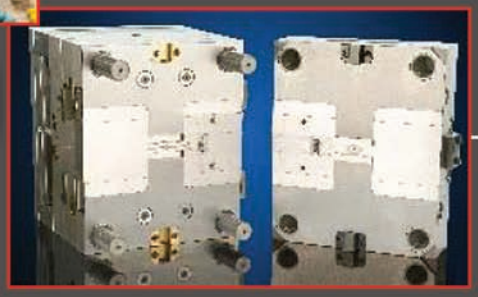
Spring 2017 | No. 104



MOLDING VIEWS

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

Chair's Message

Spring is upon us and looking forward to the events for the next year, we have a lot planned. First, ANTEC is scheduled for May 8-10, 2017 at the Hilton Anaheim. At that event, the Injection Molding Division (IMD) will be presenting our technical program as well as holding our annual networking reception on Tuesday evening. Our ANTEC reception has continued to gain popularity over the past few years and we are looking forward to another great event. Once ANTEC has finished, we turn our sights to the 2017 Injection Molding Division Conference (IMTECH) from August 1-3 at the Oak Brook Marriot in Oak Brook, IL (outside of Chicago). This new conference is coming together and looks to be a great event. We are planning evening receptions, a display

In This Issue:

This Month's Features:

Chair's Message Continued

area for vendors and sponsors, and local facility tours. In addition, we have great speakers to headline this event. Bill Carteaux, President and CEO of PLASTICS, John Beaumont, President and CEO of Beaumont Technologies and the American Injection Molding Institute, and David Kusuma, Vice President of Product Development and R&D Wordwide for Tupperware Brands will be the headline speakers. This event is going to be excellent.

As the IMD continues to do more outreach and planned events, we depend on sponsorship to be able to make these opportunities available. Our sponsors allow us to continue to work towards our mission of promoting the scientific and engineering knowledge relating to the injection molding of plastics. Our sponsors have made it possible for us to be able to fund student research, some of which will be presented at ANTEC in Anaheim this year, as well as have the confidence to put together a new conference. As always, we are looking for additional sponsors. If you would like to provide sponsorship for research projects, our conference, or for other activities, we are more than happy to have you as part of our collective group and network. Please reach out to either David Okonski, sponsorship chair, or myself and we will get things moving in the right direction.

Best regards to all,
Ray McKee
2016-2017 IMD Chair
Sonoco
Raymond.Mckee@sonoco.com

Industry Events Calendar

Click the show links for more information on these events!

MARCH 2017

MARCH 21-22: Thermoset 2017 Conference
Phoenix, Aarizona

MARCH 28-29: Successful Plastic Part Design - NorthEast 2017
Marlborough, MA

APRIL 2017

APRIL 4: North Texas Section Injection Molding Seminar With Bill Toban
Dallas/Fort Worth, TX

MAY 2017

MAY 2: Auto EPCON 2017
Troy, MI

MAY 8-10: ANTEC® Anaheim
Anaheim, CA

MAY 9: Placticity
Anaheim, CA

MAY 10: Industry 4.0
Anaheim, CA

MAY 16 - 17: The Conformal Cooling Conference
Minneapolis, MN

JUNE 2017

JUNE 19: Plastics Decorating and In-mold Decorating
Lincolnshire , IL

JUNE 14 -15: amerimold 2017
Rosemont, IL

AUGUST 2017

AUGUST 1-3
IMTECH
Oak Brook, IL

AUGUST 14: Plastics 3D
Indianapolis, IN

SEPTEMBER 2017

SEPTEMBER 14-15
Midwest Design - 2 Part Show
St. Charles, MO

SEPTEMBER 11-14
Thermoforming Conference®
Orlando, FL

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The plastics technology conference
May 8-10, Anaheim, CA

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ABSTRACT DEADLINE **MAY 31, 2017** **EMAIL ABSTRACTS TO:** *PFGrp@aol.com*

Key Conference Contacts

DAVID OKONSKI, Conference Chair
David.A.Okonski@gm.com

PETER GRELLE, Technical Program Chair
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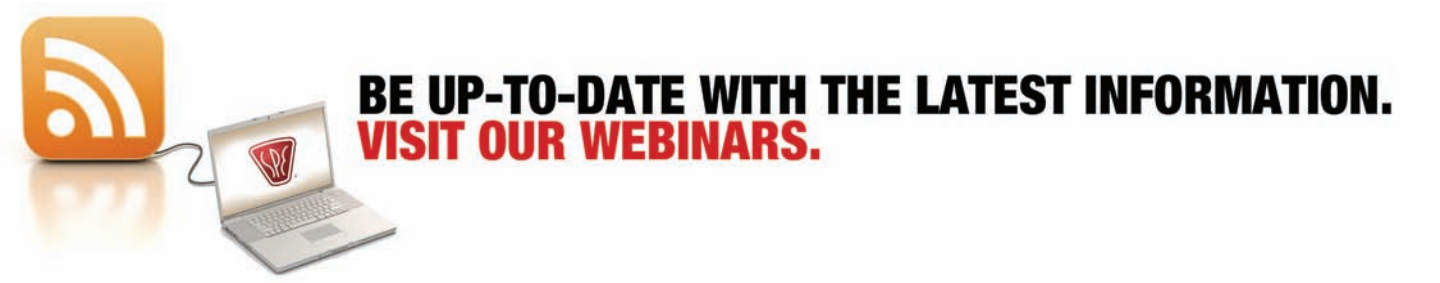

Transformation of a Metal Component in a Plastic Material. How To Take Into Account the Effect of the Manufacturing Process on the Mechanical Performance?

11 April 2017—11:00 AM Eastern time

Lightweight materials and design have always been an important topic in product design across several industries including automotive and aerospace. Engineers show a strong interest in the replacement of metals with composite and plastic materials. Lightweighting is most often achieved considering chopped and/or continuous fibers reinforced plastic, leading to their ever-increasing use in the design of semi-structural and structural components.

Are You Over or Under Engineering Your Plastic Component?

Predicting the as-manufactured performance of injection molded plastic components is imperative to reducing design cycles and creating lightweight and efficient components. Design requirements such as stiffness and strength are typically simulated with implicit finite element methods, but the material properties and strengths are usually approximated or simplified. In reality, the manufacturing process has a very large influence on both the stiffness and strength of the plastic components.

Introduction to Moldex3D: Modern Injection Molding Analysis

Computer-aided Engineering (CAE) simulations have played a large role in addressing critical design challenges and enhancing product quality. This webinar will guide you through the latest developments in modern injection molding simulation and how it will help you create better plastic parts and mold designs.

Part Design for Cycle Time Reduction

Ask the Experts: Bob Dealey

Cooling Time of the Injection Molding Cycle

Q: John M. from Massachusetts asks: The cooling time is a major component of the injection molding cycle:

1. What are the drivers?

2. Exactly when does cooling time start?

3. How can it be calculated?

4. Does the cooling time vary due to the plastic material?

5. What ways are there to reduce cooling time?

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

1. What are the drivers?

Answer: Factors influencing cooling time are the thickness of the plastic part: a. The plastic material, its thermal conductivity, its density and/or its thermal diffusivity. b. The injection mold material the thermal conductivity, the diameter, number and size and placement of the temperature control channels and the flow of the coolant described in Reynolds Numbers to insure turbulent flow. c. The part geometry, material shrinkage and surface in contact with the mold core and/or cavity where the transfer of heat can take place. d. The initial plastic melt temperature, the mold surface temperature (in particular the core), the temperature at which the part is sufficiently formed to keep its shape and not warp when ejected and the time the mold is open allowing the mold surface temperature to stabilize.

2. Exactly when does cooling time start?

Answer: The injection molding cycle is typically thought of as consisting of the injection time (further broken down to fill, pack and hold), the cooling cycle and the mold opening, ejection and closing phase. It is generally assumed that the cooling phase of the cycle starts half way through the injection phase, but in reality cooling begins in the filling stage. For purposes of our discussion we will assume that the cooling phase begins once the mold cavity has been filled, or at the end of the fill portion. In the hold and packing phase the plastic is definitely in contact with the core and cavity and cooling of the plastic is taking place.

Current molding philosophy follows the concept of mostly filling the cavity quickly, often under one second. Followed by transferring into a pack and then hold phase. Pack can last from one to several seconds depending upon part size. The hold stage follows and lasts until gate seal, this phase can take a number of seconds. Therefore, my opinion is that the proper point to begin the cooling phase is at the end of fill, as the pack and hold stage could vary anywhere from as short as a couple of seconds to as long as 15-20 seconds. Using half of the injection cycle to start the cooling cycle time when long hold and pack times are present does not then make sense.

Ask the Experts: Bob Dealey Continued

3. How can it be calculated?

Answer: A number of equations attempting to calculate cooling time are published. It has been my experience that due to the large number of variations in molding parameters a single equation cannot accurately predict a cooling time. I've found that most equations will under predict the cooling time of a thin wall part and over predict a thick walled part. The computer generated mold fill and cooling programs used today provide a much closer approximation of the actual cooling time experienced.

Having said that, the following is an example of an equation for calculating cooling time developed by K. A. Stelson:

$tc = a^2/\pi^2 \propto \times Ln(4/\pi (Ti - Tf)/(Te - Tf)))$

Where:

tc = Cooling Time

a = Part Thickness

$\propto$ = Thermal Diffusivity (m2/t) ($\propto = k/C_p$)

K = Thermal Conductivity

P = Density

C_p = Specific Heat Capacity

Ln = Log Number

Ti = Initial Temperature

Tf = Final Temperature (surface)

Te = Ejection Temperature (i.e. heat distortion temperature + 1°C)

4. Does the cooling time vary due to the plastic material?

Answer: Yes, Cooling time varies with the type of plastic material specified due to its thermal conductivity, density, volumetric heat capacity or its thermal diffusivity, its filler and/or reinforcement type and amount.

5. What ways are there to reduce cooling time?

Answer: Reducing cooling time can be accomplished by: a. Reducing the part thickness. b. Removing thick sections by coring. c. Utilizing mold materials with higher thermal conductive (i.e. lower alloy steels, use of high thermal conducive copper alloys like C-17200, C-17500 or C-18000 which are 3 to 6 times more conductive than P-20). d. Placing mold temperature control lines closer to the plastic forming surface and reducing the pitch (distance between channels), and increasing the channel diameter to increase the Reynolds Number describing coolant flow. e. maintaining an even and constant mold surface temperature.

As always reader comments adding or correcting information are welcome and will be published with the responder's permission.

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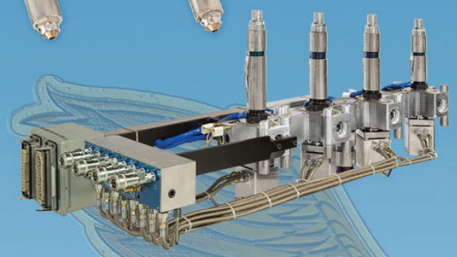

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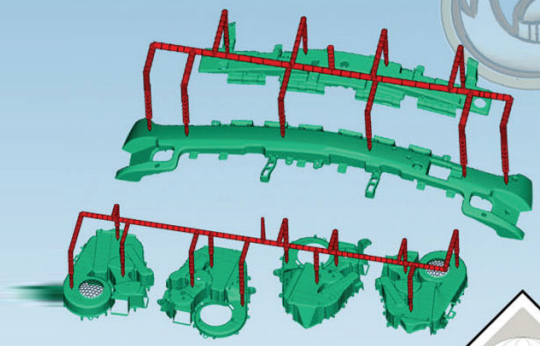

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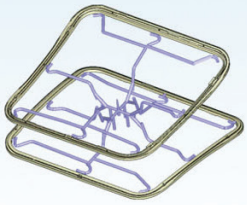

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Cycle Time

Cycle time has always been very important for a molder to help create a profit. Molders must be aggressive with cycle time quotes, as competition is furious. How can we help a molder with a cycle time quote? The following is a tech brief to help the molder to understand cycle time complexity. Listed below are some techniques that can help.

In order to understand how cycle time is developed we must examine the following:

- Material type
- Cavity shape
- Length of flow
- Wall-section thickness
- Gate size, shape and location

Once we have determined which material is going to be used and understand the part complexity we now need to optimize the flow path by properly sizing the diameters of the following:

- Sprue
- Runner
- Sub-runner
- Gate depth, width and land

We have now determined which material is going to be used. We understand the parts complexity and have sized all diameters of the sprue, runner and gating system. There is now another list we must look at too fully understand and optimize cycle time. This includes:

- Study the flow characteristics of the material.
- Open up existing vents.
- Add vents wherever possible.
- Change ejector pins to reduced diameter or vented groove.
- Make sure that the screw is designed properly for the given material. A general purpose screw is most common, with a low compression and has a ~20:1 L/D. The screws zone distribution is best at 40% feed, 40% compression and 20% metering. Last but not least, remember that your screw acts like an auger. The depth of the root in comparison to the flights is very important for resin delivery to the cavity.

For argument sake, we will assume that most of the steps above have not been followed. In order to help meet cycle time demands I have developed a list of trouble-shooting techniques. I have listed them in accordance to ease and least time consuming.

