STORK®
Materials Technology

Do Whatever it Takes

Winter 2003, Issue No. 1

SMT Philosophy: Do Whatever It Takes

Jay Haber (Stork Materials Technology U.S. Manager)

Welcome to the first issue of "Do Whatever It Takes". This publication is designed to be a source of education and information regarding the latest materials engineering and testing trends as well as issues facing the industry. Each quarter, you will find articles and case histories written by Stork Materials Technology experts on a variety of subjects including failure analysis, materials testing, geotechnical testing, nondestructive examination, product evaluation and much more.

Who Is SMT?

Stork Materials Technology is more than just a group of facilities scattered coast-to-coast. We are true leaders in the materials engineering and testing industry. Our history begins with Stork, a highly diversified, engineering-oriented industrial company located in Naarden - the Netherlands. As a technology-based company, Stork adds value to production processes worldwide by the provision of components, systems and services. This is done through the integrated chain of design, production and maintenance on the basis of technology and over 135 years of experience.

The original "Stork" company, C.T. Stork, was founded in 1868. Mergers and acquisitions over the next 135 years resulted in the final name "Stork" and five distinct operational units: Textile Printing, Poultry & Food Processing, Aerospace, Industrial Components and Technical Services. The laboratory within Stork was initially established as an "in-house" testing department intended to support all of the various operating companies within the organization. Starting in 1987, six branch locations and 85 employees were joined together as Stork FDO to service not only the various Stork operating companies, but also to act as independent outside engineering facilities, responsible for generating their own revenue and profits. Over the next 15 years, the group eventually became known as Stork Materials Technology. SMT now consists of 44 independent operating facilities with over 1100 employees, and we are a major supplier of materials engineering and testing services worldwide.

SMT uses the word "independent" in its true form. Stork is a strong believer in decentralized management. As such, each division is fully responsible for its own

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Free 'Team Day' Training Session

March 6, 1:00-5:00 CST
Stork Technimet, Inc. New Berlin, WI

Review of Arc Welding Methods and Techniques

Quick, efficient, and cost free, Team Day sessions are a great opportunity for you to team up with other industry professionals and learn about the latest techniques in testing and practical materials problem solving.

"Reivew of Arc Welding Methods and Techniques" will provide attendees with a review of SMAW, GMAW, and GTAW methods focusing on carbon and stainless steels and aluminum alloys. Attendees may suggest additional methods or materials by submitting a request with their reservation.

See Page 5 for additional Team Day sessions scheduled in 2003. For more information or to register, please contact **Barb Tucholke** (barb.tucholke@stork.com or 262-782-6344). Hurry ... space fills fast!

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destiny. Facilities must develop and manage their operation in a fashion that best suits their market and customers' needs. Each location must also be "entrepreneurial" with a strong, unified company culture that is customer-oriented and guided by inspirational leadership. This entrepreneurial management produces a results-oriented group and stimulates synergy between all locations worldwide. Entrepreneurial management also allows for greater flexibility when working with you as our client, which is the cornerstone of our worldwide philosophy, "Do Whatever It Takes".

Single Source for Materials Engineering and Testing

The SMT facilities work together to provide you with a single source for all of your materials engineering and testing needs. Most U.S. locations offer chemical, mechanical, metallurgical, and non-destructive testing in addition to failure analysis as its core activities. Surface and heat treatment solutions and calibration of your instrumentation are also available. The list on the right provides a summary of the services SMT collectively offers.

To review our current list of capabilities, keep up to date with seminars we offer, or obtain a list of the trade shows and conferences that we will be attending, you are encouraged to visit us regularly at www.storksmt.com.

As the name of this newsletter implies, "Do Whatever It Takes" is a vehicle of regular communication that we will utilize to meet and exceed your expectations of Stork Materials Technology. We look forward to serving you with this new resource, and hope that you will find it informative and beneficial. If you have any questions or comments about this publication, please contact our editor, **Barbara Tucholke** at barb.tucholke@stork.com or call 262-782-6344.

