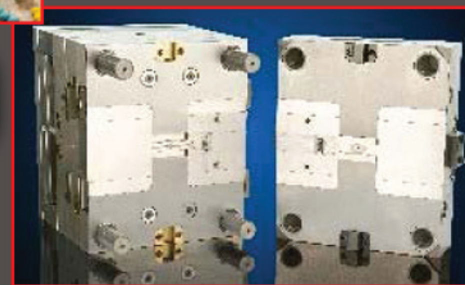
Summer 2013 | No. 93



MOLDING VIEWS

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

In This Issue:

This Month's Features:

Chair's Message

Encouraging Signs and Moving Forward!

Dear Members,

This April, SPE held its annual technical conference (ANTEC) in Cincinnati, Ohio. While in attendance I was encouraged by the quality of the papers and the overall attendance of the conference. The Injection Molding Division (IMD) organized 10 sessions over the three-day conference that highlighted new technologies in the areas of materials, tooling, processing, and simulation. While the main topics of interest have not changed significantly from past years, I did notice two growing trends. The first is the increased number of papers co-authored between industry and academia. Several collaborative papers were presented on injection-molding simulation validation, and microcellular injection molding. These two technologies seem to be exciting technologies that are pushing the plastics industry forward

Chair's Message Continued

and are helping engage the next generation of plastic professionals. The second trend is the increased presence of tutorial sessions at the conference. Several of the divisions, including Injection Molding, dedicated Tuesday afternoon to presenting several one-hour tutorials on topics ranging from failure analysis and prevention to setting up an injection molding process. The injection molding tutorials were well attended by both students and plastic professionals. During these tutorials the discussions that developed and passing of knowledge between these two groups was an encouraging sign for the future of our industry.

These two trends also highlighted the mission of the Injection Molding Division — to help educate the membership and help grow the industry to a viable future. While I firmly believe that ANTEC is the best place to remain informed on the newest technologies in plastics and build a professional network, I also understand that it is not feasible for all to attend this conference. Our out-going chair, Susan Montgomery, and technical Director, Peter Grelle, have also recognized this and are currently developing a series of one-hour webinars where the membership will learn about new technologies and industry trends. These webinars are a great way to learn about relevant new technologies that can improve job performance. They are also an avenue to professional networking. The current board is also actively planning several smaller topical conferences (TOPCON) in Chicago, and China that will highlight industry trends in the medical plastics industries.

I must extend a great amount of gratitude to our out-going chair, Susan Montgomery, for having the vision and drive to get many of these new value-added initiatives started. As your current division chair, I will continue the work Susan started and further build on these programs. I encourage you to participate as your input and ideas will only enhance this project. 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 IMD.

Best Regards,

Erik Foltz
Chair, IMD Board of Directors

Industry Events Calendar

Click the show links for more information on these events!

September 2013

9-12: Thermoforming 2013 Conference®
Renaissance Atlanta Waverly Hotel and Cobb Galleria Centre
www.expologic.com

22-24: CAD RETEC® 2013
Color Comes Alive
Baltmore Marriott Waterfront
Baltimore, MD
http://www.specad.org/index.php?navid=149

October 2013

6-9: Automotive TPO® 2013 Conference
Detroit-Troy Marriott Hotel
Troy, MI
www.4spe.org

7-9: Blow Molding® 2013 Conference
Crowne Plaza Atlanta Perimeter at Ravinia
Atlanta, GA
www.4spe.org

8-10: FlexPackCon™ 2013
Westford Regency Inn and Conference Center
Westford, MA (greater Boston area)
http://www.flexpackcon.co/Home_Page.html

21-23: Vinyltec® 2013
PVC Processing and Additives
Renaissance Woodbridge Hotel
Iselin, NJ
www.4spe.org

16-23: Kunststoffen (K) 2013
Messe Dusseldorf GmbH
Messe Dusseldorf, Germany
http://www.k-online.de

November 2013

18-19: Understanding Extrusion Seminar
Sheraton Sand Key Resort
Clearwater Beach, FL
www.rauwendaal.com

18-19: Troubleshooting Extrusion Seminar
Sheraton Sand Key Resort
Clearwater Beach, FL
www.rauwendaal.com

SPE Medical Plastics Division and Chicago & Milwaukee Sections Present MEDICAL PLASTICS MINITEC 2013

Society of Plastics Engineers

Technology Advances in Plastic Materials and Processing for Medical Devices

Monday, September 9, 2013

Holiday Inn Gurnee
6161 West Grand Ave
Gurnee, IL 60031

Schedule of Events:

7am – 8am
Registration & Continental Breakfast

8am – 9pm (all day & evening)
Tabletop Exhibition

8am – 5pm
All Day MiniTec
(Lunch and Breaks Included)

5pm – 6pm
Reception & Networking

6pm – 9pm
Dinner & Keynote Speaker

Register to Attend:
Early Registration before July 22

MiniTec Only:	$125
MiniTec and Dinner:	$150
Dinner Only:	$35

Late Registration after July 22

MiniTec Only:	$150
MiniTec and Dinner:	$175
Dinner Only:	$35

Info & Online Registration:
http://tinyurl.com/medicalminitec

Contact Information:
Kimberly Rush
Phone: 224-659-0708
E-mail: cspeef@gmail.com

A one day conference where 14 presentations from the industry will discuss the latest developments in the area of medical plastics.

Morning Session on New Materials

High Performance Polymers
Maureen Reitman – Exponent

Silicone Biomaterial Applications: Past, Present and Future
Alexis Proper – PolyOne Corporation

Specialty Polymer Solutions for a Changing Healthcare Landscape
Dane Waund – Solvay Specialty Polymers

PEEK in Medical Implant Applications
Kenneth Ross – Evonik Cyro

Morning Break

PET: A Sustainable Material for Medical Packaging Applications
Scott Steele – Plastics Technologies Inc.

Fluoropolymers in Healthcare Applications
John Felton – Daikin – America

Polycarbonate Resins for Medical Applications: Today and Tomorrow
Pierre Moulinie – Bayer Material Science LLC

A Multi-pronged Approach to Meeting HAI Challenges with Specialty Engineered Thermoplastics
Lynn Collucci Mizenko/Manish Nandi – SABIC

Lunch

Afternoon Session on New Processing Technologies

Exciting, New Extruded Tubing Materials for Medical Applications
Ed Boarini – Teleflex Medical OEM

Advantages of Co-extrusion for Use in Medical Tubing
Tom Thompson – Teel Plastics

Openair® Plasma Improves Adhesion of LSR to Medical Grade Polymer Substrate Materials
Jeff Leighty – Plasmatreat

Afternoon Break

Why Your Perfect Mold and Process Produces Imperfect Parts
Kevin Rottinghaus – Beaumont

Advanced Process Controls for Injection Molding
Susan Montgomery – Priamus Systems
Umberto Catignani – Orbital Plastics

Seeing Beyond the Surface: How CT Scanning Redefines Industrial Metrology
Jennifer Raymond/Tom Casali – NyproMold, Inc.

Q & A Discussion *program subject to change

Reception and Dinner with Keynote Speaker – Steve Goreham

TABLETOP EXHIBITOR OPPORTUNITIES AVAILABLE
Showcase Your Company

- Early registration before July 22 - $450, after July 22 - $500
- Registration includes 2 admissions
- Company Name Recognition published in promotions and on event signage!
- Booth Setup 7am-8am; requests for electricity accepted

SPONSOR OPPORTUNITIES AVAILABLE – CHOOSE YOUR LEVEL:
Company Name Recognition published in promotions and displayed on signage!

Corporate: $1000 (includes 2 admissions)
Lunch Sponsor: $500 (2 available)
Breakfast Sponsor: $400 (2 available)
Reception Sponsor: $300 (2 available)
Break Sponsor: $100 (5 available)

SPE Medical Plastics Division and Chicago & Milwaukee Sections Present MEDICAL PLASTICS MINITEC 2013

Society of Plastics Engineers

Technology Advances in Plastic Materials and Processing for Medical Devices

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5pm – 6pm
Reception & Networking

6pm – 9pm
Dinner & Keynote Speaker

A one day conference where 14 presentations from the industry will discuss topics relating to trends, performance materials, application testing and latest developments in the area of medical plastics. Engineers and management personnel will benefit by attending this MiniTec!

Special Hotel Accommodations at the Holiday Inn Gurnee

- **Room Rate: $99**
- **Contact hotel directly at 847-336-6300**
- **Mention *MEDICAL PLASTICS MINITEC 2013* for special rate**

Dinner with Keynote Speaker Steve Goreham

Environmental Researcher & Author of *The Mad, Mad, Mad World of Climatism*

www.heartland.org/steve-goreham

For more information and to register online:
http://tinyurl.com/medicalminitec

Registration Form

Early Registration before July 22			Late Registration after July 22			Sponsorship Opportunities		
MiniTec Only:	$ 125	☐	MiniTec Only:	$ 150	☐	Corporate:	$ 1000	☐
MiniTec and Dinner:	$ 150	☐	MiniTec and Dinner:	$ 175	☐	Lunch:	$ 500	☐
Dinner Only:	$ 35	☐	Dinner Only:	$ 35	☐	Breakfast:	$ 400	☐
Tabletop Exhibit:	$ 450	☐	Tabletop Exhibit:	$ 500	☐	Reception:	$ 300	☐
						Break:	$100	☐

Mail to: Attn. Kimberly Rush, Polyform Products Company, 1901 Estes Avenue, Elk Grove Village, IL 60007
Check payable to: SPE Chicago Email with credit card information to: cspeef@gmail.com

☐ Please charge my Credit Card **$**______________ ☐ Enclosed is my Check for **$**______________

Card #:*(AmEx/Visa/MC)* ____________________ Exp. Date: _______/________

Authorized Signature: ____________________ Security Code: ______________

Name: ____________________

Company: ____________________

Address: ____________________

City/State/Zip: ____________________

Phone: ____________________ Fax: ____________________

Email: *(please print legibly)* ____________________

Questions? Contact Kimberly Rush at 224-659-0708 or Email: cspeef@gmail.com

Webinars

BE UP-TO-DATE WITH THE LATEST INFORMATION.
VISIT OUR WEBINARS.

Click title to view: Top 11 Things Every Molder Should Know About a Molding Job

Click to view: Additive Manufacturing - Injection Molding and Steel Stamping

Presenter: Jason Reznar, Senior Product Develpment Engineer, Rayce Americas Inc.

Synopsis: There has been little to no discussion in the industry about using low-cost machines to manufacture production quality parts. In this two-part webinar, injection molding with a low-cost additive manufacturing machine, as well as utilizing additive manufacturing to create steel stamping tools, will be discussed. For injection molding, Rayce Americas sought to determine the capabilities and limitations of this low-cost machine. For steel stamping, again Rayce Americas wanted to determine the capabilities and limitation of creating tools from a low-cost machine as well as a high-end machine.

Click title to view:

Plastic Failure Analysis Part 2: Introduction to Plastic Component Failure Analysis

(YOU MUST BE AN SME MEMBER TO VIEW THIS CONTENT.)

Presenter: Jeffrey A. Jansen, Senior Managing Engineer and Partner, The Madison Group

Synopsis: In this webinar, the most efficient and effective approach to determining plastic component failure will be discussed. The information presented in this session will assist engineers, scientists, technicians and managers who design, fabricate and manufacture plastic components; enable attendees to more quickly respond to and resolve plastic component failure; provide knowledge that will allow attendees to work more effectively and efficiently with internal or external testing laboratories in the analysis of plastic part failures; and allow participants to gain a better understanding on why plastic components fail, and how to avoid future failures by applying the knowledge learned.

Click title to view:

Plastic Failure Analysis (2/05/13) Title: Part 1: Introduction to Plastic Failure Analysis

(YOU MUST BE AN SME MEMBER TO VIEW THIS CONTENT.)

Presenter: Jeffrey Jansen, Senior Managing Engineer, The Madison Group

Synopsis: The information presented in this session will help a wide range of engineers, scientists, technicians and managers who design, fabricate and manufacture plastic components. After attending, participants should be able to more quickly respond to and resolve plastic component failure.

Injection Molding Question From WPD, Reston VA:

How can I determine the difference in stiffness between steel and the polycarbonate replacement?

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 in process of designing a replacement product for my company. My goal is to not only cost-reduce the product, but to improve corrosion resistance caused by moisture collection. I'm researching replacing a steel component with plastic. My concern with a direct plastics substitution is that of equivalent stiffness. How can I determine the difference in stiffness between steel and the polycarbonate replacement?**

A: When replacing a steel component with plastics you should look to incorporate ribs and structural geometry into the design. Flat plastic parts tend to bend, flex and warp with little stress. The strategic placement of ribs, crowns and curvatures will significantly increase the stiffness of a component.

Checking my reference books I find a reference to equivalent thickness that will be of interest to you. In a design manual from Dow Plastics, they say: In a replacement of a metal part with a thermoplastic "…the new part often needs to have the same stiffness as the old one." "Essentially, that means making sure that the new part, when subjected to the same load, will have the same deflection as the old part."

Dow goes on to say: "Deflection in bending is proportional 1/EI (E = modulus and I = moment of inertia), and I is proportional to t_3 (t = thickness).

Ask the Experts: Bob Dealey Continued

Then the formula for the equivalent thickness of a flat thermoplastic part can be calculated.

$$t_2 = t_1 \sqrt[3]{E_1/E_2}$$

Where:

t_1 = Thickness of old material
t_2 = Thickness of new material
E_1 = Flexural Modulus of material being replaced
E_2 = Flexural Modulus or Creep Modulus of thermoplastic replacement

A check is to calculate on the basis of the cube root of the ratio of the moduli of the two materials, or:

$$t_2 = t_1 \times TCF$$

Where: TCF for steel is 1.00, Polycarbonate is 1.44.
Good luck on your project.

INJECTION MOLDING Fundamentals©

Short Course

October 28 - 30 2013

Michaels at Shoreline
Mountain View, CA

Presented by:
Lawrence R. Schmidt
LR Schmidt Associates
Schenectady, NY

Sponsored by:
Golden Gate Polymer Forum

Golden Gate Polymer Forum

An in-depth understanding of the basic principles of the injection molding process

Day 1 October 28
Basic Principles and Critical Design Parameters of the Injection Molding Process

Day 2 October 29
Fundamental Relationships Between Flow, Structure and Properties - Application of Advanced Concepts to Problem Solving

Day 3 October 30
Managing Viscoelastic Melt Behavior for Part Quality and Process Optimization

Larry Schmidt is President of LR SCHMIDT ASSOCIATES, a plastics consulting firm specializing in advanced process designs product concepts, technology assessment and root-cause analysis of viscoelastic processing problems. He earned chemical engineering degrees from Ohio University, Washington University and the University of Colorado, where his PhD research was on polymer processing. Prior to starting his consulting company in 1992, he worked for General Electric for 22 years, including 11 years as manager of the polymer engineering programs in the Corporate Research and Development Center.

- Continental breakfast and lunch provided on site each day
- Additional instructions will be provided to those who register for the event before the deadline of **October 18, 2013**.
- Hardcopy lecture notes will be provided to all attendees.
- The instructor will stay until 6:00 PM to discuss specific issues.

www.ggpf.org

CLICK TO REGISTER TODAY!

Register By September 30, 2013 For Registration Discounts!

Ask the Experts: Terry L. Schwenk

Hot Runner Questions

The purpose of this column is to provide valid information concerning hot runner technology. We invite you to submit questions or comments to our hot runner expert; Terry L. Schwenk has over 36 years of processing and hot runner experience. Terry is currently employed with EWIKON Molding Technologies and can be reached by mailing: terry.schwenk@ewikonusa.com.

Q: What's the most stable injection molding process?

A: This is a very complicated question. The injection molding process is a very dynamic process where the control of a multitude of variables is very complex. We like to think we have all these tools at our finger tips, but the reality is we only have three controls on the molding machine to control the process of injection moldable plastic.

