Fall 2017 | No. 105

MOLDING VIEWS

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

Chair's Message

Dear Friends,

The past year and a half has been a real pleasure as being the chair of the IMD Board. Over that time we have done more collaboration, introduced more technical materials, and facilitated our mission as a Society. Our goal with IMTECH was to make a conference that was more focused on the practical side of Injection Molding, to have a conference that people at all levels of an organization could participate and take something away that would help them in their respective business. Putting on a conference isn't an easy thing and I have to thank Dave Okonski and Pete Grelle for everything they did to make the conference a success. As we go forward, industry support is critical to continuing these programs, both from a content standpoint as well as financial sponsorship. If you would like to offer support with our events, please feel free to contact me. With that, we look forward to another exciting and busy year.

Best regards to all,

Ray McKee 2016-2017 IMD Chair
raymckee@gmail.com

In This Issue:

This Month's Features:

Industry Events Calendar

Click the show links for more information on these events!

JANUARY 2018

JANUARY 23 - 24
Forum by JEC & SPE Composites for Performance in Sports
Long Beach, CA

FEBRUARY 2018

FEBRUARY 9
Medical Plastics 2018 MiniTec - "What's new in Medical Device Materials & Processing Technology?"
Anaheim, CA

FEBRUARY 20 - 21
Thermoset 2018 Conference
Indianapolis, IN

MARCH 2018

MARCH 6 - 7
Successful Plastic Part Design — Midwest 2018
Gurnee, IL

MAY 2018

MAY 1
AUTO EPCON 2018
Troy, MI

MAY 7 - 10
ANTEC® Orlando
Orlando, FL

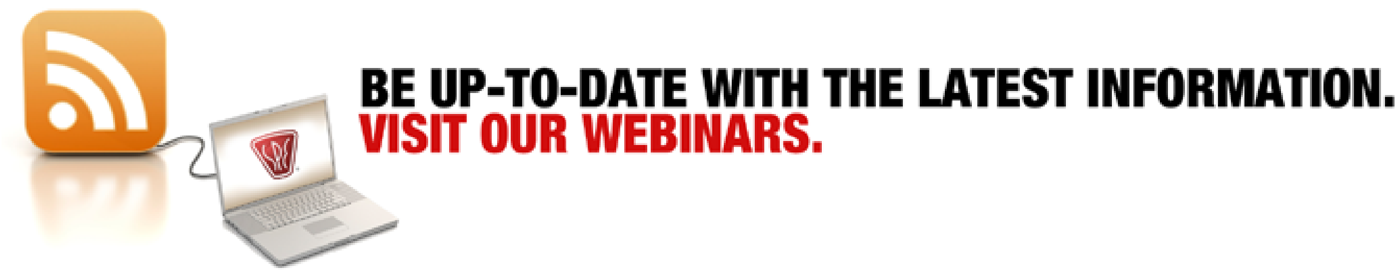
MAY 9
Additive Manufacturing Workshop
Orlando, FL

JUNE 2018

JUNE 3 - 6
Rotational Molding Conference 2018
Cleveland, OH

JUNE 13 - 14
Amerimold 2018
Novi, MI

Webinars



Degradation Failure of Plastics

November 15, 2017
Begins at 11:00 am
Approx. Run Time: 1 hour
Plastic materials offer a unique balance of strength and ductility associated with their inherent viscoelastic nature.However, they are susceptible to molecular degradation through a variety of exposures.Molecular degradation is a permanent change in molecular weight that reduces the mechanical properties and integrity of the plastic material. This degradation can occur during compounding, processing, storage, or while in service. Such degradation mechanisms include:

•Thermal Oxidation
•Hydrolysis
•Ultraviolet Radiation
•Chain Scission
•Destructive Crosslinking

The various forms of molecular degradation account for approximately 20% of plastic part failure, and an understanding of the nature of degradation can help to prevent failure. Topics covered during this session will include:

•Introduction to plastic molecular degradation, including the various mechanisms
•Material Susceptibility to degradation
•Stabilizers to prevent degradation
•Testing to assess the level of degradation

Stragtegies for Implementing Scientific Molding
Available on demand

Lower Time to Market and Boost Customer Satisfaction with 3D Printed Injection Molds
Available on demand
Learn how customers such as Berker are cutting production time and costs by switching to injection molds that are 3D printed rather than traditionally manufactured. Decrease lead time on production parts and bring in new customers by skipping the outsourcing process and mold creation using more time-consuming methods.

IMTECH Show Re-Cap

IM SPE TECH 2017
INJECTION MOLDING

"From Art to Innovative Engineering"

This past August, the Injection Molding Division held its inaugural innovations conference IMTECH 2017. IMTECH 2017 was attended by about 200 industry professionals and all seemed to enjoy the conference format of concurrent technical sessions in the morning followed by an afternoon of industry tours and evening networking receptions. The technical sessions were based on industry talks given by industry professionals who are experts in their respective fields. There were no podium presentations by any college or university student. To be quite frank, the target demographic for IMTECH is industry people; people that are process engineers, tooling engineers, design & release engineers, program engineers, engineering managers, … in general, manufacturing engineers that actually make plastic "stuff" work. It is the (Injection Molding Division) Board's desire to have attendees leave at the end-of-the-day with some information that can be immediately applied to their daily workflow. I am grateful to my fellow colleagues on the Board of Directors who authorized me to establish and create the IMTECH conference series as our way of reconnecting with the vast number of plastic industry professionals that are out there.

In 2017, we had 41 technical presentations and plant tours provided by SODICK, Plustech, and Wittmann-Battenfeld. Many THANKS to all of our speakers and to the three companies providing the plant tours. Many THANKS to our sponsors and media partners as well – we know who puts the pellets in our hopper – we couldn't have done this without your support. Finally, I would like to acknowledge and personally thank the members of the organizing committee for the 2017 conference; this team of dedicated professionals worked hard to bring IMTECH to life. You all did an amazing job – THANK YOU !!

On a personal note, I am looking forward to IMTECH 2018 and very excited about the potential opportunities the future holds for all of us. **Please "Save the Date" – IMTECH 2018 will be held November 6th through November 8th in the vicinity of Cleveland / Akron Ohio.**

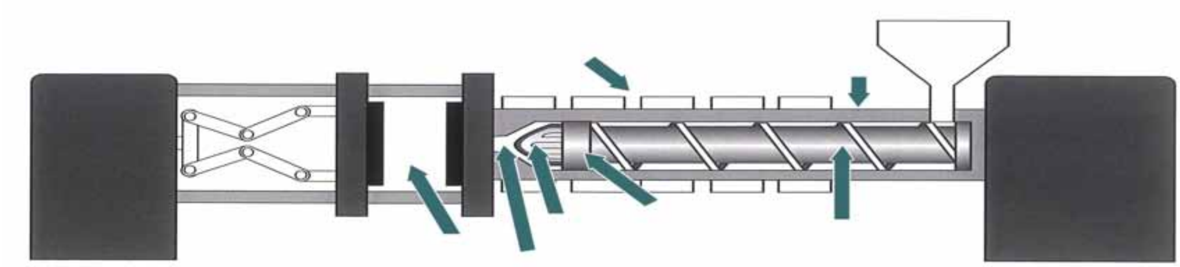
All the Best,
David A. Okonski
IMTECH Chair

Thank you to all our presenters and sponsors who helped support this years show!

Basic Rules for Retaining Long Fiber Composites in a Molded Part

Long fiber materials are usually used for metal replacement opportunities. Retaining long fiber materials in the molded part is essential for final part performance. In order to retain long fiber materials in the final part there are many key ingredients to achieve success. In this tech brief we will give the molder basic rules for achieving success with the final molded part.

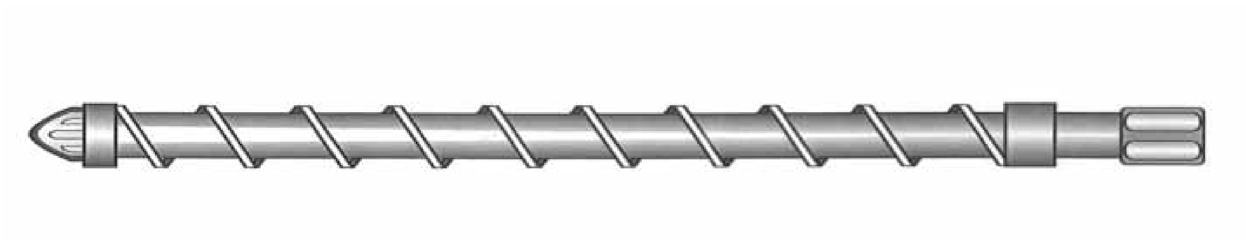
- **Injection Molding Equipment**
  - Single-stage reciprocation screw injection molding machines are preferred however; plunger type machines have been successful molding Long Fiber materials.
  - The use of a mechanical, hydraulic & hydro mechanical clamping unit when used properly, are all suitable for processing Long Fiber materials.
  - The injection unit size should allow for the use of 40 - 60% of the barrel.



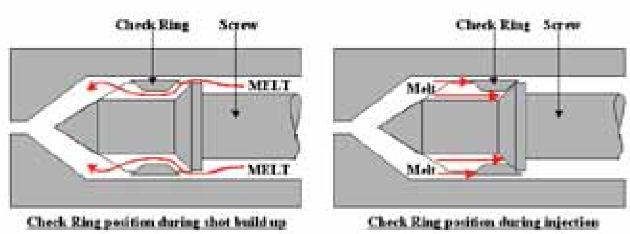
- **Screw Design**
  - General purpose metering type screws are preferred however; Pulsar® type screws from Spirex® are acceptable.
  - Compression ratio = 2:1 to 3:1.

From the Experts: Retaining Long Fiber

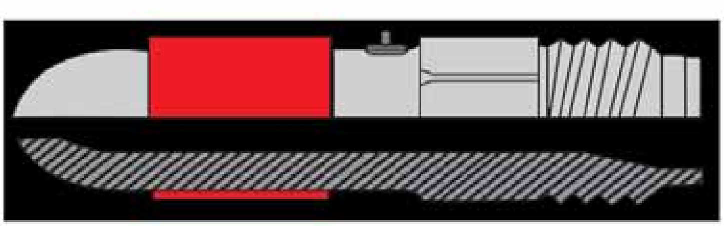
- L/D ratio = 18:1 to 22:1.
- Zone distribution = 40% feed, 40% transition, 20% metering.
- Feed zone channel depth = 7.5 mm
- Metering zone channel depth = 3.5 mm
- Pitch = 1D
- Barrier, double wave, and vented barrel mixing screw designs are not suitable for optimum processing of Long Fiber materials and should not be used.

