ANTEC reception and we received huge sponsorship of $12,000.
- ScholarOne needs to be updated or replaced as it created lot of problem both while accessing the papers as well as communicating the decision for the authors.
- Adam suggested that it would be good to compile the sessions immediately after paper review since the content is still fresh in the mind. This was there in Technical Director's guidelines and he highly recommended that it be followed.

TPC 2015 is Ray McKee and Reception In-charge is Jeremy

Technical Director's Report – Peter Grelle

ANTEC Technical Papers

Pete thanked Adam for an outstanding job in organizing the technical session for ANTEC 2014.

TOPCON Update

The upcoming TOPCONs are: Penn State Erie Injection Molding Conference, to be held on 6/18-6/19 in Erie, PA.

Injection Molding Webinar

The following speakers were finalized for presenting a webinar on injection molding design.

Title	Speaker
Moldflow Simulation-What Information Do you Get?	Matt Jaworski
Gate/Runner Design	Erik Foltz
IM Part Design Basics	TBD

Councillor's Report – Brad Johnson

Brad gave a summary report on the activities of the SPE council.

IMD Board of Directors Meeting Continued

New SPE Website

- The new website is an order of magnitude different than the old ones
- It was mainly designed to appeal to the younger audience
- The technical is completely online. One search engine for past two decades
- The new website can host micro-sites for divisions. It will cost $3,500. Contact Tom Conklin (tconklin@4spe.org) for more details

There will be four global conferences. The EUROTECH name is changed to ANTEC, Europe. There are many more divisions and sections being formed across the world such as China IMD. It was discussed on how the USA-IMD will be connected to China IMD. Will China-IMD be formed under USA-IMD? More clarification is needed.

IMD Membership Committee – Adam/Nick

Nick sent the updates from IMD membership committee to Adam and he presented it. There was an increase in the enrollment of members. Since Jan 2014, there were 110 new members with 68% from USA. However, there were also a total of 494 lapsed members.

Nominations Committee – Hoa Pham

Hoa presented the results and comments of the 2014 ballot. Also presented were the slate of incoming board officers.

Chair	Adam Kramschuster
Chair-elect	David Okonski
Secretary	Srikanth Pilla
Treasurer	Jim Wenskus
Councilor (2014-17)	Susan Montgomery

New Business and Other Topics – All

Since Pat resigned for unknown reasons, the board officers were rearranged to accommodate his resignation. David Okonski has been nominated, as chair-elect and he will also be responsible for completing the application process for Pinnacle Award for next year.

Next Meeting

The next board meeting will possibly be on 9/19/2014 from 9am-Noon EST

Adjournment

Motion: Pete moved to adjourn the meeting. David seconded. The meeting was adjourned at 7:15pm PST.

IMD Leadership

DIVISION OFFICERS

IMD Chair
Adam Kramschuster
University of Wisconsin-Stout
kramschustera@uwstout.edu

Chair-Elect
David Okonski
General Motors R&D Center
david.a.okonski@gm.com

Treasurer
Jim Wenskus
wenskus1@frontier.com

Technical Director
Peter Grelle
Plastics Fundamentals Group, LLC
pfgrp@aol.com

Past Chair
Erik Foltz
The Madison Group
erik@madisongroup.com

Councilor, 2011 - 2014
Susan E. Montgomery
Priamus System Technologies
s.montgomery@priamus.com

BOARD OF DIRECTORS

Communications Committee Chair
Adam Kramschuster
University of Wisconsin-Stout
kramschustera@uwstout.edu

TPC ANTEC 2015
Raymond McKee
Berry Plastics
raymond.mckee@berryplastics.com

TPC ANTEC 2016
Education Committee Chair
Jeremy Dworshak
Steinwall Inc.
jdworshak@steinwall.com

TPC ANTEC 2017
Rick Puglielli
Promold Plastics
rickp@promoldplastics.com

TPC ANTEC 2018
Srikanth Pilla
Clemson University
spilla@clemson.com

TPC ANTEC 2019
2013 China TOPCON Chair
David Kusuma
Tupperware
davidkusuma@tupperware.com

TPC ANTEC 2020
David Okonski
General Motors R&D Center
david.a.okonski@gm.com

Membership Chair
Nick Fountas
JLI-Boston
fountas@jli-boston.com

Engineer-Of-The-Year Award
HSM & Fellows
Kishor Mehta
Plascon Associates, Inc
ksmehta100@gmail.com