Cycle Time Continued

1. Lower fill, pack and cure time.

You must make sure you are still filling and packing the part sufficiently. An easy way to check is weighing the parts on a gram scale. Depending on part size and complexity, parts should not have more than a ~2-gram loss. If you want 100% confirmation of part fill and pack you can include optical microscopy checks of void content within the part. Make sure the cure time is adequate for part size and complexity. Too little cure time will result in part warpage and most likely part failure.

2. Adjust mold temperatures accordingly, i.e.; A-side hot, B-side cold, vice versa.

Don't get caught in the trap of lowering temperatures on both sides as this will restrict the flow of material, cause parts that are not filled, create voids within, and produce a part that will usually fail.

3. Reduce barrel (melt) temperature in 10° F increments.

Make sure you are creating a good homogenous melt by using a pyrometer to check for sufficient melt temperature.

4. Decrease residence time.

First and foremost, place the job on a machine that will use ~50% of the barrel. If this cannot be done you have to use the machine to its full potential. This means profiling temperatures in accordance to shot size and barrel size. Optimize not only fill, pack and cure time but also injection, ejection and clamp speed.

As you see, here is a lot more than meets the eye when cycle time is concerned. More often than not, the preliminary steps listed in the beginning of this paper will not be followed. When it comes to cycle time; tooling cost, material selection and the molding press are not taken into account. Nine times out of ten, it is not the molder that is making these decisions. It's all done within other levels as to make the job as cost effective as possible. This where the above trouble shooting techniques can help and you can use them to your advantage. Optimized cycle time on any job can make or break a molder.

About the Author

Dallas Cada is a highly trained plastics engineer with over 20 years of sales support experience. Owner of a plastic consulting business (DDC Consulting), his experience includes technical service, application development, market engineering, injection molding, design, tooling, material suggestions and problem solving for plastic manufacturing companies. For more information with troubleshooting plastic problems or helping with new plastic applications, contact Dallas Cada by e-mail at dallascada@charter.net. Contact Dallas by phone at (507) 458-5785 or (507) 452-1584 www.ddcconsulting4@webnode.com.

IMD SEEKING NOMINATIONS FOR SPE FELLOWS AND HONORED SERVICE MEMBERS

The SPE Injection Molding Division (IMD) encourages its members to nominate candidate(s) or self-nominate for two of the Society's distinguished memberships, namely, Fellow of the Society (Fellow) and Honored Service Member (HSM).

Fellow of the Society

To be elected Fellow of the Society, a candidate shall have demonstrated outstanding achievements in the field of plastics engineering, science or technology, or in the management of such activities; shall be sponsored, in writing, by the Board of Directors of at least one Section or Division, or by a committee of the Society organized for this purpose; shall have credentials certified by and application approved by the Credentials Committee; and shall have been a member in good standing for six years.

Detailed information on Fellow application and guidelines as well as past honorees can be found at: **http://www.4spe.org/Leadership/Content.aspx?ItemNumber=5986**

Honored Service Member (HSM)

According to SPE Bylaws, "To be elected an Honored Service Member, a candidate shall have demonstrated long-term, outstanding service to, and support of, the Society and its objectives; shall be sponsored, in writing, by the Board of Directors of at least one Section or Division." Detailed information on HSM application and guidelines as well as past honorees can be found at: **http://www.4spe.org/Leadership/Content.aspx?ItemNumber=5983**

Members interested in the nomination process please contact
Prof. Lih-Sheng (Tom) Turng, IMD HSM & Fellows Committee Chair, at
E-mail: turng@engr.wisc.edu **Phone: 608-316-4310**

IMD Best Paper

By Lun Howe Mark, Raymond K.M. Chu, Guilong Wang, Chul. B. Park

Microcellular Plastics Manufacturing Laboratory

Department of Mechanical and Industrial Engineering, University of Toronto, Canada

Microcellular Foam Injection Molding of Thick Parts

Achieving uniform, microcellular injection molded foams with large cross sectional thicknesses and high void fractions is difficult, due to the large temperature gradient. To investigate this issue, a thick part mold cavity has been manufactured and the effects of injection flow rate and mold temperature have been investigated. Higher injection flow rate resulted in higher cell density; while higher mold temperature resulted in more uniform cell density.

Introduction

Foams, and more specifically microcellular foams, are commonly used to create lighter, tougher products in extrusion, steam chest molding and injection molding. In injection molding, thermoplastic structural foams were first introduced in the 1960's. At that time, structural foams were rough with characteristically large cells for simple geometries [1]. Since this time, there has been a great push towards creating lighter and stronger products through design. Decreasing product thicknesses, results in a lighter but weaker and more flexible product [2]. Therefore, ribs and other reinforcements are added to the design to ensure higher strength and stiffness. Today, foam products with thicker cross-sections are relatively rare. Generally, the need for thick products has typically been phased out by better design. Nonetheless, there is still interest in creating thicker foam injection molded products,

Microcellular Foam Injection Molding of Thick Parts Continued

whether it be for increased sound or acoustic insulation thermal [3, 4], or for increased strength- and stiffness-to-weight ratios [5-7]. Typically, microcellular injection molds are relatively thin, with wall thicknesses ranging between 0.5 - 3 mm (1/32 - 1/8") or up to 6 mm (1/4") in special cases [8]. As the mold thickness increases, there are several difficulties which arise; chiefly, the nonuniform cell morphology which will develop across the transverse direction. The nonuniformity can be attributed to several factors, including melt temperature and flow pattern. Therefore, there remains a need to understand how to create microcellular foam injection molded products with a larger thickness and uniform cellular morphology without the need for mold-opening or core back.

In general microcellular foam injection molding (FIM) is an incredible technology used to compensate for many shortcomings of conventional injection molding (IM). With FIM, increasingly longer flow lengths and higher geometrical accuracies can be achieved without the need for high packing pressures. This means that inexpensive, lower tonnage machines are able to create large and complex products [8]. This can be attributed to the reduced melt viscosity due to plasticization and reduced warpage due to lower residual stresses. As previously mentioned, FIM products are also lighter and tougher which are vital for lightweighting and downgauging. Other FIM process savings are a result of shorter cycle times and decreased energy costs. Microcellular foams are typically described as having a cell density on the order of 10^9 cells/cm^3 and cell sizes less than 100 μm [6]. The void fraction of microcellular foams can range from 5 to 95% depending on the expansion ratio. With confined FIM, the void fraction is typically on the order of 5 to 30% [9].

In FIM, gas dosing is performed within the plasticization section of the screw for both plunger and reciprocal screw types of IM machines. In the gas metering section, high pressure (possibly supercritical) physical blowing agents are metered into the polymer melt. Through mixing and diffusion, the blowing agent is dissolved into the polymer melt to create a one phase, mixture, wherein no large gas pockets are present. At this point, macroscopically, the polymer and gas are a homogeneous mixture. The one-phase polymer and gas mixture is kept under high backpressure until it is shot into the mold. Depending on whether or not highpressure or low-pressure FIM is used, the majority of cell nucleation is triggered at different points and times. In low pressure (LP) FIM, a short shot of material is injected into the mold and no packing stage is present in the process. With the absence of packing, the overall system and injection pressures are lower. In LP-FIM, the majority of cell nucleation is due to pressure drop across the gate and cell expansion is expected to fully fill the mold cavity [10]. Typically, there is a higher void fraction and a nonuniform cell morphology along the machine or flow direction [9]. The cell morphology furthest from the injection location is coarser. In contrast, high pressure FIM is typically characterized with uniform cell morphology along the machine direction as a full shot is injected. Furthermore, a packing stage is often utilized as well. As such, the majority of the cell nucleation is expected to be during the cooling phase as contraction and possible crystallization generate voids. Typically, semicrystalline shrink around 2.5% [11], up to a maximum of 9%. However, it is rare to find FIM products with a high void fraction (> 25%) and large cavity thickness while maintaining uniform cellular morphology along the flow and the normal directions. Therefore, further understanding of how to create uniform samples is necessary.

Objectives

The objective of this study is to help understand the foaming mechanisms in thick part foam injection molding with a high void fraction. By using a relatively thicker cross-section mold, there are several significant differences from typical thin FIM. With an increase in product thickness, wall effects, namely shear, will be drastically reduced. Unfortunately, with an increase in product thickness, the uniformity of the final cellular

structure will decrease due to large temperature gradients. This work will attempt to clarify some of these issues. The mold temperature and injection speed will be varied to investigate their effects upon the cellular morphology, flow pattern and skin thickness.

Theoretical Background

It has been well documented that foaming processes such as injection molding, or extrusion, a higher pressure drop will result in greater cell nucleation. This is because the polymer, laden with a blowing agent, experiences a rapid thermodynamic instability. Prior to the pressure drop, the polymer and gas mixture exist in a, quasi-stable state with the gas fully dissolved into the polymer melt. With a sufficiently high pressure, the polymer and gas form a homogeneous, one-phase mixture. When the pressure decreases below the solubility pressure, the polymer melt can no longer contain the blowing agent gas, and nucleates gaseous cells as a secondary phase. During nucleation, there is competition between cell nucleation and growth. A faster pressure drop reduces the time available for gas to diffuse into nucleated cells; this reduces the time for cell growth and allows for more nucleation. Therefore, a faster thermodynamic instability should result in smaller and more numerous nucleated cells. Conversely, a slower thermodynamic instability will result in fewer nucleated cell which are grown to larger sizes [12].

Typically, the addition of a small shear or extensional forces on the polymer and gas mixture can aid in nucleating more cells. Local pressure variations are highly effective for lowering the free energy barrier to cell nucleation. However, during injection molding there is a large shearing stress/strain (higher than $10^3\ s^{-1}$) along the, mold wall. The shear deformation causes serious deterioration of the gate nucleated cellular structure. As cells are sheared, the thin cells walls easily rupture resulting in a lower cell density with higher cell sizes. Therefore, it is imperative to lower the shearing forces in injection molding while still maintaining a high pressure drop (flow rate) to achieve and sustain a higher cell density [13].

The cell density of the final cell morphology with respect to the unfoamed volume ($N_{unfoamed}$) is calculated from SEM micrographs by:

$$N_{unfoamed} = \left(\frac{n}{A}\right)^{1.5} \times \left(\frac{1}{1 - v.f.}\right) \qquad (1)$$

where η is the number of cells counted, A is the area, and $v.f.$ is the void fraction given by:

$$v.f._{set} = 1 - \frac{injection\ stroke}{full\ injection\ stroke} \qquad (2)$$

1

where Φ is the volume expansion ratio and $v.f._{local}$ is the true void fraction of the foam measured by the water displacement method.

Microcellular Foam Injection Molding of Thick Parts Continued

Materials

The material used in this experiment was a branched homopolymer polypropylene (Daploy WB140HMS) supplied by Borealis. WB140 is typically used for foaming applications and has higher melt strength to prevent cell coarsening. WB140 has a melt flow rate of 2.1 g/10 min (@ 230 °C, 2.16 kg) [14]. The typical melting point for WB140 is approximately 167.4 °C (DSC, 10 °C/min). Raps et al. have performed rheological measurements on WB140 with and without plasticizing gas (CO_2) [15]. It can be seen that WB140 has a generally higher zero shear viscosity indicative of its higher viscosity and infers its higher melt strength. The physical blowing agent was N_2 from Linde Gas.

Experimental

A 50-ton ARBURG ALLROUNDER 270C injection molding machine with a 30 mm reciprocating screw was used for FIM experiments. For blowing agent (N_2) dosing, a MuCell Trexel supercritical fluid delivery unit (Series II) is used.

A custom mold was manufactured and the overall part dimensions are shown in **Figure 1**. Overall, the final parts are 19 mm (3/4") in diameter with an outward draft angle of 0.59°. The final parts are 82.5 mm (3.25") in length. In this design, the flow length ratio is a paltry ~8.6 (82/9.5) compared to 40-100 and above which is typical for FIM.

A Dynisco pressure transducer (PT462E-M10) was mounted at the far end of the mold cavity. It is otherwise difficult to mount the pressure transducer elsewhere in the cylindrical mold cavity. The signal from the pressure transducer was captured in a *LabVIEW* program.