1.) Temperature

2.) Velocity

3.) Pressure

We can utilize these controls in varying degrees to influence the behavior of the plastics resin. There has been a lot of emphasis on the „scientific molding" method, which teaches us to take a more methodical approach to the molding process to achieve more consistent results. I have found profiling the injection unit can yield some of the best results. But I am not a believer in profiling just for the profile sake. It's important to take a scientific approach. There various approaches including injecting as fast as possible to get the fill velocities above the shear viscosity curve so the cavity filling velocity changes have less affect on the material viscosity. I have found although this method may work with some applications, it falls short in other applications, especially high cavity hot runner systems.

I am going to introduce another element to the injection molding process based on profiled injection. I have use this process myself for several years with solid reliable results for which I call Mathematical Molding™. Mathematical Molding™ is applying mathematical calculations relating to machine and mold cavity volume, to control and document the injection molding process. This process is totally transferable from machine to machine and is purely based on mathematical facts and calculations. Plastic resins are non-Newtonian in nature and it is precisely this attribute that

Ask the Experts: Terry L. Schwenk Continued

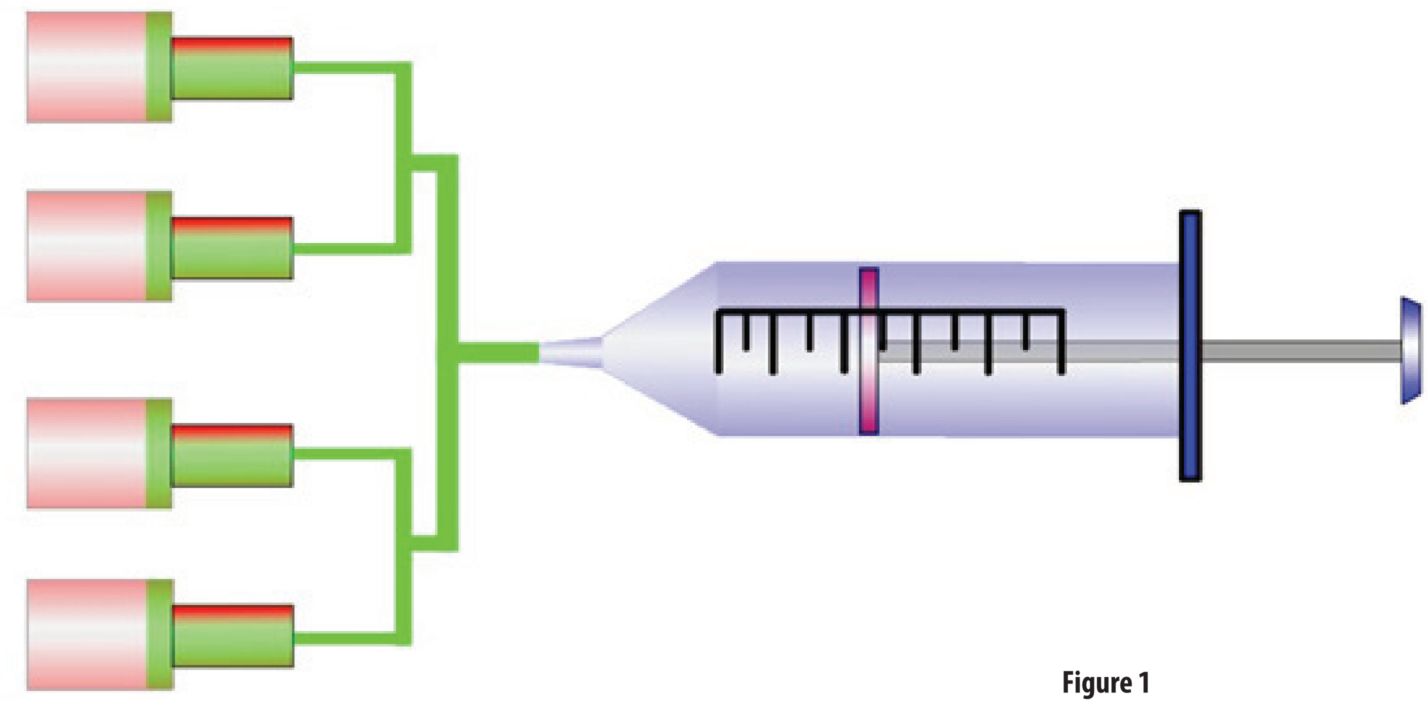


Figure 1

creates the dynamic nature of the process. Mathematical Molding™ allows you to calculate the critical values of the process and apply them in a consistent manner that stabilizes and improves the process.

In its simplest form, the injection molding process is nothing more than a volume displacement method of a liquid composition. We frequently use weight to define a plastic part or shape. In the injection molding process we are not lifting anything, so it is absurd to refer to the parts by weight for processing reasons. The weight of the plastic part is purely an accounting reference to analyze how much money is spent on the material to produce the part, since all plastic resin is sold by the pound. The capacity ratings on injection machines are also absurd, stating a barrel capacity in ounces, which only refers to polystyrene material and if you run a different material, you can throw the weight capacity out the window since the relationship between a screw and barrel is purely a volume calculation converted to weight based on the specific gravity of polystyrene material. The correct capacity rating should be defined in volume and that is exactly what Mathematical Molding™ does. The injection molding

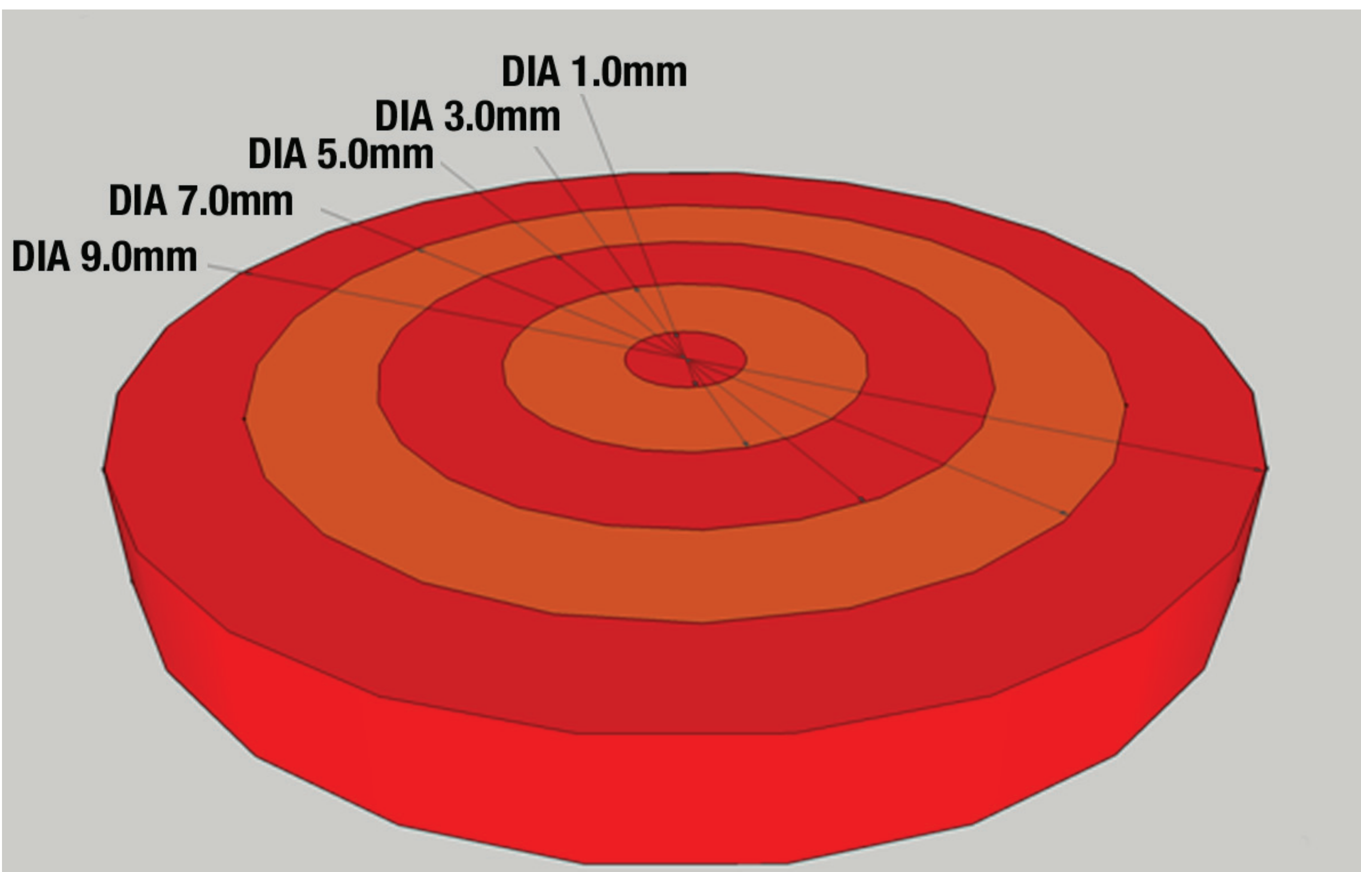
Ask the Experts: Terry L. Schwenk Continued

machine is nothing more than a giant syringe (**Figure 1**) displacing a volume of plastic from the injection barrel to the mold, which has a shape of a specific volume, and the plastic is be forced to fill this volume. So it makes no sense to process by weight when we mold in volume.

Calculating the machine barrel volume is a simple calculation of barrel diameter times the stroke of the screw. This can be in imperial metric units. I personally use the metric system since the calculations are easier. One of the primary controls on the molding machine is velocity. Thanks to several people in the plastics industry, we now have several steps of in injection velocity profile available on almost every injection molding machine, for which very few processer's utilize. We know that the plastic resin's viscosity changes with its velocity. We can also look at a part shape and realize from the gate position, the material has to flow though varying volume changes as it fills the part. When only utilizing one injection profile of velocity, the material flow front in the part will speed up or slow down as it moves to fill the part. This velocity change in the cavity filling also affects the viscosity of the material resulting in varying filling characteristics within the part. It is precisely this filling variation that can cause issues in the final part quality. So why on earth would anyone use just one injection profile velocity to fill a part is hard to comprehend.

Looking at a simple part such as a disk (**Figure 2**), we can thoroughly understand the importance of profiled injection. Mathematical Molding™ helps to calculate the filling volume changes of the part and apply it to the barrel volume of the injection unit and coordinate its movement in conjunction of the part filling. By mapping the filling profile of the part as it relates to the varying volume segments and applying that profile

Figure 2

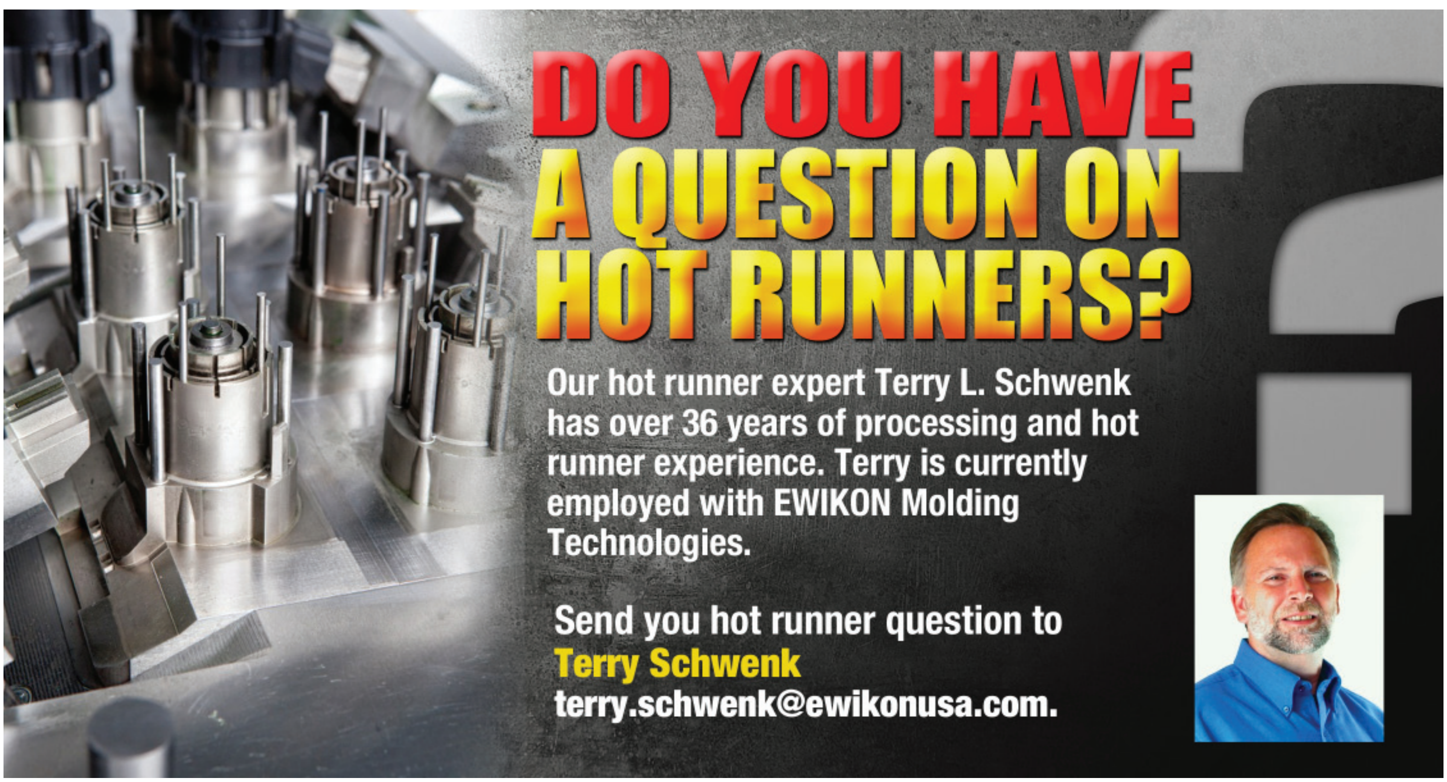


Ask the Experts: Terry L. Schwenk Continued

to the injection unit to speed up or slow down the injection velocity, a more consistent cavity filling velocity can be achieve. Figure 2 is a simple disk, center gated. When looking at the fill pattern and mapping the volume changes we can calculate for every millimeter increase in diameter the flow front volume increase 3 fold. In order to maintain a consistent velocity, the injection screw needs to increase in velocity 3 fold for every segment, moving from the ceter of the part to the outer rim. This relates to the injection profile by applying the calculation for volume over time (cubic centimeters per second). It will take a little effort to map out the flow volume changes of every part, but once done it can be coordinated with the injection molding machine. In the sample of a disk (**Figure 2**) we show 5 flow sements of different volumes. So if the total fill time is 2 seconds, then we divide 2 by 5, giving a fill time per segment of .4 seconds. The molding machine is divide into 5 profiles each being .4 seconds with increasing velocity for each segment.

By applying the injection profile technique, you can help improve the overall process stability and quality. Please feel free to contact me with any question you may have with the information in this article.

Terry L. Schwenk
EWIKON Molding Technologies
262-237-2525



Part 1

Defining the Data Barrier

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: We know our record keeping for molds is weak and we are engaged in efforts to remedy this, but we are having disagreements on how best to organize the "data duties". Who should be responsible for data collection and utilization? This dilemma has frozen the entire initiative. Help.

A: The idea of improving mold performance and maintenance efficiency through better documentation is an easy head-nod for anyone in the molding business. Just like changing the oil in our cars, we know we should but actually doing it on time is another matter. The distance between rhetoric and practice continues to grow with some who talk incessantly about the need to improve maintenance and mold reliability, and then bicker over the burden of any changing job responsibilities. "Oh, you want me to enter the data?" So it becomes easier to just do nothing while the enthusiasm dissipates and maintenance stays the wavering course of reactive fire fighting.

