

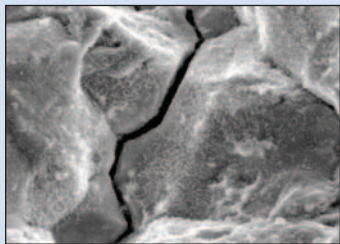
METALLURGICAL MINUTES

Materials Testing and Engineering ■ Failure Analysis ■ Manufacturing Problem Solving ■ Physical and Chemical Analysis

In The Works...

We're often asked "What do you do?" If we hesitate to answer, it's because the variety of engineered products, materials, and testing challenges we address is almost unlimited. A selection of recently completed analyses includes:

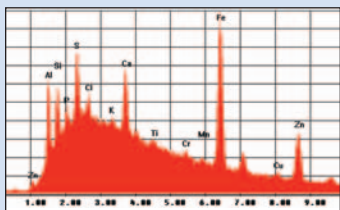
- Failure Analysis of a high strength fastener used in a military vehicle's suspension, identifying hydrogen embrittlement due to incorrect processing as the root cause of failure.



- Failure analysis of high pressure steam pipe in a multi story commercial building's heating plant. Failure resulted from fatigue initiated by a combination of thermal cycling and transmitted mechanical vibrations.



- Wear analysis of debris filtered from oil used in a portable generator motor. The elements identified facilitated identification of specific components of the motor which were subject to excessive wear.



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When "In Spec" Doesn't Work

One of the first questions that must be answered in any failure analysis is "Was the part made from the specified material?" If the answer is "yes", the analyst may be tempted to go off in another direction in search of the cause of a failure. Our recent analysis of a failed axle shaft demonstrates that a more careful evaluation is prudent even when the chemical analysis is "in spec".



The axle shaft was specified to be made from SAE 4140 alloy steel. The elements, their percentages, and the results of chemical analysis of the axle are shown below:

Element	PERCENT OF ELEMENT	
	Shaft	SAE 4140
Carbon	0.45	0.38 - 0.45
Manganese	0.96	0.75 - 1.00
Sulfur	0.026	0.040 Max.
Phosphorus	0.011	0.035 Max.
Silicon	0.17	0.15 - 0.35
Chromium	0.99	0.80 - 1.10
Molybdenum	0.20	0.15-0.25

By any criteria the shaft was within specification. However, the carbon is at the maximum specified value, manganese is near the maximum specified value and chromium is in the upper third of the specified range. The maximum or near maximum values of this combination of elements, although within spec, result in a higher than typical hardenability when this material is heat treated. The result of this higher than typical hardenability was an unacceptable percentage of quench cracks during a heat treating procedure that had been used successfully in the past on axle shafts with more typical SAE 4140 chemistries. Many of these cracked axle shafts were placed in service, resulting in short term failures.

Metallurgical Associates is in the business of solving problems, in both service failures and manufacturing process problems. We don't actively pursue the routine testing market in chemical analysis and tensile testing.

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When "In Spec" Doesn't Work

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However, many clients call on us to provide these services because of the "value added" analysis we provide by reviewing "routine" test results with an eye towards the processing and service they will see. As a



Optical photomicrograph of polished cross section through the cracked axle shaft. 40X

result, we often recommend a change in material or tightening of the material specifications which provide a significant savings "up front" before processing or service failure costs occur.

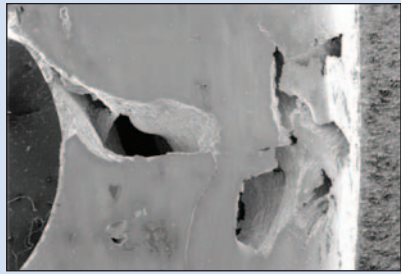
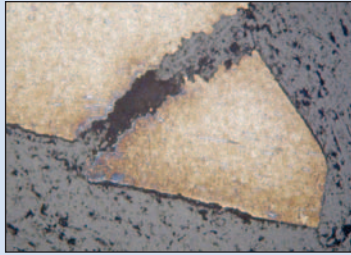
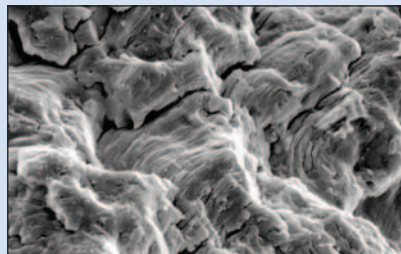
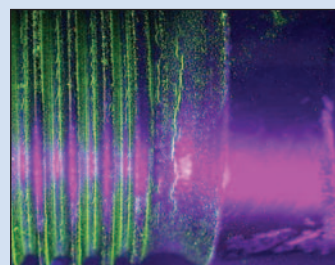
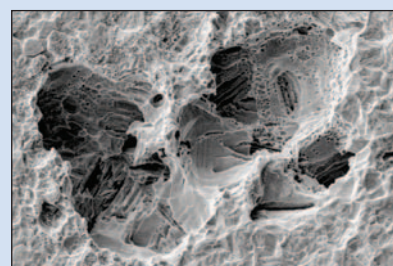
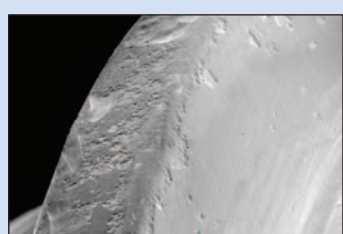
Cut To The Chase...