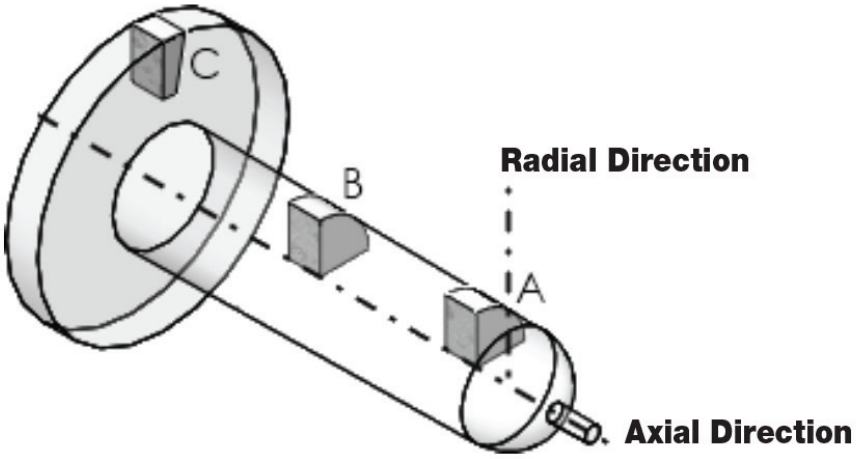

Figure 1: Part schematic and sample locations

To provide functionality similar to rapid heat cycle molding (RHCM) and to be able to quickly stabilize the foam samples, four cartridge heaters and four water cooling lines were installed. During benchmarking, it took 120 s to heat the mold to 100 °C and 80 s to cool back down to 20 °C. The cooling water lines were flushed by compressed air before each heating cycle. For each cycle, the mold was heated to the desired temperature and soaked to ensure temperature uniformity. After the melt was injected, the mold was water cooled to

Microcellular Foam Injection Molding of Thick Parts Continued

stabilize the sample. Without water cooling, 1) the cycle time will greatly increase, 2) significant cell growth can take place, or 3) the core of the part will remain too hot which warps the sample upon ejection.

Representative pressure curves are shown in **Figure 2**. Note that depending on the injection flow rate (5, 55 and 105 cm^3/s), the pressure monitored by the pressure sensor can be low due to the short shot. Given the pressure transducer placement at the end of the flow, it is difficult for pressure to rise as the melt must travel the length of the mold. In addition, with low-pressure, short shot FIM, the mold pressure is expected to be low. Finally, with a large mold thickness, the high injection pressure needed to push through thin sections is not present.

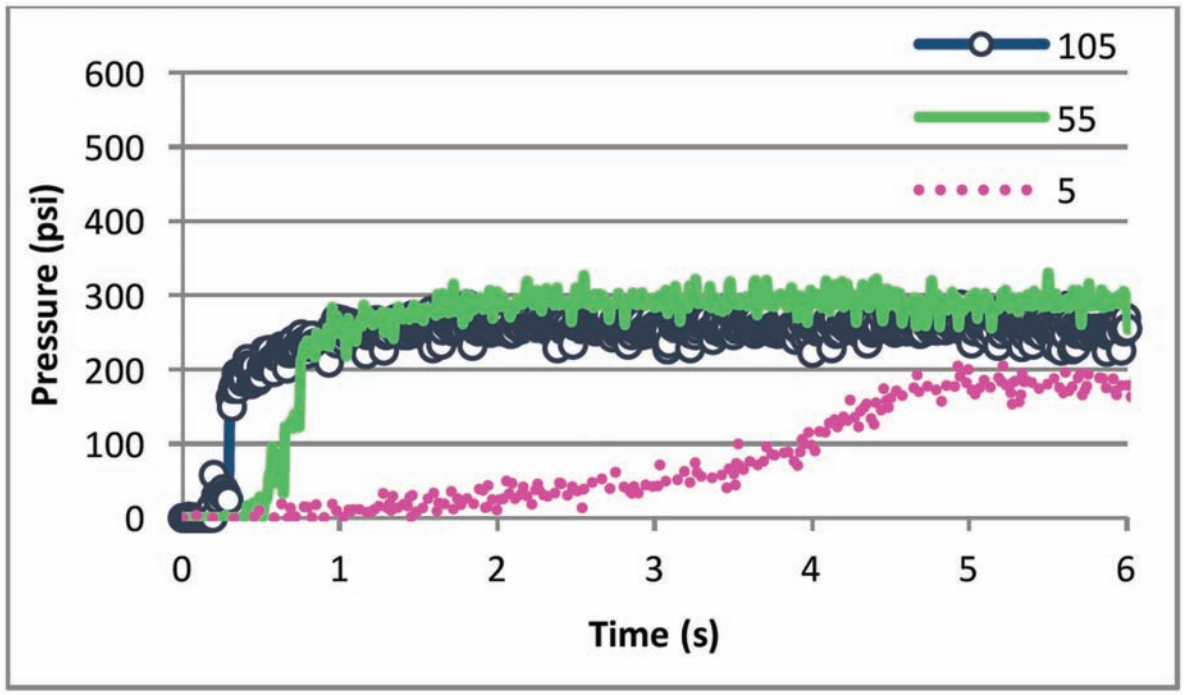

Figure 2: Cavity pressure.

The experimental conditions are described in **Table 1**.

Condition	Value	Unit
Melt temperature	190	°C
Mold temperature	40, 80, 100, 120	°C
Injection flow rate	5, 55, 105	cm^3/s
N_2 content	0.3	wt%
Set void fraction	25	%

Table 1: Experimental Conditions

These conditions were selected to observe their effect on cell uniformity and cellular structure in thick part FIM. The axial (machine) and radial (normal) directions were examined in three locations (A, B & C), as shown in **Figure 1**.

Microcellular Foam Injection Molding of Thick Parts Continued

The SEM micrographs were analyzed for the cellular morphology. Half round specimens were cut from the three locations of the solidified FIM part and cryofractured using liquid nitrogen. The fractured samples now expose the cellular morphology in the axial and radial flow directions. This can be difficult as the samples remain relatively thick, resulting in higher toughness. The SEM surface is then sputter coated with platinum and examined in an SEM (*JEOL6060*).

Results

Effect of the Injection Flow Rate

While maintaining a mold temperature of 40 °C and a set void fraction of 25%, FIM experiments with varying injection flow rate were carried out. The injection flow rate has a strong effect on the pressure and pressure drop the polymer and gas mixture experiences. By increasing the injection flow rate, a higher pressure drop rate is achieved. When the injection speed is increased from 5 cm^3/s to 105 cm^3/s there is a two order of magnitude increase in flow rate. **Figure 3** shows the SEM micrographs from the center and skin regions of samples at location B.

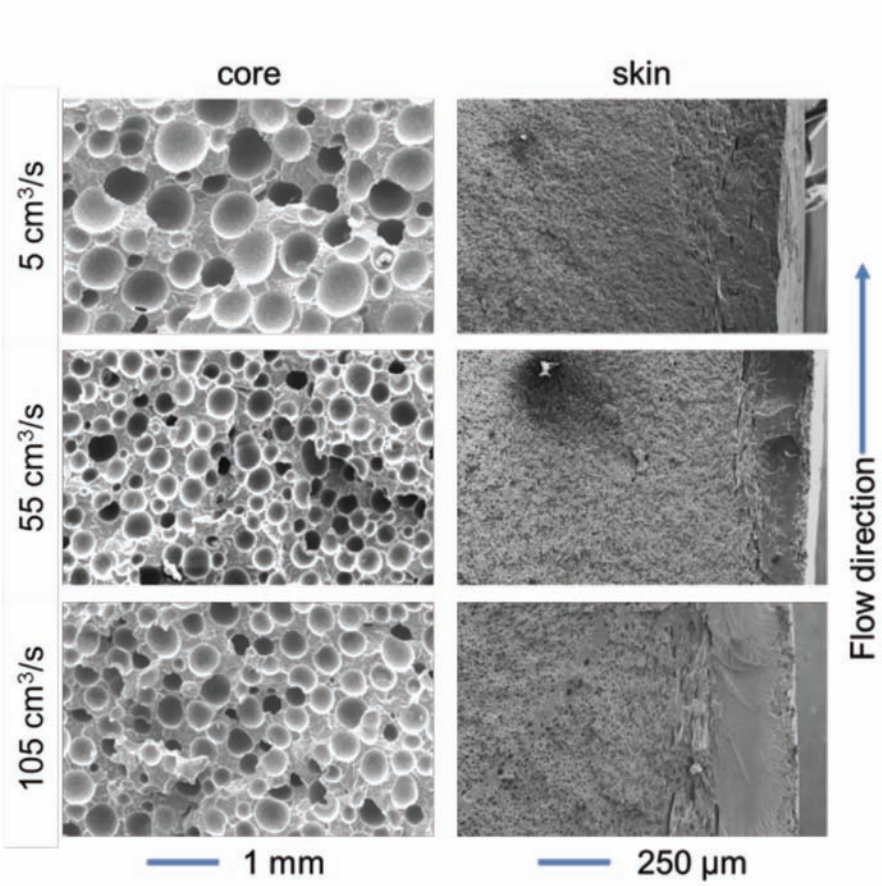

Figure 3: Cell morphology of skin and core regions.

From **Figure 3**, it is noticeable that all the cells are spherical in shape. This means that after cell nucleation at the gate, these cells do not experience a large amount of stress/strain. This may be due to the large cavity thickness which helps to reduce the shear experienced by the melt as it flows through the cavity. Furthermore, from **Figure 3**, it can be seen that the cell morphology becomes more refined (i.e. higher cell density) as the injection flow rate is increased.

Microcellular Foam Injection Molding of Thick Parts Continued

Given the nature of the large thickness mold, this process is fairly analogous to extrusion with a filamentary die. Therefore, it is possible to estimate the initial pressure drop rate by using [16]:

$$-\Delta P = 2m\frac{L}{R^{3n+1}}\left[\left(3+\frac{1}{n}\right)\frac{Q}{\pi}\right]^n \quad (4)$$

$$-\frac{\Delta P}{\Delta t} = 2m\frac{1}{R^{3n+3}}\left[\left(3+\frac{1}{n}\right)\frac{Q}{\pi}\right]^{n+1} \quad (5)$$

where ΔP is pressure drop, ΔP/Δt is pressure drop rate, m and n are from the power law, L and R are the channel dimensions, and Q is the volumetric flow rate. For simplicity, the sprue is modeled without the minor draft taper. The values used for these calculations are listed in **Table 2**, with m and n calculated from [15].

Parameter	Value	Unit
L	0.938	cm
R	0.099	cm
m	4355	Pa×s^n
n	0.464	-

Table 2: Pressure drop and drop rate parameters and

Q (cm³/s)	Δ*P* (MPa)	Δ*P*/Δ*P* (GPa)
5	-1.04	-0.04
55	-3.16	-1.50
105	-4.27	-3.86

Table 3: Calculated pressure drop and drop rate.

As seen in **Table 3**, with increasing injection flow rate, higher pressure drop and pressure drop rate are achieved. The cell densities can be found in **Figure 4**. With an increase of two orders of magnitude in the pressure drop rate, it should be understandable why there is an increase in the core cell morphology; yet, the cell density for 105 cm³/s is lower than 55 cm³/s.

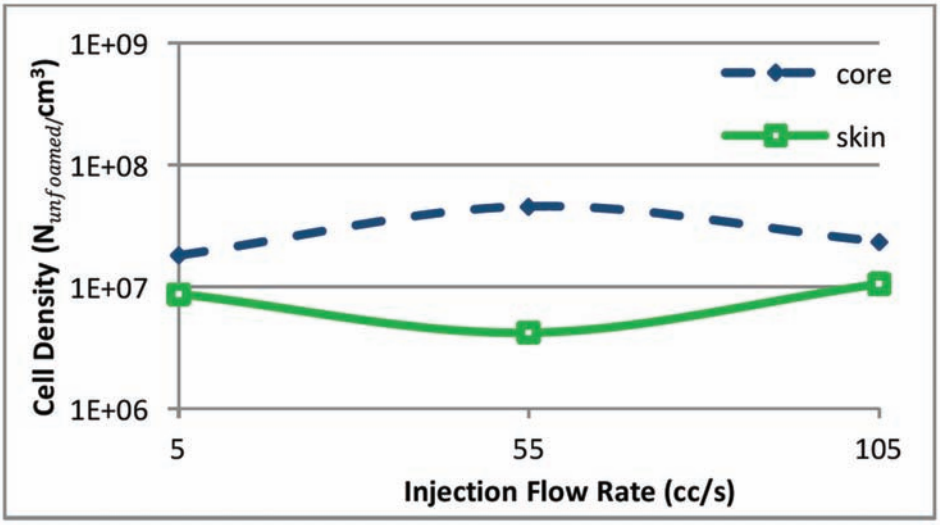

Figure 4: Cell density vs. injection flow rate.

Microcellular Foam Injection Molding of Thick Parts Continued

The injection flow rate also shows an effect on the skin thickness. In most FIM processes, the skin thickness will typically decrease with injection flow rate; longer injection time increases the cooling time. However, the initial analysis shows an opposing trend, where the skin thickness seems to increase with injection flow rate. To further clarify the skin thickness, a sample (from another set of experiments) was cut down the center, as seen in **Figure 5**. It appears that the flow within the mold may beunstable with something similar to tiger striping in the flow pattern. Other conditions exhibited more uniform flow patterns. However, further clarification of this phenomenon is required.

Figure 5: Cross-section of sample.

Effect of the Mold Temperature

For semi-crystalline thermoplastic materials such as the PP examined in this work, a change in mold temperature can potentially alter the cooling or crystallization kinetics. In addition, the mold temperature can affect the flow pattern during filling. To investigate this, the mold temperature was increased from 40 °C to 80 °C, 100 °C and 120 °C. The set void fraction and injection speed were fixed at of 25% and 105 cm^3/s, respectively. The cellular morphology can be seen in **Figure 6**. The cell density with respect to the unfoamed volume is shown in **Figure 7**.