Surfing various maintenance web sites reveals articles that contain volumes of information on implementing a CMMS system and how to improve maintenance efficiencies and asset reliability of everything from pumps to motors to molds. They all carry the same theme, which basically goes like this:

No one performing maintenance in a reactionary culture today will ever see far enough down the road to significantly reduce unscheduled downtime events, control costs or improve asset performance and reliability without electronic documentation. It also will be difficult to utilize technological advancements, or to quickly resolve any new issues that may arise from doing so without accurate and disciplined documentation habits.

But without a baseline of data to measure where you are, there can be no hope of measuring the impact of processing, engineering and maintenance initiatives on product, mold and employee improvement. Improving mold performance and maintenance reliability is all about our ability to track mold and part defects to provide targets and goals.

Ask the Experts: Steve Johnson Continued

This won't magically happen. There will be no baseline of data established unless someone in the organization champions the idea and:

1. Establishes a maintenance system
2. Trains specific employees to navigate in it and holds them accountable for their part
3. Collects mold performance and maintenance data
4. Analyzes the data (ongoing) for trends, costs and to set goals and measure results
5. Utilizes the data to make smarter and more accurate daily mold repair decisions.

It's Not My Job

As more companies adopt lean practices to increase their competitive advantage, employees sometimes undergo job description changes that usually mean taking on different and more responsibility within the organization. This can lead to spirited water cooler discussions over what someone else should be doing or how this new task does or does not fit into their daily job functions.

If the new task is not a mandate from the corner office, and if the added burden of the task has seemingly no quick payoff for the employee charged with its implementation or data responsibilities, any initial enthusiasm will fizzle out within a couple of months.

The idea of data collection and utilization among maintenance personnel will undoubtedly cause more anxiety than excitement. Some do not subscribe to the idea that accurate data will make their job easier or make them better at it. It is hard to convince most trade skill employees that a computer is anything but a pain. And those whose job performance is sometimes in question will not warm to the idea of repair criteria broken down into measurable categories, thus providing comparable, gradable metrics for management's review.

And while it is true that employee repair results may underscore that further training is necessary in some cases, in a systemized maintenance environment, the cream will still rise to the top, meaning the top employees' stats will be visible and now top performance can be verified.

Job Description versus Real Duties

Moving to a CMMS electronic maintenance system (verse a more manual approach like Excel, Log Books, etc.) only comes to mind right after a mold breaks down several times for the same reason or a catastrophic event occurs. Then they are quickly previewed, bought and installed. If nothing happens on its own, or if data doesn't mi-

Ask the Experts: Steve Johnson Continued

raculously appear, the system is simply ignored and put into the "as soon as we have time" category.

I have been part of many discussions concerning the variety of job responsibilities that make up a normal day for a process or tooling engineer, a mold repair supervisor and the mold repair technician working in a typical (captive or custom) plastics manufacturing company. In many cases, there is little thought given to how best to organize data responsibilities in a maintenance system because of the variety of tasks required to track a mold through the run/repair cycle.

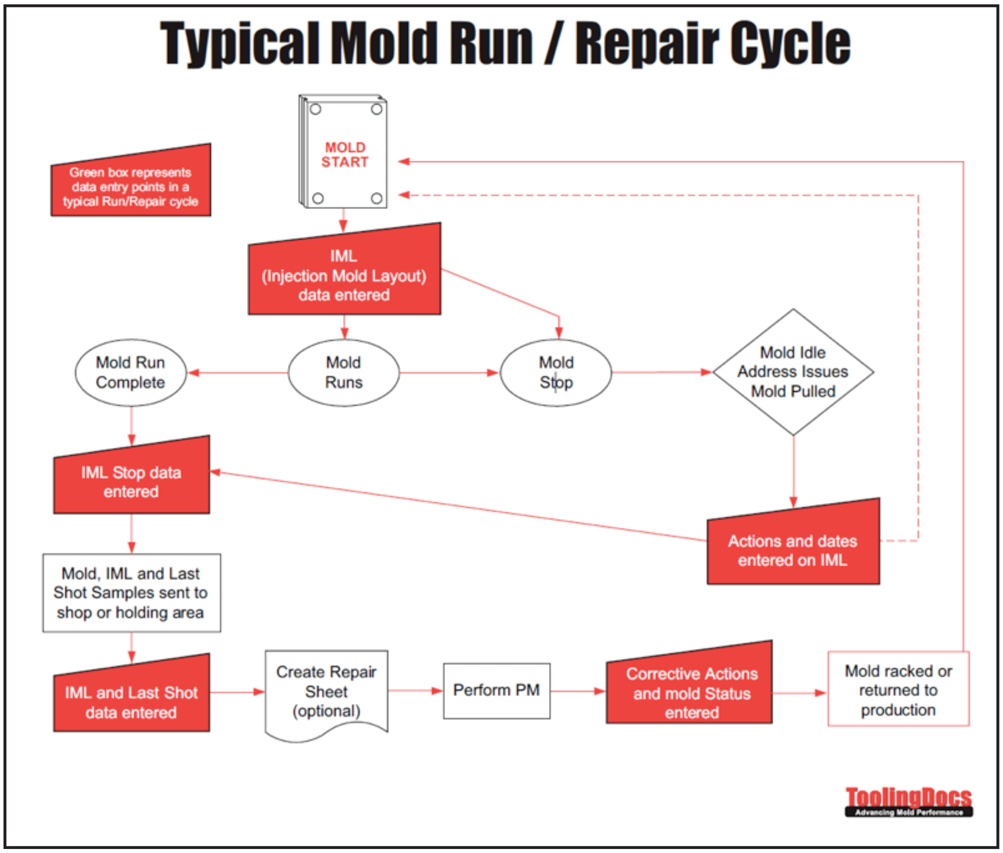
Implementing a mold tracking system in a busy plastics facility needs to be taken in incremental steps to avoid overwhelming employees. Let's look at what happens after the phone rings in sales:

- Scheduling determines what part needs to be made
- Someone decides what mold /configuration will be set and where to run the required parts
- Mold is set, started (hopefully) without incidents
- Mold runs with or without unscheduled downtime issues or blocked cavities
- If it is a long run, someone (hopefully) determines when/if the mold should be pulled for cleaning or repairs to avoid premature tooling wear/damage
- Order is run; mold is stopped, pulled, and taken to the shop or a red tag area
- Mold is cleaned, repaired and returned to storage green tagged and ready to run.

With all of the different employees involved to do the above, it is easy to see why data entry responsibilities can be a gray area that few want to voluntarily assume.

Ask the Experts: Steve Johnson Continued

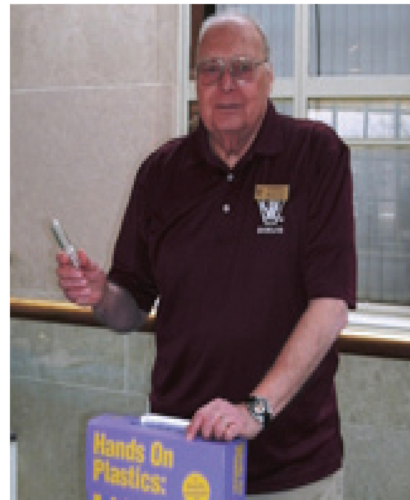
Here is a flowchart of typical data collection points in a typical "Run/Repair" cycle of a mold.



Collecting and using accurate data throughout these stages can change a reactionary environment to one where 90 percent of downtime is scheduled, corrective and preventative actions are clear, budgets are maintained, molds run better and the troubleshooting skills of all your employees are continuously enhanced. It is important to note that great maintenance tools don't always come from a toolbox.

To add some fodder to the cooler discussions, the next article will deal with breaking down what type of data should be collected, how it should be used and who (based on typical job descriptions) is best suited for managing it during the Run/Repair Cycle shown above.

Steve Johnson *ToolingDocs LLC, and owner of MoldTrax.*



Getting to Know Your IMD Board Members

James J Wenskus

After receiving a degree in chemistry from Massachusetts Institute of Technology, Jim started his plastics career in the molding laboratory at Stromberg-Carlson where he evaluated and selected materials for telephones aiming for a service life of over 30 years. After seven years, Jim moved to the Manufacturing Research and Engineering Organization of Eastman Kodak Company where he engaged in injection molding process research and development. His laboratory was located in the center of a 75-machine molding operation which streamlined knowledge transfer from the lab onto the floor. He was a pioneer in the use, development, and evaluation of in-cavity pressure sensing and analysis. He also built one of the country's first computer-monitored injection-molding machines. He retired from Kodak Park in Rochester after 33 years, leaving with seven U.S. and numerous foreign patents related to injection molding.

Jim has been a member of the Rochester Section of the Society of Plastics Engineers (SPE) for over 60 years, during which he served as the 1989/1990 Section President and received the prestigious Plastics Engineer of the Year award from the Section in 1991. He currently serves as Section Treasurer. In his tenure, he helped develop a unique, hand-on plastics program which is performed several times per year at large local science fairs. Featuring displays on recycling, an interactive presentation about "Unhappy Polymer Molecules", and a small IM machine where SPE members help students mold screwdrivers, this program has been in existence for over 25 years and reaches about 4,000 students, teachers, and parents annually.

At the national level, Jim is the Treasurer of the Injection Molding Division as well as past IMD National Councilman. In 1984, he was one of six individuals elected as the first Fellows of the Society of Plastics Engineers. In 1987, he was presented the Man-of-the-Year award in appreciation of his outstanding leadership to the Division. He was later elected as an Honored Service Member in 2005 in recognition of his exceptional service to the SPE.

Jim has served on the panel of judges for the Institute for Plastics Certification (IPC), developing and improving the certification examinations for Plastics Process Engineer and Plastics Technologist and holds CplasT Certificate #183. He recently authored the injection molding troubleshooting chapter for the new Handbook of Troubleshooting Plastics Processes: A Practical Guide (John Wiley & Sons, Inc. ISBN 978-0-470-63922-1)

In his spare time, he is president of the Rochester Council of Scientific Societies where he oversees a mini-grant program for science teachers by providing up to $200 for approved science classroom projects. Jim

Meet Your IMD Board Members Continued

has served on the board of the Urban Network Project for Math, Science & Technology Education (National Science Foundation — Statewide Systemic Initiative) as well as past president of the M.I.T. Club of Rochester. He is also a member of the Society for Interdisciplinary Studies (UK), Aircraft Owners and Pilots Association (AOPA), and MENSA. He has been a radio amateur for 60 years (specializing in digital communications) with additional interests in astronomy, prehistoric geocatastrophism and its derivative mythos. Jim recently retired as Rochester Region Group Commander for the USAF Auxiliary/Civil Air Patrol (CAP) with the rank of Lt. Colonel. He now acts as CAP Communications Officer for the Finger Lakes region of New York, where he pioneered digital radio communication packet network for support of CAP search-and-rescue and disaster-relief missions in New York State.

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Abrams Scholarship Hits $50,000, Thanks to Students' Donations

A symbolic donation by a group of University of Wisconsin-Stout students has pushed a special scholarship fund to the $50,000 mark.

The UW-Stout student chapter of the Society of Plastics Engineers recently donated $100 to the John Leon Abrams Memorial Scholarship to help it reach the milestone funding level in less than one year.

"We are honored to have the opportunity to make this donation in the name of a Stout alumnus who died for our country. This scholarship will help plastics engineering students shape their future and prepare them for a career in the field," said Dayton Ramirez, of Lone Rock, the chapter vice president.

The SPE chapter, which has 36 members, recently was named one of two outstanding chapters of the year at an annual conference in Cincinnati. The chapter also received a Certificate of Merit this spring from the Stoutreach Service Council for volunteering with STEM Career Day and three local Science Olympiad events.

The Abrams scholarship fund benefited from a second symbolic donation of $132 to move it closer to the $50,000 goal. That donation was made by the scholarship's memorial committee.

The scholarship was created in 2012 by eight members of the Sig Tau Gamma fraternity, of which Abrams was a member. The group started the committee to honor their friend, who died in action in 1968 in Vietnam.

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Mold Temperature Control Leveraging Hidden Potential

Reduced cycle time, minimized rejects and increased process reliability are significant competitive advantages in injection molding. To gain these advantages, companies rely increasingly on high-precision injection molding machines — often in combination with appropriate process monitoring systems. But an important factor that is often overlooked is mold temperature control.

To maintain high rates of repeatability — even over long periods — it is necessary to keep the key manufacturing parameters constant. Modern injection molding machines offer processors the option of monitoring and documenting a wide variety of process parameters. However, there is generally not a lot of information available about the current temperature status in the current process. This is all the more surprising since the temperature exerts a strong influence on the product quality, as well as being at the source of a range of malfunctions and influencing factors (**Figure 1**). Therefore, it is understandable that, according to study, an average of 24% of rejects can be attributed to defects in mold temperature control [1].

To eliminate these influences, the flow rates through the individual heating/cooling circuits and the supply and return temperature should be measured, monitored and, if necessary, corrected. However, the manual flow meters that are widely used for this purpose are often not up to the job. For that reason, ENGEL has developed and launched a cooling water distribution system with electronic sensor, which can be integrated into the machine control.

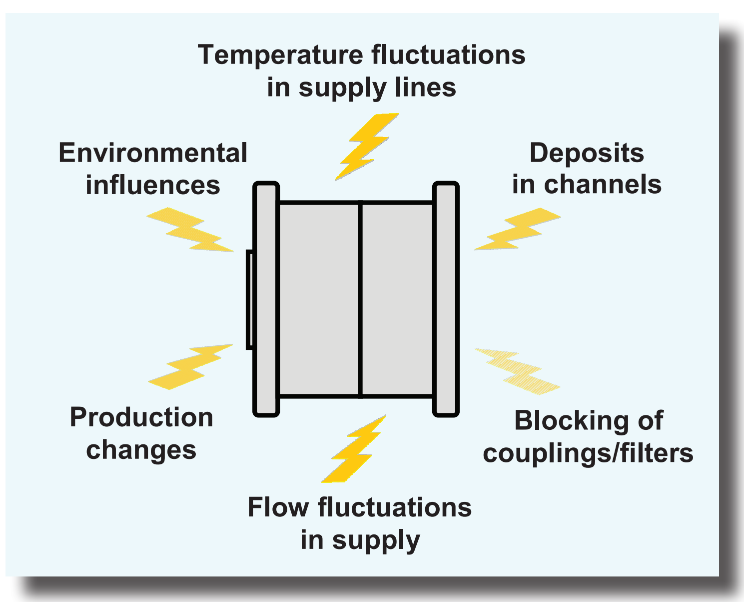

Figure 1:
Mold heating/cooling is subject to a range of malfunctions and influencing factors.

Figures courtesy of ENGEL.

Modern Distribution Systems Increase Process Reliability

If multiple temperature control circuits are operated with the same water or oil temperature, the question arises concerning mold set-up of whether to connect the operating media supply in sequence or in parallel with the mold heating/cooling circuits. Generally, the parallel circuit supports a high overall through-flow and the temperature differences between the mold input and output are smaller because of the shorter heating/cooling channel length. This can in turn benefit the mold quality — for example lower warpage. However, this major advantage of the parallel circuit should not blind us to the fact that the media distribution is uncontrolled. There is a strong risk of the individual circuits becoming blocked unnoticed [2].

With the Flow Monitoring System (**Figure 2**) — it is possible to combine the advantages of the parallel circuit with high process reliability. The compact, manually adjustable water distribution system, whose integrated sensors can register flow rates, temperatures and pressures, is mounted directly on the injection molding machine — in the direct vicinity of the mold if desired and space permits. The measurements are transmitted to the machine control so that they can be visualized, monitored and documented. Integration into the machine control also makes it convenient to operate.

Figure 2: ENGEL flomo is a compact sized cooling water distributor/manifold with electronic monitoring.

Water distribution systems of this kind are more expensive than conventional flow meters due to their electronics, but in practice their purchase pays off very quickly. An automotive supplier that produces PA parts in a two-cavity mold now uses ENGEL flomo. Previously, their five cooling circuits were supplied by flow meters. During production, contaminants in the cooling water had become deposited on a quick-connection coupling and completely interrupted the supply to the cooling circuit without anyone noticing.

