FAILURE ANALYSIS & PREVENTION

Special points of interest:

- ANTEC 16
- When Standard Enviironmental Stress Cracking Resistance (ESCR) Testing Falls Short
- Announcements
- FAPSIG Board

Letter from the Chair — Jennifer Hoffman

Letter from the Chair:

Welcome to the Failure Analysis and Prevention Special Interest Group (FAPSIG) spring newsletter! I am excited to be a part of such a committed group of professionals who are passionate about Failure Analysis and Prevention. Every year we organize a variety of interesting, relevant and engaging sessions at ANTEC. Over the past several years, we have offered interactive expert panels and educational tutorials in addition to joint sessions with a variety of divisions and SIGs.

It is hard to believe that ANTEC 2016 is only one month away! We hope to see you at our joint sessions with Plastic Pipes and Fittings SIG and the Composites Division. In addition, we will be presenting the annual Dr. Myer Ezrin Best Paper Award immediately after the Monday afternoon session. We welcome you to attend the award ceremony and join us for our annual board meeting, which will take place following the announcement of the best paper winner. Please attend to learn more about FAPSIG, to provide feedback or offer sugges-tions/ideas for future ses-sions or events.

Regards,
Jennifer

Jennifer Hoffman, Ph.D.
AirXpanders, Inc.
FAPSIG Chair

FAPSIG Newsletter Editor:
Paul Gramann, The Madison Group

ANTEC® 2016

Monday 5/23/2016

Joint session presented by FAPSIG and Plastic Pipes & Fittings

Room: White River H

Time	Paper Title	Speaker	Organization
	Keynote (1 hr): Limitations of Existing Standards in Assessment of PE Pressure Pipe	Alexander	Univeristy of Illinois
1:30	Lifetime in Brittle Fracture	Chudnovsky	at Chicago
	Simulation of Fatigue Crack Growth of HDPE	Jung-Wook	
2:30	Using Crack Layer theory; Effect of Loading	Wee	Korea University
	Slow Crack Growth Fracture Resistance	Sureshkumar	
3:00	Parameter Evaluation of Parent and Joint	Kalyanam	Emc^2
3:30	Failure Analysis of a Plastic Toy Helicopter	Dale B.	ESI
	Case Studies of Plastic Failures Associated	Jeffrey A.	
4:00	with Metal Fasteners	Jansen	The Madison Group
	Evaluating the Effect of Nanoclay and		
4:30	Recycled HDPE on Stress Cracking in HDPE	Suk Joon Na	Drexel University
	Presentation of the Myer Ezrin Best Paper		
5:15	Award (FAPSIG)		
5:30	FAPSIG Board meeting		

Tuesday 5/24/2016

Joint session presented by FAPSIG and Composites Division

Room: White River G

Time	Paper Title	Speaker	Organization
	Keynote: Advances in the Prediction of Weld		
1:30	Line Strength Failures for Fiber Filled Plastics	Matt Jaworski	Autodesk
	Why it is Not Always Better to Use Fiber		
2:30	Reinforced Plastics	Antoine Rios	The Madison Group
	A Through-Process Modeling Approach for		
	Anisotropic Performance and Lifetime	Amin	
3:00	Evalution of Fiber Reinforced Thermoplastic	Sedighiamiri	SABIC
	Degradation Inspection of GFRP Storage	Masumi	Kyoto Institute of
3:30	Tank with Long-Term Use under	Ikegami	Technology
	Endurance Regression Testing: A Method to	David	NOV - Fiber Glass
4:00	Replace ASTM D2992	Granderson	Systems
	Interlaminar Fracture Toughness of Woven	Diego	Case Western
4:30	Glass Fiber-Epoxy Laminates with Carbon	Pedrazzoli	Reserve University

Exponent Welcomes Dr. Kevin Calzia to their Team

Exponent welcomes Dr. Kevin Calzia to its Polymer Science and Materials Chemistry practice. Dr. Calzia's expertise is in the areas of physical, chemical, and biological characterization of polymeric materials as well as materials selection and component design. He has over 10 years of industrial experience at Rohm and Haas, Dow Chemical, and the biofuel company Joule Unlimited. During that time he has worked on a variety of applications including bio-based polymers, photovoltaics, LEDs, plastic piping, and film-based photobioreactors and has investigated product performance issues related to weathering, chemical compatibility, mechanical overloading, creep, thermal degradation, and changes in optical properties. Dr. Calzia received his Ph.D. in Polymer Science and Engineering from the University of Massachusetts Amherst where he studied the yield and fracture behavior of glassy thermosets and composites. Dr. Calzia joined Exponent on May 2, 2016 in its Natick, MA office.

