



What Came First, The Mold Design or The Moldflow?

Erik Foltz

While injection molding simulation is a common tool used by molders and toolmakers to help evaluate their mold design, it is often implemented after the plastic part design has been finalized and a tool design has been developed. This article will highlight how proactively using injection molding simulation (Moldflow®) can help yield information that allows for better plastic part design and help drive mold decisions prior to developing the mold design.

Injection molding simulation has become a powerful tool to help optimize plastic part design and mold construction. However, it is often a tool that is delegated to molders and toolmakers to validate their proposed design to their customer and get approval to move forward with the tool construction. By delaying the use of simulation in the design process, both part designers and molders/toolmakers limit the opportunity for using simulation data to drive design decisions and yield a higher quality part. This article will highlight key design decisions that can be made regarding the plastic part and mold designs before a mold design has been fully developed.

Establishing a Nominal Wall

One of the most important decisions that a designer can make is to properly select the nominal wall for their plastic part design. The nominal wall will help drive many decisions regarding the overall part dimensions, required auxiliary features such as ribs, bosses and snap fits, gate location, and material selection. While this

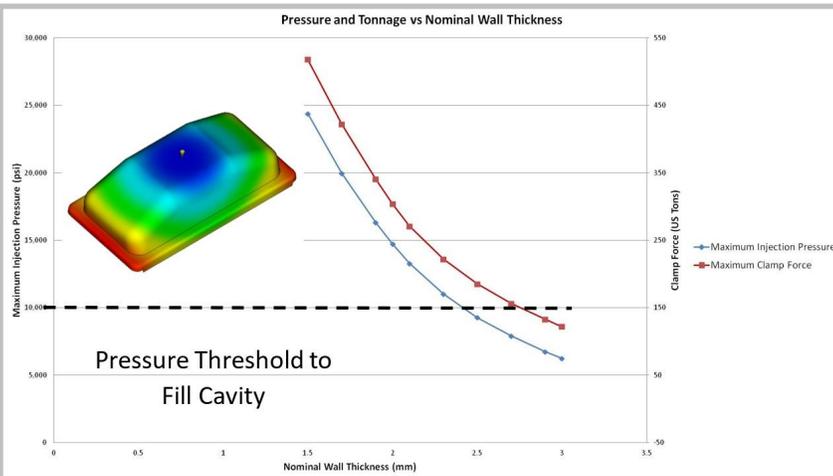


Figure 1: Injection molding simulation can help determine what is a feasible nominal wall thickness of a part for the desired material and design of a product based on maintaining an attainable injection pressure to fill the mold.

multiple gates may be required to fill the mold. Utilizing injection molding simulation can help a product designer better select that nominal wall by ensuring the pressure to fill the part remains below a certain pressure threshold. This will allow the part to be manufacturable for the molder with a wider processing window, Figure 1.

decision is ultimately driven by the required performance criteria for the plastic part, the designer needs to be remember that the part must also be manufacturable. Since injection molding is a pressure-driven flow process, the designer must understand that as the nominal wall is reduced, the required injection pressure to manufacture the part will increase. If the required pressure becomes too high, then the nominal wall will need to be increased or

Inside This Issue:	
What Came First, The Mold Design or The Moldflow?	1
FREE Webinars	5
The Case for Performance-Based Material Specifications	6
NEW – Through the Lens of The Madison Group	9
Moldflow Training Courses	10
Webinars	11

What Came First, The Mold Design or The Moldflow? (cont.)

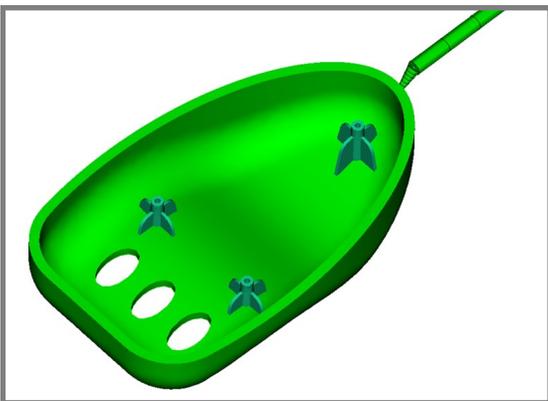
Erik Foltz

Once the nominal wall thickness of the part has been established, the designer should avoid any unnecessary wall thickness variation in the part to avoid different cooling rates and potential part warpage during manufacturing. Additionally, the designer should drive their decisions regarding rib thickness and boss placement based off the nominal wall selected.