Band saws, abrasive saws and diamond wafer saws are in constant use here at MAI extracting samples from the parts and components we analyze. These samples are then prepared and examined to identify chemical composition, microstructure, hardness, fracture type and a wide range of other characteristics critical to an accurate material analysis. Much of this cutting is performed on pretty tough, hard, wear resistant material such as "bulldozer" tracks and links, tool steel dies and 14" diameter hardened pinion drive shafts weighing up to 1500 pounds. Our latest weapon in the "Saw Wars" is the Hyd-Mech S20. With a 2000 pound bed capacity and the capability to cut a 16 by 18 inch part, we can cut, test and complete analyses faster than ever.



In The Works

Continued from page 1

- Processing analysis of die cast aluminum automotive transmission case. Electron microscopy and microstructure analysis confirmed gas porosity as the cause which was resolved by our recommendation of an alternative mold release compound. 
- Failure Analysis of a hydraulic piston. Examination of the microstructure revealed heat treating deficiencies which resulted in excessive hardness. An alternative heat treatment procedure was developed, preventing further failures. 
- Failure Analysis of bicycle carrier rack. Electron microscopy revealed fatigue fracture as the failure mode. Alternate material or design options were provided. 
- Magnetic particle inspection of automotive cylinder head bolts which identified cracking at the thread/shank transition. The vendor acknowledged an unauthorized change in the specified heat treatment and replaced the bolts with parts to the original spec. 
- Corrosion Analysis of Type 304 stainless steel tubing, taken from stored inventory. SEM and EDS Analysis revealed high levels of chlorides which evolved to hydrochloric acid when exposed to moisture from temperature driven condensation. 
- Analysis of plating defects on semi tractor trailer component. Micro-analysis identified organic contaminants from rinse water used in the pre-plating cleaning process which "masked" areas on the component, inhibiting plating adhesion. 

In The Works

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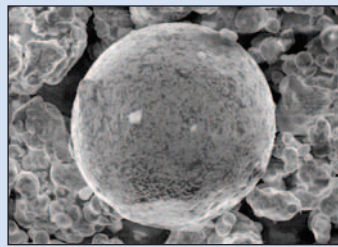
- Weld Procedure Certification for frame component fabrication of mineral mining machinery.



- Case Depth/Hardness Evaluation of security bolt to verify conformance to specification using microhardness (indents at right) traversed at 0.002" intervals. These readings are converted to Rockwell Hardness numbers and used to plot a hardness profile.



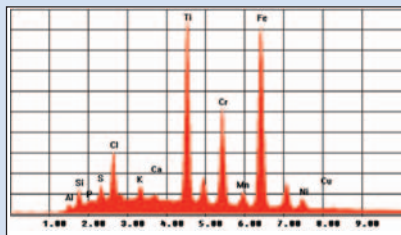
- Analysis of stainless steel powder metal powder particles using Scanning Electron Microscopy to characterize size and shape to specification. This material is filled into dies and sintered at high temperature to form solid parts.



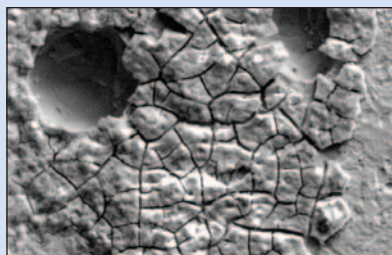
- Failure Analysis of Type 316 Stainless Steel tubing fabrications from food processing plant. Investigation determined failure resulted from stresses induced during the manufacture of the tubes.