From **Figure 7**, the cell density varies from the front of the flow (location A) to the back (location C). The cell density at the gate appears to be lower than the other regions. However, the expansion ratios of the samples are relatively similar, ranging between 1.40 to 1.43 (v.f.local of 29%). The results may be due to three pos-

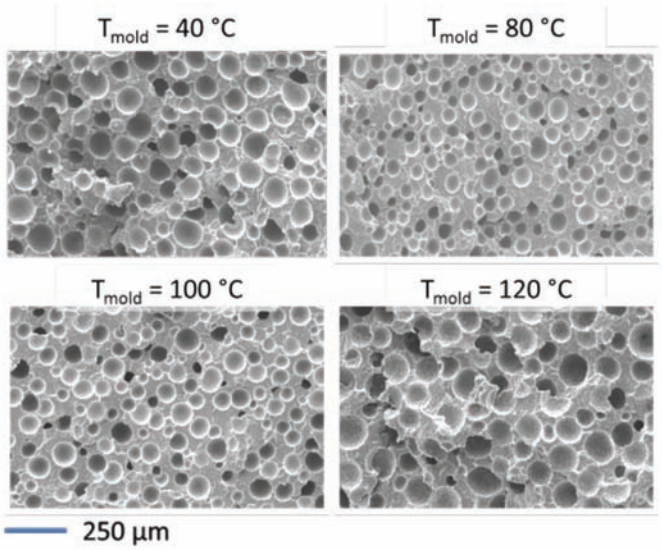

Figure 6: Cell morphology with increasing mold temperature.

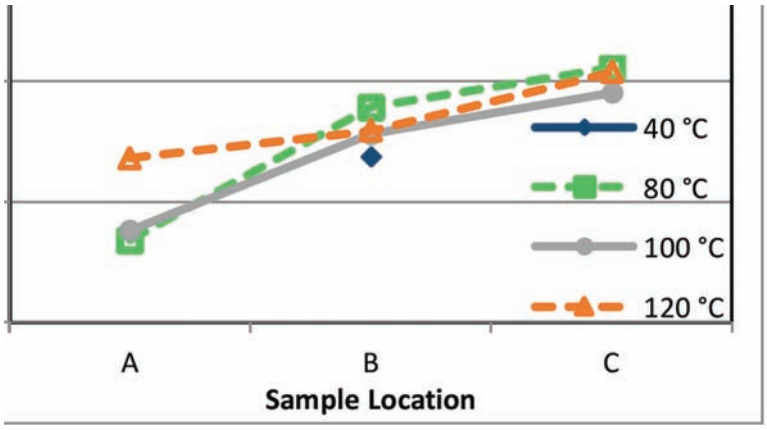

Figure 7: Cell density for each sample location.

Microcellular Foam Injection Molding of Thick Parts Continued

sible reasons: the pressure drop rate, pressure level or the mold temperature. During mold filling, the cavity pressure will increase due to the already injected material. Instead of injecting into ambient/atmospheric pressure ($\Delta P_2 = 0$), material injected near the end of the filling stage experiences a large amount of back pressure or resistance ($\Delta P_2 >> 0$). Therefore, the overall pressure drop rate and nucleation rate is lower. It may also be possible that similar pressure drop rates are experienced, but starting at different degrees of supersaturation. Another cause of decreased cell density may be due to a higher temperature near the front of the mold. Due to a large thickness, heat is easily retained within the center of the part for longer. This leads to polymer drool from the sprue if the nozzle is retracted. As such, the front of the mold experiences a higher temperature caused by direct nozzle contact. This allows for more time in which cells can grow or coalesce together.

With respect to the mold temperature, it appears the uniformity through the sample locations increased at a high mold temperature of 120 °C. The higher mold temperature allowed for easier filling with reduced shear along the wall. In addition at 120 °C, instead of a solid, impervious skin, a foamed skin was developed as seen in **Figure 8**. Due to the higher mold temperature, the gate nucleated cells were subject to less severe shearing and cooling along the mold wall. As a result, striated/elongated cells are visible inside the skin.

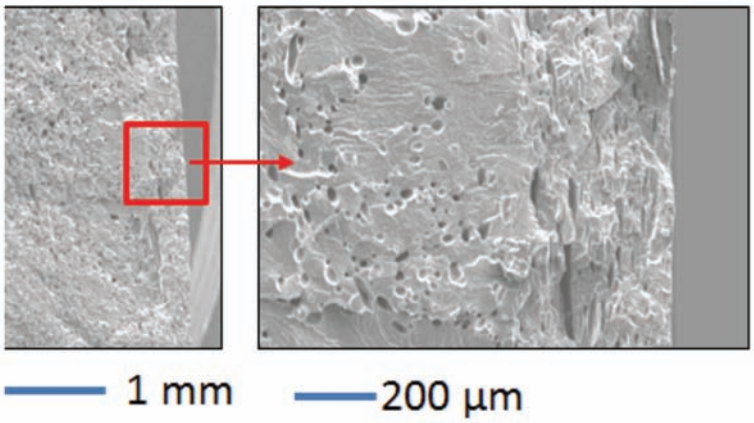

Figure 8: Foamed skin with temperature mold at 120 °C.

Conclusions

An injection mold with large cross-sectional thickness was successfully designed and created with integrated heating, cooling and pressure measurement. The cellular morphology of high void fraction samples was measured to observe the effects of injection flow rate and mold temperature. With increasing injection flow rate, the cellular morphology was refined with smaller cells and higher cell density. A higher pressure drop rate, related to the thermodynamic instability, was used to explain this phenomenon. The mold temperature appeared to provide a higher uniformity along the sample. It was also interesting to find a foamed skin at high mold temperature.

Acknowledgements

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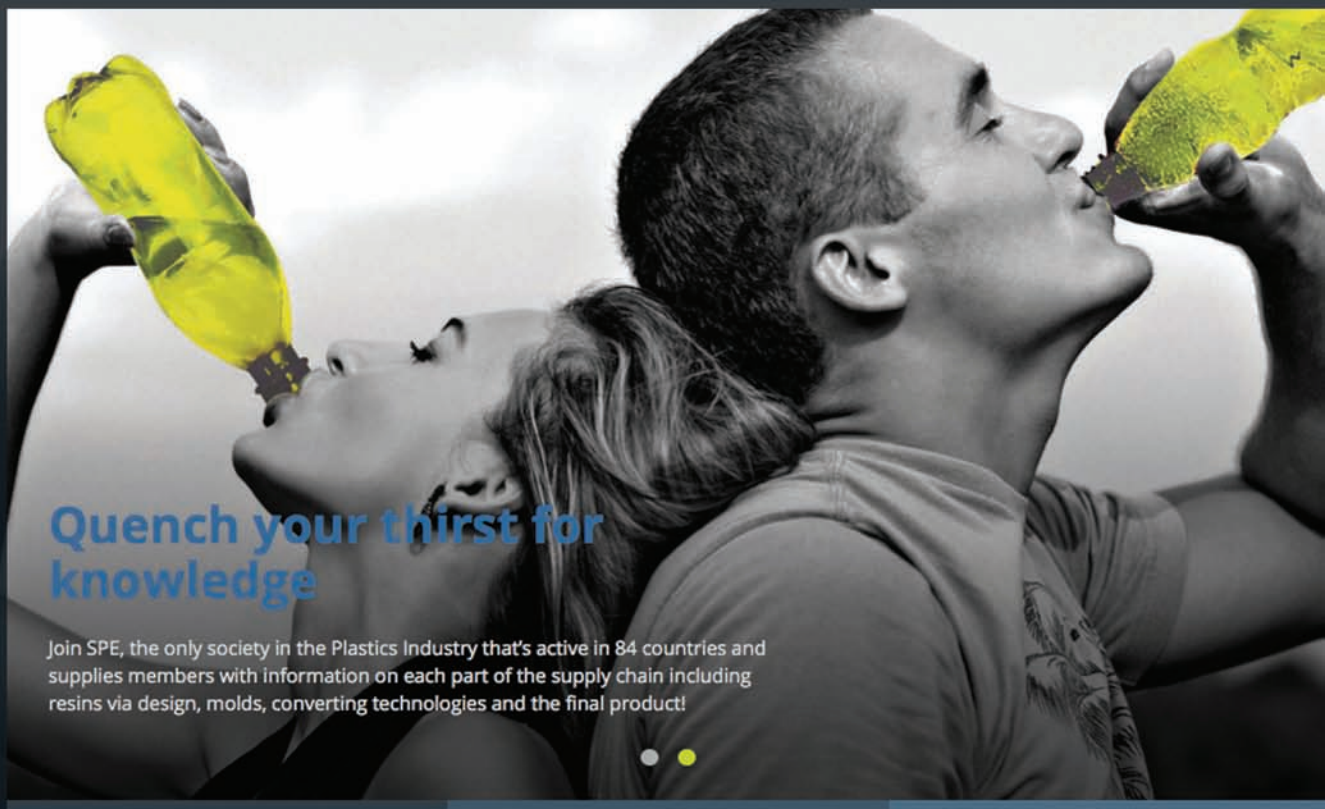

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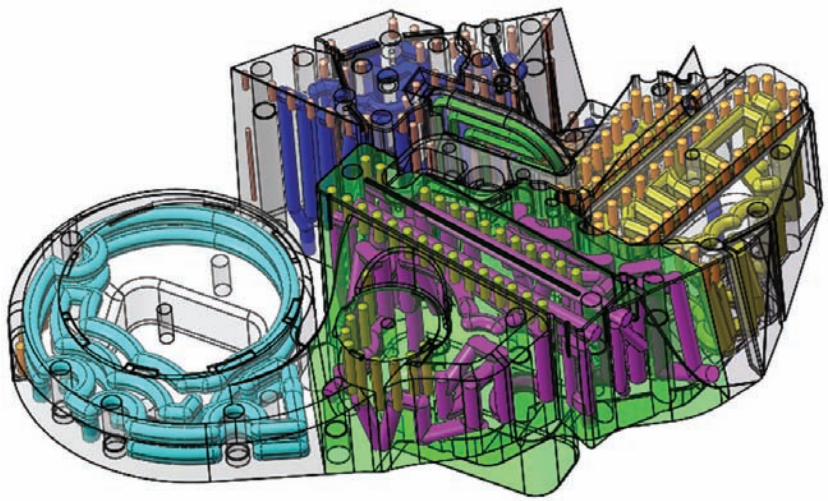
Conformal Cooling



The use of conformal cooled mold inserts are finally going mainstream. Conformal cooled mold inserts have been successfully manufactured in Europe for over 25 years. For 25 years, Europe has enjoyed molds that have reduced cycle time by 20% to 40%, reduced rejects and produced stronger parts because of reduced molded-in-stress.

Conformal cooled mold inserts have been a stealth technology. Every time a conformal cooled mold was built, everybody that anything to do with the project was (and still is) required to sign a Non-Disclosure agreement. This has given Europe a competitive financial advantage for a very long time.

The following representative products were made from vacuum brazed conformal cooled mold inserts:

- Automotive lift seat panel
- Blood transfusion filter
- Automotive B-pillar exterior trim
- Automotive center console
- Headlight bezel
- Automotive engine cover
- Automotive door panels
- Aerosol spray cap

and were successfully supplied to Europe's major automotive, medical and packaging companies, by Contura GmbH (Germany), and produced reduced manufacturing costs.

On May 16-17, the Conformal Cooling Conference will be held in Minneapolis, MN.

(www,ConformalCoolingConference.com)

Contura will be one of the speakers, coming from Europe, to share the applications and the results that they have had with their technology. For the first time ever in North America, Dr. Jan Pfieffer from PVA Lot - und Werkstofftechnik GmbH (Germany), will give a technical presentation on both vacuum brazing and diffusion bonding (which have been a very secretive technology till now) in regards to conformal cooled inserts. And 2 speakers from Poland will give presentations on a new diagnostic & maintenance machine for conformal

Conformal Cooling Continued

molds and another presentation on combining simulation techniques with thermovision

Millions of dollars are pouring into R&D for additive manufacturing processes. We're seeing the results of this research in the many companies that are building additive manufacturing machines. OEM's, molders and moldmakers now have many choices and methods for building conformal cooled molds.

Dr. Dan Thoma, Director of the Grainger Institute For Engineering, University of Wisconsin - Madison, will give a talk entitled "Metal Additive Manufacturing: Strengths, Weaknesses, & Opportunities"

However, taking on a project for building a conformal cooled mold, is like a three legged stool. The 1st leg is the design and simulation work, the 2nd leg is the manufacture of the mold inserts, and the 3rd leg is the running of the mold. The failure of any one leg, causes the project to fail. Simulation software only displays results for what the designer entered. To get the most out of the technology, the designer optimally would have a knowledge of Fluid Mechanics and Dynamic Heat Transfer, so that he would have the knowledge of cause and effect when he changed something. Conformal cooling has opened up the freedom of design that we never had before. The old rule of thumbs does not necessarily apply. Jeff Higgins from Moldflow will present the does and don'ts of designing for this technology.