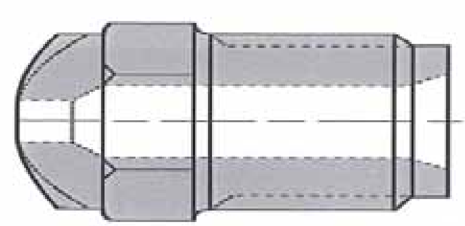


- **Non-return valve and screw tip**
  - A three piece screw tip assembly with a free flowing non-return check valve provides 100% free flow, is most preferred. All passageways should be sized to provide smooth open melt flow.



- **Nozzles & nozzle tips**
  - Both must be general purpose!
  - A generous orifice diameter will ensure the restriction-free flow of material.
  - Nozzle orifice diameter should be 0.020" smaller than the sprue bushing.
  - Do not use internally tapered tips (often called "nylon tips"), or tips without a constant diameter pathway.





From the Experts: Retaining Long Fiber

- **Dryers & Drying**
    - Use a desiccant drying unit with dew points from -20° F to -40° F. This will ensure all moisture is eliminated from hygroscopic materials.
    - Non-hygroscopic materials are susceptible to surface moisture that should be removed before processing.
    - When drying materials it is important to keep the air returning to the desiccating unit below 130° F. This may require the use of an after cooler. If the air returning from the dryer hopper to the desiccation unit is above 130° F, the desiccant cannot remove the moisture from the air, it, in effect, is regeneration all the time. The hotter the return air is, above 130° F, the less efficient the drying will be. With return air above 150° F there will be no drying at all.
    - All material matrixes have their own individual drying conditions. It is recommended to follow all preferred drying conditions outlined in the manufactures molding guide.
    - It is recommended to do a moisture analysis on all hygroscopic materials.

Now that we have reviewed the necessary injection molding equipment and drying requirements we must now use the correct processing method to retain the long fibers into the molded part.

- **Long Fiber Processing Tips**
    - Set barrel and mold heats accordingly to particular material (PA6, PA66, TPU, etc.) using manufacture recommendations.
    - Use low backpressure, i.e. 25 – 50 psi & slow screw speed, i.e. 25 – 50 rpm.
    - Use slow to medium fast injection screw speed, i.e. 1 – 3 in/sec.
    - Low shear conditions are imperative.

Now that we have the necessary molding equipment, drying and processing requirements we must now use the correct tooling designs to retain the long fibers into the molded part.

General Tooling Information

- **Runners**
    - Full-round runner systems of ~0.250" are preferred, although trapezoidal equivalents are acceptable.
    - Use adequate radii on sharp corners.

- **Sprues**
    - An initial diameter of at least ~0.250" is preferred.

- **Gates**
    - For smooth flow, gates should be large and rectangular, at least ~0.250" x ~0.125" or 40-90% of wall thickness.

From the Experts: Retaining Long Fiber

- Width = ~1.5-2.0 x Depth (use higher % for reinforced materials).
- Land Length = 1/2 of gate depth.
- Excessive land length causes jetting; insufficient land length causes blushing and sinks at the gate.

- **Venting**
  - Vent wherever possible, at parting lines, runners, ejector pins, bosses, ribs, projections, etc.
  - Vent Land = ~0.002" Deep
  - Vent Channel = ~0.005" - ~0.020" Deep
  - Runner = Double preferred vent channel depth
  - Ejector Pins (per side) = 0.0065"

Now that we have the necessary information to retain long fibers within the final molded part we can assure success for the adequate parts performance. If by chance the part fails you may want to check the part for fiber length by doing a part burn off in a muffle furnace. If you want more scientific evidence of long fiber retention you can submit the part for an optical microsposy. The best areas of the part to check are the sprue, runner, gate and end of part or material flow.

As you can see there are many key ingredients for retaining long fiber in the molded part.

Following the noted technical suggestions will help.

About the Author

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

By Jose M. Perez, Jr.,
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A Study of Two Processing Induced Part Failures

Of the four pillars required for the successful development of a plastic part; material selection, part design, processing, and service environment, processing is often assumed to be the most controllable. Even when the service environment has been properly defined, the best design principles implemented, and the appropriate material selected, seemingly insignificant changes in processing can grossly and adversely affect an otherwise well developed product. This paper will explore two case studies where the failure of the parts can be traced directly back to changes in the injection molding processing parameters and how these changes ultimately predisposed them to premature failure.

Introduction

A literature review revealed that an estimated 20% of plastic product failures can be traced back to improper processing [1]. The term improper processing encompasses several factors including improper compounding/blending, thermal and hydrolytic degradation, and the formation of voids and weak areas in the parts secondary to incomplete packing of the material. Any one of these actions can serve to weaken a finished part and make it more susceptible to subsequent mechanically or chemically induced stresses. Secondary processes can also be included in this category, but are not addressed within the scope of the two case studies presented in this paper.

Processing of the raw material into a finished part is often overlooked insomuch that it is considered to be constant, once the original parts have gone through a production part approval process (PPAP) and actual production has begun. However, as with any endeavor, diligence is required to ensure that changes made to the process do not ultimately predispose a part to failure. Examples of these changes include those deliberately made in order to increase productivity as well as changes that result from moving of the tool into a different press than the one used to qualify the part or those that result from prolonged use of a tool such as wear or scale buildup. While some part design and material combinations allow for generous processing windows before defects form, others are less forgiving and require closer monitoring to avoid potentially catastrophic results.

A Study of Two Processing Induced Part Failures

Case Study 1 – POM Fuel Filter Housing

The first case began as a contracted root cause analysis of a cracking issue with fuel filter housings molded from an unfilled polyacetal copolymer (acetal or POM) resin. The customer reported that the housings had an established performance history with a very low failure rate, however a recent increase in leaking had been detected. The housing design consisted of an open ended cylinder with a flat bottom mounting plate. The design also incorporated two screw bosses, each 180° apart and designed as semi-circular extensions of the cylinder wall.

The part was molded by a third party in a single cavity cold runner tool that used a single gate at the edge of the mounting plate which resulted in material flowing into the cylinder feature from the bottom outside edge. The molder reported that no changes to the tool or to the molding process had been implemented since the initial production of the housing, but did confirm that the tool was molded using multiple different presses, each reportedly with similar capabilities.

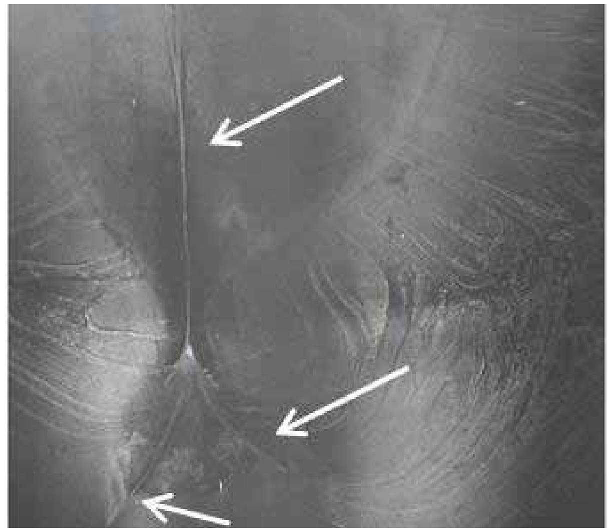

Figure 1: Matte appearance, semi-circular markings, and indications of cold flow (white arrows) were present on the inside surface of the fuel filter housing.

In service the housings were internally pressurized with automotive fuel, reportedly to a nominal 3-5 psi. The failure was described as the formation of a vertical crack on the outside wall of the cylinder feature through which fuel leakage occurred. The time to failure was described as the approximate mid-point of the housing's anticipated service life. No anomalies in the service condition were discovered by the customer and their end users. Because no molded-in date code wheel was used and no other form of date coding was available, traceability of the part to a production date was not possible.

Tests and Results

Visual examination of a representative housing confirmed the presence of a single crack, oriented parallel to the cylinder's central axis. A pair of faint witness lines on either side of the crack was observed but no evidence of mechanical damage or macro-ductility in the form of stress whitening or permanent deformation was noted. Comparison between the failed housing and a known good part revealed stark differences at their respective interior surfaces. Specifically, the failed housing's inside surface had a matte appearance with several concentric semi-circular features were observed adjacent to the fracture surfaces, as shown in **Figure 1**. Matte areas on parts with an otherwise glossy appearance are commonly associated with mold temperature variances. A representative fracture was completed at ambient laboratory conditions, cleaned in a soap solution, and gold coated to accentuate the fracture details. Electron image overviews of three fracture

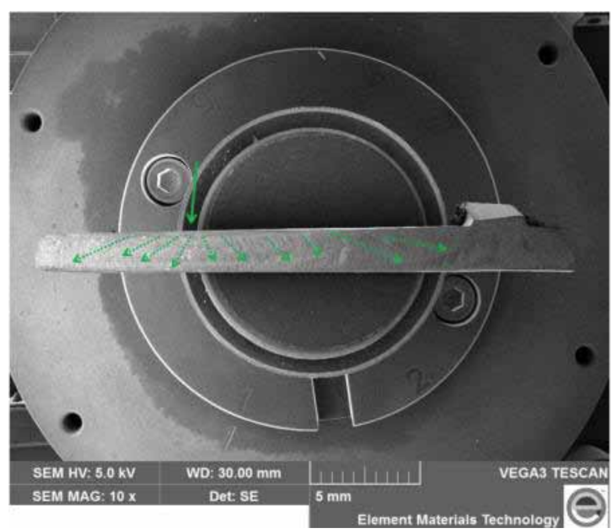

Figure 2: Overview of the gold coated fracture surface. Arrows indicate the origin and crack extension directionality.

A Study of Two Processing Induced Part Failures

surface locations are provided as **Figures 2 through 5**.

Inspection of the fracture surface revealed the presence of a recessed linear area along the outside surface. The texture within this area was consistent with the as-molded surface, suggesting that it represented either a depression on the part surface or a sink area formed either during or immediately after initial molding. A single crack origin region was observed at the outside surface along the knit line. At this origin, a distinct shelf-like area was noted, which indicated that the Initial crack extension was radial in nature first extending across the part wall followed by bilateral extension. A semi-circular band of fine micro-ductility with a flame-like appearance was observed adjacent to the origin. This morphology has been previously observed in cases of fatigue in POM materials. The presence of banding indicated that the cracking occurred in multiple steps, not a single event. Beyond the origin, an overlapping morphology was noted, which is consistent with mechanical overload of the material. This region then transitioned into a second area of flame-like morphology. The overlapping morphology was also noted in the lab fracture region.

Specimens from the failed and known good housings were analyzed via micro-Fourier transform infrared spectroscopy (FTIR) and differential scanning calorimetry (DSC), both of which confirmed the composition of both samples as being consistent with a POM copolymer resin with no evidence of bulk contamination. No evidence of under-crystallization or differences in the crystallinity between the samples was noted.