Reception Committee Chair
Jack Dispenza
jackdispenza@gmail.com

Awards Chair
Lih-Sheng (Tom) Turng
Univ. of Wisconsin — Madison
turng@engr.wisc.edu

Assistant Treasurer
Nominations Committee/Chair
Historian
Hoa Pham
Avery Dennison
hp0802@live.com

Lee Filbert
IQMS
lfilbert@iqms.com

Michael C. Uhrain IV
Sumitomo
michael.uhrain@dpg.com

Brad Johnson
Penn State Erie
bgj1@psu.edu

EMERITUS

Mal Murthy
Doss Plastics
Dosscor@GMAIL.com

Larry Schmidt
LR Schmidt Associates
schmidtlra@aol.com

IMD New Members

The Injection Molding Division Welcomes 103New Members...

Erika Albury
Gary Arinder
Marco Arras
Flent Ballantyne
Jeff Barnett
Ronald Beitler
Smita Birkar
James Bourne
Andrew Boyd
Bryan Brightman
Carl Brown
Dennis Brown
Matt Brown
Christian Cassel
Thomas Catinat
Maggie Chau
Mark Costain
William Cypert
Joe Davis
Marc-Claudel Deluy
Renee Desbles
Tom Downs
Kevin Dyer
David Erculiani
Martyn Faville
Scott Fraser
Matthieu Germain
Joseph Giamo
Jinsu Gim
Stephan Gnatiuk
Chris Goetz
Christopher Greene
Robert Hale
Seongryeol Han
Kim Hanes
Tom Hansen
Joshua Hautamaki
Bernd Henkelmann
Ruben Hernandez
Heath Holste
Marc Hutto
Josh Jia
Damon Johnston
Evan Knapp
Michael Koss
Indika Kulatunga
Howard Kunz
Sanjay Kuttappa
Jaime Lafita
Scott Large
Hui Li
Adam Loch
Johnny Lu
Dan Manning
Stan Martin
Steven Matthews
Sharon McCord
Michelle McManus
Patrick McNutt
Vahid Mortazavian
Victor Naegelin
David Naughton
Dylan Nixon
Craig Olroyd
Justin Olsson
Craig Ozols
Jacob Pathuis
Sofie Peeters
Jim Peplinski
Raquel Perez
Anita Quillen
Mauro Cesar Rabuski Garcia
Thomas Reffle
Syed Rehmathullah
Antonio Righez Mesquita
Dave Sander
Michael Sarver
Terrence Saul
Christopher Schneider
Maxime Schunder
Keith Scutter
Todd Sholtis
Vishal Singh
Edward Smith
Jeremy Smith
Aaron Spalding
Roy Spatz
Ronald Springer
Wipoo Sriseubsai
Oliver Stauffer
Con Stavropoulos
Paul Stidworthy
Brian Summerkamp
Shih-Po Sun
Scott Sutherland
Dana Thompson
Daryl Thompson
Shannon Vaughn
Rubal Verma
Alan Walker
Maria Wang
Roy Woodley

IMD New Members Continued

...from 16 countries:

Australia
Brazil
Canada
China
France
Germany
Hong Kong
India
New Zealand
South Korea
Spain
Sri Lanka
Taiwan
Thailand
United Kingdom
U.S.A.

...representing more than 87 organizations including:

Advanced Plastiform Inc.
Ajou U.
Aladdin Temp-Rite
Alco Plastics
Ambrit Engineering Corp.
Americhem
Amsted Rail
AST Technology UK Ltd.
Autodesk
Barr Inc.
Basell Australia
Becton Dickinson
Bemis Manufacturing
Berry Plastics
Callaway Golf
CalsonicKansei N.A.
CE Engineering
Celanese
Clariant
CoreTech System (Moldex3D) Co. Ltd.
Corma Inc.
Custom Service Plastics
Kongju National U.
Diversified Engineering & Plastics Inc.
DME Co.
Elgin Molded
EMS-Chemie
EMS-Grivory
ETS
Eve Hook Fall Protection
Evenflo Company Inc.
Executool Precision Tooling
Generation Four LLC
Global Precision Industries Inc.
Hennepin Technical College
Hochschule Darmstadt
Icon Plastics Pty. Ltd.
Innovative Design
International Contract Molding
InterPRO
ISPA
ITW
Kellen
King Mongkut's Institute of Tech. Ladkrabang
Kraft Foods Group
Lacks Trim Systems
LORD Corporation
McCord Executive Search
MGS Manufacturing Group
Milacron Inc.
Milliken Chemical
Mission Plastics Inc.
MRIGlobalPlastics
Nanosyntex, Inc.
National Plastics Color
New Berlin Plastics
Nextool Canada Limited
NIT Hamirpur