Exponent Adds More Analytical Testing

Exponent continues to expand its analytical capabilities to support consulting services for failure analysis and prevention, material and contaminant characterization, and leachables and extractables identification. Our existing optical and electron microscopy, computed tomography (CT), thermal analysis, electrochemistry and spectroscopy capabilities are enhanced by the addition of gas chromatography-mass spectrometry (GC-MS) with thermal desorption capabilities, full range IR spectroscopy including a Thermo Scientific iN^{TM} 10 MX microscope for ultra-fast chemical mapping of material surfaces and Time of Flight- Secondary Ion Mass Spectrometry (ToF-SIMS) which allows extremely sensitive (<2 nm) chemical analysis of surfaces. The techniques allow Exponent's scientist and engineers to perform high-resolution chemical analysis in support of our on-going and growing work, especially in the area of consumer electronics, medical devices, and wearables.

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When Standard Environmental Stress Crack Resistance (ESCR) Testing Falls Short

By Jake Nemec, The Madison Group

A common chemical compatibility test for thermoplastic materials is a bent strip test where a chemical is locally applied to a specimen while under a controlled strain level, Figure 1. The strain levels selected are typically below yield, but are higher than what the part would experience in the field in order to accelerate the appearance of any adverse interactions. This test is intended to evaluate the environmental stress crack resistance (ESCR) for a plastic material. The sample is periodically inspected for cracking during the chemical exposure period, and may also be mechanically tested for property retention at the conclusion of the test. This test method is good for determining bulk chemical incompatibilities of plastic materials, and should be conducted at the onset of any new product development process where chemical exposures are known and expected.

An issue with this method is that the testing is typically performed on samples with optimal material properties, whereas failures in plastic parts often present themselves at areas of less-than-ideal material/part properties. A well-molded single end-gated tensile bar will have an optimal molecular orientation in the gage length, no significant degradation, a smooth surface, and no knit lines. Often times, the specimens may also be annealed prior to the testing to reduce molded-in stresses. This ideal material condition for the testing will almost never imitate the actual condition of a molded plastic part.

A plastic part will commonly possess molded-in stress, knit lines, thickness transitions, abrupt geometric features, and varying levels of molecular weight reduction. Therefore, caution must be taken when translating chemical compatibility data generated for an ideal material specimen, to the expected performance of that material in an injection molded part.

For example, plastic materials will typically have reduced mechanical properties at a knit line. Per a knit line study conducted by BASF[1], this reduction can be as high as 20% for common unfilled materials and up to 80% or more for highly reinforced materials. The same mechanisms leading to reduced mechanical properties at the knit line will also reduce the ESC resistance of the material at the knit line. Thus, a resin that appears to be compatible with a chemical under the ideal test conditions, may suddenly start failing at the knit line after exposure to a chemical that was thought to be acceptable.

In the above scenario, a study of the chemical compatibility on a dual end-gated tensile bar with a knit line in the gage length could have revealed the incompatibility. In this situation, the typical chemical screening failed, which highlighted the need for tailoring a chemical compatibility test to the reality of the situation, not just the ideal case.

Other factors that could make normally compatible chemicals develop a heightened level of incompatibility with a molded part could be processing-induced degradation, changes in molecular weight, molded-in residual stresses, and sharp geometric features. These factors all have the effect of increasing stress levels or reducing the strength of the material, both of which will correspondingly reduce the material's resistance to potential ESC agents.

When developing a chemical compatibility test for a new product or material, take a hard look at the part design. Does it have knit lines? Does it have sharp corners? Might it have residual stress? If the answer is "yes" to any of these questions, the standard chemical compatibility test methods may not be enough.