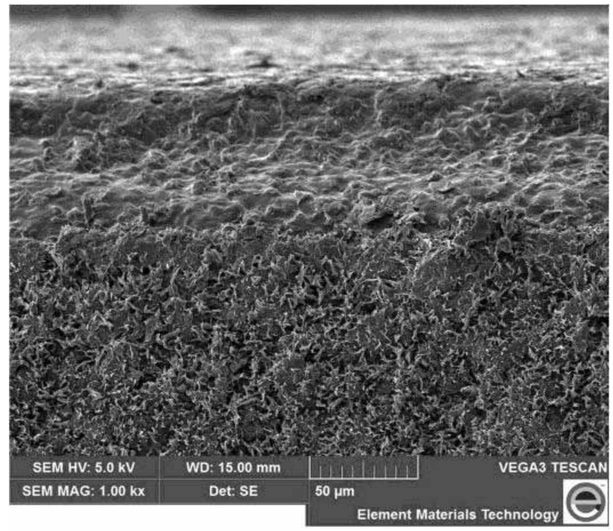

Figure 3: Electron micrograph of the outside surface near the origin on the failed fuel filter housing.

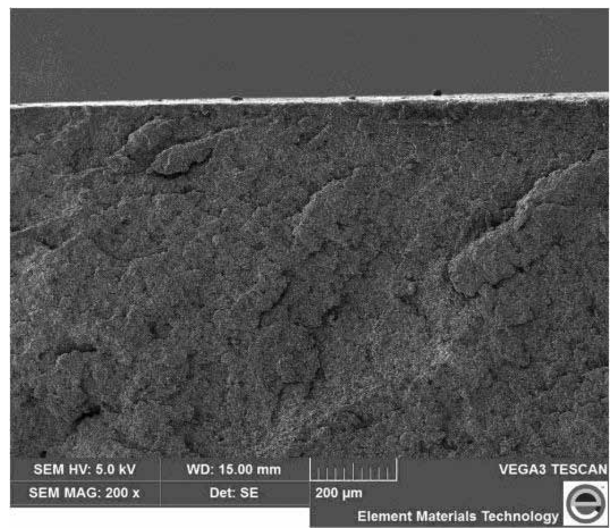

Figure 4: Electron micrograph depicting the overlapping morphology on the failed fuel filter housing.

Conclusions

The fractographic examination, particularly the presence of the flame-like morphology in a banded pattern interspaced with an overlapping morphology, indicated that the housing failed via alternating phases of fatigue and mechanical overload. This was exacerbated by the presence of a weld or knit line coupled with evidence of cold material flow leading into the weld line region. The source of the stresses was the typical loads applied to the housing during operation. The knit line resulted in poor molecular entanglement at the fracture surface, which predisposed the part to failure.

This conclusion was based on: 1) the presence of a matte appearance on the inside surface of the failed housing, which was consistent with the part having been molded in a relatively cold tool, and 2) semi-circular markings adjacent to the crack indicated that the resin itself was also relatively cold as it filled the mold cavity. The cold flow of the material would have increased the amount of residual stress present at the weld line and reduced the resin's ductility within this region of the part.

A Study of Two Processing Induced Part Failures

Discussion

A knit line represents an area of a molded part wherein two divergent flow fronts converge and can become the weakest location in a molded part. The degree to which a knit line impacts the mechanical properties of the finished part is dependent on the amount of molecular entanglement across the knit line This can be minimized by utilization of proper melt and mold temperatures as well as higher pressures during the packing phase of the injection molding process [2]. Higher melt and mold temperatures will result in a thinner frozen layer at the flow front, which will subsequently entangle to a greater degree, when they merge. Conversely, colder melt and mold temperatures will result in a thicker frozen layer, which will result in a weaker knit line and exacerbate its effect on the performance of the finished part. Lastly, the absence of these features on the known good sample indicated that the tool and process were both capable of producing defect-free parts. Follow-up discussions with the molder suggested that improper translation of the processing parameters may have been at fault, but the lack of traceability prevented a definitive conclusion from being drawn.

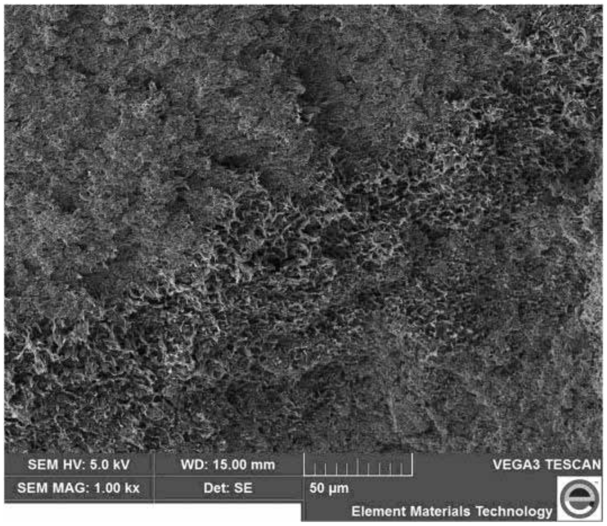

Figure 5: Electron micrograph depicting a band of flame-like morphological features (white arrows) on the failed fuel filter's fracture surface.

Case Study 2 – Glass Filled Nylon Suspension Mount

The second case also involves a contracted failure investigation of a component used as a vehicle suspension support. The shape of the support resembled a bundt pan with a threaded stud at the peak of the central cylinder feature. A dozen support ribs, each approximately 50 mm deep, were present within the bowl region but did not span across the opening, instead forming a U-shape. A star-shaped rib network spanned the open end underneath the stud. The nature of the failure was cracking of the primary wall of the central cone shaped feature at a site between two of the U-shaped ribs. The customer reported that the failures ranged from either formation of a crack or catastrophic cracking of the support within this area.

Figure 6: Close up view of the crack on the outside surface of the failed support.

It was reported that the tool used to mold the part had been in service for over ten years without incident, but that the failure rate had recently spiked. The support had always been molded from the same material, described as a polyamide 66 (PA66) material with 33% glass fiber filler. A small quantity of this material was also provided. The support was molded in a single cavity cold runner tool with a sprue gate at the intersection of the star-shaped ribs within the cone feature.

A Study of Two Processing Induced Part Failures

Tests and Results

Visual examination of the support confirmed the presence of a single through wall crack, oriented parallel to the support's central axis, as shown in **Figure 6**. No evidence of mechanical damage was noted. Upon sectioning, multiple distinct flow lines were noted, each forming relatively deep fissures, as shown in **Figures 7 and 8**. The fracture was completed, at which time it was discovered that the fracture surface was not actually a crack, but instead a molding defect. Specifically, a region with morphology consistent with the as-molded surface was noted, as shown in **Figure 9**. This surface was cleaned in a soap solution and gold coated to accentuate the surface details. Electron image overviews at three locations are provided as **Figures 10 through 12.** The transition between the outside surface and the defect surface revealed that the morphology between the two was almost identical, as shown in Figure 10. The same was true at a point along the defect and at the edge of the defect.

Figure 7: Photomicrograph of the cold flow fissures (white arrows) on the inside surface of the failed support.

Figure 8: Higher magnification view of the cold flow markings on the right of Figure 6.

Figure 9: Photomicrograph of the defect surface from the failed support.

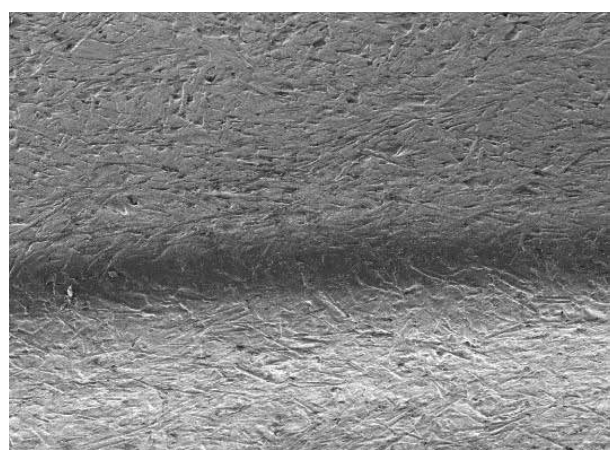

Figure 10: Electron micrograph of the transition between the outside surface and the defect surface from the failed support.

A Study of Two Processing Induced Part Failures

Specimens of the resin and the failed support were analyzed via FTIR, DSC, and thermogravimetric analysis (TGA). The results of these analyses determined that the material was consistent with its stated composition as a PA66 resin with a nominal 33% glass filler content. The melt flow rates (MFR) of the resin and failed support material were determined, with a summary of the results provided in **Table 1**. A review of the MFR data indicated that the failed support material was significantly different in terms of its average molecular weight relative to the virgin resin. This disparity suggested either the use of a different resin grade or of gross molecular degradation.

Conclusions

The fractographic examination determined that the support crack was actually a molding defect which extended across the full wall thickness. A review of the part design in relation to the gate suggested that air

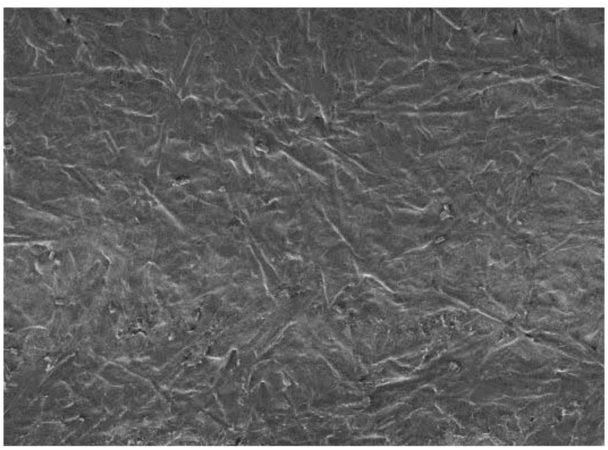

Figure 11: Electron micrograph of the defect surface from the failed support.

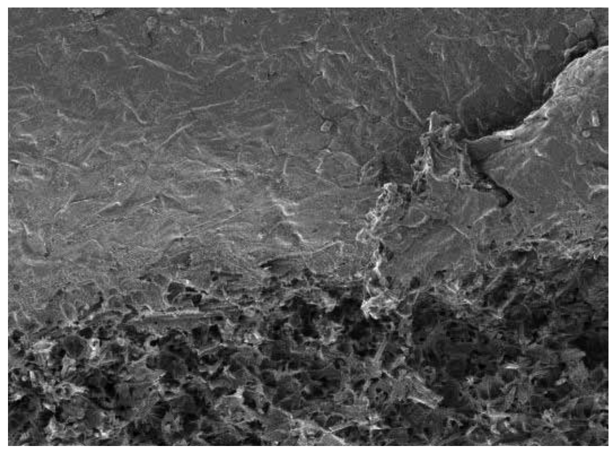

Figure 12: Electron micrograph at the edge of the defect -from the failed support.

Table 1
Average melt flow rate results for the frame material utilizing a test temperature of 275 °C and a constant load of 1.0 kg.

