SAE Fatigue Design & Evaluation Committee Meeting Minutes
October 17.20, 2005
U.S. Army Research, Development & Engineering Comman
National Automotive Center – U.S. Army Tank Automotive Command (TACOM)

Tuesday, October 18, 2005

Meeting called to order by Russ Chernenkoff; Drs. Gorsich and Lamb are in charge of local arrangements.

Curtis Schmidt from the University of Tulsa delivered the Henry O. Fuchs presentation, "The Influence of a Taper on the Stress Concentration Factor of a Shoulder Filleted Shaft," based on an article which appeared in the Journal of Machine Design in 2001:

- Removing material to improve stress concentration factor
- tapered billet shaft – replace shoulder fillet shaft
- looked at axial, bending and torsion Ansys solutions

David Gorsich presented an overview of the Ground Vehicle Simulation Laboratory – TARDEC and its initiatives: the Advanced Technical Objectives (physics of failure & prognosis; high fidelity ground platform and terrain modeling) as well as

- Accreditation program
- Lab expansion
- Reliability
- PM engineering suppliers
- Universities
- Standards

A movie on lab simulation facilities was viewed.

Scott Smith presented on "FMTV Leaf Spring Tests." Physical simulation team (PST):

- Failure modes of steel and composite springs
- Reduce weight from 200 to 40 lb.
- Composite springs fail too soon
- Still in development.

Paul Decker presented on "Analytical Simulation Team Efforts in Reliability and Safety"

- Reviewed software tools used
- Addressed benefits of model simulation
- "Reliability tech director initiative"
- "Coupled simulations"
    - Rollover analysis
    - Landmine blast
    - Tank slosh
- Reliability/Safety
    - Braking system in overloaded vehicle
    - Add-on armor

- Increased usage (change in duty cycle)

Dariusz Mikulski spoke on “Run-flat Tire Testing at NATC”. Physical Simulation Team at Ford MPG & NATC; cooperative research contract to develop run flat system.

David Lamb, Parallelizing Reliability Software for Use on High Performance Computers. High performance computer systems to run reliability analysis.

- Want system level or fleet level reliability, not component
- Multi-scale and multi physics
- System reliability
  - component interactions
  - “system” is key measure
- “Multi-scale”
  - multiple components at hot spots
  - vehicle subsystem
  - scale to fleet
  - consider system as a whole
- “Multi-physics”
  - mechanical, thermal, electric, etc.
  - fatigue, corrosion, creep, etc.
- Probabilistic – uncertainty based from material, manufacturing, usage, operating environment, maintenance.
- Parallelize for fleet analysis:
  - Monte Carlo simulations on different processors
  - multi-physics on different processors
  - multi-scale on different processors
  - within one scale and physical domain
- Scalability: as the problem grows how do the solutions grow
- Goal is to predict ground vehicle reliability at the fleet level; start with 1/4-model

Jackie Rehkopf spoke on “High Strain Rate Characterization of Engineering Materials.” Usage: Crash versus cargo – 400uS/s, below ballistic rates (1000 uS/s).

- Plastics – very sensitive to strain rate.
- Plane stress, uniform stress/strain in gauge length
- Rates from 1 to 800 uS/s, with temperatures from -40C to 120C
- Used 3 material models in FEA to allow increase strength with increased strain rate.
- Test system: piezoelectric Load Cell; (LDE) Laser Doppler Extensometers; Test system must have high natural frequency (kHz)
- LDE selectable gage length down to 4 mm resolution $\pm$ 1 microstrain
- No standard high strain rate test yet

Paul Spiteri presented “Fatigue Limit Assessment of Crankshaft Sections with Inclusion of Residual Stresses.”

- Safety factor estimates include estimate of residual stresses
- Resonant bending test fixture (tuning fork fixture)
- Gage crankshafts for loads to get equivalent reversed operating load (EROL)
- Use crankshaft main-to-main sections
- Test 16 samples
- Crack arrest in crankshaft gives short analytical and resonant test life and acceptable dyno life
- Use staircase method with frequency shift rate as failure criterion
- Used FEA to get rolling stresses and operating stress
- SWT to get damage

Jack Champaigne gave an overview of the Surface Enhancement Group activities. Resources: shotpeener.com and shotpeener.org.

John Bonnen chairs Weld Challenge V – overview –

- I T bar specimen
- II T bar @ variable amplitude
- III Peened T bar
- IV Square tube
- Ralph – shot peen effects on mild steel has (80?) specimens with shot peened weld on bottom
- 3 R rations with and without peening
- Laser peen as an option
- Low plasticity burnishing as an option

The committee voted to take low plasticity burnishing off the table.

John reviewed the T bar test results from Peter Kurath

Weld Challenge V

- Hari Agrawal – median lives and locations for designs 1 and 2 (short and long)
  - short - from 2.9E5 to 4E5 cycles
  - long - from 2.2E4 to 2.9E5 cycles

- Ali Saeedy – 3D model, mesh in Algor, FEA in Algor, B10 life using F class weld, with von Mises - BS7608, 1993
  - short – 2E5cycles with R=0, 1.4E4 cycles with R=-1
  - long – stresses are too high for fatigue

- Al Conle assumes chair as John leaves. Planning session is postponed until Wednesday.