Evaluating Design Risk of Auxiliary Features

Once the nominal wall thickness and overall appearance of the part have been established, the designer often turns their focus to adding in assembly features such as bosses, ribs, and snap fits. A quick review of best plastic part design reveals that the base features are often dictated by a nominal wall section of the part. However, the integration of these design features introduce inherent wall thickness variability into the part

Figure 2: Mouse showing three mounting bosses.



that could increase the risk of manufacturing issues such as sink or short shots, and design issues like dimensional stability. **Figure 2** shows a mouse that has three bosses used for assembly. By quickly running a series of injection molding simulations the designer was able to determine how the wall thickness of the bosses influenced the predicted sink marks, or surface depression, which would develop on the show surface, **Figure 3**. From this information the designer was able to determine how the inherent assembly and operational stresses would change and ensure they remained feasible for the product design.

Determining Feasible Gate Locations

Once a product design has gone through some initial Design for Manufacturing (DFM) analyses, the next design decision for the molder or toolmaker is often how to and where to place the gate to manufacture the part. The gate location and type will dictate the mold construction, parting line decisions, and the need for secondary operations. Additionally, once again the design of the gate is often influenced by the wall thickness of the part where the gate is located.

As a general rule, the following guidelines can be used to help select an appropriate gate location:

- 1) **Place the gate to force the material to flow from thick to thin areas of the part.** Since injection molding is a pressure-driven process the plastic will take the path of least resistance. That means that as the material starts filling the mold, the molten resin will preferentially flow in the thicker areas of the part since the flow resistance is lower. Placing the gate at the thickest wall section of the part will help reduce any flow hesitation in the thinner areas, which will minimize any material cooling and decrease the pressure to fill the mold. By placing the gate at the thickest wall section of the part, the gate can be made large enough to maintain pressure on the cavity until the molten plastic has solidified. This will help mitigate any void formation or sink.

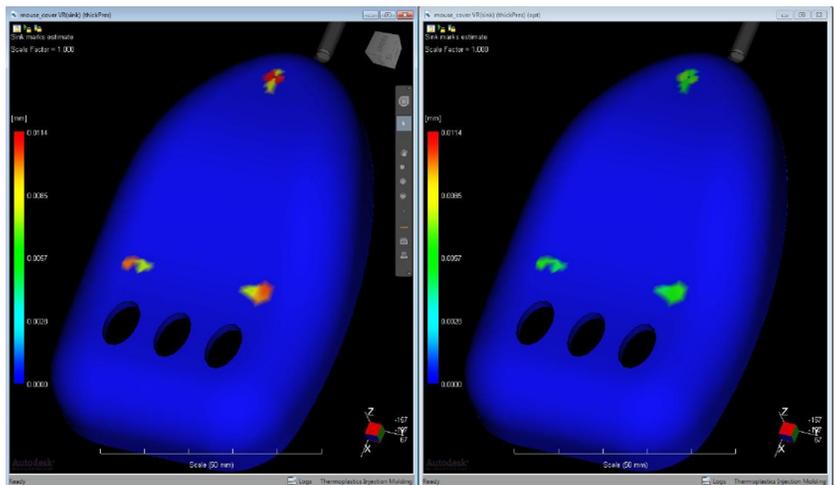


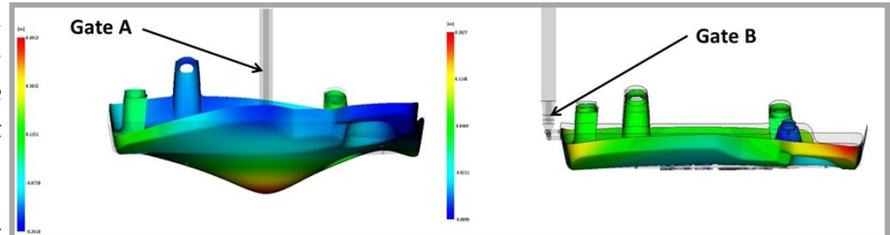
Figure 3: Sink mark plot from Moldflow highlighting the predicted sink mark depth with the original design vs. the optimized mouse and boss design.