Sample	Melt Flow Rate, g/10 min.
Resin	5.1
Failed Support	15.9

trapping may have been the result. Based on these findings, a series of molding trials were recommended to the customer.

Based on this recommendation, a short shot study was performed, which uncovered that, under certain conditions, air trapping did occur. Further scrutiny of the part dimensions and molding process parameters revealed that the part and tool were no longer within their originally specified dimensions

The impact of the gross disparity in the average molecular weight observed between the resin and part was not immediately apparent, but was suspected to have been a contributing factor in the failure.

Discussion

Attempts to improve the molding process used to form this part resulted in elimination of the defect through the implementation of a multi-stage injection profile. Improvements to the inspection process were also implemented. The customer chose to focus their molder's efforts on addressing the obvious molding defect and not the molecular weight disparity. This would be addressed by means of a process audit although no follow-up work was performed at their direction to verify auditing had or had not identified or corrected the underlying cause(s).

Summary

Undetected or undocumented variations in the processes used to mold and assemble a finished plastic part can have very significant results on how it ultimately performs in the field. While some failures in processing are evident, such as deformation or discoloration of the finished article, others, such as the ones covered in these two cases, can go unnoticed, but have similar unwanted effects on the part's integrity. In the first case study, failure to properly translate molding parameters when the mold was moved into a different press resulted in changing an established part into one which was predisposed to failure. Conversely, in the second case study, changes in the tool and molding process used to form the part resulted in the formation of severe defects.

References

1. D. Wright, Failure of Plastics and Rubber Products, Rapra Technology Limited, United Kingdom, pp 4-6, 17 (2001).

2. Scheirs, J., Compositional and Failure Analysis of Polymers, a Practical Approach, Wiley, pp 37-70, England (2000).

Fully Coupled Analysis Brings Optimal Accuracy

Current well-developed computer-aided engineering technology of mold filling simulation can help users predict potential product defects prior to actual mold production. It facilitates efficient manufacturing process and high-quality products, and further reduces trial-and-error costs. In order to provide more accurate simulation results and reliable analysis data for product and mold designs, the fully coupled process simulation capability in Moldex3D R15 is now available. In this analysis calculation, the simulation data in every time-step program solver can be delivered, bringing optimal analysis accuracy. The differences between conventional and fully coupled process simulation will be interpreted below.

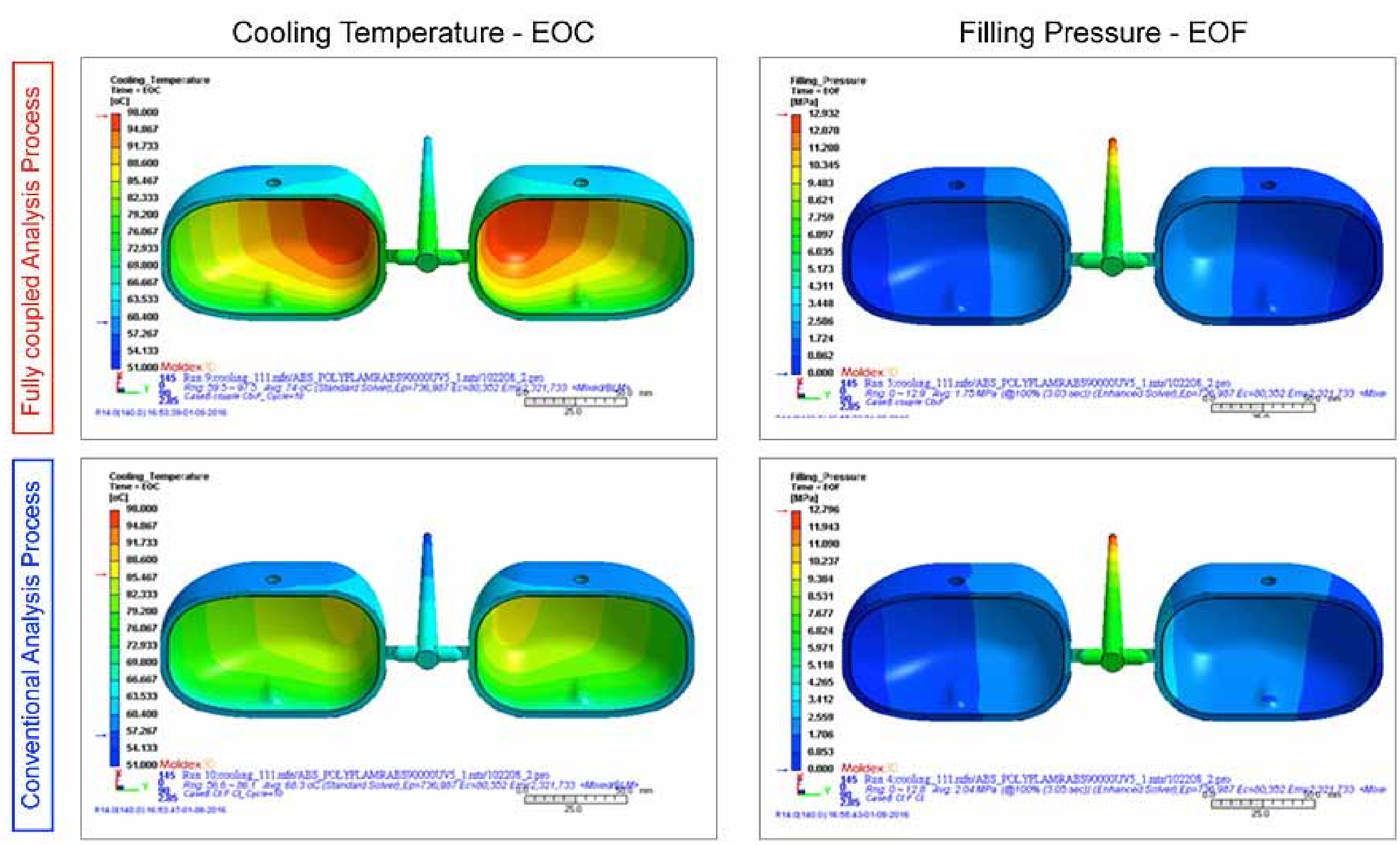

Figure 1:
The comparison of fully coupled and conventional analysis results.

Conventional Analysis Process

Filling, Cooling, Packing and Warp are separate solvers and will run analysis sequentially instead of simultaneously. The data transmits among different programs hrough file communication, which is a one way process. For instance, when Filling analysis is proceeding, Cooling analysis has already finished, means Filling and Cooling analysis cannot interact immediately. Moreover, the required file and hard disk space will be larger if the communications get more frequent.

Fully coupled Analysis Process

In fully coupled analysis process, the kernels of Filling, Cooling, Packing and Warp are integrated and can run simultaneously, thus, the physical quantities in the mold can affect each other. Fully coupled analysis results can be more reliable and consistent to real-world molding. This can also be utilized in predicting heat accumulation areas of complex geometric products.

The case in **Figure 1** shows the difference between conventional and fully coupled process simulation. The shear heating at filling stage will frequently interact with the mold temperature at cooling stage. The interactions can be considered in fully coupled analysis, so obvious heat accumulation results can be calculated. This is shown by the difference of pressure analysis results between two simulation types. The highest temperature in fully coupled analysis is 97.5 °C. This is 11.4°C higher than in conventional analysis (86.1 °C. Because the pressure data can be delivered more easily, the average internal pressure of the product in fully coupled analysis is 1.75MPa, which is 0.29MPa lower than in conventional analysis (2.04MPa).

As shown in the case above, Moldex3D's fully coupled analysis brings increased levels of accuracy. This is especially an ideal option for demanding applications such as automotive parts that require complex geometric designs and optical lenses that made to be high precision ofμm. Moldex3D fully coupled analysis provides design guidance product engineers require to make informed design decision, cutting significant costs.

Moldex3D
MOLDING INNOVATION

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Development of an Inline Plasma Treatment During Injection Molding Process

In order to fulfill continually increasing requirements in optical and haptic applications, in particular requirements for the functionality of injection molded components, it is frequently necessary to make use of additional processing steps such as coating, bonding, or two-component injection molding. However, due to the low surface energy of many polymers, the necessary adhesive strength cannot be achieved without further modification. One typical surface treatment for increasing the surface polarity of plastics and improved adhesion properties is atmospheric pressure (AP) plasma treatment. Typical applications of this method use CNC-automated machinery, which enables good results to be achieved with a high degree of consistence, but which unfortunately are difficult to implement for inline application.

With that in mind, the goal of the research presented here was to develop a surface treatment process which makes inline plasma surface modification during an injection molding process possible. This contribution describes the development and investigation of surface treatment with a stationary plasma jet, as well as the integration of this technology in the injection molding process.

Introduction

AP plasmas are employed for a variety of tasks in today's industrial processes, including cleaning, pre-treatments, and surface coating. Due to the low surface energies of many plastics, the plastics-processing industry frequently utilizes plasma technology to effect targeted modification of part surfaces and to prepare them for later process steps such as bonding with adhesives or coating. When activating polymers, chemical functional groups are deposited on and coupled to the substrate surface, causing an increase in surface energy. This leads to significant improvement in surface wettability and high adhesion strength in surface-bonded systems such as varnishes or adhesives. [1, 2]

For such treatments, jet nozzle concepts are often employed which involve an uncharged plasma beam forced through a stream of ionized gas (air, nitrogen, argon, etc.) before it hits the surface to be treated. When using surface treatments with AP plasma, the effectiveness of the treatment is dependent on multiple factors, such as the distance between substrate and jet and the speed at which the process occurs. These and other influencing factors affect the treatment intensity and the homogeneity of the activated polymer surface. Although using CNC-automation ensures that 3-D parts and components are produced with replicable quality and are activated with a defined level of intensity, such processes nonetheless require the expansion of the chain of production, which is economically undesirable. Prior developments to integrate plasma treatments into the injection molding process have continued to use CNC-supported systems, with which the plasma treatment takes place in situ: the molded part is plasma treated at the end of the production cycle while resting in the opened tool [3, 4]. In such a case, however, the plasma treatment is not independent of the cycle time, due to the add-on nature of the process. It is only during the injection molding cycle itself that an in-situ and cycle-time-neutral plasma treatment is possible. The use of CNC-supported plasma treatment in that case is no longer a viable option.

The goal of this research was to develop a surface treatment which works independently of CNC-automation technologies and nonetheless provides homogeneous surface activation. Additionally, the desire was to create a treatment process that was compatible with typical existing injection molding processes. The subject of this paper is the conceptualization of such a process, the depiction of experimental results from preliminary investigations to determine significant influential factors, and the development of an injection molding comprising integrated plasma treatment.

