TMG News

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Handle with Care – The Hazards of Shipping

Jacob Nemec

Recently, The Madison Group has encountered several instances of shipping-related plastic part failures. The failures occurred as a result of multiple sources that created differing failure modes. The sources causing failure during shipping ranged from temperature extremes to incompatible packaging materials to forklift operations. The failure modes varied from brittle impact related cracking to degradation of the material itself. The variation in the individual failures highlighted shipping as an aspect of the product lifecycle that may often be overlooked, but cannot be ignored.

When shipping finished parts or components several factors need to be considered. It should be noted that all of the following factors have caused actual failure and malfunction within plastic parts and assemblies.

Figure 1: Products stacked on pallets during shipment and storage.

What type of shipping loads could the part be exposed to?
Often times parts are stacked on pallets (Figure 1) or fastened for shipment in a way that could cause them to experience loads not typical of their end-use. Additionally, the packaged parts will see impact or shock loads from conveyors, forklifts, and rough roads.

What materials will contact the part?
To combat the risk of physical damage during shipment, one might think to include more packaging to better protect the part. However, care must be taken with packaging. Many types of packaging materials (polyethylene bags, bubble wrap, etc.) contain surface treatments that may be amide or amine-based. These surface treatment functionalities can lead to chemical attack in certain plastics, as shown in Figure 2. Similarly, polyurethane spray foams often contain accelerants and reactants, that in their monomeric or liquid state, can be aggressive towards plastics, as illustrated in Figure 3. Thus, you

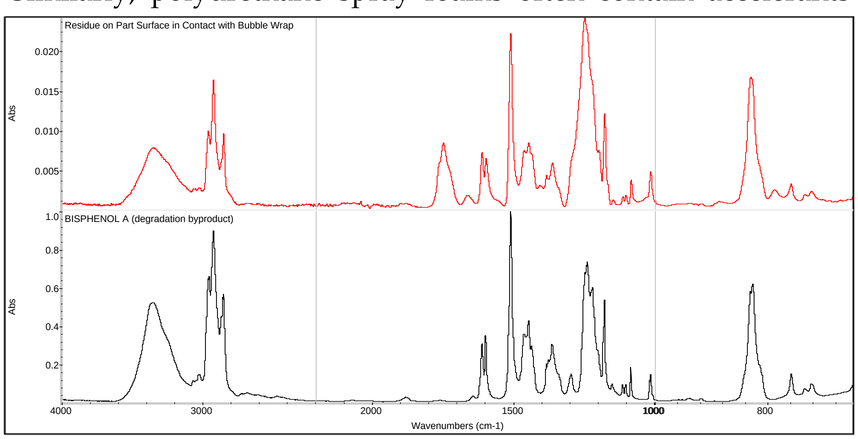


Figure 2: FTIR spectra showing material degradation from packaging material contact.

Inside this issue:

may be unknowingly harming the very part you are trying to protect.

What temperatures will the part experience during shipping?

Parts may experience temperatures during shipping that are below or above the intended end-use temperatures for the product. A product may perform adequately within the service temperature range. However, that product may experience failure when it bounces around in a container or semi trailer while at elevated or sub-freezing temperatures.

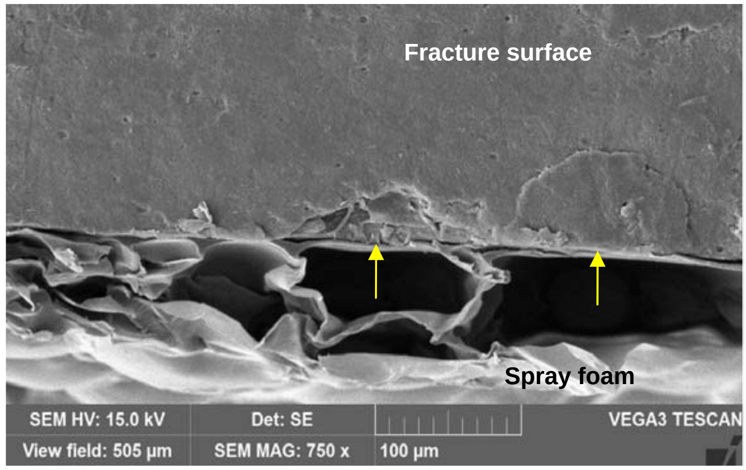


Figure 3: SEM image of crack initiation sites (arrows) along interface with an incompatible spray foam.