The goal of this conference is to take the secrecy lid off of this technology in order to provide technology for our industry to compete on the global market. To continue the conversation, attend the Conformal Cooling Conference (www.ConformalCoolingConference.com) on May 16-17, in Minneapolis. 4 speakersm from Europe, 3 PhD's plus others to answer any and all questions.

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Feature

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Martin Dehnert, Robert Magerle, Chemnitz University of Technology Professorship of Chemical Physics, Chemnitz, Germany

Process-Integrated Printing Technology for Plastic Parts During Injection Molding

In-Mold technologies, such as In-Mold Labeling or In-Mold Decoration, have been used for several years for the process integrated decoration of plastic surfaces. The additional handling and transport processes cause consi-derable costs and are a big disadvantage. The new in-mold printing, a process integrated printing technology offers an alternative and enables the decoration of plastic parts during injection molding. Here, the image is pad printed onto the surface of the mold and then transferred to the surface of the plastic part during injection molding. The feasibility of this method is demonstrated on PP and a process related phenomena of the ink transfer and the ink adhesion are identified. The mold temperature is conside-red to be particularly critical. This is due to the fact that the temperature of the ink is affected by the mold tempe-rature and liquid ink is necessary for a transfer of the ink to the polymer surface. In this study the thermal situation at the ink-plastic interface as well as the microscopic structure of the ink-plastic-interface are investigated. The goal of this paper is to show the influence of process para-meters and conditions and their influence on the ink adhesion of printed motives

Introduction

Nowadays the end-users are setting higher standards for the plastic parts and their surface properties. Thereby the requirements to achieve more effective printing, paint-ing or coating of plastic parts are increasing. The printing of finished parts is a very popular way to increase the visual esthetics of the part for a relatively low cost. But often, except In-Mold Decoration or In-Mold Labelling [1, 2], printing of polymer parts takes place as an additional process. Because of the hydrophobic character of plastic parts, a pretreatment for activation of polymer surfaces is needed. This is currently achieved through flame, plasma or corona treatment. The functionalities introduced by oxidation improved bondability results from increased wettability, due to increased surface energy and interfacial diffusivity, caused by chain scission [3]. This surface treatment must occur immediately before plastic part will be printed. These types of surface functionalization repre-sent an additional step and cause higher costs for time, energy and equipment (handling, logistic).

The current study has been triggered by the need to reduce the number of process steps and surface functionalization during injection molding. Härtig et al. [4] and Kalinowska et. al [5, 6] developed in-mold printing,

Process-Integrated Printing Technology for Plastic Parts During IM Continued

where the entire decoration process is integrated into the injection molding cycle. The image is pad printed directly onto the surface of the injection mold, then the plastic melt is injected into the mold and during solidification, the ink is transferred from the mold surface to the plastic part. **Figure 1** shows a schematic sketch of the in-mold printing process.

It is therefore aimed to investigate possibilities and li-mits of a processing window. In view of the decoration mechanism that takes place during the injection molding, the variable process parameters were chosen. Further-more, the scientific background of an innovative approach of process integrated surface decoration during injection molding is investigated and its potential is explored.

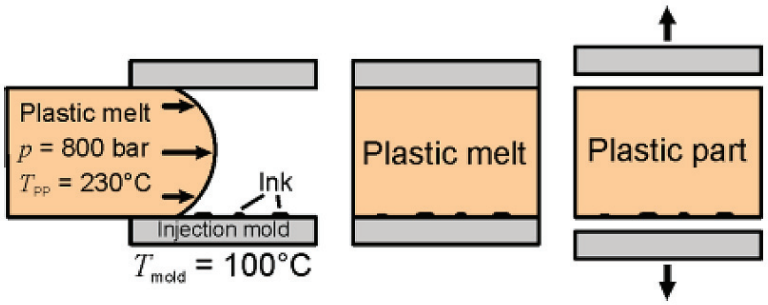


Figure 1: Principle of in-mold printing process.

Experimental

For the in-mold printing experiments polypropylene (PP Moplen 501 H, LyondellBasell Industries AF S.C.A) was used as thermoplastic material and PP plates ($60 \times 60 \times 2$ mm^3) were produced by injection molding with Arburg Allrounder 320 S injection molding machine (model: 500-150/60, Arburg GmbH & Co. KG). The injection molding machine was operated at various melt and mold temperatures. In this study the influence of injection molding parameters on ink transfer to the plastic part was examined and occurring phenomena were characterized. The influence of process parameter and conditions and their influence on the ink adhesion of printed motives are also investigated. The commercially available ink Nori-Prop N 948 (Pröll KG, Weißenburg i. Bay.) with 25 wt.-% thinner was used. NoriProp N 948 is an one-component ink suitable for untreated and pre-treated polypropylene. The experiments were also carried out with a self-developed pad printing machine. The employed cliché was an etched photo-polymer with a gravure depth of 25 µm.

After injection molding the in-mold decorated PPplates were examinated by means of polarizing microscope (Type: BX51, Olympus) and atomic force microscope (Type: NanoWizard II, JPK Instruments AG) to estimate a structure of surface layer of polypropylene. Also the structure of polypropylene under the ink layer and at the marginal side of the ink layer were investigated.

In addition to microstructural features of in-mold decorated samples the mechanical performance determined. Mechanical properties of in-mold decorated polypropylene samples were investigated by means of chemomechanical hand-abrasion test in according to DIN EN 60068-2-70 and to BMW Group Standard GS97034-1[7, 8]. In this test the continuous damage to a decorated surface by the human hand is simulated. To permit realistic chemo-mechanical testing the samples were moistened with testing fluid (artificial sweat according to DBL 7384). The testing parameters are shown in Appendix (**Table 2**).

Results

The temperature of the melt has enormous influence on the ink transfer, as shown in **Figure 2**. The temperature of the mold was increased continually. The specimens produced at standard injection molding parameters (Tmelt = 230°C, Tmold = 30°C, p = 350 bar) show that no ink transfer from the mold to polypropylene parts took place. First the temperature increase caused an ink transfer. At mold temperature of 100°C almost complete ink transfer with high replication of printed pattern took place. Only a thin layer of the contours remained on the mold wall (**Figure 2H**). This contours of the printed image dry on the fastest and contain less solvent than inside of the ink layer. The investigations show that this area of the dried paint adheres better to the mold so that these contours are not transferred to the plastic component and remain on the mold.

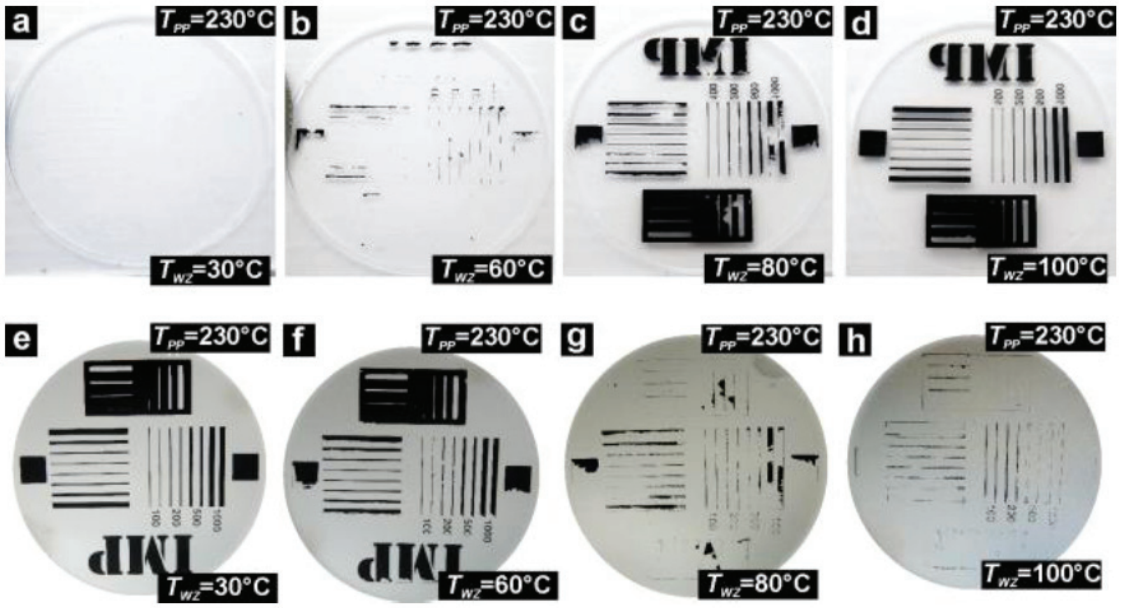


Figure 2: Photographs of the plastic part surface (a-d) and the injection mold surface (e-h) after part removal at different mold temperatures Tmold = 30-100°C and a constant plastic melt temperature TPP = 230°C

To check how the temperature of the plastic melt influences the temperature of the ink a Finite Element Model (FEM) simulation of the temperature distribution at the mold-ink-melt interface was conducted. **Figure 3** shows the temperature as function of the distance to the mold surface for several seconds after injecting of the thermoplastic melt. The model system consisted of a 20- µm-thick ink layer between two 3-mm-thick steel molds and a 2-mm-thick plastic melt. On the left side of **Figure 3**, the temperature of the melt was set to Tm(PP) = 230°C, the temperature of the steel and the ink to Tmold = 30°C and the temperature at the border of the simulation was hold at 30°C, which represents the cooling of the injection molding machine. This situation corresponds to the shown experiment in **Figure 2a and 2e**, where no satisfying ink transfer were observed. On the right side of **Figure 3** the mold temperature was changed to Tmold = 100°C. The temperature of the melt and the borders stayed constant. Parameters for the density ρ, the heat capacity C and the coefficient of heat conduction k were chosen for steel and polypropylene from [9, 10] are shown in **Table 1**.

Process-Integrated Printing Technology for Plastic Parts During IM Continued

Table 1. Parameters for the FEM-simulation [9].

Characteristic Value	Mold	Polypropylen/Ink
Density ρ [kg/m^3]	7854	905
Heat capacity C [J/kgK]	434	1930
Coefficient of heat conduction k [W/Km]	60	0, 24
Melting range of PP [°C]	-	165-175
Process parameters		
Melt temperature of PP T_m [°C]	-	230
Mold temperature T_{WZ} [°C]	30, 100	-

For the thermal properties of the ink, the same parameters as for polypropylene were taken. The ink is an unknown composition of polychlorinated polyolefins with different additives, but the thermal properties are in the same range as the properties for polypropylene [9]. The FEM was carried out in MATLAB 2007a PDE Toolbox. A simple model of heat transfer in equation 1 was used:

$$\rho C \frac{\partial T}{\partial t} - \nabla \cdot \left(k \nabla T \right) = 0 \qquad (1)$$

The determined melting temperature of the ink TMink = 80°C and the melting temperature of polypropylene TMPP = 183°C [11] are marked in the diagrams with dashed lines. The core temperature of the polymer TMAX, the ink temperature at the interface between the ink and the plastic melt TinkMAX, and the ink temperature at the interface between the ink and the mold TinkMIN are plotted for the different time steps in **Figure 3e and 3f**.

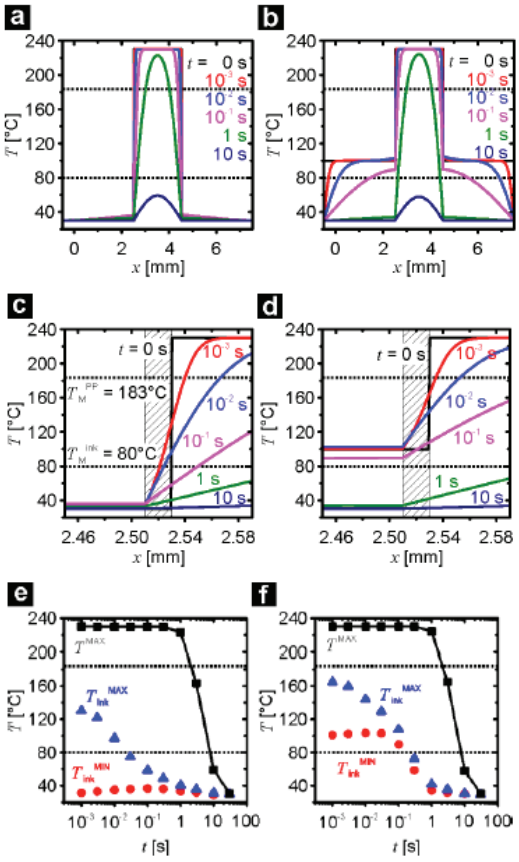


Figure 3:
Results of the FEM-simulation of the temperature distribution between plastic melt and the mold for different time's after injection molding.

Left: the mold temperature was set to 30°C and the mold walls were hold on 30°C.