What Came First, The Mold Design or the Moldflow? (cont.)

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As a general rule, the following guidelines can be used to help select an appropriate gate location: (cont.)

2) Select a gate that will generate unidirectional filling pattern. The gate is the location in the mold where the material will start to fill in the mold cavity. By selecting a gate location that avoids any changes in flow direction, the polymer molecules and any high aspect ratio fillers, such as glass or carbon fiber, will orient more uniformly. By orienting the molecules and fillers more uniformly, that material will shrink more consistently and develop less stress in the part that should lead to less part warpage, **Figure 4**.



3) Place weld lines in non-critical locations.

Weld lines are areas of a molded part where the molten material flow front split and then rejoin again. At the interface where the flow fronts rejoin, there is often limited molecular entanglement or fiber reinforcement in these areas, which can make them weaker, more brittle regions that have a higher probability of failure. Weld lines are a result of the flow progression in the mold which is often driven by the gate location. Injection molding simulation can help identify the location of these weld lines, and can be compared to a stress distribution plot from a structural FEA to see if the weld lines coincide with high stress or strain areas in the part, **Figure 5**. By proactively selecting a gate location that avoids placing these weaker areas in critical locations, the part performance should be improved.

Selecting a Material

During the design evaluation a great amount of time and effort are placed on selecting the correct resin for an application to help ensure robust part performance and obtaining the desired part aesthetics. However,

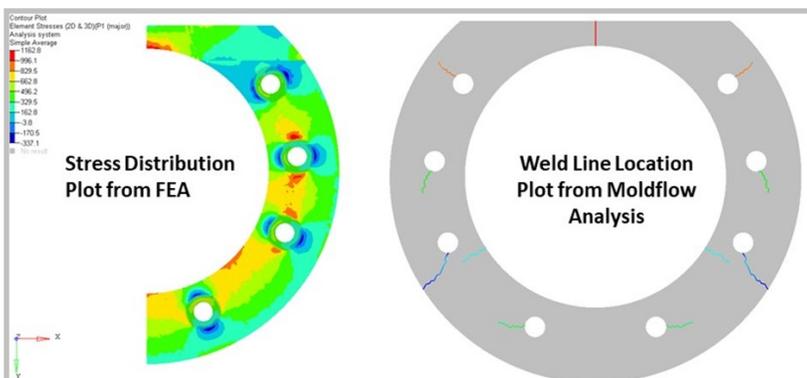


Figure 5: Images showing the predicted weld line locations in a part coinciding with high stress areas, which could adversely affect the part performance.

material selection cannot be decoupled from manufacturing, and often there are several potential material options that can be selected from after the selection process is complete. By utilizing injection molding simulation during the material selection process or at least early in the design phase, the optimal material for both manufacturing and while in service can be selected. By ensuring the material selected is capable of meeting tolerances and part aesthetics prior to having first shots also permits a wider possible selection of alternative resins where shrinkage can be adjusted in the 3D CAD. By waiting to have first shots, the manufacturer and designer are

more restricted to select a resin based on shrinkage value, that is less well suited for service in the field. By integrating injection molding simulation into the material evaluation the correct material can be selected for the application and will avoid having to shoe-horn a material into an application that may result in a suboptimal part.