SMT Services

Our materials engineering and testing services add value to any phase of a project or product lifecycle. From initial design through manufacturing and field maintenance, whether we're evaluating a component, organic compound, or structure, Stork Materials Technology performs thorough investigations that yield valuable information to optimize processes and product performance.

Materials Testing | SMT offers analytical services for a wide range of materials used in a variety of industries and applications. These include chemical, mechanical, and metallurgical analysis; testing of polymers such as plastics, rubber, elastomers, paints/coatings, adhesives, lubricants, and organic chemicals; and dimensional inspections including first article inspections, reverse engineering, mold qualifications, and process capabilities studies.

Non-Destructive Testing | From visual inspections to radiographic techniques, ultrasonic evaluations to liquid penetrant methods, SMT offers a comprehensive portfolio of non-destructive testing and evaluation services that work to optimize production and assure the quality of finished products in the lab and in the field.

Failure Analysis | SMT conducts in-depth investigations and analysis to determine the root cause of part and assembly failures and identify the means for preventing future problems.

Calibration | Our calibration laboratories are specialized in the calibration of pressure, temperature, humidity, electrical, geometric and mechanical instruments. All calibrations are traceable to national and international standards and certificates are provided to support this.

Construction Materials Engineering | We provide sampling and testing services for a full range of construction materials and processes including concrete, asphalt, aggregate, and soil. SMT also provides geotechnical engineering and testing services, offering comprehensive analytical and consultative support.

Surface Treatment | SMT offers a full range of thermally sprayed surface treatments that work to extend the life of your parts and, ultimately, maximize the efficiency of your processes.

Heat Treatment | Designed to improve strength and durability, SMT offers heat treatment services for weldments, full constructions, coatings, insulating surfaces, and process heating.

Consultancy Services | SMT engineers and scientists often look beyond test results to explore why failures or problems occurred and then determine how they can be resolved. Our comprehensive consulting services can help facilitate the development of your products and processes, optimizing production efficiency and shortening time to market.

When Worlds Collide

Brett A. Miller, P.E. and Jeffrey A. Jansen (Stork Technimet, Inc.)

Many commercial components are produced using a combination of metallic and polymeric engineering materials. The use of metals and polymers in an assembly brings special considerations. Too often, unique characteristics of one of the materials, which could be deleterious to the other material, are overlooked. The following examples illustrate the potential interactions between metal and polymeric components that can have detrimental effects on the complete assembly.

Hinge Handles

Handles produced from a hinge assembly had cracked in service. The handles were produced from a polycarbonate/acrylonitrile:butadiene:styrene resin blend (PC/ABS), and were assembled together with a base unit using a metallic roll pin. A visual examination of the failed plastic components revealed multiple cracks within the molded boss, which secured the roll pin. The cracks exhibited an irregular, but continuous propagation pattern. A residual film, identified as a hydrocarbon-based oil, was present covering the fracture surface and adjacent locations. This oil was also present within the corresponding roll pins, and it appeared that this material was present as residual lubricant remaining from the pin forming operation.

Examination via scanning electron microscopy (SEM) revealed multiple crack origins along the inner diameter of the molded boss in areas that contacted the roll pin as shown in Figure 1. The observed features were suggestive of environmental stress cracking (ESC). ESC is a phenomenon whereby a plastic resin is affected by a specific chemical agent while under tensile stress. The chemical responsible for the cracking appeared to be residual lubricant remaining from the fabrication of the mating roll pin.

Over-Molded Instruments

Several over-molded instruments cracked during an engineering evaluation in which the parts were undergoing a cyclic thermal shock program. The parts were designed with a brass insert and an over-molded unfilled polyacetal copolymer. Visual examination of the parts revealed the presence of multiple cracks within an area immediately adjacent to the metal insert.