Right: the mold temperature was set to 100°C and the boards were also hold on 30°C

Process-Integrated Printing Technology for Plastic Parts During IM Continued

For both initial temperature of the mold, the core temperatures TMAX reaches the melting point of polypropy-lene after 3 seconds and the thermoplastic become solid. The melt cools down in the same way, so we conclude that the melt temperature is not the key parameter for a satisfying ink transfer. At a mold temperature of Tmold = 30°C, the temperature TinkMAX on the ink-melt-interface is after 0.03 seconds under the melting point of the ink. At the mold-ink-interface, the temperature TinkMIN are always lower than 37°C. This has no influence on the nanomechanical properties (**as shown in Figure 1b-Appendix)**. The heat is faster transferred through the ink and the steel mold that the hot melt cannot heat up the ink over the melting point. With a starting mold temperature of Tmold = 100°C, the ink is at the injection of the melt above its melting point. The ink solidifies after 0.3 seconds and after 1 second, the ink and the thermoplastic have the same temperatures as with the lower starting temperature. The ink has to transfer from the mold to the melt before one second is over. The adhesion between melt and ink have to be greater in the liquid state than the adhesion between mold and ink. That the temperature of the ink is for short times higher than the mold temperature could be an explanation for the observed beginning ink transfer at 60°C mold temperature in **Figure 2H**.

Morphological Characterization

In the present work sections of in-mold decorated samples of PP were examinated by means of polarizing microscope. This arrangement has been visualized for both systems, where the ink was backmolded in wet and dried condition. In dried samples, microscopic investigations show a variance of optical properties of the surface layer (**Figure 4**). The ink layer is situated at the polymer surface. At the same time (during cooling phase by injection molding) this ink layer stopped a formation of amorphous frozen layer. It can be concluded that the ink layer has a function of thermal isolator. This ink layer originate, that the thermal energy from the plastic melt cannot be easily led away. In the effect the polymer under the ink layer cools slower as polymer at marginal side of ink layer, where the amorphous layer can be observed.

Figure 4:
Surface layer of in-mold decorated polypropy-lene. Ink layer backmolded in dried condition. Research in transmitted and polarized light.

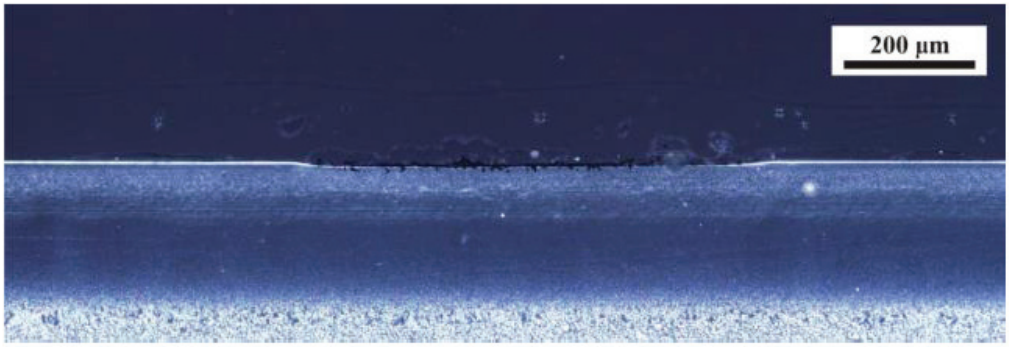
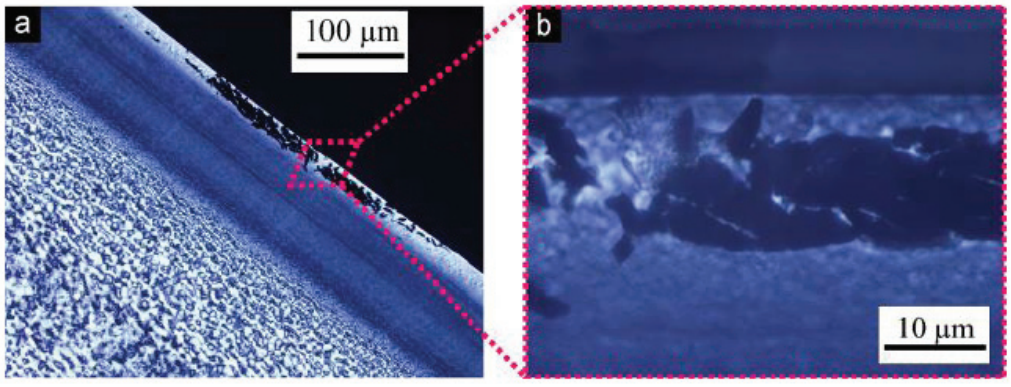


Figure 5:
Surface layer of in-mold decorated polypropylene. Ink layer backmolded in wet condition. Research in transmitted and polarized light.



Process-Integrated Printing Technology for Plastic Parts During IM Continued

Backmolding with rapid cooling system of freshly printed ink layer leads to another result, shown in **Figure 5**. In-mold printed ink layer is completely enclosed in the surface layer of polymer. Ink layer is well recognizably. The surface layer of polymer remains in the same state, marginal surface layer and decorated surface layer are the same.

Moreover, the thin section of the interface between the ink and plastic in the cross section by means of scanning force microscopy was studied. The microstructure of the interface between ink and plastic (**Figure 6**) shows dark domains (ink retention) in the polypropylene approximately 100 nm. This indicates that at this interface deformation of the ink through flowing melt takes place and the ink components diffuse inside the plastic. It also can be clearly seen that there is a segregation of ink and plastic melt. The shape of the interface is not flat or smooth, which is a further indication that the ink melts and de-forms when it comes in contact with the plastic melt. The diffusion of components of ink in the polypropylene as well as the expansion and integration of the interface between ink and plastic is an important contribution for the good ink adhesion by in-mold decorated samples.

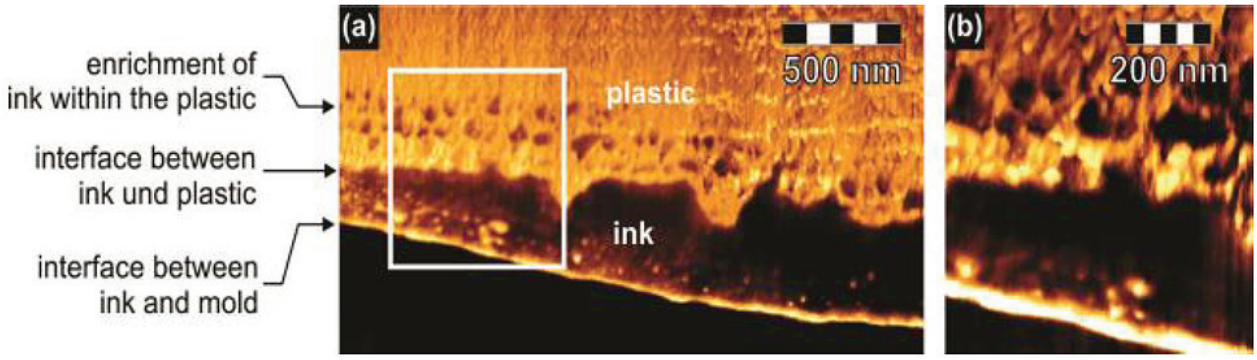


Figure 6: Phase images made by atomic force microscopy of ink-polymer-interface. Dark domains are ink retention in polypropylene.

Mechanical Properties

Figure 7 shows the results of hand-abrasion test. For the first test the in-mold decorated specimens with previously dried ink patterns were used. After 60 cycles on the fabric and a sample were no traces visible. First visible traces and a discoloration on the fabric were visible after 2,000 cycles. After 4,000 cycles the test was canceled due to the clear abrasion of the ink from polypropylene.

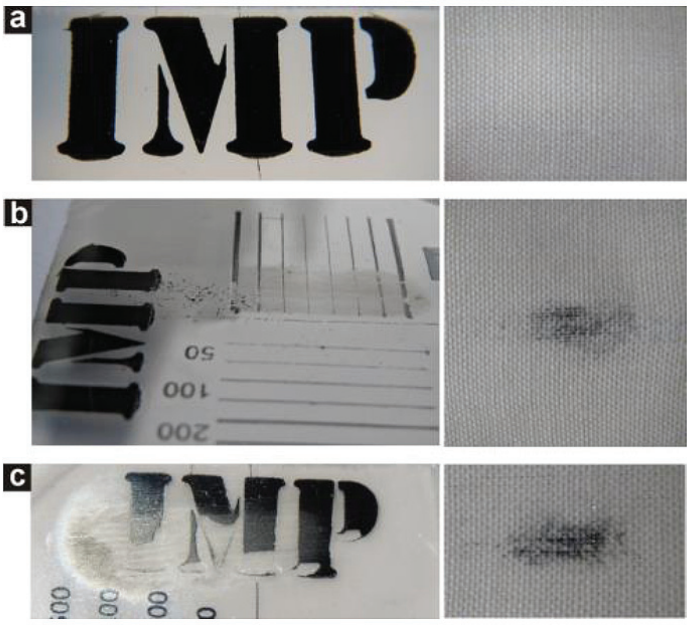


Figure 7:
In-mold decorated specimen and correlatively fabrics after chemo-mechanical abrasion test: a) after 60 cycles (without testing fluid), b) after 2,000 cycles (without testing fluid), c) after 4,000 cycles (without test-ing fluid)

Process-Integrated Printing Technology for Plastic Parts During IM Continued

In-mold decorated specimens, which the ink was just printed onto the mold wall and backmolded, were also in-vestigated. In this case, because the ink layer is enclosed in polymer, even after 4,000 cycles no defects were visible (**Figure 8**).

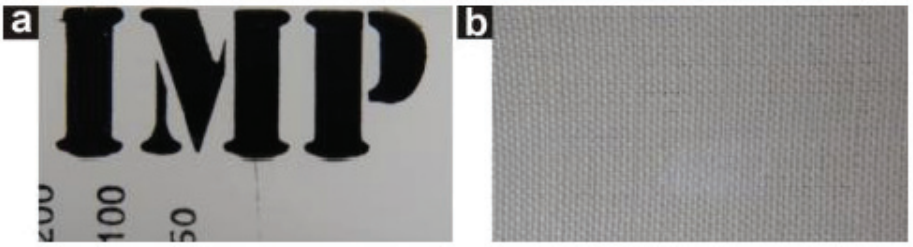


Figure 8: In-mold decorated specimen and correlatively fabrics after chemo-mechanical abrasion test: a) after 4,000 cycles (without testing fluid).

Remarkable is the fact that all of the samples passed the chemo-mechanical abrasion test with testing fluid. There were no disruptive arte-facts in the ink layer. After all tests (after 60; 2,000 and 4,000 cycles) the specimens were functional and no traces were visible. The structure of the specimens after the test was still unchanged.

Discussion

The adhesion between ink and the polymer is the key property for a satisfying ink transfer. The most important process parameter is the temperature of the mold surface. The mold temperature has influence on the ink transfer, whether it is incomplete, where only the shape of the ink is molded into the polymer, a complete ink transfer but with the contours of the image, or a complete transfer of the ink together with an undisturbed image. Between 80°C and 100°C of mold wall, promising results were achieved.

The adhesion between the ink and the polymer is not the problem, if the ink is heated, but the adhesion between the ink and the injection mold appears to be too strong. To improve the in-mold printing process, this adhesion has to be smaller.

Finally, the experiments show that the ink layer have an influence on the morphological structure of polymer directly under the ink layer. A surface layer under the ink is different as a surface at the marginal side of the ink layer. A special process control during in-mold printing enables fully embedding of the ink layer in the polymer. Such complete encapsulation of the ink induced at the same time higher mechanical properties of the decorated parts.

In-mold decorated polypropylene parts fulfilled the industrial standards for functional and non-functional decorated plastic strips. This new decoration technique can be an alternative solution for industrial applications.

Conclusions

In-Mold Printing is a new manufacturing technique which enables decoration of plastic parts already during injection molding. This method does not need post-processing steps for industrial applications. First the image is printed onto the mold surface and then transferred to the surface of the produced part during injection molding. The present research focuses on identifying, investigating and tailoring the technological as well as physico-chemical processes during ink transfer.

An application of in-mold printing to nonpolar polyolefins was currently investigated and the results are presented. The printed image was successfully transferred to polypropylene parts during injection molding. The temperature of the injection mold seems to be a key parameter for satisfying ink transfer. This is due to the fact that the temperature of the ink is affected by the mold temperature and liquid ink is necessary for a good transfer of the ink to the polymer surface. Furthermore, backmolding of direct-ly printed ink pattern

Process-Integrated Printing Technology for Plastic Parts During IM Continued

allows the complete ink transfer as well. At the same time better mechanical properties of decorated areas are guaranteed.

The phenomena of in-mold printing were investigated with surface analysis methods like optical microscopy and atomic force microscopy as well as mechanical properties to define the adhesion of the ink on polymer substrate.

With the knowledge of the process control and result-ing properties of the parts we improved the in-mold print-ing process for polypropylene, which is an important polymer for industrial applications.

Acknowledgements

We would like to acknowledge the Deutsche For-schungsgemeinschaft (DFG) for financial support of this project (GE 627/8-1, HU 811/12-1, MA 1744/6-1) and the company Pröll KG for providing inks.