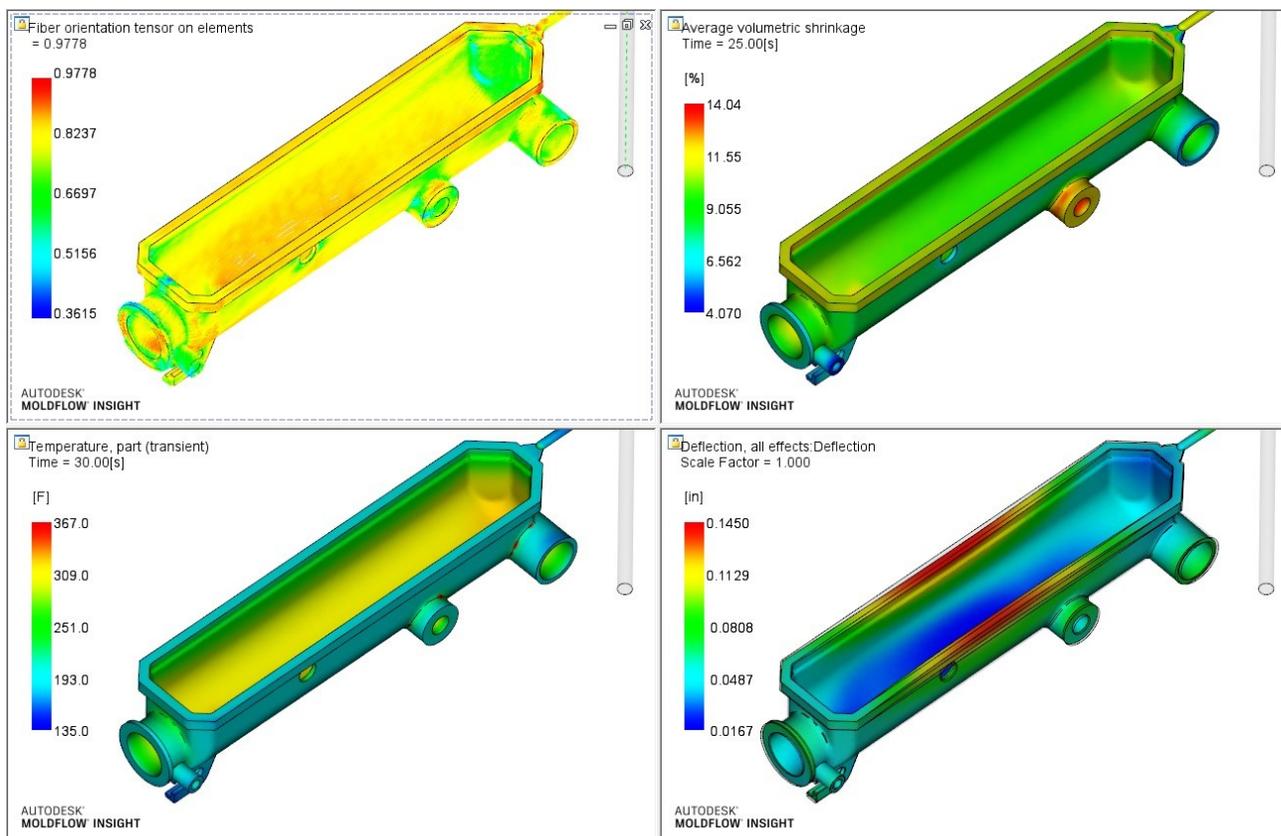
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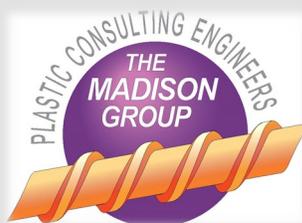
Bringing it All Together

The optimization of a plastic part design requires a holistic approach that dictates designers consider the part design, material selection, and manufacturing process collectively. Often in order to find a viable option within each selection area there need to be trade-offs in other areas. By integrating injection molding simulation early on in the design phase any potential risk that could be detrimental to the part performance can be identified prior to any mold construction, and actually help accelerate the mold design process by minimizing any rework.

Need help driving your decision making to optimize your plastic part design?
Contact our experts at Info@madisongroup.com



Additional case studies can also be found at:
<https://www.madisongroup.com/case-studies.html>



Announcements

FREE – Virtual Personalized Training Opportunity

At The Madison Group, we firmly believe that **knowledge** is the key to success in any industry. **Developing** a fundamental understanding of plastics including material selection, design, processing and performance are essential to creating a robust product.