Further examination using scanning electron microscopy (SEM) confirmed ductile crack initiation, as indicated by the presence of stretched fibrils. The fracture surface features revealed that the cracking originated within an area that contacted the mating metal insert.

Thermomechanical analysis (TMA) of the insert and the over-molded plastic showed a significant difference in the coefficients of thermal expansion. Evaluated across the temperature range of the thermal shock program, a wide disparity in the expansion was apparent, as illustrated in Figure 2. This difference was consistent with the relatively ductile crack initiation, which suggests that the fracture was associated with exposure to high stresses above the yield point over a short period of time. It is significant to note that the cracking likely occurred during a low temperature exposure portion of the thermal program, when the over-molded plastic would have contracted onto the metal insert.

Naturally there are analogous cases where polymeric materials have been the proximate or contributory cause of metal failures. In many instances the design of the metal parts is sufficient and the presence or behavior of the plastic was not afforded the requisite consideration. The following are two examples of failures of this type.

Food Processing Tank Water Jacket

Leaking occurred in a Type 304 stainless steel water jacket surrounding a food processing tank. The purpose of the insulated jacket was to circulate hot and cold water to alter the tempera-

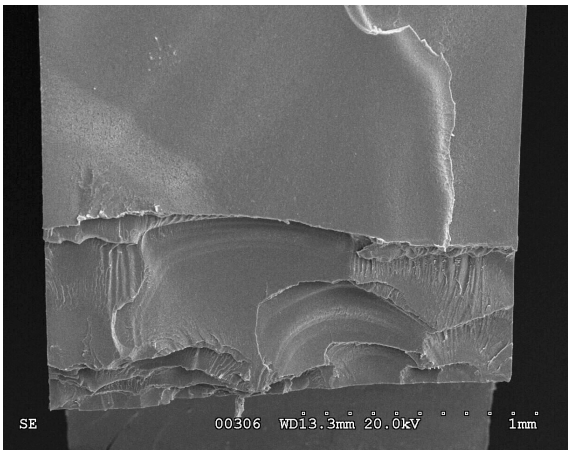

Fig. 1 - Electron image of the hinge fracture surface. (Approx. 50X)

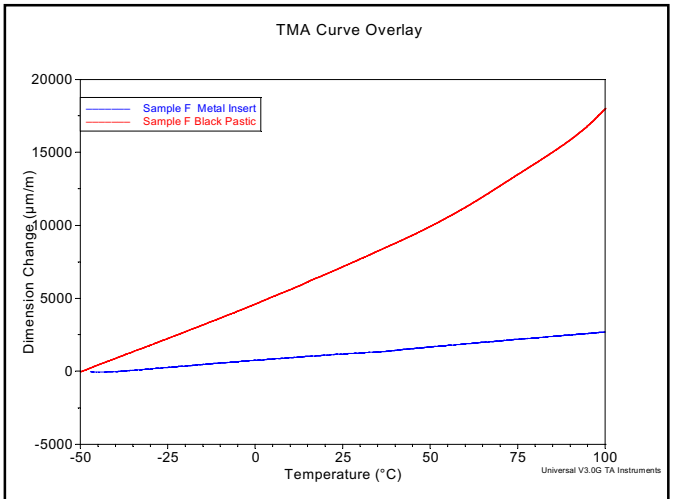

Fig. 2 - TMA plot overlay of the over-molded instruments.

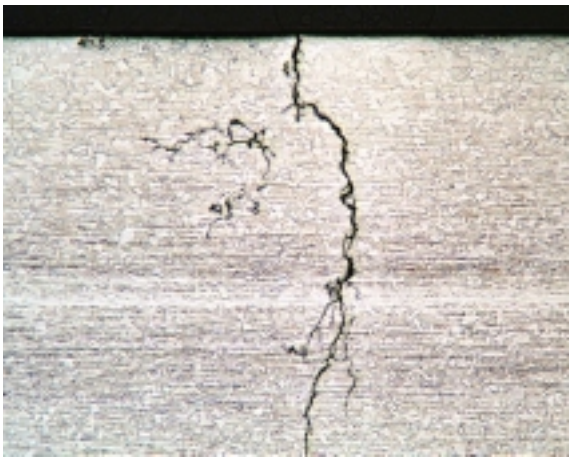

Fig. 3 - Branching cracks in a stainless steel jacket.