The part geometry was still okay before shipping; off-spec dimensional deviations were only recognized in the customers' incoming goods control. Consequently, the entire delivery was rejected. It was only after

Feature: Mold Temperature Control Continued

a long search that technicians identified the lack of flow as the cause. This defect, which caused post-shrinkage of the parts, was expensive. The overall cost for the automotive supplier amounted to almost $40,000 US.

Turbulent Flow in Demand

Modern distribution systems offer the opportunity to identify and counteract defects of this kind at an early stage before the defective parts are shipped. At the same time, the systems provide the user with new parameters that can be used for process optimization, for example the flow rate.

The thermal balance of an injection mold is influenced significantly by the volume flow rates in the individual cooling circuits. But who knows the ideal flow rates for their process? In essence, the greater the flow rate, the better the heat exchange between the mold and heat exchange medium, and the lower the temperature difference between the mold inlet and outlet. In many companies, to be on the safe side, it should be ensured that the flow controllers of all circuits are completely open. It remains a mystery whether the individual flow rates are then too low, unnecessarily high or just right.

ENGEL's developers have investigated the question of optimum flow rate in cooling circuits in depth and performed a wide range of simulations and experiments. In principle, the minimum required flow rate is principally determined by two factors:

- The temperature increase between mold inlet and mold outlet,
- Reynolds number.

The maximum permissible temperature increase should not be exceeded. According to [3], this is between 3 and 5K for standard injection molding and between 1 and 3K for precision injection molding. To determine the actual influence of the temperature increase on the thermal homogeneity of a part during cooling it is advisable, in many cases, to use an injection molding simulation for the application.

Reynolds number Re characterizes the turbulence of flow. This must be so clearly developed that the system-dependent flow fluctuations do not significantly affect the mold wall temperature. From a Reynolds number of 10,000, turbulent flow is completely developed. To a first approximation, this value serves for definition of the minimum required flow rate. How does the

Feature: Mold Temperature Control Continued

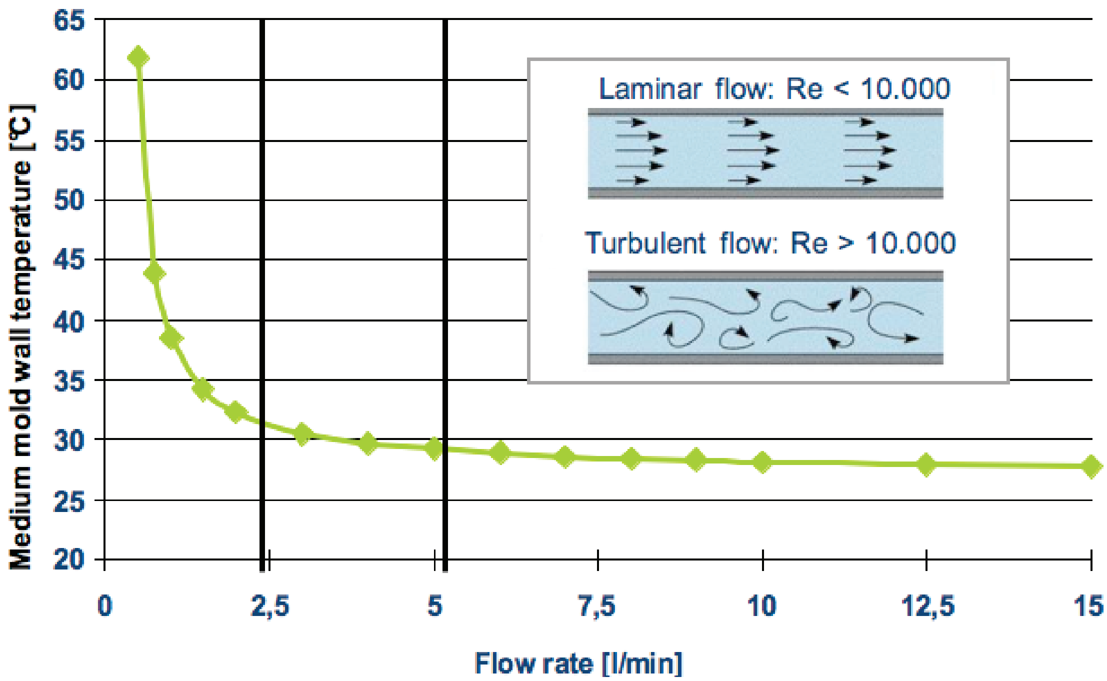

Figure 3: The mold wall temperature depends on the flow rate of the cooling water (cooling water temperature in the illustrated process: 20°C)

average mold wall temperature depend on the flow rate? While the temperature change is very significant at low flow rates (Reynolds number Re <10,000), only a very small effect on the mold wall temperature can be seen at high flow rates (**Figure 3**). Reynolds numbers Re <10,000 denote a somewhat uneconomic process because of the reduced heat exchange. In addition, the steep drop of the curve shows that the mold wall temperature responds sensitively to low flow fluctuations. For this reason, it is recommended to choose the flow rate such that Re >20,000. The characteristic curve profile is generally applicable for injection molding processes.

Reynolds number in turn depends on three factors:

- The flow rate,
- The bore diameter and
- The viscosity, which in turn is strongly influenced by the temperature.

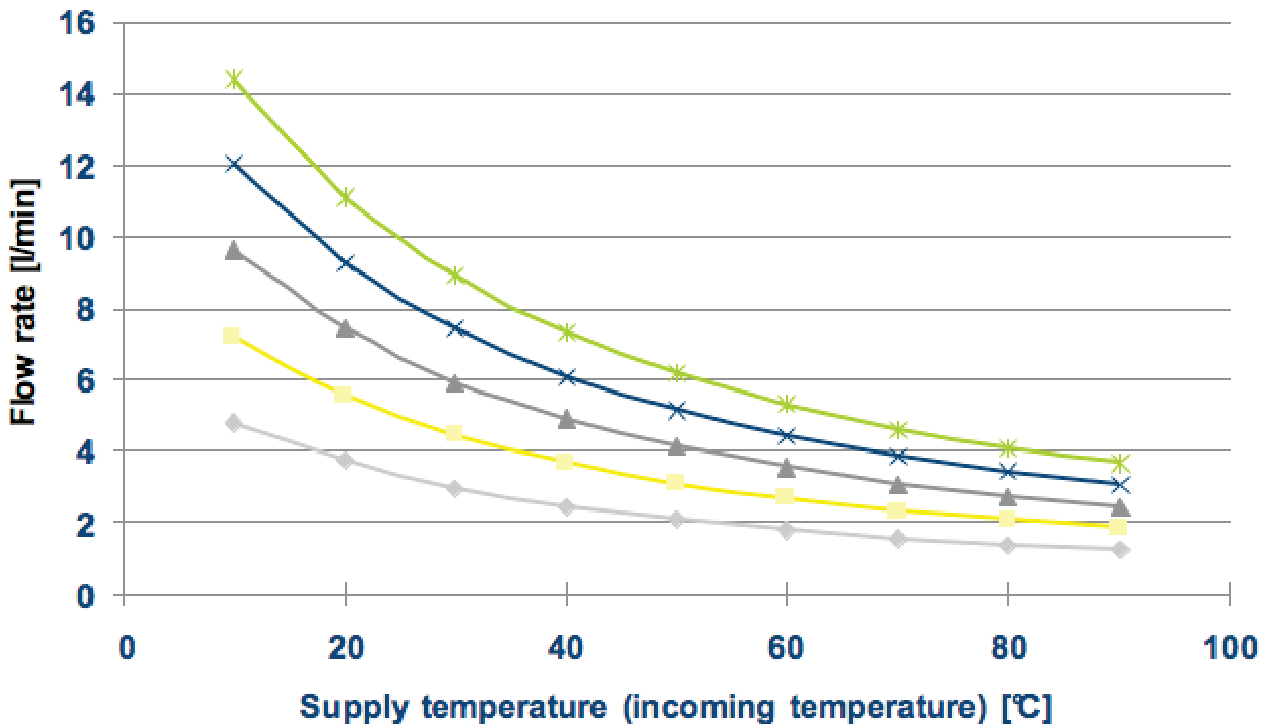

Figure 4: The flow rate necessary for reaching the optimum Reynolds number (Re = 20,000) is calculated from the supply temperature and bore diameter of the cooling channels.

The flow rates that allow the recommended Reynolds number Re = 20,000 to be reached can be read from the graph (**Figure 4**). If, for example, water can pass through a bore with a diameter of 10mm, with a supply temperature of 60°C, a flow rate of 4.5l/min is necessary.

Do Not Underestimate Hydraulic Connections

The necessary flow rates cannot always be achieved right away. This may be because the pumps are not dimensioned powerfully enough, or they are worn. A simple way of still reaching the flow rates consists in optimizing the hydraulic mold connections. Long hoses between the heat-exchange medium supply and mold, as well as small hose diameters and a wide variety of pressure-reducing quick connection couplings are only one characteristic of hydraulic mold connections that are found in many injection molding companies. Each of these components causes pressure losses and is therefore partly responsible for reducing the flow rate.

The biggest pressure consumers generally include, besides the heating/cooling channels in the mold, the quick connection couplings. A distinction is made between quick-action couplings that are open, ones that can be sealed on one side, and those that can be sealed on both sides. The pressure loss functions are different depending on the design (**Figure 5**). For nominal size 13 (right) it can be seen that those which can be sealed on one side have about 2.5 times the pressure loss compared to the open model, while those that can be sealed on both sides have over 6 times the pressure loss. For nominal size 9 (left) it can be seen that the pressure losses are generally higher than for nominal size 13. The model that can be sealed on one side has

Feature: Mold Temperature Control Continued

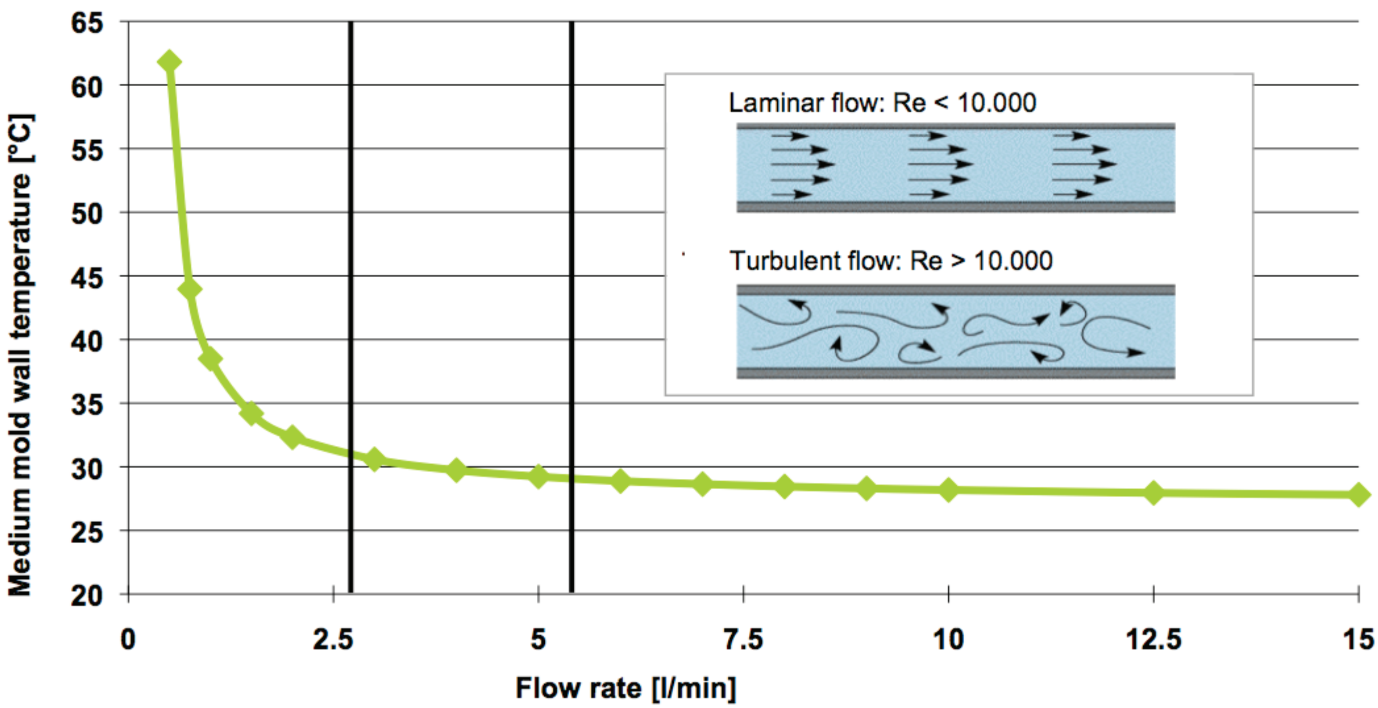

Figure 5: Rapid couplings cause pressure loss — to different degrees depending on the design and nominal size. At a nominal size 13 (right) the design that can be sealed at one side causes about 2.5 times the pressure loss compared to an open model, while the model that can be sealed at both sides has over 6 times the pressure loss. At nominal size 9 (left), the model that can be sealed at one side has about 1.5 times the pressure loss compared to the open design, while the version that can be sealed at both sides has over twice the pressure loss.

a pressure loss about 1.5 times the pressure loss of the open design, while the version that can be sealed on both sides has over twice as high a pressure loss. In general, therefore, sealable quick connection couplings should be avoided in cooling systems or should be adequately dimensioned (or sized).

Process Optimization by Hydraulic Balancing

Despite careful choice of the components, it may be that the flow rate in individual cooling circuits is too low. If the hydraulic resistances of the circuits are very different, the water will choose the path of least resistance. Hydraulic balancing – selective throttling of the flow rates into the individual cooling circuits — may be a remedy here. This can compensate for unbalances in the water distribution. Distribution systems such as the ENGEL flomo have valves for adjusting the flow rate.

The flow distribution for producing a flat PP part with a wall thickness of 2mm will illustrate the problem (**Figure 6**). In the vicinity of the mold inserts, the temperature-control bores are designed with a diameter of 6mm, and 10mm in the main mold. The cooling water temperature is 20°C. The effect of greater hydraulic resistance in the inserts is that most of the water flows through the main mold, while the greatest heat flow would actually have to be dissipated from the inserts (left). If the hydraulic resistance is increased by throttling the flow rates in the main mold, more water flows through the inserts. Consequently, the flow rate increases from 4.8 to 7.1l/min (right) and as a result is above the recommended value of 5.7l/min (**Figure 4**). This sim-

Feature: Mold Temperature Control Continued

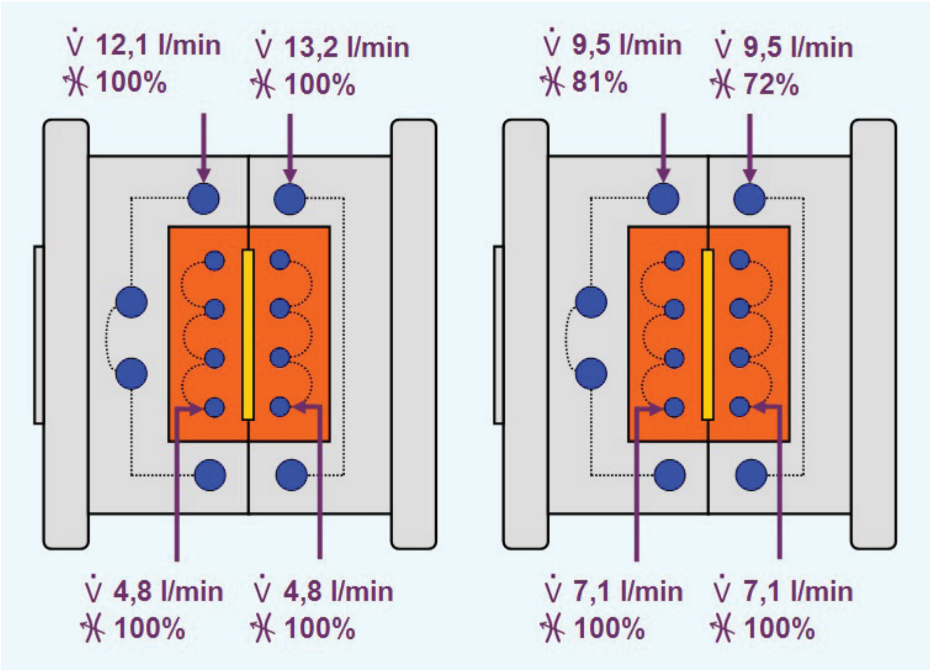

Figure 6:
Natural flow distribution without hydraulic balancing (left) and flow distribution after hydraulic balancing (right). This simple measure increases the heat exchange between the mold and heat- exchange medium.

ple measure increases the heat exchange between the mold and heat-exchange medium; which results in a reduction of the cooling time of 7%. At the same time, the temperature increase between the mold inlet and mold outlet is reduced.