Process Design

The goal when conceptualizing the process was to develop a plasma treatment that could be applied to partial surfaces in situ without affecting the cycle times of the existing injection molding cycle. While doing so, activation should be limited to a pre-defined area of the molded part. The basis for these experiments was a typical application scenario in which a groove encircling the part was to be activated; such situations frequently occur in the cases of housing covers with injected seals or the housings of automobile headlamps.

The process was to be developed with the provision that it should influence the standard injection molding process as little as possible, in order to keep restrictions on such a process low. In order to avoid affecting the injection molding cycle, the plasma treatment must therefore be implemented parallel to one or more of the steps in the existing cycle. The cooling phase offers a suitable process step that can be further exploited within the cycle. During this phase and after the part has solidified, other process steps (such as plasticizing and dosage metering) can be carried out in parallel. Consequently, the process was conceived so that the plasma treatment follows solidification (**Figure 1**). Due to the still-closed position of the mold, the area of the part to be treated must be freed by a core-back. This creates an area of free volume between the molded part and the injection molding tool (**Step 3 in Figure 1**). After the channel release, the channel can be used for the plasma stream. During this stage, the plasma is

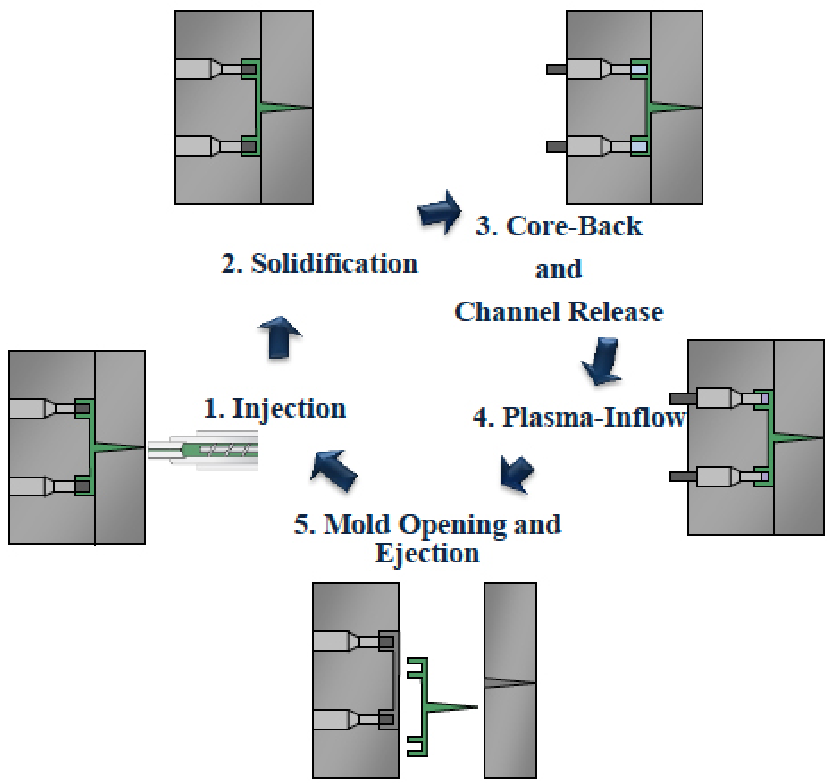

Figure 1: Process flow of the DIP treatment.

funneled over the relevant surface area, simultaneously activating it (**Step 4 in Figure 1**). At the end of the cooling phase, the plasma treatment is also ended and the part is ejected (**Step 5 in Figure 1**).

In contrast to conventional plasma treatments, CNCsupported plasma jets cannot be employed here, as the mold remains closed. This means that a localized plasma treatment was not possible; instead, a new plasma treatment process, with a stationary mounted plasma jet, had to be developed. The technical challenge in doing so is that the plasma flow interacts with its environment and that resulting recombination processes lead to a weakening of the plasma jet. The required distances of the jet stream cannot be effectively bridged under conventional circumstances. In CNC-supported systems, the distance between jet nozzle and part is a crucially influential factor; at distances of more than 50 mm, the plasma jet is so far weakened that surface activation is no longer possible. This technical challenge was solved by sending a plasma beam through a stationary mounted jet nozzle into an atmospherically sealed and controlled region [5]. This treatment process will be referred to in the following as a Direct Injection Plasma treatment (DIP treatment).

Experimental Setup

The process concept for DIP treatment represents an entirely new development, requiring verification through preliminary experimental investigations. An experimental testing setup has therefore been developed in order to obtain a general understanding of the process, as well as to, determine influential factors and possible disturbances; these experiments are capable of reflecting the application requirements for real-world use of such a plasma treatment in an injection mold.

For the experimental setup, the Openair® PFW30 plasma jet was flanged onto a channel up to 600 mm in length. The channel has a rectangular cross section that can be varied between 6x6, 8x8 and 10x10 mm^2. The channel is divided into two sections, positioned at an angle of 90° to each other. Using this setup, the influence of flow obstructions on the targeted surface activation will be examined. Along this channel section, six plastic specimens are used that are activated by the plasma flowing through them. For the experimental tests, two target values were defined. Firstly, the surface activation, represented by the surface energy, is determined by the sessile drop method.

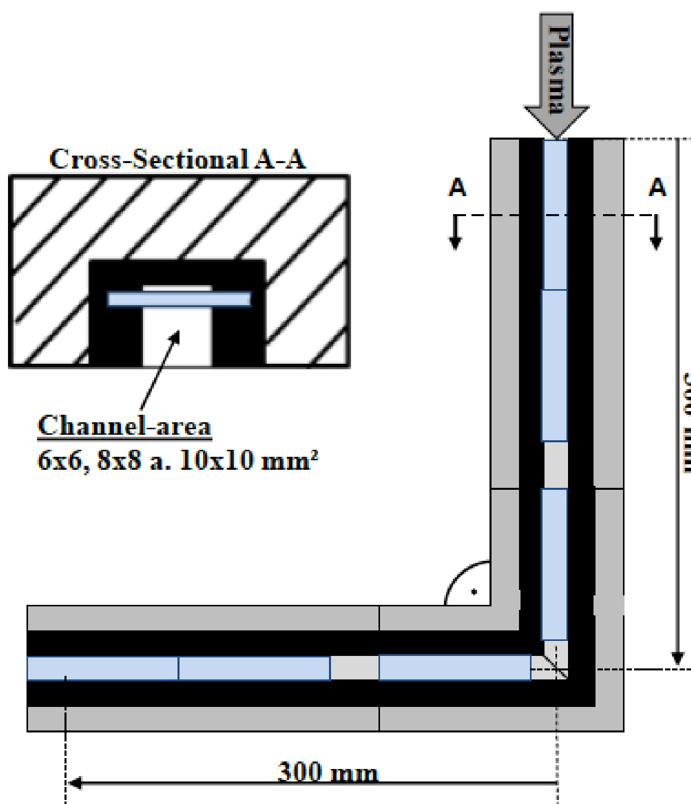

Figure 2: Diagram of the stationary installed plasma jet and the flow channel.

For this, the OCA 35 contact angle measuring device from manufacturer Dataphysics was used.

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The tests were carried out with two probe liquids. In the second set (D-T-W), water was used instead of ethylene glycol to also enable the detection of high-energy surface activations. In addition to the two polar liquids, ethylene glycol and water, the highly disperse diidomethane was also used. The third liquid was thioldiglycol (**Table 1**). The evaluation was made according to the principle of Owens, Wendt, Rable and Kaelble (OWRK). The second important target value is the maximum temperature of the plasma at the beginning of the flow channel. During ionization of the plasma within the plasma jet, the gas is heated so strongly that the temperature may well rise above the melting temperature of common plastics, with the result that the surface becomes damaged. For process control, the flow temperature of the plasma is therefore measured at the beginning of the channel.

Liquid set	Testing liquid	Surface tension (total) [mN/m]	Surface tension (disperse) [mN/m]	Surface tension (polar) [mN/m]
D-T-E	Diiodemethane	50.8	50.8	0
	Thioldiglycol	54	39.2	14.8
	Ethyleneglycol	48	29	19
D-T-W	Diiodemethane	50.8	50.8	0
	Thioldiglycol	54	39.2	14.8
	Water	72.1	19.9	52.2

Table 1: Surface tensions of the different liquids.

The parameters under examination are, in addition to the channel geometry, in particular different ionization gases, the volume flow of the plasma gas, the voltage of the high-voltage transformer, the frequency, the plasma cycle time (PCT) and the duration of treatment. In addition, the ignition behavior of the plasma is pulsed. For all the tests, a non-polar HDPE (Basell GD6260) was used as the sample for treatment.

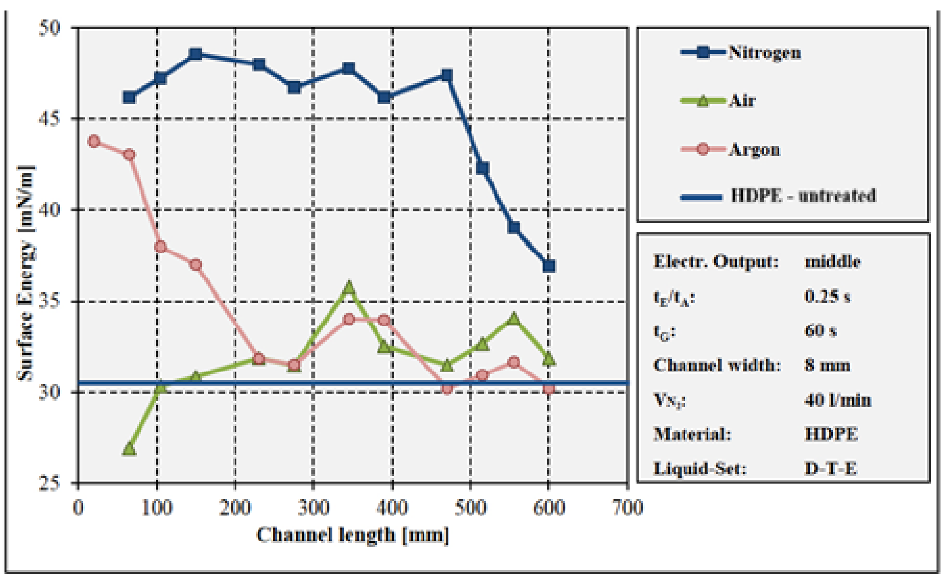

Figure 3: Influence of the ionization gas on the surface activation along the channel.

Experimental

First of all, the influence of different ionization gases on the attainable surface activation was examined. The results show clearly that there is no significant improvement in the surface energy compared with the reference sample. It is to be supposed that the activated oxygen types recombine with each other after only a short time and can no longer treat the surface. In the second step, two inert gases (nitrogen and argon) were therefore examined. The result of this test shows clearly that only the nitrogen can significantly increase the surface energy of the, plastic. Up to a distance of around 500 mm, significant surface activation is recognizable.