Could the material change during shipment?

Another consideration for thermoplastic parts is whether the material may further crystallize or anneal during the shipping process. Certain semi-crystalline materials may be exposed to temperatures exceeding their glass-transition temperature, which can cause the material to crystallize and change dimensions. Thus, a part that is placed into the truck may not be the same as the part unloaded from the truck.

Could materials in an assembly outgas or leach plasticizers?

When certain plastics, rubbers, and adhesives are heated during shipment, they may outgas volatiles or leach plasticizers. If a complex assembly is shipped in a sealed bag or container, these volatiles may condense or transfer to other components in the assembly, causing the components to malfunction or fail. Figure 4 illustrates an instance where a silicone residue was detected on a plated component after shipment.

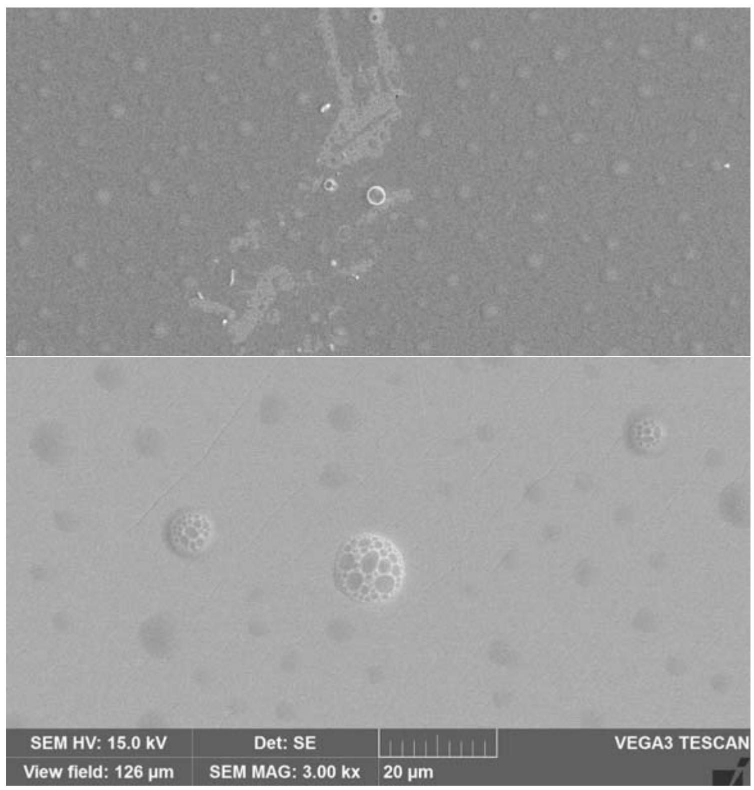


Figure 4: SEM images showing surface deposits on a plated part after an overseas shipment.

Though considerable resources may have been devoted to designing and manufacturing a plastic part, too often their transportation is an afterthought left to the logistics department or a third party. Fortunately, some shipping failures can be obvious in certain cases – such as crushing or direct external damage. However, others are concealed and may not be apparent until they ultimately cause failure while the part is in service. To avoid these costly failures down the road, do not forget to consider the shipping process used to take the parts to their end use.

If you would like more information regarding plastic material properties, compatibility, or failure please contact The Madison Group for more information at 608-231-1907 or send an email to jake@madisongroup.com.