IMD New Members Continued

Nypla Industrial
Olsen Tool & Plastics
Orel Corporation (PVT) Ltd.
Osterman & Company Inc.
Outerspace Design
Oxylane
Parker-Hannifin
Parmalat Australia Pty. Ltd.
Penn State Erie
Pikes Peak Plastics
Poly
Polymer Resources Ltd
PolymerWarehouse LLC
PTI Inspection Systems
RGI
Serigraph
Shure Inc.
Styron LLC
Teleflex Medical
Theranos
TMaG
U. Mass. - Lowell
Underground Devices
United Solar Ovonics
Visy
Walter Pack S.L.
Weili Plastics Machinery (HK) Ltd.
Xiamen U. of Technology
YESCO Electronics LLC

Membership Application

Society of Plastics Engineers Membership Application

13 Church Hill Road, Newtown, CT. 06470 USA
Tel: +1 203-775-0471 Fax: +1 203-775-8490
membership@4spe.org www.4spe.org

European Member Bureau
Tel: +44 7500 829007
speeurope@4spe.org www.speeurope.org

Applicant Information: (please print)

My Primary Address is home_____ or business_____ (check one)

Name ________________ ______ _________________________
First MI Last

Phone Number_______________________ Home___ Work____ Cell___

Organization Name_______________________________________

Job Title____

Address ____

Address ____

Email(Required Field)____

Address ____

Alternate Email ____

City______________________State_________________________

Date of Birth___________________ Graduation Date*_________________

Zip/Postal Code_____________ Country______________

Gender: Male _____Female_____ *Required for Student Membership

Membership Types (please check one)

_____ Student $31 **_____Young Professional $99** **_____Professional $144(**includes $15 new member initiation fee)
Choose up to 2 Member Groups on the back of this application.

_____Professional +2 Additional Member Groups $**164** Choose up to 4 Additional Member Groups on the back of this application.

_____Professional +4 Additional Member Groups $184 Choose up to 6 Additional Member Groups on the back of this application.

Payment Information: **PAYMENT MUST ACCOMPANY APPLICATION-NO PURCHASE ORDERS ACCEPTED**

Amount____________ Check Number_________________ Cash _______________

Credit Card Information (Check One) American Express_______ Visa_______ MasterCard________

Credit Card Number____ Exp. Date__________ Security Code________

Name On Credit Card____ Amount____________

By signing below I agree to be governed by the Bylaws of the Society and to promote the objectives of the Society. I certify that the statements made in the application are correct and I authorize SPE and its affiliates to use my phone, fax, address and email to contact me.

Signature____ Date_______________

Recommended by____________________________ ID#______________________

The SPE Online Membership Directory is included with membership. Your information will be automatically included.
______ Exclude my email from the Online Membership Directory.
______ Exclude all my information from the Online Membership Directory.
______ Exclude my address from 3rd party mailings.

Dues include a 1year subscription to *Plastics Engineering* magazine-$38.00 value (non-deductible). SPE membership is valid for twelve months from the date your membership is processed.

Member Groups

Technical Area of Interests(Divisions)

A Technical Area of Interest gives you access to up-to-the-minute, specialized, technical information and an international community of colleagues in your area of interest. It enhances your membership by providing more targeted, practical advice, from proven experts and professionals currently working in your field.