Summary

A demand-optimized control of the flow rates in the mold can contribute significantly to increased quality and productivity during injection molding. Modern cooling water distributors with flow rates and temperature sensors form the basis for the optimization and continuous monitoring of process parameters that have often been underestimated.

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Determining Which In-Mold Sensors Should Be Used for V/P Transfer During Injection Molding for Three Different Injection Strategies

The use of in-mold pressure and surface temperature sensors was investigated to determine whether they reduced variation in part weight when variation in material viscosity and check ring leakage were introduced to the process. Velocity to pressure transfer when the part was not quite full (2-stage, pack with second stage), after the part was packed with a fast velocity (2-stage, pack with first stage), and after the part was packed with a slow velocity (3-stage) were the injection strategies evaluated. It was found that surface temperature sensors toward the end of fill were the most beneficial in all cases studied.

Seeking out and reducing causes of variation to molded parts is one of the main functions of a process engineer. Even with machines that have excellent control of temperatures, velocities, pressures, and positions, there are other significant sources of variation. Two of the biggest sources are plastic viscosity variation and injection screw check-ring leakage variation [1]. In addition to taking steps to minimize this variation, it is also important to set up processes so that they are as robust as possible to normal viscosity and check-ring or other type of non-return valve variation.

Ways that viscosity variation can be minimized include providing a consistent mix of colorants and other additives, consistent regrind, and consistent temperatures/thermal history as the plastic goes from pellet to molded part. Choosing an optimum injection velocity that will minimize variation in process viscosity when the incoming plastic has a slightly different starting viscosity is also critical [2, 3]. Replacing check-rings and/or barrels when worn or damaged is important to minimize check-ring leakage variation. However, some leakage is inevitable when the screw starts to come forward during injection and, it has been found, that the amount of decompression after screw rotation has a larrge effect on check-ring leakage [1].

One of the things that viscosity and/or check ring leakage variation can alter in the process is the transfer points from fill to pack and from pack to hold. The set-up of the injection portion of the process is commonly done using scientific or DecoupledSM molding techniques [4, 5]. There are variations to these techniques that will be referred to as 2SP1 (2-stage, pack with first stage), 2SP2 (2-stage, pack with second stage), and 3S (3-stage) injection strategies in this paper. Each can be affected by a change in transfer from fill to pack or pack to hold.

For the 2SP1 process, the part is completely filled and the pack is started with the optimum velocity. The velocity to pressure transfer (V/P transfer) therefore occurs during pack. Variation in this transfer can lead to over-packed or flashed parts and/or under-packed parts or a change in velocity before the part is full.

The 2SP2 process is, from this author's observations, the method that is most utilized by those who are doing scientific or DecoupledSM molding. With this method the part is filled with the optimum injection velocity until the flow front is just short of hitting the last place to fill (95 – 98% full) and that is where V/P transfer occurs. The remaining fill, as well as pack and hold are done with pressure control.

The 3S process is the same as the 2SP2 up to the point that the part is 95% full. At this point, the screw is slowed to typically about ten percent of the optimum velocity and the part is packed with velocity control. The V/P transfer occurs at the end of pack and hold is done with pressure control.

The surface temperature sensors used in this study work by detecting the rapid rise in temperature when the melt reaches that position (edge detection). The V/P transfer can be delayed after the edge is detected. The pressure sensors work either by edge detection or by transferring when a set pressure is reached.

Part weight is the only metric used in this study to detect variation. It has been shown to be an excellent tool for process analysis [6]. The ability to get very fast and reliable measurements are very advantageous when making many trials. It should be noted however that the weight does not always correlate well to part dimensions or other properties.

The goal of this paper is to determine whether the pressure or surface temperature sensors can be used to minimize variation in the V/P transfer when viscosity and check ring leakage vary. Other studies [7, 8, 9] done on this topic have tended to focus only on very small viscosity variations or changes in process metrics (peak cavity pressure, pressure integrals, etc.) instead of an actual part characteristic. Viscosity will be varied by using two different grades of material. Check ring leakage variation will be accomplished by using two different decompression strokes.

Materials & Equipment

Two polycarbonate resins were used for the experimental work. Both resins had a solid density of 1.20 g/cm^3 and a melt density of 1.03g/cm^3. The melt indices (MI) for the resins were 24 and 5.5 dg/min (300°C, 1.2 kg). For all experiments, the 24 MI material was used as the low viscosity material and a 5 to 1 mix of the 24 MI to the 5.5 MI materials was used for the high viscosity material. This mix gave a material that was approximately ten percent higher in viscosity than the low viscosity material when molded at the optimum injection velocity in this study.

The molded part consisted of two connected disks configured as shown in **Figure 1**. Each disk is approximately 50 mm in diameter and the entire part is 2 mm thick. The geometry connecting the two disks is about 6 mm wide. The locations of the various sensors in the part are shown in Figure 1. All the pressure sensors are piezoelectric. The BOF (beginning of fill) and EOF (end of fill) temperature sensors are N type thermocou-

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ples and the MOF (middle of fill) is a K type thermocouple which is part of a combination pressure / temperature sensor.

The parts were all molded in a 550 kN clamp injection molding machine with a 22 mm diameter screw and 53 cm^3 shot capacity. The machine had closed loop v elocity and pressure control and the ability to accept an external signal for V/P transfer. All in-mold sensor signals were read by external data collection systems which sent a signal to the molding machine when used for V/P transfer.

A digital scale with resolution to the nearest 0.01 gms was used to measure all the parts.

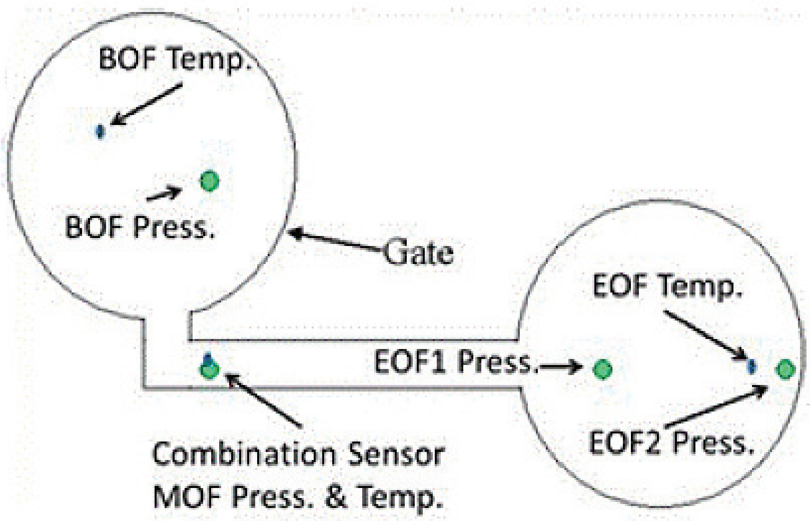
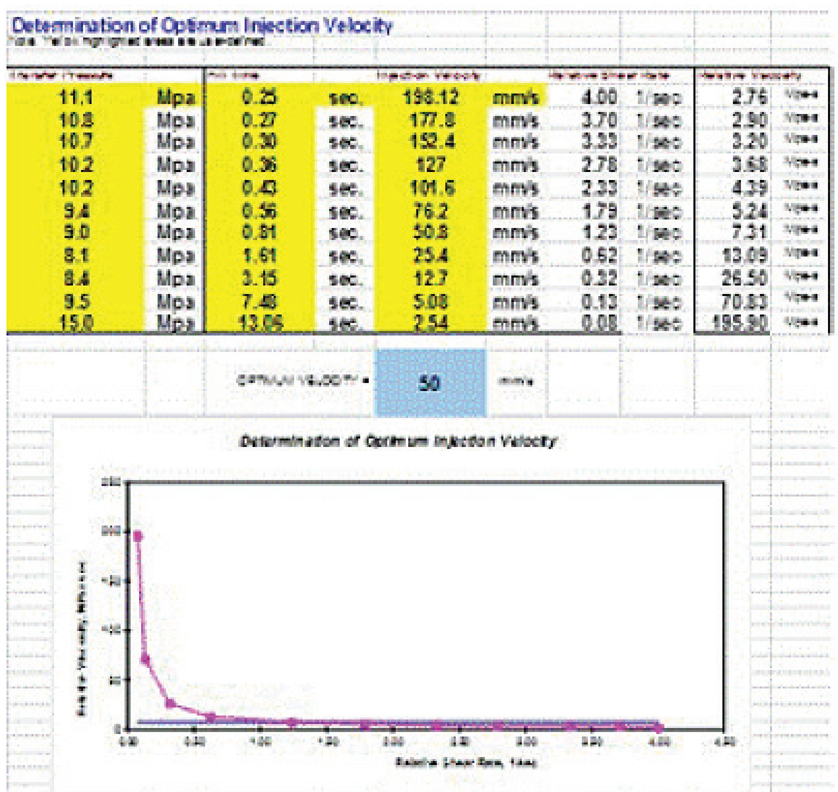


Figure 1: Sensor locations and designations.

Experimental Procedure

An optimum velocity and basic process set points were first set up with the low viscosity material. **Figure 2** shows the numbers used and results of the optimum velocity study. As can be seen, the optimum was found to be 50 mm/s using the method described elsewhere [2].

Table 1 shows the constant process parameters that were used during the experiment. Before any parts or data were collected the process was given sufficient time to stabilize. The process ran in automatic for a minimum of 30 minutes when first started and until the mold temperature stabilized after occasional process interruptions. This was important to minimize any temperature or residence time effects on the part weight.


Determination of Optimum Injection Velocity

11.1	Mpa	0.25	sec.	198.12	mm/s	4.00	1/sec	2.76	
10.8	Mpa	0.27	sec.	177.8	mm/s	3.70	1/sec	2.90	
10.7	Mpa	0.30	sec.	152.4	mm/s	3.33	1/sec	3.20	
10.2	Mpa	0.36	sec.	127	mm/s	2.78	1/sec	3.68	
10.2	Mpa	0.43	sec.	101.6	mm/s	2.33	1/sec	4.39	
9.4	Mpa	0.56	sec.	76.2	mm/s	1.79	1/sec	5.24	
9.0	Mpa	0.81	sec.	50.8	mm/s	1.23	1/sec	7.31	
8.1	Mpa	1.61	sec.	25.4	mm/s	0.62	1/sec	13.09	
8.4	Mpa	3.15	sec.	12.7	mm/s	0.32	1/sec	26.50	
9.5	Mpa	7.48	sec.	5.08	mm/s	0.13	1/sec	70.83	
15.0	Mpa	13.06	sec.	2.54	mm/s	0.08	1/sec	195.90	

OPTIMUM VELOCITY = 50 mm/s

Figure 2:
Determining the optimum injection velocity using the low viscosity material.

IMD Best Paper Continued

Table 1: Constant process settings.

Parameter	Setpoint
Barrel Temperatures (all zones)	304.4 °C (580 °F)
Mold Cooling Water Temperature	71.1 °C (160 °F)
Shot Size	38.1 mm (1.5 in)
Screw Speed	360 RPM
Back Pressure	0.4 MPa (57 psi)
Hold Pressure	0
Hold Time	7 sec
Cooling Timer	7 sec
Mold Open Time	About 5 seconds (actual)

Table 2: DOE set-up for all trials.

Run #	Material Viscosity	Decompression
1	Low	0
2	Low	6.4 mm (0.25 in)
3	High	0
4	High	6.4 mm (0.25 in)

The four run, full factorial DOE shown in **Table 2** was run for every combination of injection strategy and V/P transfer option shown in **Table 3**. It should be noted that the slower 25 mm/sec injection velocity trials were run after it was determined that the 2SP2 process could not run parts that were short at transfer when using the EOF temperature sensor. Therefore, the DOE was run at both a slow (25 mm/sec) and fast (50 mm/sec) injection velocity for the 2-stage trials. It should also be noted that the pack velocity (2nd controlled velocity) was set at 5 mm/sec when running the 3S trials.

In **Table 3**, the boxes marked "not possible" could not be run because the setting could not be set low enough to allow the V/P transfer to occur before the screw had traveled too far. The boxes marked "na" were

Table 3: V/P setpoints for each injection strategy/transfer option run (Set-up with low viscosity material).

Method/Sensor	2SP1	2SP2 25 mm/sec	 50 mm/sec	3S
Screw Position	2.54 mm (0.1 in)	5.33 mm (0.21 in)	6.35 mm (0.25 in)	3.81 mm (0.12 in)
Injection pressure	189 MPa (27400 psi)	na	na	na
BOF Pressure	48.3 MPa (7000 psi)	47.6 MPa (6900 psi)	42.1 MPa (6100 psi)	58.6 MPa (8500 psi)
MOF Pressure	27.7 MPa (4010 psi)	24.6 MPa (3560 psi)	22.2 MPa (3220 psi)	53.1 MP (7700 psi)
EOF1 Pressure	1.45 MPa (210 psi)	0.90 MPa (130 psi)	0.76 MPa (110 psi)	Na
EOF2 Pressure	not possible	not possible	not possible	48.3 MPa (7000 psi)
Edge BOF Pressure	na	+ 633 ms	+ 375 ms	na
Edge MOF Pressure	na	na	na	na
Edge EOF1 Pressure	na	+ 10 ms	+ 0 ms	na
Edge EOF2 Pressure	na	na	not possible	na
Edge BOF Temperature	+10.2 cm^3 (+.62 in^3)	+ 650 ms	+ 280 ms	+ 11.1 cm^3 (+.68 in^3)
Edge MOF Temperature	+ 9.85 cm^3 (+.601 in^3)	+ 9.83cm^3 (+.60 in^3)	+ 9.01cm^3 (+.55 in^3)	+ 10.5 cm^3 (+.64 in^3)
Edge EOF Temperature	not possible	+ 0 ms	not possible	+ 10.2 cm^3 (+.10 in^3)

not run either because it was thought that the results would not provide additional information or because of hardware issues. It should also be noted that the delay for the edge detection was sometimes set by time and sometimes by volume of screw travel. This was dependent on which data acquisition system was being used at the time.

The time on the data acquisition system was noted as the parts were molded so that process curves and summary data could be obtained for results analysis. The 2SP2 trials were run first with ten parts being collected per run. For the subsequent 2SP1 and 3S trials, five parts were collected since less variation was observed due to the parts being packed (not short shots).

After reviewing the results, one more step was taken to help analyze the results of the 3S strategy. For three of the five parts collected per run, each disk was cut off and weighed separately so that the weight close to the gate could be compared to the weight at the end of fill.

Results

The estimated effect of the viscosity change and the decompression change on the part weight was calculated for each transfer method/ strategy combination. The effects as a percent of average at the high level of either the viscosity or decompression, along with 95% confidence intervals, are shown in **Figures 3 – 10**.