[1] Reference: *OPTIMIZED MECHANICAL PERFORMANCE OF WELDED AND MOLDED BUTT JOINTS: PART II – WELD AND KNIT LINES INTEGRITY*. BASF Corporation. 2003. Retrieved from www.basf.com

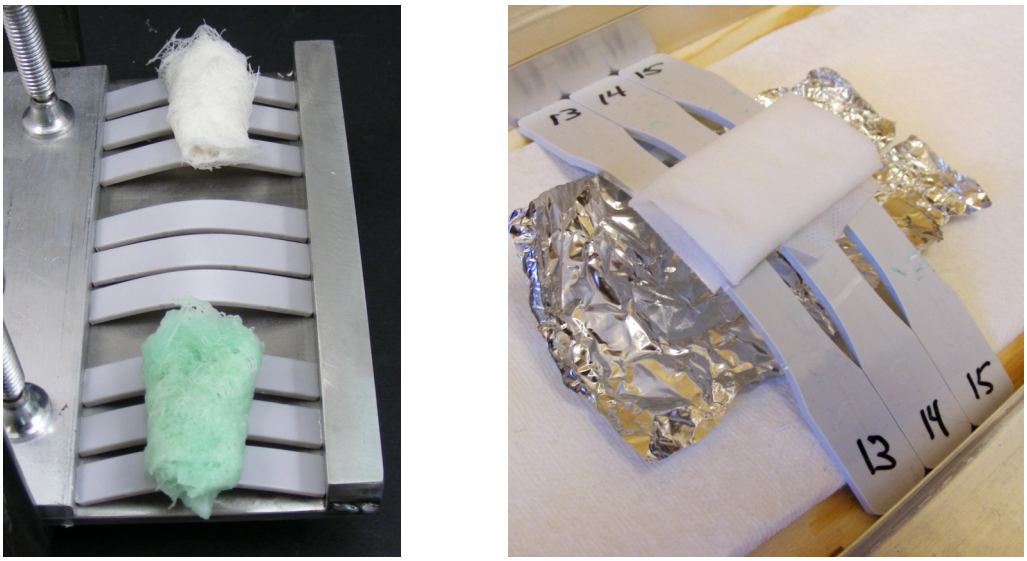

Figure 1: ESC test setups using flex and tensile bars.

Announcements

Element New Berlin is Pleased to Welcome David Macon, Ph.D.

David Macon, Ph.D., has recently joint the polymer engineering team at Element Materials Technology New Berlin as a failure analyst. Dr. Macon is a polymer engineer with an emphasis on engineering mechanics. He has over twenty years of experience working in materials and processes, research and development, materials analysis and testing, fracture and mechanical analysis. His most recent position was with Kohler Company as a R&D principal engineer focused on new product development with polymers. His prior positions include aerospace work with Alliant Technology as a R&D engineer and as a structural analyst. Dr. Macon obtained his Ph.D. and M.S. in Polymer Science and Engineering from the University of Massachusetts at Amherst. In addition, he received a M.S. in Mechanical Engineering, a B.S. in Materials Science and Engineering, and a B.S. in Chemistry from the University of Utah. Dave can be reached directly at (262) 901-0537 or david.macon@element.com.

The Madison Group Welcomes Dr. William Aquite and Jack DeSousa to their Team

William Aquite received his B.S. in Chemical Engineering from the National University of Colombia and his M.S. and Ph.D. in Mechanical Engineering from the University of Wisconsin-Madison. His research work included characterization and simulation of extrusion flow and additive manufacturing techniques. During his graduate studies, he also served as Chief Engineer for the Polymer Engineering Center, President of the student chapter for the Society of Plastics Engineers, and as Ambassador for the Wisconsin Alumni Research Foundation (WARF) where he gained experience in patenting and licensing. His teaching experience includes assisting work for courses in composites (Introduction to Composites Processing) and polymer processing (Manufacturing Processes, Engineering Design with Polymers and Modeling and Simulation in Polymer Processing). Prior to joining The Madison Group, William lectured for core courses in mechanical engineering including Manufacturing Processes and Dynamic Systems. His training in polymer processing also includes field work at one of Dow Chemical's polystyrene plants and micro-injection molding research at the Institute of Plastics Processing (IKV) at RWTH University. He holds an appointment at the Grainger Institute for Engineering at University of Wisconsin-Madison, where he manages the facilities planning and leads collaborative efforts in the use of 3D printing for teaching and learning.