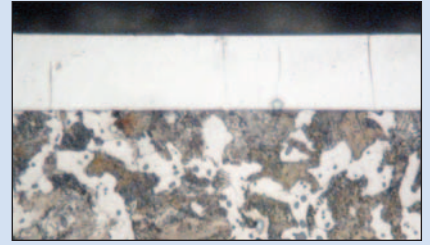
- Analysis of powder coated fasteners. Coating adhesion failure resulted in corrosion of the fasteners however, distortion of the fastener by over torquing during installation rather than any deficiency in the powder coating, was identified as the root cause of the failure.



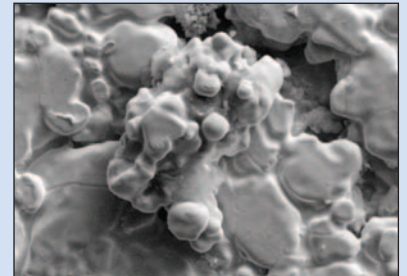
- Corrosion analysis of pitted Type 304 Stainless Steel manifold from an industrial heat exchanger. Analysis of deposits associated with corrosion pits were matched to an unauthorized cleaning solution used by a plant employee.



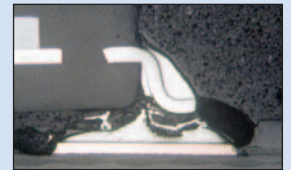
- Quality Assurance Evaluation of hard chromium plating on a hydraulic piston. Unlike "decorative" chromium plating which is applied to improve appearance and corrosion resistance, hard chromium plating provides an exceptionally wear resistant surface in "sliding wear" applications.



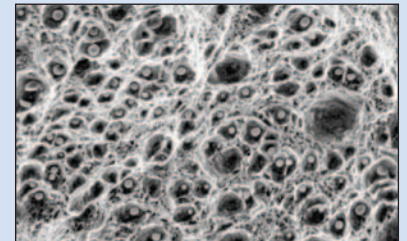
- Failure Analysis of heat treated vehicle suspension component. Examination of the fracture using one of our Scanning Electron Microscopes revealed incipient melting resulting from a poorly controlled heat treating process which exposed the component to temperatures near the material's melting point.



- Failure analysis of solder joints on a printed circuit board used in a motion control device.



- Life cycle evaluation of a steam turbine rotor including analysis of impact test samples by Scanning Electron Microscopy to determine fracture transition temperature.



- Failure Analysis of welds in sports stadium seat frames, resolved by recommended changes in the welding parameters.



- Analysis of failed ATV accessory carrier frame. Evaluation revealed fatigue failure initiating at poorly finished cross drilled holes. Options of a material substitution or an added chamfering operation were provided.



Chemical Analysis Range Continues To Grow

MAI continues to expand the range of alloys we analyze with our new Glow Discharge Spectrometer (GDS), described in the Fall 2007 issue of Metallurgical Minutes (email robh@metassoc.com for digital or hard copy back issues). In addition to the alloys listed below, we are now running ZAMAK zinc die casting alloys, corrosion resistant copper-nickel alloys and high temperature nickel alloys. Comparative testing results are excellent and analysis turnaround with emailed results is typically 48 hours or less. As always, same day analysis is available in response to "RUSH" requirements. For fast, accurate, reliable chemical analysis contact MAI.



Alloys and Metals Analyzed by MAI's GDS

Carbon Steels	Resulfurized Steels	Aluminum Alloys
Low Alloy Steels	Leaded Steels	Copper Alloys
Stainless Steels	Cast Irons	Bronzes
Manganese Steels	Tool Steels	Brasses
Boron Steels	Nickel Alloys	Powder Metal

Metallurgical Associates Inc. is an independent materials testing and engineering facility accredited by the American Association for Laboratory Accreditation (A2LA-ISO/IEC 17025). Our expertise includes failure analysis, process problem solving and process/material certification and selection. For a quote or discussion of your analytical requirements, contact Tom Tefelske (tomt@metassoc.com), Brad Lindner (bradl@metassoc.com) or Rob Hutchinson (robh@metassoc.com) or phone (262) 798-8098, or Toll Free (800) 798-4966 or contact MAI through our web site at www.metassoc.com.



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