The Madison Group would like to help you and your company build the understanding needed to achieve this through the following course offerings:

- **Essentials of Plastic Failure**
- **Optimizing Part Design for Plastics**
- **Effective Interpretation of Plastic Molding Simulation**
- **How Processing is Affecting Your Part Performance**
- **Navigating Plastic Material Selection**
- **Creep Failure of Plastics**

These 1-hour sessions are designed to be interactive and promote dynamic team-based learning, and will work best with 5 to 20 participants.

If you are interested in scheduling a training session, please click [here](#) for more information on the individual courses or to register your team. Please note that a *limited* number of sessions will be offered on a first come, first serve basis!

Information regarding upcoming educational opportunities can also be found at:

<https://www.madisongroup.com/events.html>



The Case for Performance-Based Material Specifications

Melissa Kurtz

Imagine, after nearly two years of hard work, extensive testing, and various design iterations your new product has hit the market. There is nothing quite as exhilarating as creating a new product that will help make people's lives better. Unfortunately, your joy is short-lived as the negative consumer feedback and product returns begin to build and your company's reputable brand begins to tarnish.

Your company engaged the failure analysis experts at The Madison Group and it led to some important discoveries for you and your team. The component leading to the field failures experienced melting during normal operation. How could this be? After all, you performed life testing on the product constructed from production parts! The Madison Group determined that the root cause of the issue was that the material used in the component from the field failures had very different thermal behavior than the material initially used in the component during the product testing phase.



Medical equipment.

The material that had been selected for this component was a blend of nylon 6 and nylon 6/6 resins. It was called out on the drawing using its specific tradename and grade. To their benefit, the injection molding supplier was using the material specified. But, what neither the injection molding manufacturer nor the product development company understood was that the resin supplier allowed for significant lot to lot variation in the nylon 6 and nylon 6/6 content in the compounding of the resin. Nylon 6 has a melting point of around 215 °C while nylon 6/6 has a melting point approximately 50 °C higher at 265 °C. Therefore, a resin lot with more nylon 6 content would be expected to have much lower thermal stability than a lot with more Nylon 6/6 content.

Over the years, The Madison Group has witnessed similar scenarios happen repeatedly across a variety of products and industries. It is not just an issue of variation in performance specific to resin blends. These types of issues can happen when any ingredient within the resin formulation varies including additives, base resin feedstocks, glass fiber or mineral filler content. Asking the question, what can be done to prevent this?

One option is do not specify a trade name and grade of a material on a component drawing. Instead reference a well-defined material performance specification. Such a specification is focused on how the material needs to behave in the application in order to perform successfully. Some examples of this behavior would include short-term performance criteria, like strength and stiffness at elevated temperature, flammability, sub ambient impact strength and electrical properties including dielectric strength. The specification should also include long-term performance criteria like strength, stiffness, and impact resistance following extended elevated temperature, UV, or chemical exposure, to name only a few.



Tensile testing of plastic.

The accurate ability to capture key material requirements for your application in the form of a specification is critical. If the specification developed is not adequate, then the materials that will be qualified to it will most likely be inadequate as well. This is where experts in material science and selection, such as The Madison Group, can help.

Once a robust performance-based material specification is created, material candidates that meet the specification requirements can be proposed. These candidates might include an assortment of grades from a

The Case for Performance-Based Material Specifications (*cont.*)

Melissa Kurtz

variety of material suppliers and is the beginning of the material qualification process. The objective of the material qualification process is to ensure that the candidates proposed by the material supplier meet the requirements established in the specification. In most cases, it involves the material supplier providing the customer with multipoint datasets demonstrating that their material candidate will fulfill the specification requirements for multiple, unique lots of resin. Once such data have been provided the customer can approve the material for consideration in products and components associated with the specification. It is up to the customer how often they would like to require their material suppliers to supply data for the continued approval of their material. This ongoing submission of data demonstrating that the material continues to meet the specification requirements is important to confirm the quality of the material and its continued success in the application.