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Appendix

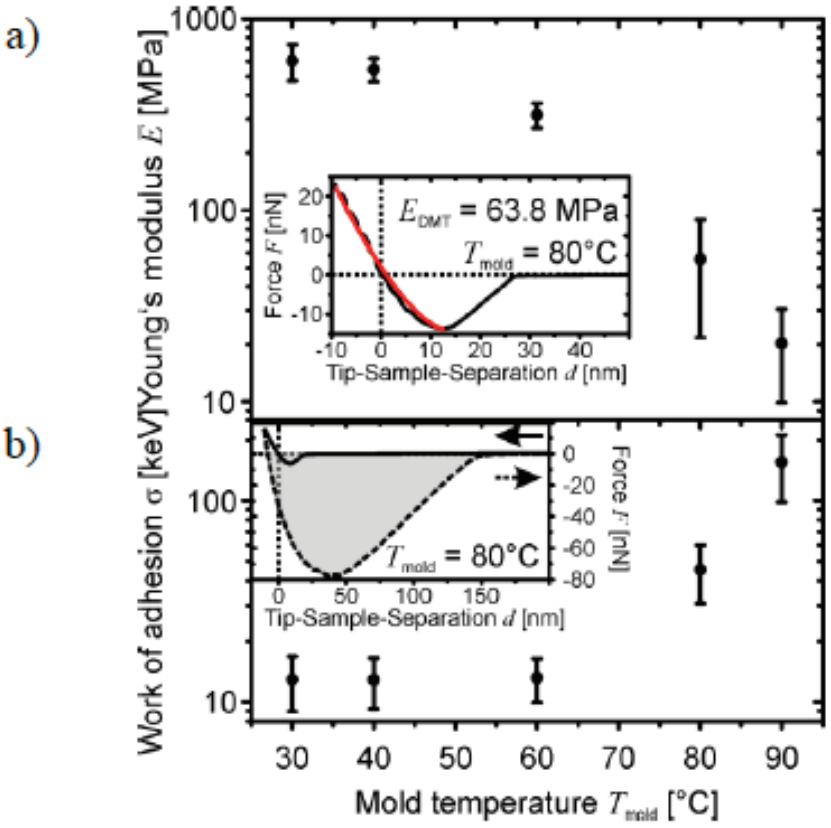

Figure 1: Young's modulus and work of adhesion of the ink at different temperatures: (top) An example of one force-distance-curve for a mold temperature of 80°C. The red curve is the fit for the young's modulus with DMT-contact-model. Young's modulus of the ink on the mold surface at different mold temperatures. Error bars represent the standard deviation of the distribution of the young's moduli. (bottom) Mean force-distance-curve for a mold temperature of 80°C. Work of adhesion at different mold temperatures.

Table 2: Testing parameters for hand-abrasion test according to GS 97034-1:2012-02.

Plastic Part	Test Travel [mm]	Test Speed [mm/s]	Fabric Feed [s/stroke]	Testing Fluid —	Test Force [N]	Number of Strokes —
Instrument panel	4060	None	Dry	10	60	
Non-functional decorative strips (Cockpit, door)	1060	None	Dry	10	60	
Functional decorative strips (door pull handle)	10	60	0.3/1000	Dry	10	4,000
	10	60	0.3/1000	Artificial Sweat	10	1,000

IMD Board of Directors Meeting

February 3, 2017

Tupperware Worldwide Headquarters located in Orlando, FL

Submitted by David Okonski

Welcome & Opening Remarks – Raymond McKee, Division Chair

Chair Raymond (Ray) McKee called the meeting to order at 9:00 AM and welcomed all attendees to the Winter IMD Board Meeting. Ray informed the attendees that we are dealing with a very full agenda and charged Secretary David Okonski to keep the meeting on schedule; the secretary called roll at 9:05 AM.

Roll Call – David Okonski, Secretary

Present in person were:

Jeremy Dworshak (Chair-Elect), Erik Foltz, Brad Johnson, Pete Grelle (Technical Director), Adam Kramschuster, David Kusuma, Joseph Lawrence, Ray McKee (Division Chair), Susan Montgomery (Councilor), Lynzie Nebel, David Okonski (Secretary), Sriraj Patel, Hoa Pham, Srikanth Pilla (ANTEC 2017 TPC), Rick Puglielli, Tom Turng, Jim Wenskus (Treasurer), on Ratzlaff (Invited Guest), Kathy Schacht (Invited Guest), and Chad Ulven (Invited Guest).

Present via teleconference were:

Vikram Bhargava, Nick Fountas, Kishor Mehta, Larry Schmidt, and Russel Broome (Invited Guest).

The participation of the official IMD Board Members constituted a quorum.

Absent were:

Jack Dispenza.

Notes:

1) New board member Lynzie Nebel and invited guests Kathy Schacht, Jon Ratzlaff, and Chad Ulven introduced themselves to the IMD Board of Directors.
2) Secretary David Okonski informed the Chair that Jack Dispenza is on track to not fulfill his "three meeting obligation" in the 2016 and 2017 calendar years so as to remain an active IMD Board Member.

Action Item: Board Member Jeremy Dworshak is to contact Jack Dispenza to ascertain his intentions with regards to remaining on the IMD Board of Directors.

Approval of the October 2nd, 2016 Meeting Minutes

The meeting minutes from the IMD Board Meeting of October 2nd, 2016 were presented.

Motion: Pete Grelle moved that the October 2nd, 2016 meeting minutes be approved as written and distributed. Jeremy Dworshak seconded, and the motion passed.

IMD Board of Directors Meeting Continued

Financial Report – Jim Wenskus, Treasurer

For the current 2016/2017 fiscal year, total revenue presently exceeds total expenses by $6,994.70 USD eaving a remaining positive balance of $47,936.31 USD. The 2017/2018 proposed/working balance sheet line items were reviewed and budget allocated based on historical data. As of this meeting, the Division appears to be in good financial standing.

Carry Over Action Item: At an upcoming meeting, the IMD Board needs to further discuss, establish, and implement a reimbursement policy (including the necessity of a trip report) for conference expenses incurred by IMD Board members who attend a conference and spend time marketing the Division for the purpose of generating membership.

Action Item: Chair Ray McKee would like the IMD Officers to meet in the near-term to discuss the Division's revenue streams.

ANTEC 2017 TPC Update – Srikanth Pilla, TPC

Srikanth Pilla informed the Board that the ANTEC 2017 paper review occurred on February 2nd just prior to the February 3rd IMD Board Meeting. In general, the paper quality was better this year than last. Forty-seven papers were received, and the ANTEC 2017 session matrix is complete. Srikanth called for session moderators, and all sessions were quickly staffed. The winners of the "Best Paper Award" were Jeremy Dworshak and Chad Ulven – Congratulations !!

Regarding the ANTEC 2017 IMD Networking Reception, Rick Puglielli (Reception Chair) submitted our request to the Hilton Anaheim for a ballroom capable of handling 300 attendees. David Okonski (Sponsorship Chair) is actively seeking sponsors.

Carry Over Action Item: Pete Grelle is to review and evaluate the use of eTouches for the purpose of reviewing papers.

Technical Director Report – Pete Grelle, Technical Director

With the ANTEC 2017 paper review being conducted only one day prior to this board meeting, Technical Director Pete Grelle elected to postpone any discussion of paper statistics to our next meeting which will take place at ANTEC 2017. Pete then proceeded to provide an update on IMD involvement in future TOPCONS as well as the fate of the IMD webinar series. Regarding TOPCONS, the IMD will once again provide technical content to the SPE Automotive Division & Detroit Section AutoEPCON Conference to be held on May 2, 2017; the conference theme is "Plastics on the Move", and Pete called on the board to submit content. The IMD will receive a share of the conference profits for our participation. Pete also informed the Board that the IMD will once again participate as a sponsor of the Penn State Erie TOPCON – "Innovations & Emerging Plastics Technologies Conference" – to be held in Erie, Pennsylvania on June 22nd & 23rd, 2017.

Regarding webinars, the IMD webinar series has been a challenge to kick-off; apparently, webinars must now be sponsored or the host division must pay a fee. Pete is still working out the details as to how and when. The planned series consists of three webinars. IMD Board member Vikram Bhargava will be presenting two webinars: "New Process Technologies" and "Material Selection for Injection Molding." The final webinar will

IMD Board of Directors Meeting Continued

most likely be "Troubleshooting the Injection Molding Process" presented by Division friend and supporter Jon Ratzlaff.

At this time, Pete yielded the floor to SPE Managing Director Russell Broome. Russell asked the IMD Board of Directors to consider creating and staffing the "SPE Injection Molding Pavilion" at NPE 2018. The purpose of the pavilion would be to highlight process innovations taking place within the industry. Board members agreed that this would be of interest, and Chair Ray McKee elected to table the request for further discussion at the next board meeting.

The floor was then yielded to David Okonski, Acting Chair of the SPE Injection Molding Conference (IM-TECH) 2017, who informed the IMD Board of Directors of the plans for the latest SPE conference offering. Headquarters asked the Executive Officers of the IMD to establish a full three day conference for about 300 attendees that would highlight the technical innovations happening within our industry, and the Executive Officers agreed. The first conference will take place on August 1st through 3rd, 2017 at the Chicago Marriott Oak Brook Property. The conference organizational chart and agenda were presented as well as the plans for registration fees and sponsorship packages. The news was well received. Time to get going !!!!

Communications Committee Report – Rick Puglielli, Chair & Adam Kramschuster, Co-Chair

Communications Chair Rick Puglielli submitted the IMD application for the Communications Award to SPE Headquarters.

Newsletter (Rick Puglielli): Rick Puglielli informed the Board that newsletter editor Heidi Jensen needs our Spring Newsletter content submitted by mid-February.

Website (Adam Kramschuster): Adam Kramschuster informed the Board that all requested changes to the IMD website have been completed. Adam also expressed concern over our current limitations in creating web content and suggested that it may be time to hire an outside vendor to takeover and manage the IMD website; this topic was tabled for further discussion at our next board meeting.

Membership Report – Erik Foltz, Chair

Erik Foltz informed the Board that current membership stands at 2,369 which is 94 down from our year ago number of 2,463. Division demographics still indicate that the majority of our members come from: 1) universities/academia and 2) material suppliers. We have many members between the ages of 40 to 80 years, but there is a dramatic drop-off in membership below the age of 40. We have a high turnover rate with many letting their membership lapse because their employer is no longer reimbursing the dues payment or they have left the plastics industry altogether. The new membership tool/software available from Headquarters appears to deliver more demographic information than what was available in the past and could be of use to the IMD as we development our own membership campaign. Erik would like to pursue several initiatives in 2017 that would be useful in generating membership and helping new members; these would include: 1) testimonials that show our diversity and 2) update our new member welcoming email to include more specifics about what our Division offers and possibly include a contact/ambassador.

Other items of note: An increase in membership dues occurred – a "Professional Membership" will now cost you $155 USD. Erik also indicated that Headquarters is planning a focused membership campaign for the IMD in 2017; we will need to supply Headquarters with a bullet list of whys – i.e.; why join the Injection Molding Division of SPE.

IMD Board of Directors Meeting Continued

Nominations Committee Report – Hoa Pham, Chair

Hoa Pham provided the following information regarding the 2017 IMD Officer Positions –

Current IMD Board Officers with terms ending at ANTEC 2017 & the 2017 Nominees are:

1)	Chair:	Raymond McKee	Nominee for 2017:	Jeremy Dworshak
2)	Chair-Elect:	Jeremy Dworshak	Nominee for 2017:	Srikanth Pilla
3)	Treasurer:	Jim Wenskus	Nominee for 2017:	Jim Wenskus
4)	Technical Director:	Pete Grelle	Nominee for 2017:	Pete Grelle
5)	Secretary:	David Okonski	Nominee for 2017:	David Okonski

Motion: Hoa Pham moved that the 2017 nominees for the Division Officer Positions be accepted. David Okonski seconded, and the motion passed.

Motion: David Okonski moved that if Jeremy Dworshak is unable to fulfill his duties as Division Chair due to potential commitments to the SPE Governing Body, then current Chair Raymond (Ray) McKee would serve a second term as Division Chair. Adam Kramschuster seconded, and, the motion passed.

Hoa Pham provided the following information regarding the IMD Board members that are up for general election in 2017:

1) Jack Dispenza
2) Brad Johnson
3) Susan Montgomery
4) Hoa Pham
5) Vikram Bhargava
6) Joseph Lawrence
7) Sriraj Patel
8) Lynzie Nebel

Motion: Hoa Pham moved that the nominees for the general ballot be accepted. Pete Grelle seconded, and the motion passed.

Note: All Board Members up for general election in 2017 must submit their biography to Hoa Pham by March 1st, 2017.

Hoa finished by confirming the following information for the ANTEC Technical Program Chair (TPC):

1) ANTEC 2017 TPC is Srikanth Pilla,
2) ANTEC 2018 TPC is Rick Puglielli,
3) ANTEC 2019 TPC is David Kusuma,
4) ANTEC 2020 TPC is David Okonski,

Hoa issued a "Call for Volunteers for TPC Chair" for ANTEC 2021 and beyond.