Jackson DeSousa joined The Madison Group in August of 2015 after receiving his B.S. in Composite Materials Engineering from Winona State University. From his internship at Milwaukee Composites Inc., Jack gained valuable work experience in process optimization including mechanical testing and analysis, and thermoset resin chemistry. His responsibilities at The Madison Group include failure and design analysis of plastic, rubber, and composite parts.

PLASTICS FAILURE ANALYSIS WORKSHOP & PREVENTION SEMINARS

August 8-12, 2016 | Aurora, IL | Engineering Systems Inc. (ESI)

A UNIQUE SERIES OF SEMINARS THAT HIGHLIGHT THE PRINCIPLES OF FAILURE ANALYSIS AND FAILURE PREVENTION IN PLASTIC PRODUCTS.

These seminars will benefit FAPSIG members who are involved in plastic design, production, quality control, or quality assurance functions.

- Understand how to determine the cause of fracture of plastic products through analysis of the fractured part.
- Analyze failure of plastic products through testing and how to prevent failures through quality control/testing and through the application of proper stress analysis and design methods.

Attendees are encouraged to bring questions and samples from actual experience for discussion and review.

SEMINARS

August 8 – 9: Plastics Fracture Analysis Workshop & Seminar

August 10 – 11: Plastics Failure/Analysis Prevention & Testing Seminar

August 12: Failure Analysis of Plastic Products through Stress Analysis Method Seminar

For more information contact:
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SPE SEMINAR:

Joining Plastic Components—Techniques and Challenges

Importance of Mechanical Properties in Interference Assemblies

Dr. Adam Kramschuster
University of Wisconsin - Stout

This presentation will focus on plastic assembly methods reliant on deformation and interference fits. For assemblies utilizing snap fits, press fits, screws, and threaded inserts, an understanding of how mechanical properties affect the integrity of the assembly will be discussed. An overview of the time and temperature dependent properties of plastics will be provided, along with how this data can be used in conjunction with material selection and assembly design to minimize failure.

Plastic Failures associated with Metal Fasteners

Jeffrey Jansen
The Madison Group

The need to secure plastic components is prevalent in the manufacture of assemblies in many industries. Joining plastic components to other plastic parts or metal parts often involves the use of mechanical fasteners, such as screws, inserts, or rivets. The joining of plastic parts is inherently more complicated than assembling two metal components because of the fundamental differences in physical properties, including strength, chemical resistance and susceptibility to creep and stress relaxation. Case Studies will be presented to illustrate failures associated with the interaction between plastic components and metal fasteners. The presented cases will illustrate how the failure analysis process was used to identify the failure mechanism as well as the primary factors responsible for the failures. The four cases depict representative failures involving varied designs and service conditions.

Joining Plastics Parts by Welding, Snap Fits and Adhesive/Solvent Bonding

Paul Gramann, Ph.D.
The Madison Group

This presentation will give an overview on joining plastic parts by welding, snap fits, and adhesives/ solvents. A review of common plastic welding methods will be given, as well as what is required for each to create a long lasting and cosmetically pleasing plastic weld. The design and functionality of commonly used snap fits, along with enhancements that increase longevity and usability, will be discussed. The advantages and disadvantages of each joining method will be given so that the attendee will be more informed on what technique to employ for their application. The expected pitfalls and hurdles that commonly lead to failure will also be given. Demonstrations, examples, and case studies will be given throughout the presentation.

SPE
UW-Stout SPE Student Chapter

Waukesha County Tech College
The Madison Group

The seminar is offered at two locations and is **free of charge**:

Thursday - May 5, 2016
University of Wisconsin - Stout
Menomonie, Wisconsin
9:00-12:20: Presentation
12:30-1:30: Tour of UW-Stout Plastics Facility

Wednesday - June 8, 2016
Waukesha County Technical College
Waukesha, Wisconsin
9:00-12:20: Presentation
12:30-1:30: Tour of WCTC Plastics Facility

For more information or to register contact Jeff Jansen at jeff@madisongroup.com

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