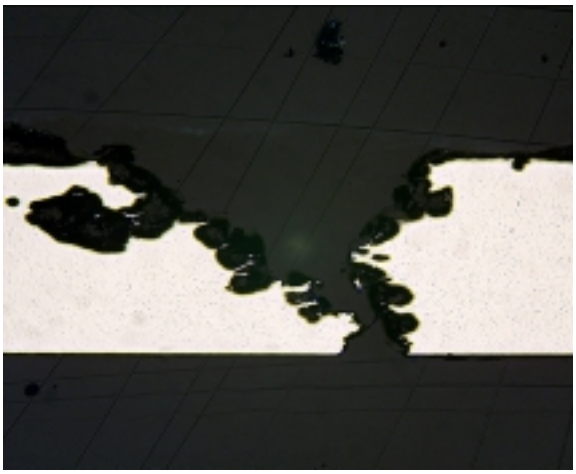

Fig. 4 - Diesel fuel tank perforation.

ture of the tank as necessary during the brewing process. The tank was a welded construction and the water temperature ranged from 32-240°F. Several years of satisfactory service was reported prior to the noticed leaking of the jacket.

The jacket was visually examined and exhibited exterior corrosion products accompanied by visible cracking. A variety of fine cracks were apparent upon destructive physical examination.

SEM examination and EDS analysis of acetate replicas prepared on-site revealed cracking accompanied by a significant level of chlorine. Rust was present, as type 304 austenitic stainless steel is susceptible to many types of corrosion in the presence of chlorine compounds. Metallographic examination of steel samples excised from the jacket revealed telltale branching cracks coming from the surface, as shown in Figure 3.

Evaluation of the insulation wrapped around the exterior of the jacket was then performed. Chloride leach testing of old and new insulation samples revealed levels of leachable chlorides up to 245 ppm.

The conclusion reached in this case was that ingress of water into the insulation around the jacket resulted in the leaching of chlorides from the polymeric insulation. The presence of chlorides on the surface of the Type 304 stainless steel tank resulted in stress corrosion cracking. The stresses necessary for this failure mechanism were likely cold work stresses, fabrication and welding stresses, and stresses from thermal cycling. The cracking eventually continued through the jacket wall and resulted in leakage of the jacket cooling water.

Diesel Fuel Tank

A diesel fuel tank that had leaked during over-the-road trucking was submitted for failure analysis. The aluminum tank was suspended under the cab of the tractor and attached by austenitic stainless steel straps. An elastomeric liner was placed between the tank and straps for insulation and vibration damping.

Disassembly of the submitted tank revealed a few isolated pits through the tank wall that permitted fuel leakage. It was originally thought that these pits were associated with tank assembly welds.

Laboratory testing indicated that the tank was fabricated from an aluminum alloy 5052 and the hardness was suggestive of the annealed condition. Analysis of the pits revealed high levels of chlorine. The aluminum microstructure did not contain inherent flaws. The two pits were found to have occurred in base metal regions not associated with assembly welds. A pitted cross section region is shown in Figure 4.

FTIR analysis of the liner identified the material as a butadiene-based polymer that was highly loaded with oil and carbon black. Analysis showed the synthetic rubber was not degraded and it was not a potential source of the chlorine detected on the tank surface.

It was concluded that rapid pitting corrosion was occurring to the aluminum fuel tank due to moisture and chlorides present under the rubber liner. The source of chlorides was likely road deicing salt.