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The second key parameter to be examined was the influence of the volume flow of the nitrogen plasma on the surface activation. With increasing volume flow and constant plasma parameters, the surface activation is more intensive and reaches further (**Figure 4**). Furthermore, a higher volume flow also has a positive influence on the maximum temperature at the beginning of the flow channel. Low volume flows lead to much higher plasma temperatures, which have a considerable negative effect on the surface of the plastic. Through the higher flow temperatures, lower surface energies and even surface damage are recognizable up to a length of 100 mm (**Figure 5**). To ensure a low surface damage, one requirement for the system is that at least the flow temperatures are lower than the melt temperature of the plastic.

Another important influencing factor for the surface activation is the channel width. In addition to increasing the size of the treatment area, a larger channel width also reduces the flow velocity of the plasma. While the intensities of the surface activation at the beginning of the channel are comparable, the treatment range is reduced as a result of the increase in the channel width (**Figure 6**). Apart from the described effects, the influences of the plasma-specific parameters have also been examined in other studies.

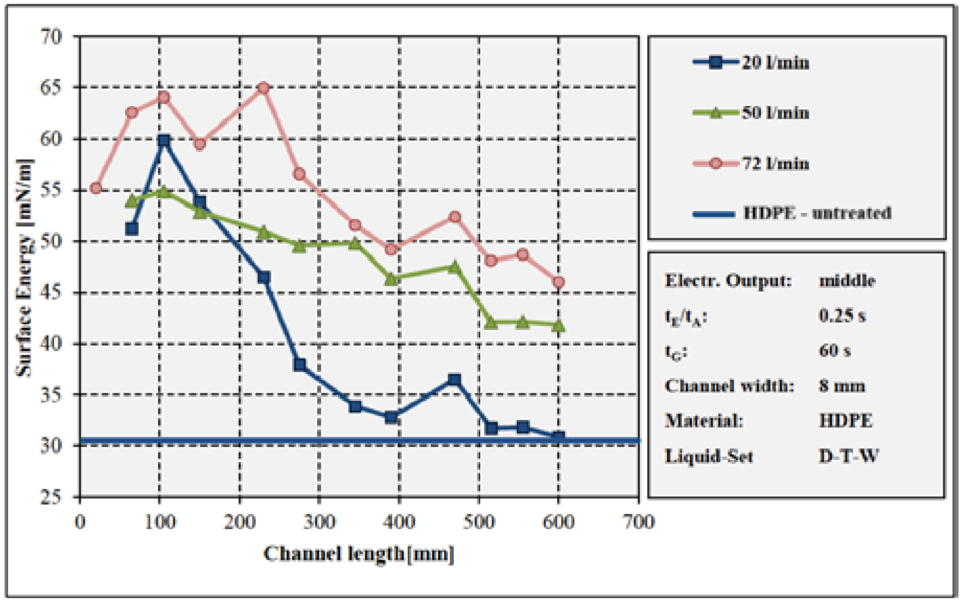


Figure 4: Influence of the volume flow on the surface activation along the flow channel.

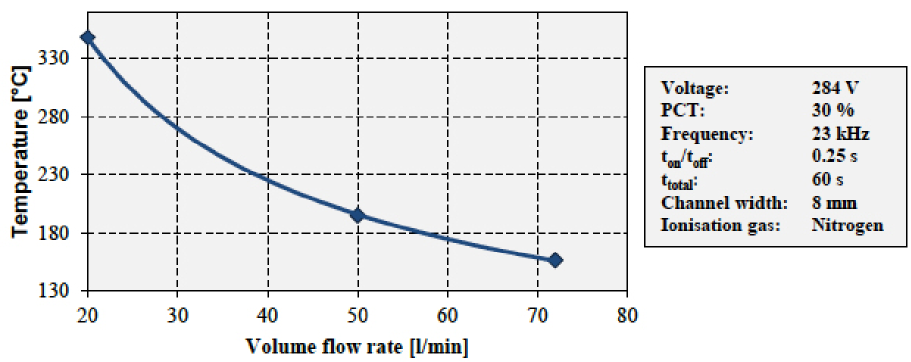


Figure 5: Diagram of the stationary plasma jet and flow channel.

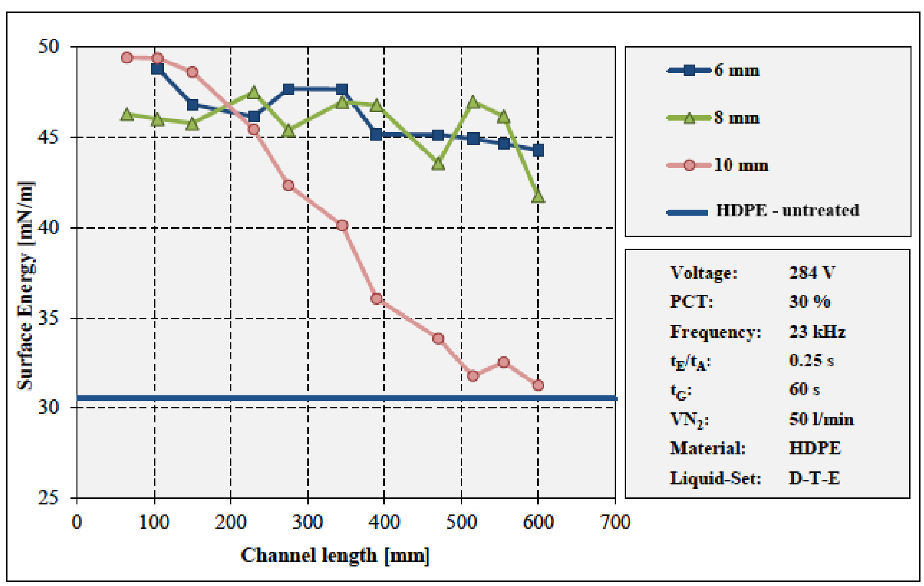


Figure 6: Influence of the channel width on the surface activation along the flow channel

To validate the test results, further non-polar materials such as other HDPEs with different melt flow rates, LDPEs and PPs were examined in addition to the standard plastic. The tests also included a number of ngineering plastics such as PA6, PBT+ASA and PC+ABS. Figure 6 shows some of these results. It can be seen clearly that similar results can be achieved in terms of both the intensity and the reach of the surface activation. Despite a small decline in the intensity of the surface activation, activated distances of more than 500 mm can be achieved (**Figure 7**).

DIP Injection Mold

The direct integration of DIP treatment into an injection mold was used not only to investigate various phenomena in the process, but also to demonstrate the opportunities such a process offers. The development of the molding tool was based on the process sequence described above. A sheet with an internal 8-mm-wide groove was used as a test specimen. The process concept specified that, when the part has cooled far enough to solidify, the groove is freed by pulling back the core, creating a sealed area between the cavity and the part which can be treated. The length of the treated region (in terms of the neutral axis) of just over 530 mm corresponds to the length of the treated area in the experimental setup. The design includes two places of in- and outlets for the plasma in the treated space **(Figure 8**).

Further requirements for the system were that the plasma system had to be protected from the thermoplastic melt while the cavity was being filled. In addition, it had to be ensured that the sealed treatment space was completely isolated from the surrounding atmosphere. These requirements were fulfilled by a hydraulically

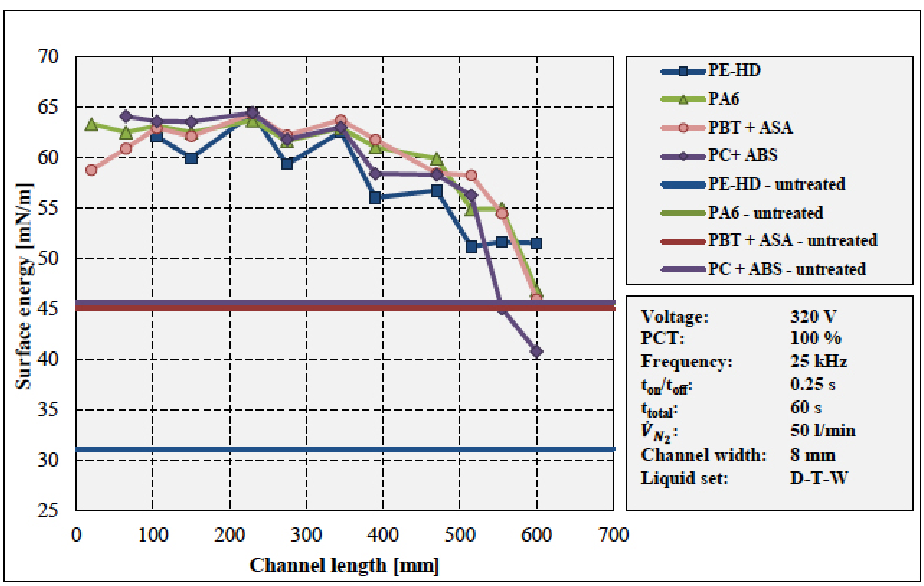


Figure 7: Diagram of the stationary plasma jet and the flow channel.