Let us go back to our initial case study. Having a specification requirement of a minimum melting point of 240 °C across multiple lots of resin would have raised a concern at the material supplier of the nylon 6, nylon 6/6 resin blend. From a capability standpoint they would have recognized that their compounding allowed for too much variation to hold this requirement. As a result, the supplier could have offered a nylon 6/6 resin or a blend where they have tighter controls in place. In this case, a well-thought-out material specification would have ensured a more accurate performance of the component in the application.

Performance-based material specifications also have the potential to increase the number of suppliers and possible materials allowing for more competitive pricing. Calling out a specific tradename and grade on your drawing are great for the material supplier and only for them. Let us take for instance OmniPro™ HPP GRC30 resin. There is only one resin with this tradename and grade that is available from two different distributors. Keep in mind that there are over 150 injection molding grades of 30% glass fiber-reinforced polypropylene resin available in North America alone. However, one needs to ensure that these alternative grades will perform successfully in the application. Relying on product testing to verify the performance of an alternative material can be costly for a company and even obscure any material cost savings that can be realized on a product. Comparing the material datasheets, which report only single-point, short-term properties, do not reflect the long-term, lot-to-lot performance of a material. Nor do they capture all your application requirements. Depending instead on performance-based material specifications that have captured the key requirements of the application improve confidence in an alternative material. This can also limit the necessary product testing which can result in greater economic gain.



Scientific equipment.

Having your materials well characterized for your application by way of performance-based material specifications also make it more straight forward to select a material for your application when your requirements change. For instance, your next generation product will see even higher temperatures, new chemical exposures, increased stresses, etc. By modifying an existing specification to consider these new or increased requirements, the appropriateness of the existing material can easily be evaluated along with potential alternatives. As a result, the number of design iterations needed are reduced, and confidence is higher when product testing begins.

In product development, a lot of time is spent selecting the right materials and validating those choices through product testing. That hard work and success can be preserved through the use of performance-based

The Case for Performance-Based Material Specifications

Melissa Kurtz

material specifications and the material qualification process that ensues. Quality does not have to suffer to offer your supplier material flexibility or your purchasing group cost savings opportunities. These specifications can also shorten your “go-to-market” timeline when developing your next generation product by reducing the number of design and testing iterations.

If you want more information, please contact [The Madison Group](#).

The Madison Group

2615 Research Park Drive

Madison, WI 53711

P: 608-231-1907

Email: info@madisongroup.com

Website: <https://www.madisongroup.com/>



<https://www.linkedin.com/company/the-madison-group-plastic-consulting-experts/>



<https://www.facebook.com/tmgplastics>

Additional case studies can also be found at:

<https://www.madisongroup.com/case-studies.html>



Announcements

Appearing for the First Time! NEW- VHX-7000 – Microscope Capability at The Madison Group



Through the Lens of The Madison Group

The Madison Group has acquired a new state-of-the-art Keyence High Definition Digital Microscope VHX-7000. This microscope has greatly expanded our examination capabilities to the next level by:

- With automatic 3D technology it is possible to examine rough and deep fractures in one image.
- The magnification capabilities up to 2,000x makes it possible to measure the thickness of coatings and films.
- The new advanced illumination options allow for backlighting, multi-angled oblique lighting, polarization and an optical shadow effect mode that allows the visualization of crack features and textures not visible in a SEM microscope.
- Stitching of high magnification images allows for a large field of view to improve analysis and visualization.
- With remote capabilities, this microscope also opens the door for remote inspections for our customers.

Starting with this issue of the TMG Newsletter, we will be showing images to highlight the enhanced analysis capabilities made possible by microscopy. The images below show the examination of a half pipe taken with the automatic 3D mode and backlighting of the VHX-7000. The pipe being translucent allows for the light to travel through the thickness to reveal defects not otherwise visible. These images are made from stitching 12 separate micrographs to create a large high magnification view of the pipe. This analysis allowed for the examination of multiple cracks in the pipe wall that otherwise, were not visible without the proper illumination.