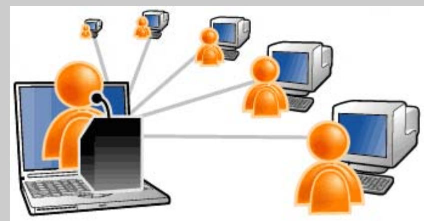
Upcoming Society of Plastics Engineers Webinars

Educational Opportunities - SPE Webinars

Webinars provide a cost-effective way to expand your knowledge of plastics. The Society of Plastics Engineers (SPE) offers a wide selection of high quality webinars, many of which are taught by Jeffrey A. Jansen from The Madison Group. Below is a list of the upcoming webinars:

Understanding Wear of Plastics
Wednesday, September 16, 2015 10:00 a.m. Central Time

Fourier Transform Infrared Spectroscopy in Failure and Compositional Analysis
Wednesday, October 7, 2015 10:00 a.m. Central Time



Dynamic Mechanical Analysis of Plastics
Thursday, November 12, 2015 10:00 a.m. Central Time

For more information on the webinars or to register, contact SPE's Scott Marko at 203-740-5442 or smarko@4spe.org.

Webinars that have been previously given are also available as a recorded DVD. Some that may be of interest are:

Non-Destructive Analysis of Plastics Parts using CT Imaging

Opening up Injection Molding with Virtual Design of Experiments

Failure Analysis of Plastics — 3 Parts

Introduction to Plastics

Degradation Failure of Plastics

Creep Rupture Failure of Plastics

For more information contact SPE's Scott Marko at 203-740-5442 or smarko@4spe.org.

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

SPE
SOCIETY OF PLASTICS ENGINEERS

From the TMG Solutions Archives:

Optimizing Cooling

Keywords - Moldflow, Simulation, Cooling, Optimization, Mold Design

The Problem

Toolmaker Carlson Tool and Manufacturing had to determine if their proposed cooling line layout would achieve turbulent flow and maximize cooling efficiency in a twelve-cavity injection mold. The Madison Group used injection molding simulation to investigate the cooling layout design and determine how much coolant was required to maximize the efficiency of the proposed design.

Evaluation

Efficient cooling of multi-cavity molds can be difficult to achieve due to limited space, and the use of parallel cooling circuits. The key to maximizing the efficiency of any cooling line layout is to ensure that the coolant is able to achieve turbulent flow. Turbulent flow allows new coolant to continually come into contact with the mold wall of the cooling channels and results in significantly greater heat removal efficiency, compared to laminar flow, Figures 1 and 2. While turbulent flow is necessary for efficient cooling, it is generally recognized that ideal cooling occurs with a Reynolds number of 10,000.

The Madison Group used injection molding simulation to determine the minimum flow rates required to achieve turbulent flow through all of the channels in the toolmaker's design, Figure 3. Specifically, this simulation provided useful information regarding the predicted mold and coolant temperature distributions and head pressure requirements. While the baseline simulation indicated that all circuits would achieve turbulent flow, it also predicted that the mold surface temperature would vary on the core side of the mold. Subsequent simulations revealed that a more uniform mold temperature could be achieved by increasing the amount of coolant flowing into the tool.

Conclusion

Injection molding simulation enabled the problem areas in the tool design to be identified prior to being built, and ensured that the cooling efficiency of the proposed design can be maximized with the customer's achievable processing conditions.

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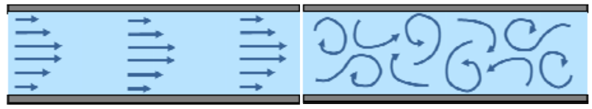

Figure 1: Illustration of laminar (left) and turbulent (right) flow.