The weights of the gate end versus the vent end for three parts from each run of the 3S strategy were compared by subtracting the gate end weight from the vent end weight. In all cases, the vent end (end of fill) weighed more than the gate end (beginning of fill). The effect of viscosity and decompression on the difference between the two ends was then calculated. The effects as a percent of the average difference at the high level of either the viscosity or decompression, along with 95% confidence intervals, are shown in **Figures 11-12.**

Discussion of Results

When examining **Figures 3 – 10**, a bar that is above zero means that that V/P transfer method gave heavier parts at the high level of the factor, either the high viscosity or the 6.4 mm decompression. If the bar is below zero, the part weight was higher at the low level of the factor, either the low viscosity or when decompression was set at zero. The results for each processing strategy will be discussed as to which transfer methods would be better than the traditional position method. If the 95% confidence interval includes zero then the effect of that factor, either viscosity or decompression, is not statistically significant.

2SP1 — 2-Stage, Pack with First Stage

Figure 8 shows that the only transfer method that was affected by decompression was Stroke. The parts made with decompression weighed about 2 % more than those molded without decompression. This was expected since only one viscosity was used and the only difference was the check-ring leakage as the screw started to come forward. As long as there was still a cushion at the end of injection and the in-

Figure 3: Viscosity effect with 2SP2 at a 25 mm/sec injection velocity.

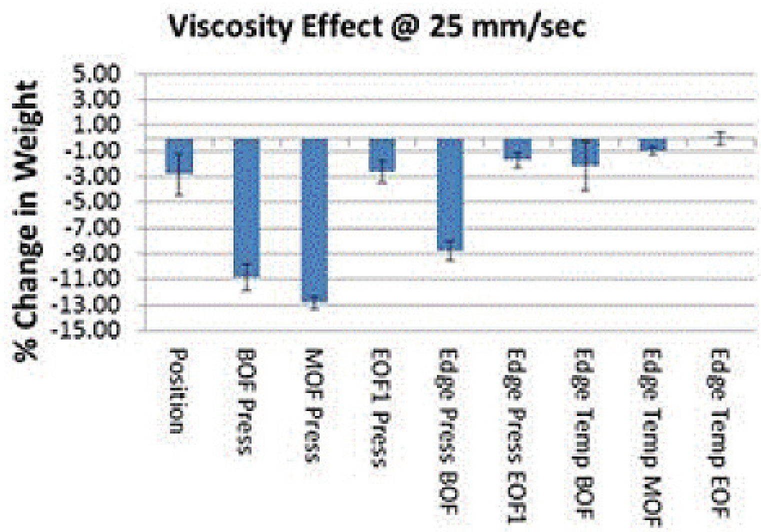


Figure 4: Decompression (check ring leakage) effect with 2SP2 at a 25 mm/sec injection velocity.

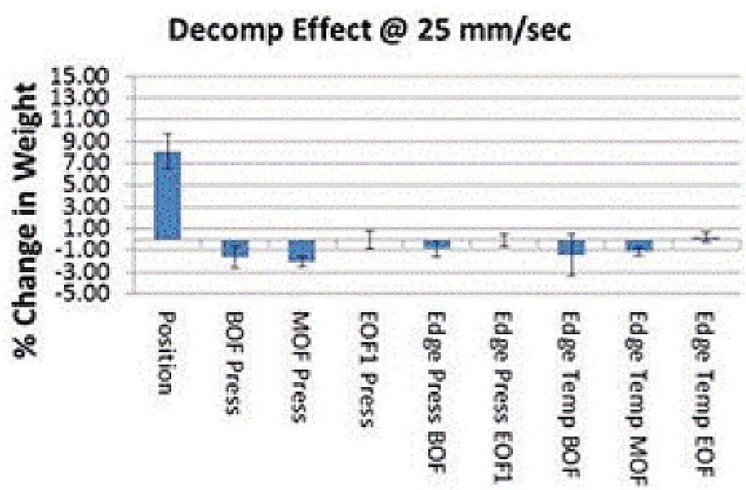
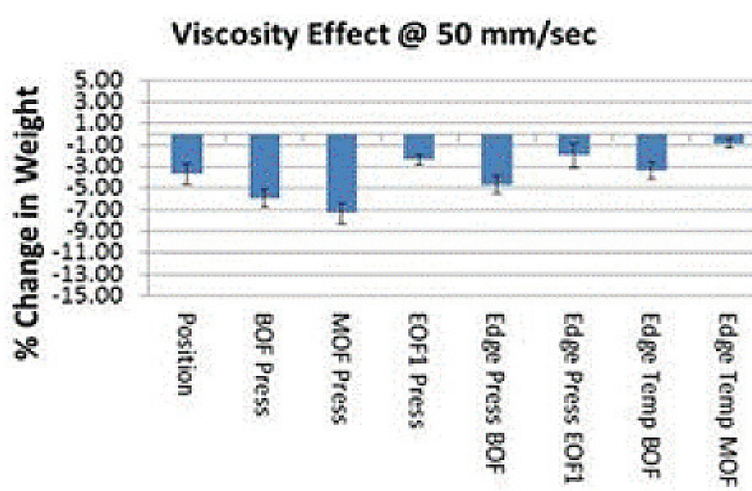


Figure 5: Viscosity effect with 2SP2 at a 50 mm/sec injection velocity.



IMD Best Paper Continued

jection time was not limited, the other V/P methods could compensate and transfer at different times.

Figure 7 shows that Injection Pressure and BOF Pressure were affected most by viscosity. The parts molded with the low viscosity weighed about 20% and 12% more respectively. This large difference was because the parts molded with the high viscosity were short shots. This result was expected for Injection Pressure, but not for BOF Pressure.

Figure 13 shows the pressure, velocity, and surface temperature curves from a typical shot for the BOF Pressure transfer for both the low and high viscosity material. The notable difference is that the EOF pressures that can be seen with the low viscosity material are not present in the high viscosity curves. This is because the high viscosity gave short shots. To further examine why this occurred, two shots molded with low and high viscosity using MOF Pressure transfer are shown in **Figure 14**. These two shots gave almost identical parts. It should be noted that the low viscosity curves were shifted to the right by 0.015 seconds to compensate for the small effect of viscosity on Position transfer weight. The MOF

Pressure transfer of 27.7 MPa is shown in **Figure 14** and it can be clearly shown that both the low and high viscosity materials reach that pressure at the same time, which explains why the parts were the same. The transfer pressures that were used for the Injection Pressure and BOF Pressure trials, 189 MPa and 48.3 MPa respectively, are also shown in **Figure 14**. The points where the low and high viscosity curves meet the transfer pressure for each of these two methods are not the same. The large difference explains why the effect of viscosity was so large with Injection Pressure and BOF Pressure. It is obvious

Figure 6: Decompression (check ring leakage) effect with 2SP2 at a 50 mm/sec injection velocity.

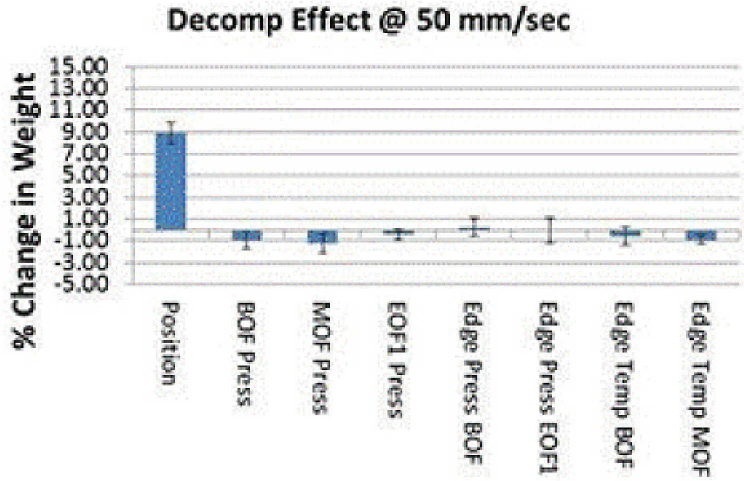


Figure 7: Viscosity effect with 2SP1 at a 50 mm/sec injection velocity.

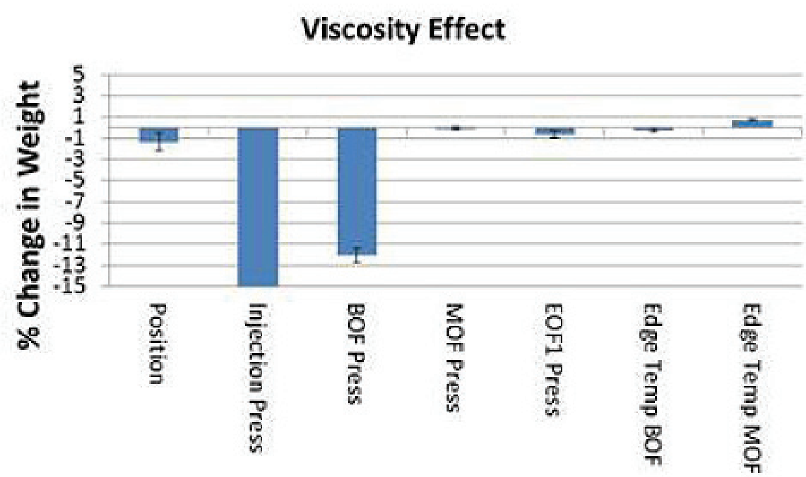
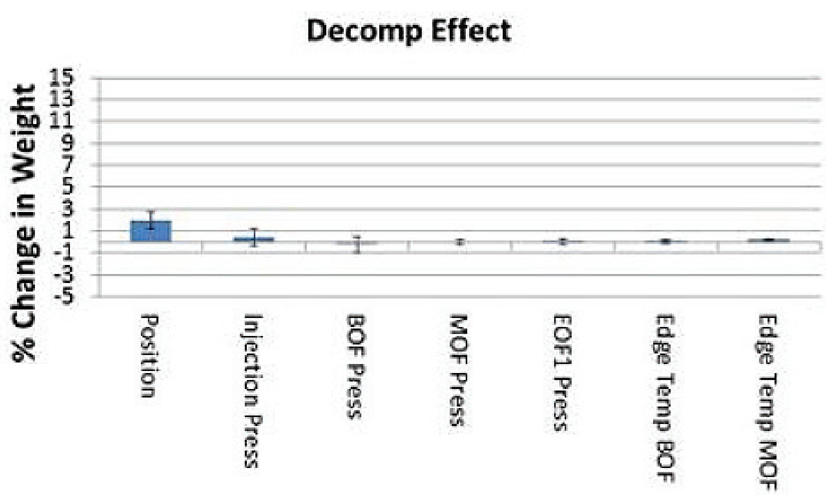


Figure 8: Decompression (check ring leakage) effect with 2SP1 at a 50 mm/sec injection velocity.



looking at the curves that nothing could improve the Injection Pressure results. However, if the BOF V/P transfer pressure were increased from 48.3 to about 55 MPa, it is very possible that the viscosity effect would disappear for this method. This is because the transfer would be reached after the part was full and the steep cavity pressure slope would minimize any difference in transfer.

In addition to MOF Pressure, viscosity had no effect on EOF1 Pressure, BOF Temperature, or MOF Temperature. These four methods all show an advantage over using Stroke. The EOF2 Pressure and EOF Temperature sensors were located too close to the end of fill and could not be used without the screw over-travel flashing the mold.

2SP2 — 2-Stage, Pack with Second Stage

For the 2SP2 injection strategy, using edge detection with the MOF Temperature and EOF Temperature were the only two methods that showed an improvement over Stroke when considering both the effect of viscosity and decompression (check ring leakage) at both 50 mm/sec and 25 mm/sec injection velocities (**see Figures 3 – 6**). The BOF Temperature and EOF1 Pressure and Edge EOF1 Pressure were much better than Stroke when considering just decompression and about the same as Stroke when considering viscosity changes.

The large effect of decompression variation (check ring leakage variation) can be seen graphically in **Figure 15** and in the difference in the size of the parts at transfer in **Figure 16**. The parts with decompression weighed more than the parts without decompression by 8% at 25 mm/sec and 9% at 50 mm/sec. **Figure 15**

Figure 9: Viscosity effect with 3S at a 50 mm/sec injection velocity and 5 mm/sec pack velocity.

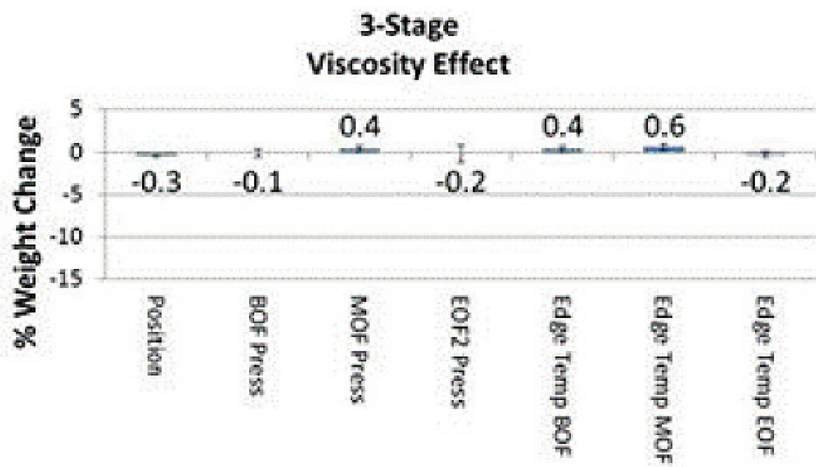


Figure 10: Decompression (check ring leakage) effect with 3S at a 50 mm/sec injection velocity and 5 mm/sec pack velocity.

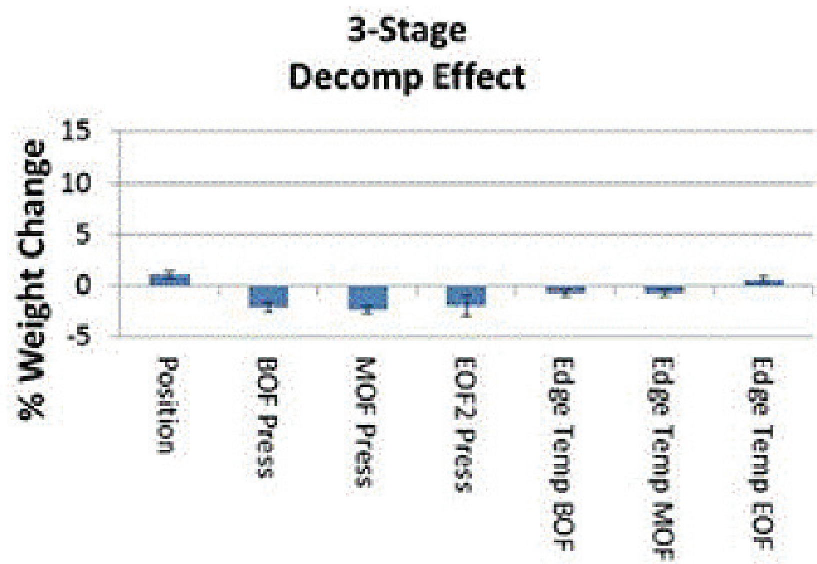
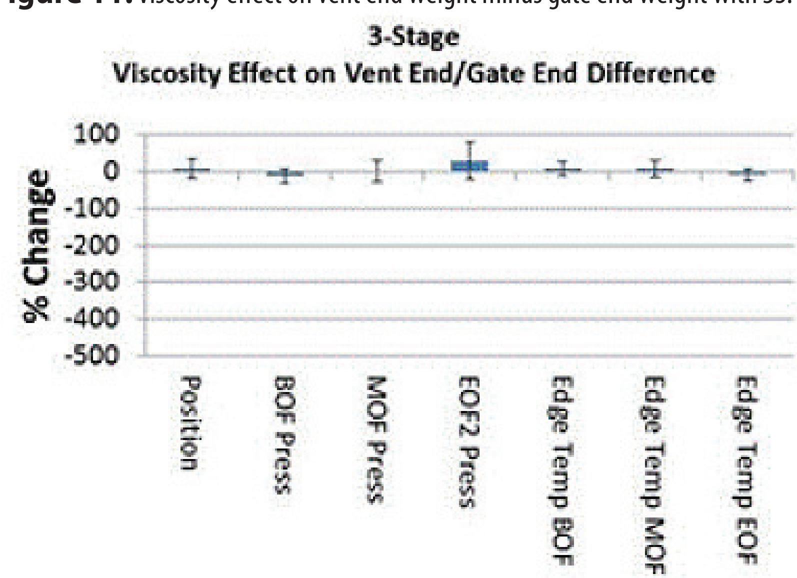


Figure 11: Viscosity effect on vent end weight minus gate end weight with 3S.