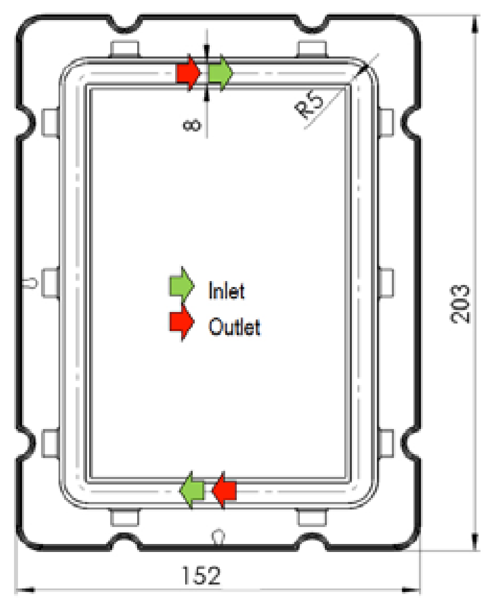
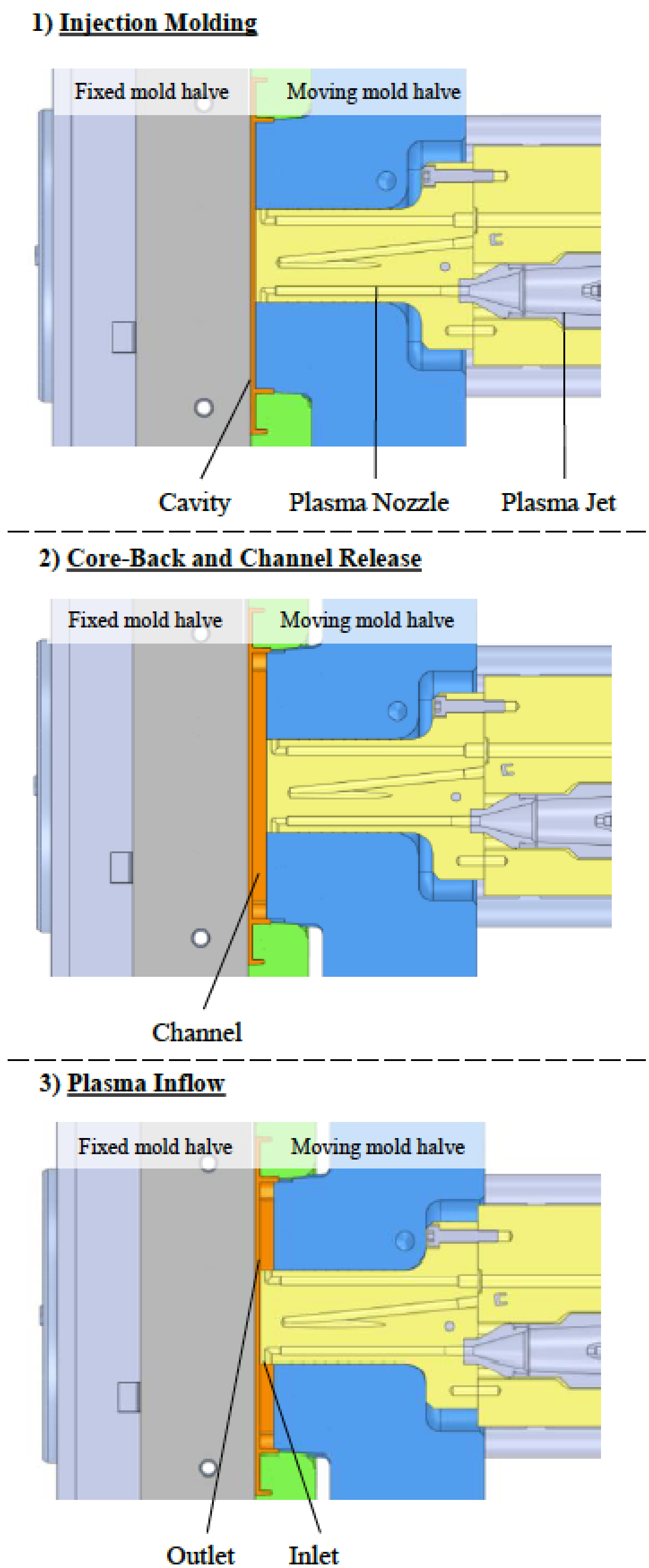


Figure 8: Test specimen with visualization of the in- and outlet for the plasma jet

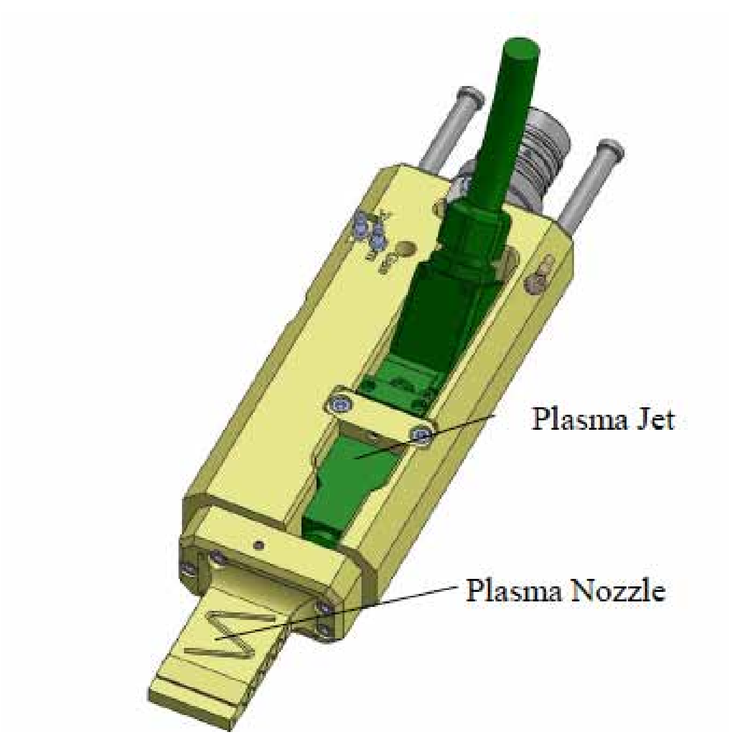
Figure 9: Cross section views of the DIP injection mold during the DIP treatment.



controlled displacement system, which, after pulling back the core as required, could be re-positioned in the treatment space and so controlled both the start of the plasma flow and the cutoff; the relative movement between the core and the plasma unit were thereby responsible for closing and opening the plasma nozzle (**Figure 9**).

The plasma jet was integrated inside of the mold, in order to keep the distance between the charging zone and the treated surface minimal. Based on future-oriented considerations of possible integration in existing constructions, the combination of plasma jet with positioning control has been constructed in a modular format (**Figure 10**).

Figure 10:
Modular design of the plasma jet.



Conclusion and Prospects

In this paper, a DIP treatment was investigated in preliminary experimental investigations and the outcome of that investigation presented. The obtained results show that, despite the use of a stationary plasma jet, the surface treatment could span a much larger distance in comparison to previous uses of AP plasma; treatment intensities which are sufficiently high for use in later process steps can be generated for distances of up to 500 mm.

Using the results from the experimental investigations, a specialized injection molding process was developed. The conception of DIP treatment is following a modular approach with an eye on future integration; this is intended to facilitate the use of this technology in both existing and future applications. Further development goals include an investigation of process behavior, an investigation into the effects of various injection molding parameters on activation and a time dependency of the treatment, as well as the further standardization of the DIP treatment. Among other concerns, size reduction of the system is also a central goal of future development.

Acknowledgments

This research and development project is funded by the European Union, the European Font for Regional Development (EFRE) and by the State of North Rhine- Westphalia.

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The SPE Injection Molding Division Newsletter is issued three times a year, with readership of a captive audience of professional individuals specifically involved in all aspects of injection molding.

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Autonomous Optimization Significantly Improves Molding Process

This example demonstrates the application of the Autonomous Optimization product developed within the core of SIGMASOFT® Virtual Molding. The mold design for a thick-walled part was supposed to deliver a cycle time of less than 60 seconds including fill, pack, cool, and mold open/close. When 60% or more of the cycle is cooling (packing and cooling), the focus was put onto the cooling design for the mold. Not only cooling strategy would do; it must be optimal.

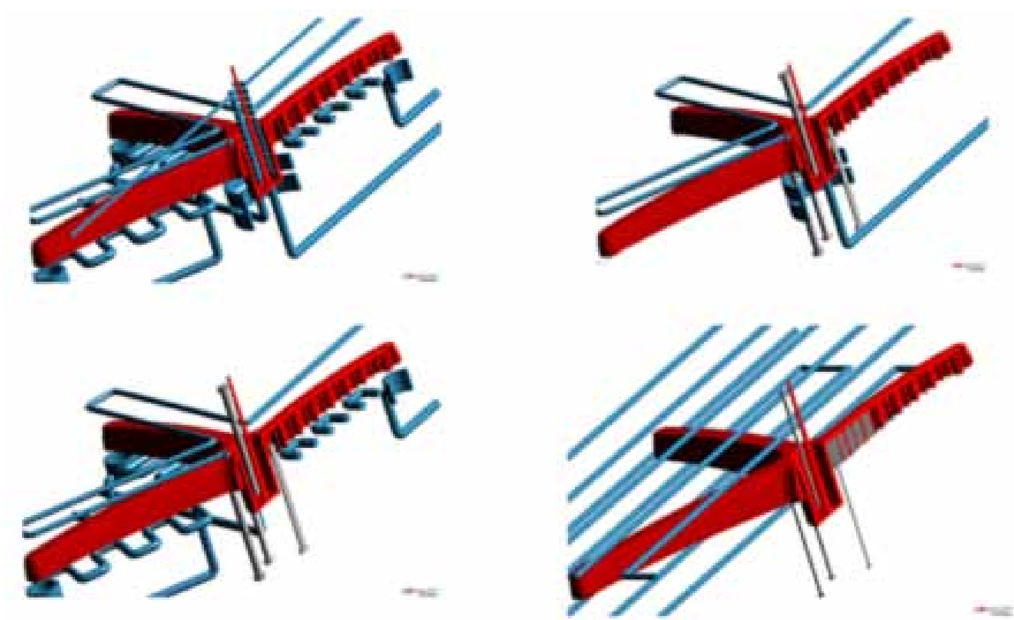

Figure 1: Production cycle time for the part (in red) was scheduled to be at or below 60 seconds. SIGMASOFT Virtual Molding; Autonomous Optimization was used to find the best design, based on user input, autonomously.

Autonomous Optimization Reduces Costs in Injection Molding

August 10th 2017 – Cooling plastic takes time, it typically accounts for 60% or more of the total cycle time. Differential (non-uniform) cooling creates problems, like dimensions out of specification. These two things are completely related so one of the objectives was minimizing the cooling time while the other was main-

Case Study

taining dimensional stability. With an ever increasing pressure over individual part costs and shorter mold development deadlines it is imperative to produce affordable, reliable and efficient molding solutions within the shortest possible time. Cooling lines are often the last concept brought into a mold but when it accounts for so much of the success of a molding trial, shouldn't it be one of the first?

A new tool, released at Fakuma 2017 for the first time, allows mold makers to find the numerically optimum solution for their designs. SIGMA Engineering GmbH (Aachen) has released the Autonomous Optimization solution as part of its SIGMASOFT® Virtual Molding software, where the best possible solution can be found out of all the possible combinations of the input parameters.

In this example, the mold maker was confronted with the problem of designing the most efficient mold possible at the lowest cost. A cycle time below 60 seconds was targeted.

The mold maker selected different variables in the mold to achieve the desired cycle time. The mold material, the layout and diameter of the cooling channels, a conformal cooling concept and high-conductivity pins were of the available options. All the possible combinations of these variables resulted in a total of 40,000 different mold design possibilities. The autonomous optimization engine was able to create, simulate, and evaluate all possible design scenarios so the engineer only needed to evaluate the scenarios with the best outcomes.

The designs with the lowest possible cycle time were compared amongst each other to see which also have the lowest tooling cost. The end result showed that conformal cooling was not necessary, and that the required heat dissipation effect to achieve the targeted cycle time could be obtained using high-conductivity pins. The final optimal water channels were also produced as a solid model making it that much easier to communicate to the toolmaker about what the final design should look like. The final cycle time (45s) was even better than the target because all of the focus was put directly in the area of concern.

The autonomous optimization engine available in SIGMASOFT® Virtual Molding was able to find the most effective mold design with the lowest possible cost. Not only cycle time could be optimized, but also part deformation, energy costs and molding defects through the identification of the optimal parameter combination.