NEW VHX-7000 at The Madison Group.

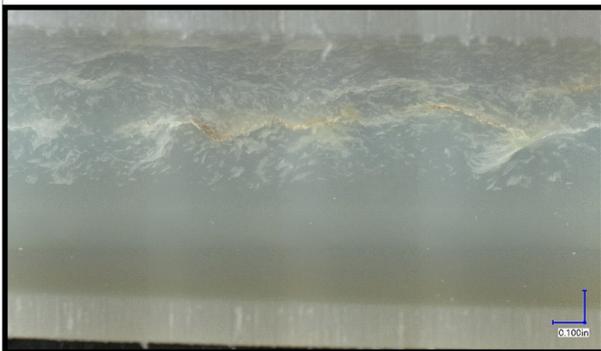
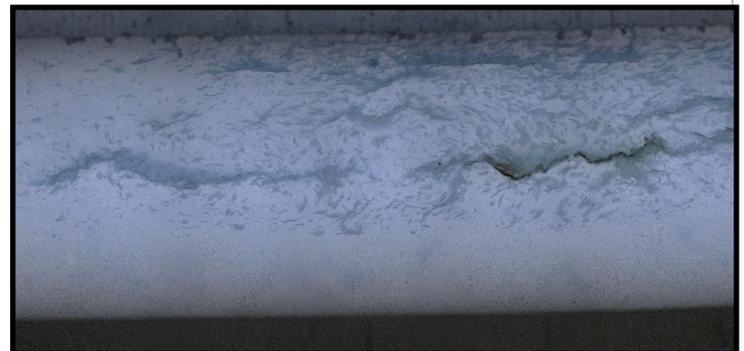


Image of the internal diameter of a cracked pipe.
(composed of 12 stitched micrographs)



Backlit image of the internal diameter of a cracked pipe.
(composed of 12 stitched micrographs)

If you are interested to learn more about the capabilities that we have at The Madison Group, please feel free to contact us at info@madisongroup.com.

Announcements

TMG – Industry News



New Moldflow Training Courses

Learn ways to utilize Moldflow technology in your manufacturing processes.

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PLASTIC CONSULTING ENGINEERS
THE MADISON GROUP

3D TECHNOLOGIES

The Madison Group is excited to offer our training for all Autodesk Moldflow products, both Insight and Advisor.

The need for optimizing our plastic part designs, processes and mold designs prior to first shots, is more critical than ever. Autodesk Moldflow has multiple products to help assist and optimize your project at any stage. Whether you are a part designer that is interested in better understanding your externally provided Moldflow reports, a user that is looking to take full advantage of the tools you already have, or explore what additional tools are available to take you to the next level, we have a training package that can help you accomplish just that.

The Madison Group has a training plan option for any circumstance and budget. **Choose any of the following options:**

- **On-site Training**
- **Remote Instructor-Led Training**
- **Private Training**

Benefits of Virtual Training Sessions:

- Allow any of your employees to gain the training without being out of the office.
- Eliminate travel costs so you can have more employees trained.
- Choose interactive, live, instructor-led classes for one-on-one assistance with solver set-up and results interpretation.
- Installation of software not needed prior to training opportunities.

Benefits of Investing in Moldflow Training

- Keep up to date on the newest solvers and simulation tools for all the Autodesk Moldflow Products designed to save you time.
- Improve your results interpretation skills and help optimize your design.
- Increase your internal knowledge quickly and economically to improve communication and create a culture of innovation.
- Explore additional simulation capabilities to improve overall customer satisfaction.

Find a listing of all of our Upcoming Training Sessions [here](#).

Upcoming Educational Webinars

Webinars provide a cost-effective way to expand your knowledge of plastics.

Below is a list of the upcoming webinars presented by TMG Engineers:

Thursday, June 11, 2020 – *Jeffrey A. Jansen* – Society of Plastics Engineers

The Effects of Impact Loading Mechanisms on Plastics

10:00 AM (CST)



While in service, plastic materials are subjected to many different types of mechanical stress. One common type of stress that is typically severe on plastics is rapid impact loading. The rate at which loading is applied, otherwise known as the strain rate, is a very important factor in the performance of a plastic component. Impact, together with snap fit assembly and rapid pressurization, are the most common forms of rapid loading or high strain rate mechanisms.