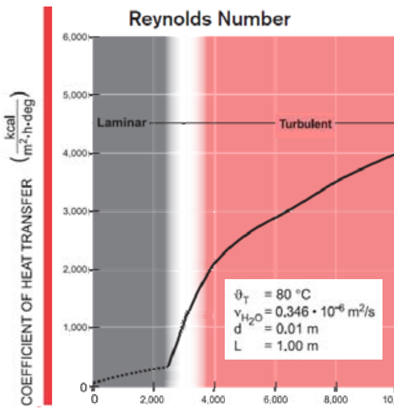

Figure 2: Chart showing the effect of the Reynolds number (x-axis) on the coefficient of heat transfer (y-axis).[1]

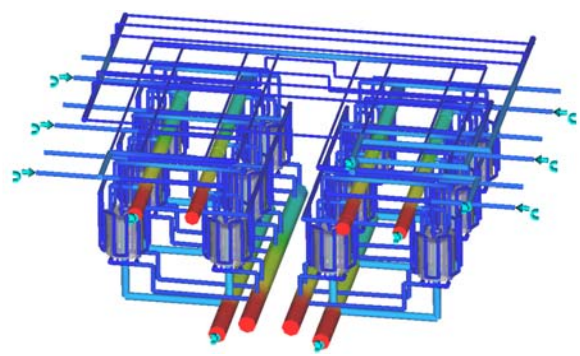

Figure 3: Macro view of the flow rates in the cooling system. Red indicates the highest flow rates, and blue indicates the lowest.

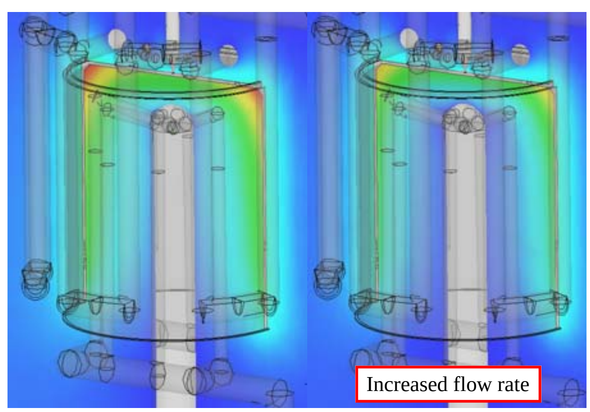

Figure 4: Result highlighting that the increased coolant flow rate leads to a more uniform mold temperature.

[1] *LANXESS Part and Mold Design Guide*, LANXESS Corporation, 2007.

The Madison Group Teaches Failure Analysis, Design & Prevention Course

The University of Wisconsin—Milwaukee School of Continuing Education is offering a 3-day course entitled, **"Plastic Part Failure: Analysis, Design & Prevention"** taught by The Madison Group Engineers Antoine Rios, Erik Foltz, Javier Cruz, and Jeffrey Jansen. The course will cover a broad range of topics essential to understanding and preventing plastic failure. Get introduced to the strategies behind analysis, design and prevention with course material that includes:

- Essential knowledge of why plastic components fail
- The five factors affecting plastic part performance: material, design, processing, installation, and service
- The process of conducting a failure investigation
- The importance of ductile-to-brittle transitions and their role in plastic component failure
- Methods for understanding how and why a product has failed
- Approaches to more quickly respond to and resolve plastic component failure
- Methods and techniques to avoid future failures
- Failure prevention through improved part and tool design

Course Outline:

- Overview of Plastic
- Composition
- Properties
- Plastic Part Failure
- Failure Correction and Prevention
    - Part Design
    - Mold Design
    - Material Selection
    - Processing
    - Validation Testing
- Failure of Plastics Overview
- Failure Mechanisms
- The Roles of Multiple Factor Concurrency and Statistical Distribution in Plastic Part Failure
- Failure Analysis
    - Problem Solving / Investigation Techniques – FA and RCA
    - Failure Analysis Test Methods
    - Case Studies

Plastic Part Failure: Analysis, Design & Prevention
Monday through Wednesday, October 12-14, 2015
8am to 4:30pm
Location: University of Wisconsin – Milwaukee School of Continuing Education
CEUs: 2.0/PDHs: 20
Program No. 4830-7956

For more information, contact:
Murali Vedula, mvedula@uwm.edu, 414-227-3121

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