Subsequent permeability testing of the rubber liner revealed that the material allowed water to pass through. Therefore, the permeability of the liner likely allowed the creation of a localized galvanic cell between the aluminum tank and stainless steel straps via moisture laden with chlorides. Aluminum and austenitic stainless steels are substantially different in electrochemical potential and are known to form rapidly corrosive couples.

Conclusion

These examples illustrate the necessity of adequately evaluating the potential interactions when using polymeric and metallic components in an assembly. The case studies also show that while the failure analysis processes are similar, the evaluation of metal and polymeric materials requires specific knowledge and experience. Very often in complex investigations of this type it is necessary to involve both polymer scientists and metallurgists in order to better identify the probable causes of failure. Stork Materials Technology is uniquely positioned to handle the complexities of both metallic and polymeric material failures. Metallurgical engineers and polymer scientists are available to assist you in solving materials problems regardless of the material.

Trade Show and Conference Schedule for Winter/Spring

TNRCC Air Emissions Inventory
February 11-12
Sheraton North Houston Hotel, Texas

AFS Wisconsin Regional Conference
February 13-14
The Pfister Hotel, Milwaukee, Wisconsin

SAE 2003 World Congress
March 3-6
Cobo Center, Detroit, Michigan

NACE Corrosion Expo 2003
March 16-20
San Diego Convention Center, California

World of Asphalt 2003
March 18-20
Nashville Convention Center, Tennessee

AWS Welding Show 2003
April 8-10
Cobo Center, Detroit, Michigan

Offshore Technology Conference 2003
May 5-8
Reliant Center, Houston, Texas

TNRCC Environmental Trade Show and Conference
May 5-7
Austin, Texas Convention Center

National Industrial Fastener Show
May 8-9
Orange County Convention Center, Orlando, Florida

Visit www.storksmt.com for updates and direct links to event sites.

SMT Participates in 54th Annual International Appliance Conference

On March 11, SMT will be represented by **Jeffrey A. Jansen** (Stork Technimet, Inc.) with his presentation entitled, "The Evaluation of Appliance Hose Failures." The talk will cover environmental and mechanical stresses exerted on polymeric hoses. It will focus on the investigation of appliance hose failures, including the determination of the nature and cause illustrated through the presentation of case studies from appliance applications. The presentation will also detail hose failures associated with chemical interaction, ultraviolet radiation degradation, and fomulation compositional changes.

The conference is being held March 10-12, 2003 in cooperation with Purdue University at Cumberland Place Exhibition Center in West Lafayette, Indiana. For more information or to obtain a preliminary program and advanced registration form, please contact **Jeffrey Jansen** or **Brad Kokal** at Stork Technimet (262-782-6344).

SMT Featured in Failure Analysis and Prevention Handbook

Three chapters written by SMT professionals were recently published in the ASM Handbook - Volume 11 entitled, Failure Analysis and Prevention.

Two chapters authored by **Brett Miller** include "Materials Selection for Failure Prevention" (Page 24) and "Overload Failures" (Page 671). The chapter entitled "Characterization of Plastics in Failure Analysis", written by **Jeffrey Jansen,** appears on Page 437.

We applaud the efforts put forth by Brett and Jeff, and the display of their level of expertise. Be sure to review these chapters when you receive your copy of this edition of this ASM Handbook.

2003 Team Day Schedule

March 6: "Review of Arc Welding Methods and Techniques"

June 26: "Aluminum and Its Alloys"

September 19: "Design Aspects of Fatigue Failure"

October 9: "Failure Analysis of Plastic Components"

Team Day sessions are typically held at Stork Technimet, but can be conducted at your location if requested. For more information about Team Days including an updated schedule of topics being presented, please visit www.storktechnimet.com/news/seminar or contact **Barb Tucholke** (barb.tucholke@stork.com or 262-782-6344).

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Introducing a new publication from Stork Materials Technology

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