IMD Board of Directors Meeting Continued

HSM & Fellows Update & Awards Committee Report – Tom Turng & Kishor Mehta, Chairs

HSM & Fellows Update (Tom Turng): Tom Turng informed the Board that no IMD Fellow and Honored Service Member applicants were accepted this year; the "Call for Applicants" has already been issued for next year.

Engineer of the Year Award (Kishor Mehta): David Okonski was selected as the IMD "Engineer of the Year"; the award is to be presented at the ANTEC 2017 IMD Networking Reception – Congratulations !!

Education Committee Report – Srikanth Pilla, Chair

No education report/update was provided.

Councilor Report – Susan Montgomery, Councilor (additional content provided by Jeremy Dworshak & Kathy Schacht)

Susan Montgomery reminded the Board that the Executive Committee becomes the Governing Body at ANTEC 2017. The Governing Body will consist of a Treasurer, the Chief Staff Executive plus ten other positions; two of the ten will be filled by progression, six will be voted on by Council, and the remaining two voted on by the membership at large. The Council will retain the full control of a simplified set of bylaws, and Council has veto power to overturn Governing Body actions. Our own Jeremy Dworshak is running for election to the Governing Body – the position of Vice President, Treasurer. Elections to be held just prior to ANTEC 2017.

Other items of note: 1) Society CEO Willem De Vos has resigned – his resignation takes effect at ANTEC 2017, 2) there is a search for a new CEO happening now, 3) Society membership continues its downward trend – Russell Broome introduced a new membership tool, the Membership Dashboard, and 4) with membership down, the Society is not making its budget targets for membership (and overall sponsorship in general) – membership drives are planned for 2017.

Pinnacle Award Application – Discussion of 2017 Goals & Work Plan – Jeremy Dworshak

Chair-Elect Jeremy Dworshak completed the Pinnacle Award Application and submitted to SPE Headquarters. The Goals & Workplan was updated to reflect our current direction with the assistance of Raymond McKee, David Okonski, Erik Foltz, and Rick Puglielli. Jeremy Dworshak offered many THANKS to those who participated. Jeremy also informed the Board that a new awards structure was to be rolled-out at ANTEC 2017; in the future, the Pinnacle and Communications Excellence Awards may not be given at ANTEC.

Old Business – Ray McKee, Division Chair

With regards to IMD Outreach, discussion focused on how best the IMD could support the SPE Foundation.

Action Item: David Okonski is to contact Eve Vitale, SPE Foundation Director, and solicit her opinion as to how best the IMD can support the SPE Foundation.

Carry Over Action Item: In the 2017 calendar year, the Board needs to amend our bylaws to include a Sponsorship Committee.

IMD Board of Directors Meeting Continued

New Business & Round Table – Ray McKee, Division Chair

Chair Ray McKee appointed invited guest Chad Ulven to a one year term on the IMD Board of Directors. Invited Guest Jon Ratzlaff informed the Board that his successful Injection Molding Troubleshooting Guide was being turned in to a mobile app. Jon invited the Board to review its content when the app is available and participate in the launch as a means to generate revenue for the Division. No other board member raised any additional new business or round table items for discussion.

Adjournment – Ray McKee, Division Chair

Motion: Ray McKee moved to adjourn the meeting. David Okonski seconded, and the motion passed. The meeting was adjourned at 3:30 PM Eastern Standard Time (EST).

The next meeting will be held during ANTEC 2017 on May 7th, 2017 at the Hilton Anaheim.

Hilton Anaheim, 777 Convention Way, Anaheim, California 92802
Meeting Room: TBD

Respectfully Submitted by Secretary David Okonski
March 10th, 2017

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Society of Plastics Engineers **INJECTION MOLDING DIVISION**

IM SPE TECH 2017

INJECTION MOLDING

SPONSOR OPPORTUNITIES

August 1 -3, 2017 Chicago Marriott Oak Brook, Oak Brook, IL

Diamond $5,000

Must sponsor lunch or reception on Tuesday or Wednesday

Includes: 15 pre-paid admissions plus 2 exhibit staff passes
- Exhibit Space – preferential location and size
- Banner ad on conference app & website recognition
- All media and promotional coverage

Sapphire $3,500

Includes: 5 pre-paid admissions + 2 exhibit staff passes
- Exhibit Space
- $500 credit if sponsor a breakfast or a break
- Banner ad on conference app
- All media and promotional coverage

Ruby $6,500

Includes: 10 pre-paid admissions + 2 exhibit staff passes
- Exhibit Space – preferential location
- $1,000 credit if sponsor a breakfast or a break
- Banner ad on conference app
- All media and promotional coverage

Emerald $2,000

Includes: 2 pre-paid admissions
- $250 credit if sponsor a breakfast or a break
- Banner ad on conference app
- All media and promotional coverage

Other Sponsorship Options

Special sponsor recognition poster/signage

Breakfast $3,000
- Choose display on: Tuesday, 8/1, Wednesday, 8/2 or Thursday, 8/3

AM Break $2,000
- Choose display on: Tuesday, 8/1, Wednesday, 8/2 or Thursday, 8/3

Other Promotional Item Options

Badge Lanyard	$500
Note Pads with Logo	$500
Pens / Pencils	$300
Hotel Room Key Advertisement	$500
Flash Stick with Logo	$500
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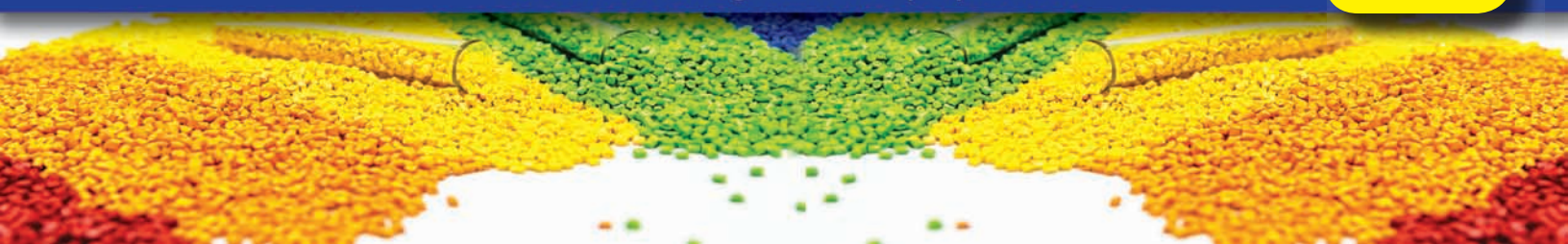
For more information or to sign up for a sign up program contact David A. Okonski
David.A.Okonski@gm.com Tel.: (248) 521-9101

Click for more information or to sign up



IMD New Members

The Injection Molding Division welcomes 69 new members…

Thomas Garman,The Ames Companies, Inc.
Anastasia Massey, North Carolina A&T State University
Matthew Toms, REXNORD
John Cadotte, Corning, Inc.
David Holcomb, Shawnee State University
Lekeem McDouga, North Carolina A&T State University
Joseph Serel, Sun Plastech Inc
Gian Riccadonna
Montrell Parker, North Carolina A&T State University
Edwin Tam, Teknor Apex Company
Bill Goralski
Rachael Cuthbertson, AGC Automotive Americas
Michael Cradic, Eastman Specialty Plastics
Don Dillon, Mettler-Toledo Rainin llc
Blake Copley, Shawnee State University
Danny Burnette, North Carolina A&TState University
James Soule, University of Massachusetts Lowell
Anthony Girgenti, Baxter Enterprises
Sua Kim, SONGWON Industrial., Ltd
Bon Gi Gu, NARA Mold&Die Co., Ltd.
Joseph Faiso, North Carolina A&T State University
Richard Nathan, RTC Industries
Annie Gohn, Penn State Erie, The Behrend College
Timothy Vander Kooi, Fordham Plastics
Yaneck Simon, PolyOne
Christopher Parikh, Adtec Colorant Corporation
Joseph Lawrence, University of Toledo
LeDaniel Brown, North Carolina A&T State University
Gregory Kenneally, East Coast Dyes
Doug Dolan, 3D Systems/Quickparts
Robert Madden, Shawnee State University
Alyssa Arend, Cummins Emission Solutions
Kenny Pravitz, Elite Plastics
Kendell-Edward McGee, North Carolina A&T State University
Shulong Li, Milliken and Company
Kevin Vasilakos, Corning Inc.
Volker Plehn, Toray Resin Company
Tino MEYER, Loughborough University
Lauren HULETT, FBD - Frozen Beverage Dispensers
Muhammad Ali, North Carolina A&T State University
Keith Shanter, John Deere
Demitri Shotwell, UW-Madison
Gaston Astoul, Plastimec S.A.
Sara Desai, Rutgers University
Caleb Roof, Shawnee Sate Univeristy
Michael Elwell, Aliaxis R & D
Tom Knight, AST Technology - S9108
Geoffrey Brooks, Flex-N-Gate
Ricardo Pena, PTM - Plasticos Tecnicos Mexicanos
David Spriggs, Shawnee State University
Pattabi Doraiswamy, Watchfire Signs
Johnathan Haines, Shawneee state university
Raghu Vadlamudi, Donatelle
Nathan Renwald, Brandt Technologies, LLC
Craig Watson, TrendPac
Nicholas Ercolani, Pittsburg State
Avdheesh Goel, UMass Lowell
Peter Friddle, Progressive Components International Corporation
Zeke Kljucaric, Penn State Behrend
Richard Kuhr, Richard Kuhr Consulting and Training
Christopher Butler, Rochester Institute of Technology
Samuel Dix, Trexel Inc
Keith Bagley, Ritus Corporation
Douglas Bosch, Channel Prime Alliance
Kirby Crutchfield, North Carolina A&T State University
Treveon Harris, North Carolina A&T State University
Samuel Touroonjian, DOMO Engineering Plastics
Angela Rodenburgh, Ladder Up
Dominique Parrish, North Carolina A&T State University

Society of Plastics Engineers
6 Berkshire Blvd., Suite 306
Bethel, CT 06801-1065 USA

Membership Application

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ACCT #70841841 IBAN #GB03MIDL40051570841841 SWIFT CODE #MIDLGB22 SORT CODE #400515

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☐ Automotive - D31
☐ Blow Molding - D30
☐ Color & Appearance - D21
☐ Composites - D39
☐ Decorating & Assembly - D34
☐ Electrical & Electronic - D24
☐ Engineering Properties Structure - D26
☐ European Medical Polymers - D46
☐ European Thermoforming - D43
☐ Extrusion - D22
☐ Flexible Packaging - D44
☐ Injection Molding - D23
☐ Medical Plastics - 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
☐ Thermoplastic Materials & Foams - D29
☐ Thermoset - D28
☐ Vinyl Plastics - D27

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☐ Australia-New Zealand
☐ Benelux
☐ Brazil
☐ California-Golden Gate
☐ California-Southern California
☐ Caribbean
☐ Carolinas
☐ Central Europe
☐ Colorado-Rocky Mountain
☐ Connecticut
☐ Eastern New England
☐ Florida-Cental Florida
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☐ France
☐ Hong Kong
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☐ Indiana-Central Indiana
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☐ Kansas City
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☐ Ohio-Cleveland
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☐ Oklahoma
☐ Ontario
☐ Oregon-Columbia River
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☐ Southeastern New England
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☐ Taiwan
☐ Tennessee-Smoky Mountain
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☐ Texas-Lower Rio Grande Valley
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☐ Utah-Great Salt Lake
☐ Virginia
☐ Washington-Pacific Northwest
☐ West Virginia-Southeastern Ohio
☐ Western New England
☐ Wisconsin-Milwaukee

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☐ Alloys and Blends - 010
☐ Applied Rheology - 013
☐ Bioplastics - 028
☐ Composites Europe - 026
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☐ Failure Analysis & Prevention - 002
☐ Joining of Plastics & Composites - 012
☐ Marketing & Management - 029
☐ Nano/Micro Molding - 023
☐ Non-Halogen Flame Retardant Tech. - 030
☐ Plastic Pipe & Fittings - 021
☐ Plastics Educators - 018
☐ Plastic in Building and Construction - 027
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INTRO-JL

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Message from the Publisher

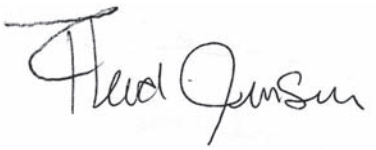
Hello members!

Now that Spring is here it's time to gear up for some very exciting and informative shows. ANTEC held on May 8-10, 2017 at the Hilton Anaheim will be presenting IMD technical program and our annual networking reception.

Coming in August 1 - 3, 2017 is the first IMTech show in Chicago, IL. This show features technical sessions, plant tours, networking reception plus industry exhibits. Mark your calendar and save the date! More updates on this event will be featured on the SPE website and IM facebook page.

Our next newsletter will be the Summer edition. Anyone who would like to participage with articles or sponsors please let us know! The IM Newsletter is always seeking information and support by readers to share with fellow members.

Thank you to all the authors and sponsors for their continued support.



Heidi Jensen PublisherIMDNewsletter@gmail.com

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