IMD Best Paper Continued

shows that the pressures are not as high without decompression because not as much plastic was pushed into the cavity, which can be seen in Figure 16.

Using pressure to transfer when the parts are not full is a problem for the reasons discussed with 2SP1 and pointed out in **Figure 14.** The reason that edge detection does not work as well with the pressure sensors as it does with the temperature sensors is because the pressure does not rise nearly as fast during fill as the temperature does and the pressure increases at a slower rate if the viscosity is lower (**see Figure 14**). The most likely reason that the EOF1 (Pressure and Edge) worked about as well as Stroke was that the transfer occurred just after the melt front hit that sensor. The EOF1 Pressure V/P transfer setting was less than 1 MPa for both the 50 mm/sec and 25 mm/sec injection velocities.

3S, 3-Stage

It was found that for the 3S injection strategy that none of the transfer method weights were significantly affected by the viscosity (**see Figure 9)**. Figure 10 shows that decompression (check ring leakage) most significantly affected BOF Pressure, MOF Pressure, and EOF Pressure with the parts molded without decompression weighing about 2 % more than those molded with decompression. Position was affected slightly by decompression with the parts molded with decompression weighing 1 % more than those molded without.

The effect of decompression is most likely related to the fact that the change from the 50 mm/sec to 5 mm/sec velocity is done by screw stroke in all cases (at

Figure 12: Decompression (check ring leakage) effect on vent end weight minus gate end weight with 3S

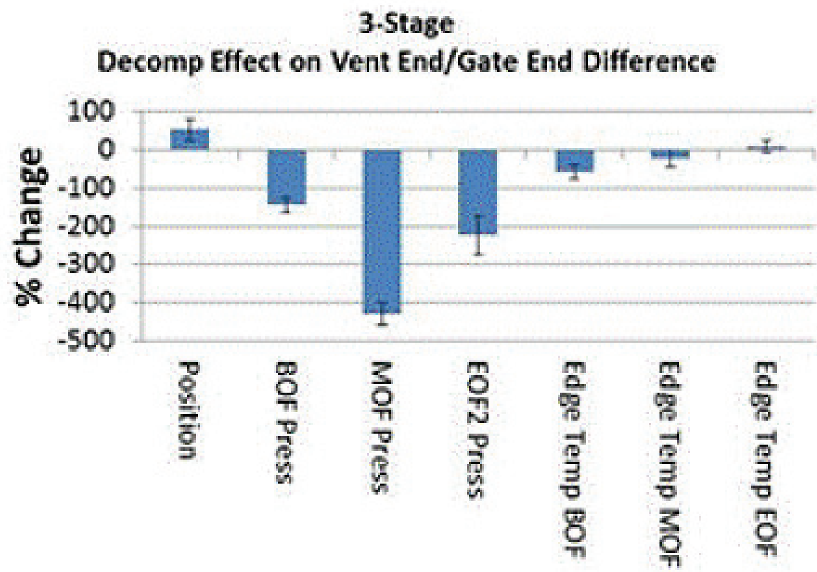
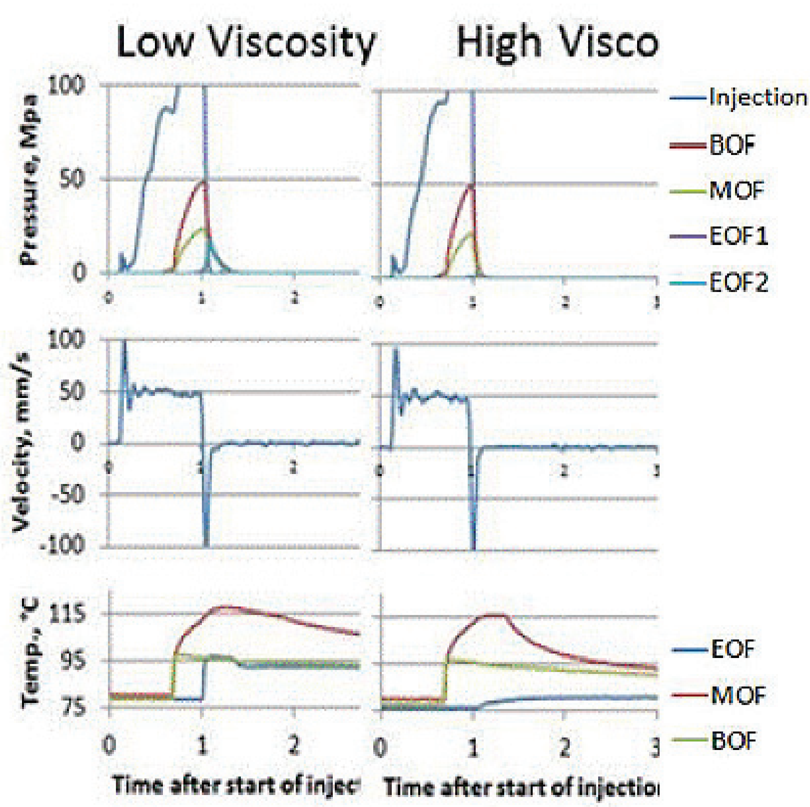


Figure 13: 2SP1 injection with low and high viscosity material, BOF Pressure transfer, and with decompression.



IMD Best Paper Continued

0.25 inches). The parts were about as full as Figure 16 shows when the velocity changed occurred. As can be seen in **Figure 17**, this causes more of the part to be filled with the second, slower velocity and for the part to not be packed to as high of a pressure. **Figure 18** shows that, for in-cavity pressure transfer, in addition to more fill with the slower velocity the parts are also packed longer until reaching the set pressure. This causes the parts without decompression to weigh more than those with decompression when BOF, MOF, or EOF2 Pressure is used for transfer.

Figure 12 shows how the difference in weight at the end of fill (vent end) and the weight at the beginning of fill (gate end) is affected by transfer method. The pattern is the same as for the overall weight; the difference was more than four times as much for the no decompression compared to with decompression for the MOF Pressure transfer, and the difference was half as much for the no decompression compared to with decompression for the Position transfer. The longer pack at the low velocity affected the weight at the vent end more than the gate end. **Figure 19** shows one possible explanation for this. The part shown was molded with the 3S process and is the first part when changing from clear to white material. The white areas show where the material was flowing during pack and gives an indication of what areas will be packed more with additional pack time. The vent end disk clearly has more white than the gate end.

Figure 14: 2SP1 injection with MOF pressure transfer showing the effect of a viscosity change.

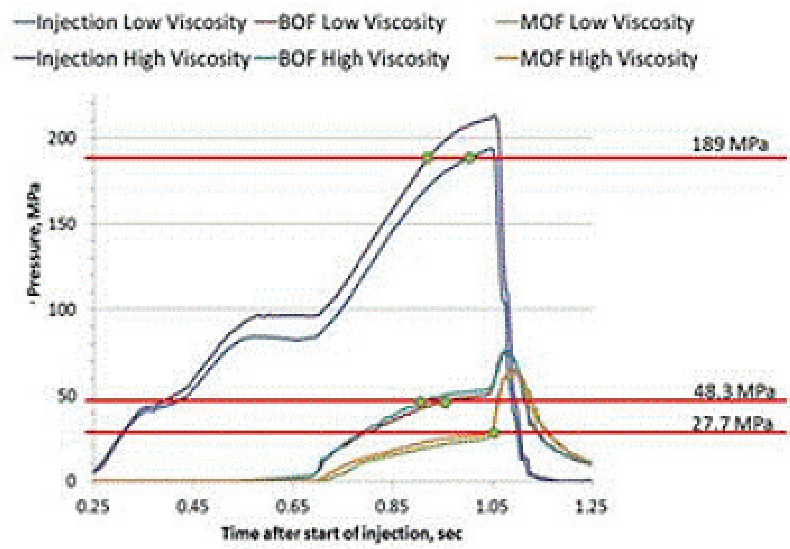
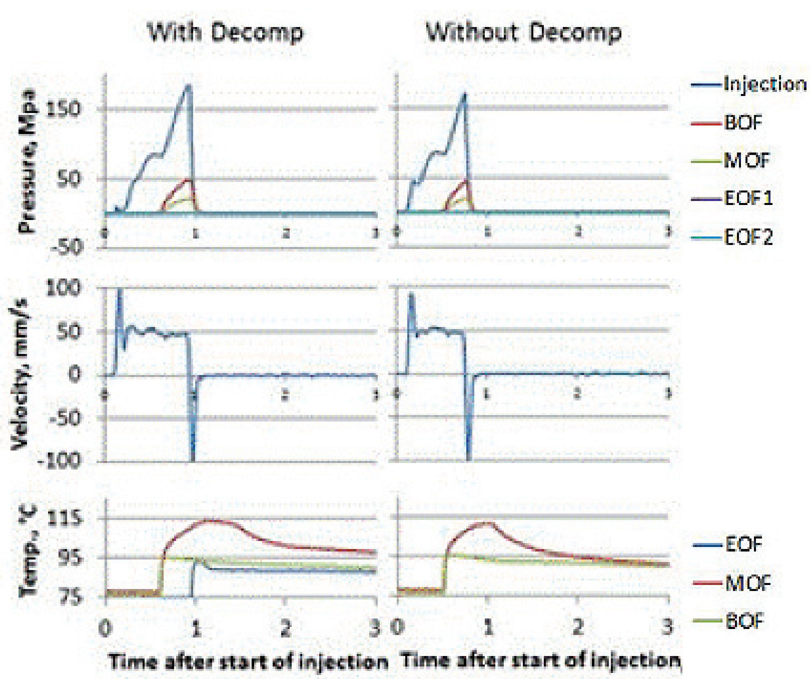


Figure15: SP2 injection with position transfer and low viscosity material, with and without decompression.



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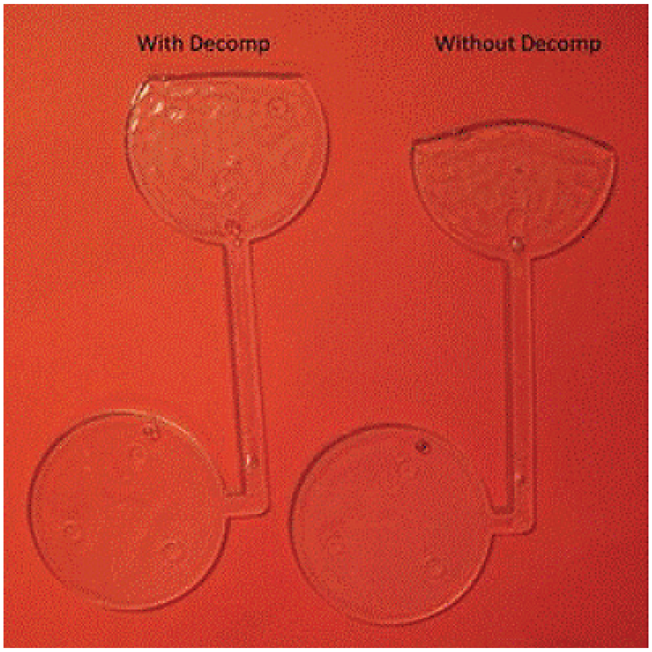


Figure16: Parts at transfer with a 2SP2 injection, with position transfer, and low viscosity material, with and without decompression.

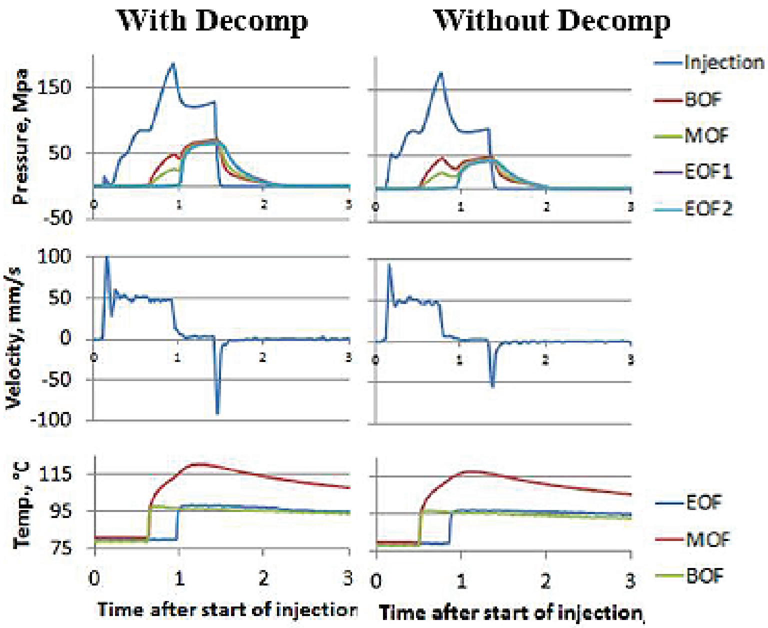


Figure 17: 3S process with position transfer with and without decompression.

With Decomp Without Decomp

All the Temperature transfer methods were affected the least by decompression. Of these, the EOF was best, most likely because the melt front did not hit it until it had slowed down to the final pack velocity.

Conclusions

For the material, part geometry, and process set-up conditions used in this study, the following conclusions can be made. It should be noted that the effectiveness of a V/P method is in comparison to traditional screw stroke V/P transfer.

1. For all three injection strategies studied (2SP1, 2SP2, and 3S), a V/P transfer with a surface temperature sensor close to the last place to fill in the cavity showed the least variation when either the material viscosity or the decompression (check ring leakage) varied.

2. For the 2SP1 or 2SP2 injection strategies, using any of the in-mold sensors for V/P transfer

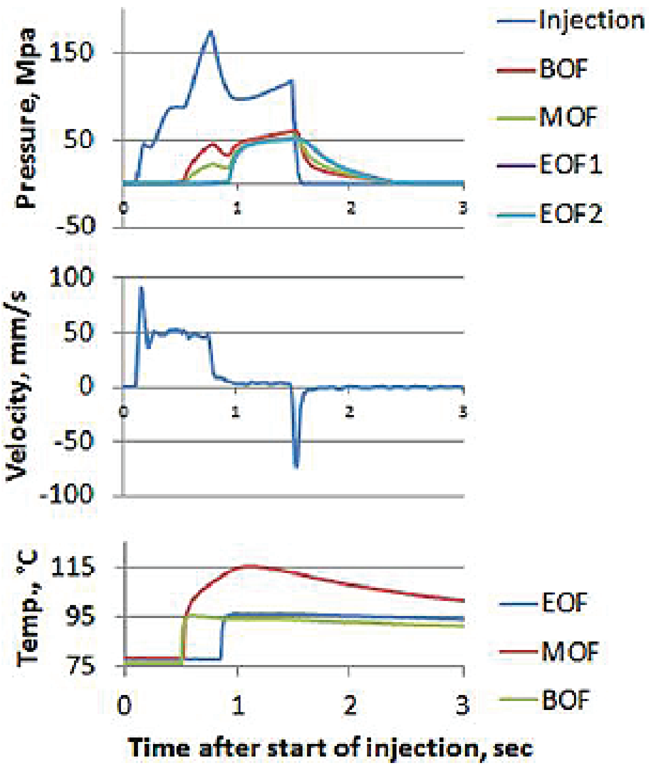
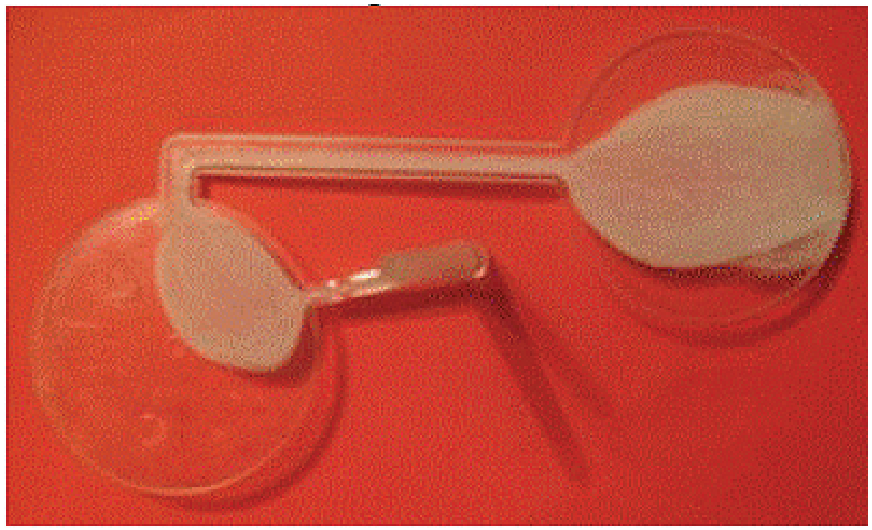


Figure18: 3-stage process with MOF transfer and without decompression.