Please circle choice(s) below:

None

Additives & Colors Europe - D45
Automotive - D31
Blow Molding - D30
Color & Appearance - D21
Composites - D39
Decorating & Assembly - D34
Electrical & Electronic - D24
Engineering Properties & Structure - D26
European Medical Polymers - D46
Extrusion - D22
Flexible Packaging - D44
Injection Molding - D23
Medical Plastics Technical Area of Interest - D36
Mold Making & Mold Design - D35
Plastics Environmental - D40
Polymer Analysis - D33
Polymer Modifiers & Additives - D38
Product Design & Development - D41
Rotational Molding - D42
Thermoforming - D25
European Thermoforming - D43
Thermoplastic Materials & Foams - D29
Thermoset - D28
Vinyl Plastics - D27

Geographic Locations(Sections)

A Geographic Location connects you to your local plastics colleagues and your local industry. Please circle choice(s) below:

None
Alabama-Georgia-Southern
Arkansas
Australia - New Zealand
Benelux
Brazil
California - Golden Gate
California - Southern California
Caribbean
Carolinas
Central Europe
Colorado - Rocky Mountain
Connecticut
Eastern New England
Florida - Central Florida
Florida - South Florida
France
Hong Kong
Illinois-Chicago
India
Indiana-Central Indiana
Iowa
Israel
Italy
Japan
Kansas City
Korea
Louisiana-Gulf South Central
Maryland-Baltimore-Washington
Mass-New Hampshire-Pioneer Valley
Mexico-Centro
Michiana
Michigan-Detroit
Michigan-Mid Michigan
Michigan-Western Michigan
Middle East
Mississippi
Missouri
Nebraska
New Jersey - Palisades-New Jersey
New York
New York-Binghamton-Scranton
New York-Rochester
New York Mid-Hudson
North Carolina-Piedmont Coastal
Ohio-Akron
Ohio-Cleveland
Ohio-Miami Valley
Ohio-Toledo
Ohio-Firelands
Oklahoma
Ontario
Oregon-Columbia River
Pennsylvania-Lehigh Valley
Pennsylvania-Northwestern Pennsylvania
Pennsylvania-Philadelphia
Pennsylvania-Pittsburgh
Pennsylvania-Susquehanna
Portugal
Quebec
Southeastern New England
Spain
Taiwan
Tennessee-Smoky Mountain
Tennessee-Tennessee Valley
Texas-Central Texas
Texas-Lower Rio Grande Valley
Texas-North Texas
Texas-South Texas
Turkey
United Kingdom & Ireland
Upper Midwest
Utah-Great Salt Lake
Virginia
Washington-Pacific Northwest
West Virginia Southeastern Ohio
Western New England
Wisconsin-Milwaukee

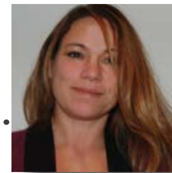
Special Interest Groups(SIGs)

Special Interest Groups are where like-minded Plastics professionals come together to explore the emerging science, technologies and practices that will shape the plastics industry. There is no charge for membership. Choose as many as you would like. Please circle choice(s) below:

Advanced Energy Storage – SIG 024
Alloys and Blends – SIG 010
Applied Rheology – SIG 013
Bioplastics – SIG 028
Composites Europe – SIG 026
Extrusion Europe – SIG 025
Failure Analysis and Prevention – SIG 002
Joining of Plastics and Composites – SIG 012
Marketing & Management Division – SIG 029
Nano/Micro Molding – SIG 023
Non-Halogen Flame Retardant Tech-SIG 030
Plastic Pipe and Fittings – SIG 021
Plastics Educators – SIG 018
Plastics in Building and Construction – SIG 027
Process Monitoring and Control – SIG 016
Quality and Continuous Improvement – SIG 005
Radiation Processing of Polymers – SIG 019
Rapid Design, Engineering and Mold Making – SIG 020
Thermoplastic Elastomers - SIG 006

Publisher Note | Sponsors

Message from the Publisher



Greetings everyone!

First I would like to thank Erik Foltz for all his dedication as chair for the past year and a congratulations to Adam Kramshcuster who is this years new IMD chair.

In addition there is the new and improved SPE web site! If you haven't had a chance to login, please take a moment and do so. You will see a great change visually, with the eye popping colors and images it portrays. The site continues to provide industry news, technical resources and event information. New features are being added such as a professional e-Network, Innovation Partners Program to view new products and services, the online SPE store and more.

I would also like to thank all of article contributors and sponsorship supporters this month with their continued support to SPE and the newsletter.

I hope everyone has a wonderful summer. Our next issue is the Fall edition and contributors and sponsorships are available. If you or your company has an article to share please send it in for the next edition or if you would like to promote your product and or services please contact me for more information at PublisherIMDNewsletter@gmail.com

Thank you all, stay in touch!

Heidi Jensen PublisherIMDNewsletter@gmail.com

A big thank you to the authors and sponsors who supported this month's issue.

Linked in twitter

Find us on Facebook RSS