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IMD Board of Directors Meeting

August 3rd, 2017

Chicago Marriott Oak Brook located in Oak Brook, Illinois

Submitted by David Okonski

Welcome & Opening Remarks – David A. Okonski, Secretary

Division Chair Raymond (Ray) McKee could not attend IMTECH 2017 due to personal reasons; as such, Division Secretary & IMTECH 2017 Chair David Okonski assumed the responsibility for conducting this meeting. David called the meeting to order at 1:00 PM (Central Time Zone - CT) and welcomed fellow board members and invited guests to the meeting. As was explained, the primary purpose of this meeting was to recap the events of the last three and a half days so as to dissect the IMTECH conference offering in to its good and bad components for future consideration in adjusting the conference format.

Secretary David Okonski called roll at 1:05 PM (CT).

Roll Call – David Okonski, Secretary

Present in person were:

Jeremy Dworshak (Executive Committee VP), Brad Johnson, Pete Grelle (Technical Director), Adam Kramschuster, David Kusuma, Joseph Lawrence, David Okonski (Secretary), Srikanth Pilla, Tom Turng, Angela Rodenburgh (Invited Guest), Russell Broome (Invited Guest), Jon Ratzlaff (Invited Guest), Mercedes Landazuri (Invited Guest), and Len Czuba (Invited Guest).

Present via teleconference were:

Vikram Bhargava, Nick Fountas, Ray McKee (Division Chair) and Susan Montgomery (Councilor).

The participation of the official IMD Board Members constituted a quorum (not needed for the purposes of this particular meeting).

Absent were:

Alex Beaumont, Jack Dispenza, Erik Foltz, Kishor Mehta, Lynzie Nebel, Sriraj Patel, Hoa Pham, Rick Puglielli, Chad Ulven, and Jim Wenskus.

Notes:

1) Invited guest Angela Rodenburgh introduced herself to the IMD Board of Directors. Angela is the President of Ladder Up which is a marketing firm that does digital marketing strategies and implementation. Angela was instrumental in helping with and developing the marketing plan for IMTECH 2017.

2) Chair Ray McKee appointed Angela Rodenburgh to a one (1) year term on the IMD Board of Directors. Welcome Angela !!!!

IMD Board of Directors Meeting Continued

Approval of the May 7th, 2017 Meeting Minutes

The meeting minutes from the IMD ANTEC 2017 Board of Directors Meeting of May 7th, 2017 were presented.

Motion: Pete Grelle made a motion to approve and distribute the May 7th, 2017 meeting minutes as written. Adam Kramschuster seconded, and the motion passed at 1:15 PM (CT).

Conference Round-Up – IMTECH 2017 Chair David Okonski / All

Attendance: There were 195 registered attendees; of the registered attendees, about 60 paid the registration fee while the remaining were complimentary (roughly 15 organizing committee, 30 sponsors, 5 media partners, and the remaining 85 were brand owners).

Financials: The IMD was a 50 / 50 partner with SPE Headquarters on IMTECH 2017, and the organizing committee was projecting a loss going in to our first conference based on the number of sponsors and advanced registrations. The goal of the organizing committee was to minimize the impact on the balance sheets of both the division and headquarters. Cancelation fees amounted to $62,530 USD which would translate to a loss of $31,265 USD to each of the partners. The actual "IMTECH 2017 Conference Reconciliation Statement" is listed below:

IMTECH 2017 Revenue	
Sponsorship	$30,800.00
Attendee Registration	$28,901.00
Total	**$59,701.00**
IMTECH 2017 Expenses	
Food & Beverage	$40,314.30
Audio / Visual (A / V)	$23,920.50
Attrition	$10,868.39
Taxes	$4,045.43
Service Charges	$15,371.30
Member dues	$1,526.00
Buses	$3,905.00
Total	**$99,950.92**
Conference Loss	**$40,249.92**
IMD Share of Loss:	**$20,124.96**
HQ Share of Loss:	**$20,124.96**

Going forward, the organizing committee must do a better job of: 1) obtaining sponsors, 2) minimizing A / V costs (while still maintaining A / V quality), and 3) limiting attrition charges due to unsold room nights at the hotel. In addition, a "Conference Go / No Go" decision must be based on a set of predetermined metrics that guarantees the division and our future partners will not suffer a financial loss.

IMD Board of Directors Meeting Continued

Attendee Feedback: In general, attendees thought this was a very good inaugural conference; with some minor tweaks, future IMTECH conferences have the potential to become excellent. Attendees seemed to really appreciate the format of having technical talks in the morning with tours (or tutorials) in the afternoon. Concurrent sessions worked well and are acceptable as long as presentations from all sessions are available for distribution afterwards. Attendees expressed interest in having less commercial content in the presentations and, in general, having more information made available about processing.

Sponsor Feedback: In general, sponsors believed this conference provided "value" to their respective companies and several verbally committed to becoming a sponsor of IMTECH 2018. The adjustment that sponsors would like to see in the conference format would be a break in the morning technical sessions at about 10 AM to create more traffic in the primary exhibit hall. Sponsors greatly appreciated that meals were provided by the conference organizing committee; many compliments were received on the high quality of the food presented at breakfast, lunch, and the evening receptions.

SPE Headquarters Feedback: Russel Broome offered the feedback listed below that is based on both personal experience as well as comments he received from attendees throughout the three day conference:

- Receptions should be on the exhibit floor when the venue allows
- Prime speaking slots should be given to those that sponsor or exhibit or provide tours
- Only have one track on last day since we know the attendance numbers shrink
- Sell raffle tickets throughout the event (with proceeds going to scholarships) for giveaways after the last speaker – i.e.; rotomolding raffled-off kayaks and Yeti coolers on the last day of their conference and the room was full
- Promotional marketing emails should also include track speakers / sponsoring companies / session topics in addition to the keynote presentations - new names / information with each e-blast
- App needs to have tracks and rooms identified better – lots of complaints on how hard it was to even determine which room each talk was in; everyone shouldn't have to go room-to-room to read a printed sign at the door
- Enable an "opt-in" procedure for posting presentations even if they need to submit one with redacted detail
- Countdown clocks needed for the speakers
- Preview next speakers at each break
- Use MAPP & NPE to promote 2018 event
- Require hotel to have recycling front and center to help with "plastics" image
- Panel discussion as part of a sponsorship package

Future Conference – IMTECH 2018: The tentative dates for IMTECH 2018 are November 6th through November 8th. IMD Conference Chairs David Okonski and Pete Grelle are actively searching for a venue in the Cleveland / Akron Ohio area.

IMD Board of Directors Meeting Continued

Old / New Business & Round Table – David Okonski, Division Secretary

No new items were discussed.

Adjournment – David Okonski, Division Secretary

Motion: David Okonski made a motion to adjourn the meeting. Pete Grelle seconded, and the motion passed. The meeting was adjourned at 3:45 PM (CT).

The next meeting is tentatively scheduled for (Thursday) November 16th, 2017. Agenda to be distributed prior to the meeting.

This meeting will be conducted using a WebEx and call-in telephone number.

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IMD New Members

The Injection Molding Division welcomes 120 new members...

Angel Kuse
Scott Adams
Mark James
Fabian Bettiol
Michael Hayden
Fred Clark
Mike Butler
Philip Shoemaker
Motozo Horikawa
Daniel Damas
Thomas Schoen
John Billenstein
John Albertson
Steve Schick
Mark Bondi
Anthony Gasbarro
Zulkifli Mohamad Ariff
Dan Watson
Dax Allen
Matt Thomson
Laina Macklin
Evan Syverson
Brian Stanczyk
Matthew Galloway
Jacob Rutkowski
Toby Hartley
Mark Turner
Clayton Hoperich
Michael Wolkowicz
Ji Young Hong
Ankil Shah
Brennan Wodrig
Norbert Kovács
Tibor Karpathegyi
Eileen Gallihugh
Szabolcs
Alain Choquet
Gregory Spires
Angel Kuse
Scott Adams
Nicholas Lawrence
Ralph Nolan
Matthew Schrauder
Claudio Grubicy
Randy Krell
Eduardo Belous
Frank Savel
David Shirley
Onofrio Palazzolo
Jesse Matola
Max Rodriguez
Amar Patel
Ted Castleberry
James Vincent
Jerry Presley
Stefan Carlsson
Kelsey Wu
Ehsan Behzadfar
Robert Quinlan
Joe Parisi
Mark Juliano
Allison Osmanson
Ryan Bauer
Bobby Krause
Chris Allen
Matt Headrick
JunJun Li
Ryan Menkin
Sandesh Jain
Dan Flemmens
Brent Barefoot
Jacob Woody
Bryan Coppes
Mark Neuhalfen
Jennifer Stewart
Kamron Beard
William Ridenojr
Leonard Koren
Hunter May
Timothy Lewis
Joseph Huegel
Pat McGill
Heath Van der Waerden
Michael Kvalo
Tom Van Pernis
David Stevens
Siddharth Ram Athreya
Cody Johnson
Ralph Thibodeau
fiorenzo parrinello
Bryce Haley
Tim Redler
Steven Petinakis
Martin Johnson
Fred Daum
Benjamin Lopez
Mark Casey
John Rosemeyer
Anthony Wagner
Vincent Etchen
Bradley Northern
Behzad Ghorbani Elizeh
Michael Prada
Andrew Marsch
Sam Armstrong
Joseph Friedli
somayeh shirdel
Scott Kuechler
Garrett Lesh
Shabnam Arianta
Kristen Birkmayer
Omar Solorza-Nicolas
Nicholas Jeffers
Bradley Cameron
Ryan Haithcock
Reynaldo Espada
James Brady
Joshua Hicks
Mitchell Barton
Brian Tran
Antonio Urbano
Myneke Artis
Benjamin Gaster

Message from the Publisher

Hello members!

This has been a truly busy year for the IM Division! The division board members have spent many hours and great dedication to the shows this year and plus adding a new conference, IMTECH 2017, which provided great sessions for all attendees. The IM website has also been updated, now providing viewers with more information on shows, webinars, news and more.

A big thank you must be sent to all the board members for their time and a special thank you to Ray McKee for his year as the division chair, and Dave Okonski and Peter Grelle who have spend many long hours developing successful conferences for the injection molding industry.

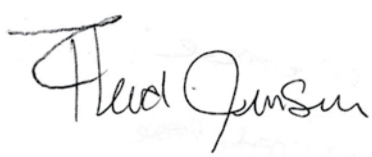
With all the new projects from the IM Division, we do seek your help! In order to keep the conferences, newsletter and website available, it is critical to get outside support with articles, technical papers, company news and sponsors. The following items are what is currently needed:

ANTEC 2018: Technical papers and sponsors

Newsletter: Papers, technical articles, and sponsor

Website: Company news/press releases and sponsors

I hope you enjoyed this latest issue. Be sure to visit us online for more news, and event updates!.
Have a wonderful holiday and see you next year!



Heidi Jensen
PublisherIMDNewsletter@gmail.com

Keep informed on recent event information, industry news and more.

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