IMD Best Paper Continued

Figure19: First part with colorant when changing from clear to white. Shows where material flows during pack.



was advantageous over Stroke when only the decompression (check ring leakage) was considered.

3. For the 2SP1 and 2SP2 injection strategies, the screw over-travel must be considered when deciding on the placement of sensors. If placed too close to the end of fill, the over-travel will prevent transfer from occurring soon enough.

4. For the 2SP1 injection strategy, in-cavity pressure V/P transfer can be effective when viscosity varies if the V/P transfer pressure is set at a pressure reached after the part starts to pack.

5. For the 2SP2 injection strategy, in-cavity pressure V/P transfer is not effective when viscosity varies.

6. For the 3S injection strategy, none of the transfer methods are sensitive to viscosity variation.

7. For the 3S injection strategy, in-cavity pressure V/P transfer is not effective when decompression (check ring leakage) varies. This is due to the variation in how much of the cavity is filled with the low velocity.

8. Surface temperature sensors are more effective than cavity pressure sensors when used to detect the arrival of the melt front (edge detection).

Acknowledgments

The author would like to thank Bayer MaterialScience LLC for donating the polycarbonate used for this study; Priamus System Technologies, RJG Inc., and Kistler Instrument Corp. for donations of sensors and data acquisition systems.

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IMD Board of Directors Meeting

April 21, 2013

Cincinnati, OH

Submitted by Hoa Pham, Secretary

Welcome

The outgoing Chair Susan Montgomery called the meeting to order at 8:05 AM. She thanked the Board for the support over the last two years during her terms as Acting Chair and Chair of the Board. She passed the gavel to the incoming Chair Erik Foltz.

Erik thanked Susan for her service and welcomed everyone to the meeting.

Roll Call

Present were:

Erik Foltz (Chair), Susan Montgomery; Jim Wenskus; Peter Grelle; Hoa Pham; Pat Gorton; Adam Kramschuster; Jeremy Dworshak; Tom Turng; David Okonski; Rick Puglielli; Srikanth Pilla; Brad Johnson, Jack Dispenza, Nick Fountas; Larry Schmidt and Mal Murthy.

Guest was: Barbara Spain (SPE Staff)

Absent were:

David Kusuma; Michael Uhrain; Kishor Mehta; Lee Filbert and Raymond McKee.

This constituted quorum.

Nominations Committee — Hoa Pham, Chair

Hoa presented the results and comments of the 2013 ballot. Also presented were the slate of incoming Board officers and the Technical Program Chairs from current through 2020.

Board Officers and Councilor

Erik Foltz, Chair
Susan Montgomery, Past Chair
James Wenskus, Treasurer
Hoa Pham, Secretary
Peter Grelle, Technical Director
Brad Johnson, Councilor

Technical Program Chairs

ANTEC 2013: Pat Gorton	ANTEC 2017: Rick Puglielli
ANTEC 2014: Adam Kramschuster	ANTEC 2018: Srikanth Pilla
ANTEC 2015: Raymond McKee	ANTEC 2019: David Kusuma
ANTEC 2016: Jeremy Dworshak	ANTEC 2020: David Okonski

IMD Board of Directors Meeting Continued

Approval of February 1, 2013 Meeting Minutes

Motion: Erik moved that the February 1, 2013 meeting minutes be approved, as written and distributed. Tom Turng seconded and the motion carried.

Pinnacle Award — Erik Foltz

Erik reported that the IMD earned the Pinnacle Award — Gold Level. Adam Kramschuster would be representing the Division to receive the Award. Areas to strengthen were online presence and TOPCON offerings. Pat Gorton would be leading the efforts to prepare for the 2013 Pinnacle Award (to be presented at ANTEC 2014).

Financial Report — Jim Wenskus, Treasurer

Jim presented the financials ending in March 31, 2013 and the 2013 — 2014 budget.

Although the SPE fiscal year was changed to run from January to December, the IMD budget was still from one ANTEC to another. Thus, the rebates appeared slightly behind the budgeted amount.

The website expense, which was approved at the last meeting, was captured on the Miscellaneous line. Funding of the IMD scholarship was briefly discussed.

Motion: Erik moved that the Board continue to contribute $5,000 to fund the IMD scholarship. Tom Turng seconded, and the motion carried.

Action Item: Jim Wenskus to present the payment of $5,000 to the SPE to fund the IMD Scholarship.

Communications Committee — Adam Kramschuster, Chair

Adam reported on the state of the newsletter and the IMD online presence. Sponsorships for the newsletter has been healthy, resulting in a net profit. The upcoming newsletter deadlines for submissions of content, sponsorships and payments are:

- Summer (July 2013) – June 10
- Fall (November 2013) – October 10
- Spring (March 2014) – Feb 10

The development of the IMD webpage is in progress. The content and layout were completed. The next phase would be building the page and uploading the content.

The traffic on the IMD Facebook page has been increasing. Adam called for Board members to 'like' the page, and send in events or information to be posted. The administrators of this page are: Jeremy Dworshak, Raymond McKee and Adam Kramschuster. If any Board member wants to be an administrator, let Adam know.

ANTEC 2013 Technical Program Committee — Pat Gorton, Chair

Pat presented the final session matrix and schedule for the keynote address. Since the information on the keynote address was not included in the ANTEC final program, Barbara Spain would include it in the Errata page. For the sessions, Pat would be sending the transition slides to all moderators. Barbara noted that the moderators had the option to use the printed form or online Surveymonkey to provide their feedback.

IMD Board of Directors Meeting Continued

Erik announced that Jim Peret was resigning from the Board, leaving the Awards Chair vacant. Tom Turng agreed to take this role and Erik appointed him to the position.Tom thanked Jim for his work as Awards Chair over the past years. The Board noted that David Kusuma had offered access to Tupperware's rapid protyping capability to help with creating the awards.

IMD Reception

Pat had made arrangements for the IMD reception on Tuesday, which would be held in the Prefunction Lobby of the West meeting room on the second floor of the Duke Energy Center.

Erik noted that getting primary sponsors for the IMD reception at ANTEC was becoming more challenging. Thus, he suggested leveraging the newsletter to recruit secondary sponsors. Banners at ANTEC were discussed. The suggestion was to add $200 to the ANTEC budget for printing banners. Also, Srikanth proposed to offer a one time sponsorship space in the newsletter. For this year's reception sponsor, Moldex, Erik would mention the appreciation in the Chair's message and include their logo.

Technical Director Report — Peter Grelle, Chair

ANTEC Papers

Pete thanked Pat for an outstanding job in organizing the technical session for ANTEC 2013.

Injection Molding Webinar

Jeremy Dworshak, Ray McKee and Nick Fountas worked on a survey to determine our customers' needs in a training program. Nick had sent out a survey and Pete presented the results to the Board at this meeting.

Discussions ensued with recognition that custom molders' often hesitated conducting webinars for fear of giving away their trade secrets. Other means were suggested: approach machine vendors, conduct short series covering basics to advanced levels, include business topics, or obtain sponsorships and provide the webinars for free.

TOPCON Update

The upcoming TOPCONs are: Penn State Erie Injection molding Conference, to be held on May 22 – 23, 2013 in Erie, PA, and the 13th Annual International Polymer Colloquium at the University of Wisconsin to be held on April 26, 2013.

China TopCon — Tom Turng for David Kusuma

The team had a teleconference on March 25 with the SPE HQ staff to discuss China TOPCON to be held in Shanghai. To avoid any Chinese major holidays, the selected dates were December 11 and 12, 2013. The proposed title of this conference was 'Shaping the Future of Injection Molding Through [Radical] Innovation".

The Board was asked to consider the word 'Radical' in the title and its implications. After discussions, the Board agreed using "Game Changing" instead of "Radical".

The conference would offer four technical sessions: Molding & Processing, Part Design & Geometry, Material Developments and Innovative Case Studies.

The presentation included information on proposed registration, budget, promotion plans and financial arrangement with SPE.

The Board approved the proposed program and agreed with moving forward.

IMD Board of Directors Meeting Continued

IMD Membership Committee — Nick Fountas, Chair

Nick presented the trends and demographics of the IMD membership. Following the general membership trend of SPE, the Division membership saw approximately 20% decline. Most of the secondary membership came from eight divisions.

In discussions, Adam noted that despite having a strong student chapter, the college was not able to recruit freshmen and sophomores to join SPE. The student members have been juniors and seniors. To better understand this phenomenon, Nick would re-analyze the data on student members.

Action Item: Nick to reanalyze the data to clarify trends on student membership.

SPE Membership Campaign — Recruitment & Retention — Rick Puglielli

Rick conducted a review of the membership value to better understand how to recruit and retain members. His presentation underscored the desire of potential members to experience more than just membership benefits. The Division, and the Society at large, needed to demonstrate clearly a solid return on investment on membership dues. Rick proposed some steps to engage and reach out to the target membership.

In discussions, the following actions were proposed:

1. Erik will create some YouTube clips on injection molding
2. Rick will show molding of nylon
3. Brad will show how to set up injection molding machine at the Penn State-Erie Conference.

Action Item: Erik, Rick and Brad to execute on the proposed actions to start engaging the target membership of the Division.

Training & Learning — Erik Foltz for Jeremy Dworshak

The objective of this effort was to determine how the Board could leverage our expertise to guide our members on the offerings of injection molding training. Jeremy proposed that the Board invite different trainers to the Board meetings, record the training sessions and post them online. Further discussions led to other ideas.

The Board agreed that Jeremy would lead the effort to develop a schedule for the training presentations. The goal was to present this schedule to the Board for approval at the next meeting. To initiate, Adam would place a 'call for trainers' in the upcoming newsletter (Summer)

Action Item 1: Adam to publish a 'Call for Trainers' in the Summer issue of the newsletter.

Action Item 2: Jeremy to develop the schedule for training presentations.

Councilor Report — Brad Johnson

Brad gave a summary report on the activities of the SPE Council. The IMD rebate was given. With the changing role of Council and the Executive Committee, Council was reading the book, "Race for Relevance — 5 Radical Changes' to gain insights into this change.

IMD Board of Directors Meeting Continued

The SPE instituted a policy change on rebates. Another change afoot was the requirement on the appointees made by the incoming President. Under current practice, the President can appoint one or two members who must be Committee or Section Chair. To keep the Council fresh with new ideas, this requirement will be removed.

The SPE monthly financials are available on line. With the US still being the largest market, efforts have been underway to attract members, such as SPEconnect, collaboration with other organizations (SPI, ACC, Plastics News, etc) to draw in new members, and increase visibility through conferences around the world.

HSM & Fellows, IMD Historian Update — Larry Schmidt, Chair

Larry announced that he would like to be an Emeritus member, and would pass on his responsibilities for HSM & Fellows, and IMD Historian. The Board proposed that Kishor take the responsibilities for HSM & Fellows. Erik would confirm with Kishor. For Historian, Hoa would take this role.

Action Item 1: Erik to confirm with Kishor on taking up HSM & Fellows

Action Item 2: Larry to send to Hoa all documents relating to the IMD history

IMD Training Presentation — Umberto Catignani

As part of the Training & Learning initiative, Erik arranged for Umberto from Orbital Plastics Consulting, Inc. to give a short presentation outlining the injection molding training that his company provides. The program offers courses for certification, as well as public, private or customized training.

New Business — Erk Foltz, All

Erik reported that a month ago, the Board received a member's suggestion to recognize long time members who had contributed to the Board and Division. After discussions, the Board agreed that the Chair could write about the selected individuals for the newsletter.

Action Item: Erik to select a long time member of the Board to highlight in the newsletter.

Erik noted that the ANTEC meeting format could be condensed. Options discussed were: (1) Instead of meeting early, the Board could hold the meeting in the evening and open up the 'New Business' section to Division members to attend and participate. (2) the Board could have the meeting before the IMD Reception. (3) the Board could hold a shorter technical session on Tuesday afternoon of the event, followed by the Board meeting and then Business meeting. The Board favored option 3, and Erik agreed to follow up.

Action Item: Erik to follow up on the feasibility of implementing option 3.

Another suggestion was to post the history of injection molding on line. Tom Turng said he had some presentations ready and would provide them to Adam to post on the IMD website.

Action Item: Tom and Adam to coordinate to have the History of Injection Molding presentation posted on the IMD website.

IMD Board of Directors Meeting Continued

Special Recognition

Erik presented the Chair's appreciation plaque to Susan Montgomery. Erik and the Board thanked Susan for her leadership as Acting Chair and Chair.

Old Business

None discussed.

Next Meeting

The next Board meeting will be in September-October time frame. Erik to provide the date and time.

Adjournment

Motion: Adam moved to adjourn the meeting. Rick seconded.
The meeting was adjourned at 2:05pm ET.

IMD Leadership

DIVISION OFFICERS

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

Chair-Elect
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Energizer
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Treasurer
Jim Wenskus
wenskus1@frontier.com

Secretary
Assistant Treasurer
Nominations Comm. Chair
Historian
Hoa Pham
Avery Dennison
hp@0802@live.com

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

Past Chair
Susan E. Montgomery
Priamus System Technologies
s.montgomery@priamus.com

Councilor, 2011 - 2014
Brad Johnson
Penn State Erie
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TPC ANTEC 2019
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TPC ANTEC 2020
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China TOPCON Chair
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Membership Chair
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HSM & Fellows
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Plascon Associates, Inc
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Reception Committee Chair
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Awards Chair
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Larry Schmidt
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IMD New Members

The Injection Molding Division Welcomes 170 New Members...

Mark Wallace Alexander
Peter Allan
Andrew James Angros
Dave Anthony
Yasir H. Arain
Sohail Asghar
David Ross Astbury
Dave S. Axford
Jane Barefield
Mark C. Baysinger
Clemens Behmenburg
Roy Biederman
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John Birle
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Chemplast Inc.
CIMA Plastics Group
Clariant Australia Pty. Ltd.
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Comtec IPE
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Injection Molding - D23
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Plastics Environmental - D40
Polymer Analysis - D33
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Tennessee-Tennessee Valley
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Rapid Design, Engineering and Mold Making – SIG 020
Thermoplastic Elastomers - SIG 006

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Message from the Publisher

I hope you enjoyed this issue of *Molding Views*. *Molding Views* strives to find useful information for all of the Injection Molding members. I would like to thank Susan Montgomery for all her hard efforts this past year as IMD Chair and a warm welcome to Erik Foltz who is taking on her role this year. Thank you and well wishes to you both!

As the summer is underway, hopefully you will be able to relax and take some time to check out the upcoming shows and webinars coming this fall. The SPE web site is daily updating all event information.

The next issue of Molding Views will be here before you know it and we need articles! Please don't hesitate to send in your papers this summer! Any questions on how to submit your article please e-mail PublisherIMDNewsletter@gmail.com

Thank you all and have a great summer!

Heidi Jensen
PublisherIMDNewsletter@gmail.com

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