The response of plastics to impact and the ability of a plastic part to withstand the stress through absorption of the applied energy is dependent on many aspects, including the material, design, processing and the service conditions.

Topics covered as part of this presentation will include:

- Failure Mechanism of Plastics
- Strain Rate as a Ductile-to-Brittle Transition
- Impact Failure
- Factors Effecting Impact Resistance
- Impact Testing
- Case Studies

Impact loads are among the most challenging stresses that plastic component designers and manufacturers must deal with. In many cases impact stress is not adequately accounted for. Often this leads to unnecessary, premature or unexpected failures.

Click [here](#) to register.

Wednesday, June 17, 2020 – *Jeffrey A. Jansen* - SpecialChem

Using FTIR for Identification and Evaluation of Plastics

9:00 AM (CST)



Possessing an understanding of FTIR will allow participants to more efficiently and effectively use the technique in the analysis of polymeric materials, whether directly or through testing laboratories. The course will cover the applications of FTIR and explain the strengths and weaknesses of this analytical method.

The course will focus on:

- Understanding what information FTIR can provide in the analysis of polymeric materials in order to maximize polymer problem-solving evaluations.
- Appreciating what other analytical techniques provide complementary information to get the most out of polymer analysis.
- Recognizing the challenges of sample preparation and how to overcome these obstacles to get optimal results.
- Comprehending how to interpret the spectral data generated through FTIR analysis to get the most out of the results.
- Presenting the basic theory behind FTIR analysis so that the obtained results can be better understood.

Having a thorough knowledge of FTIR analysis will allow scientists and engineers that use FTIR spectral data, to better understand the results and apply the data to problem solving and material investigations. This includes quality control material analysis, failure analysis, and reverse engineering material characterization.

Click [here](#) to register.

Upcoming Educational Webinars (cont.)

Friday, August 28, 2020 – Jeffrey A. Jansen - SpecialChem
Nylon Selection in Demanding Applications: How to Avoid Failure
9:00 AM (CST)



Polyamide (nylon) is a generic designation for a family of synthetic thermoplastics, based on aliphatic or semi-aromatic polymers with amide functionality. Polyamides can be mixed with a wide variety of additives, fillers, and reinforcers to achieve many different properties. Many different types of polyamide resins are available commercially based upon the monomers used in the polymerization process.

These include:

- Nylon 6
- Nylon 6/6
- Nylon 11
- Nylon 12
- Nylon 4/6
- Nylon 6/12
- Polyphthalamide
- Polyarylamide

Attendees will gain an understanding of the performance properties of polyamide resins, including how and where they can be used effectively. By understanding the critical performance characteristics of polyamides, attendees can make smart decisions on when polyamides are suitable for an application, and which type would be most appropriate. Recognizing the strengths and weaknesses of this important class of material will help to avoid failures.

In order to effectively design, produce, and utilize products made from polyamides, it is essential to thoroughly understand the nature of this material, including the mechanical, thermal, and chemical properties. This webinar will differentiate between the various types of polyamides, illustrating the advantages and disadvantages over other materials. Information will be discussed to allow the attendees to select between the various types, and which type may be the most beneficial for a particular application.

While the structure of polyamide is relatively straightforward, and it is often viewed as a basic resin, polyamides are used in many highly engineered and demanding applications. In order to do this, however, there must be a thorough understanding of the material.

Registration information will be available soon.



Thursday, September 10, 2020 Jeffrey A. Jansen – Society of Plastics Engineers
Fractography in Plastic Failures
10:00 AM (CST)

A review of fracture surface morphology in various plastic components including explanation of terms such as "river marks" and how to interpret. How to locate fracture origins, etc. Use of stereo microscope and SEM in evaluating fractures.

Click [here](#) to register.

Information regarding upcoming educational opportunities can also be found at:
<http://www.madisongroup.com/events.html>