Cindy Jiang delivered presentation on "Fatigue Life of GMAW Lap Joints Made with Different Steels." DOE uses 3 steels, 2 levels of heat, 2 strength filler metals; Fatigue tests at R = 0.1, F = 10 Hz

- reviewed weld geometry evaluations, microhardness survey and statistical analysis
- Results
    - Steel type and heat level are significant factors
    - primary initiation site was at the weld toe

Tana Tjhung spoke on the "Nonproportional Fatigue of Welded Joints Under Variable Aplitude Loading," – the LTJ model

- Random multiaxial loading (3D loading)
- Equivalent stress based (expanded Sosino's model)
- Non-proportional coefficient for material
- SCF to convert measured to local stress, Wang-Brown to count cycles
- Sosino's model is good for tests of sinusoidal regions – Bending, torsion, 90° out-of-phase

Jamison Weirup spoke on spot-weld fatigue: "Evaluation of Factors Influencing the Accuracy of Spot-Weld Fatigue Estimation Using the LBF Approach" – bar element and angle of spot

- From automatic-weld-mesh – large bar length & angle errors will cause large fatigue errors
- Angle ererors caused by non parallel meshing, length errors from drawing errors

Russ closed the meeting.

Wednesday, October 19, 2005

Russ called the meeting to order. Next meeting will be April 3-6, 2006, with the SAE Congress in Detroit, rooms available to Holiday Inn Express, details at the website www.fatigue.org. Presented day's schedule.

Ed Lu presented on a "Comparison of Probabilistic Fatigue Analyses," "statistical fatigue analysis."

- Variables include dimension; load spectrum; material properties (Ti-6Al-2Sn-4Zr-2Mo casting); mean stress, environment, bolt preload.
- Considered one-sided tolerance and Monte Carlo simulation

Steve Arms spoke on "Wireless Sensors for Structural Testing and Fatigue Monitoring."

- Embedded processors
- Harvest energy from environment to eliminate battery (vibration harvest)
- fatigue calculation in processor, can upload user S-N curve
- 'turtle shell' rosette enclosure with moisture detection for long term sensing

- base station with GSM/SAT uplink (wireless offset and cal)

Ralph Stephens – Fatigue and durability analysis of 8630 statisically vs. centrifical cast steel – for Jeff Gradmon from University of Iowa – M.S. thesis

- 90G cast of thick walled (75mm) cylinder and keel block for static cast
- Specimens -- 15 – keel static cast, 10 – outer centrifugal cast, 10 – middle centrifugal cast, 10 – inner centrifugal cast
- Monotonic load vs. "actuator displacement" not strain over 8% strain
- Fatigue test R = -1 for both strain and load control
- Not much difference for smooth specimens and R = -1

Bolt Program – Ralph Stephens, Task Force Leader.

Mike Dejack presents on "Fatigue Prediction in Cylinder Block Threads."

- Failures in cast aluminum block. Abaqas for FEA. FemFat for fatigue. Enhanced FemFat (Haigh dia – from lab tests on material)
- Modeled thread engagement with constraint equations – did not model threads explicitly
- Moved on to detailed thread sub model
- Global model with assembly load cases and gap eliminated; break out "sub model" of M10 and M8
- Predicted correct failure location.

C.C. Chu on "Fatigue Testing/Analysis of Bolted Structures."

- Presented a "structure" (posted on web site)
- Center bolt/plate is the "failure site"
- "Plate" failure should have gradient
- Similar to pickup truck bed attachment to frame
- Closed form plate solution based on load and displacement

John Fragnoli on "Unique Consideration for Testing Bolts" – fatigue testing. Lessons learned while testing bolts:

- Test bolts to improve joint life with more realistic performance data
- Test process: ISO 3800 good starting point for test machine/fixtures/alignment
- Alignment – minimize bending by proper fixturing
- Select test loads with end result in mind
- Use washer with clearances for head radius
- Use consistent thru-hold diameter
- Use consistent grip length/engaged thread length
- Isolate factors to steady and control all others: chemistry; heat treatment; shape; grain flow
- Thread roll process effects: discontinuities; residual stress
- Secondary process effects on surface (plated, coated, lubricated)
- Walk test parts through manufacturing process

Kirk Olsen spoke on "Static and Fatigue Bolt Shear Strength Characterization of 15-5PH Stainless Steel and the Effects of Shot Peening."

- Determine static and fatigue strength of 15-5PH – need high fatigue strength and low static – mechanical fuse for 'blade out' condition
- Ran shear fatigue tests on double shear specimens
- Shear endurance limit found to be 5 times lower than classic
- Shear fatigue 5 times lower, Shot peen helps $\simeq$ (10%)

Bolt Fatigue Group Planning – Ralph Stephens

- What does this committee want to do with bolted joints/systems?
- Dan L. – we have a new challenge from Chin Chan Chu that should generate good discussion/presentations for next meeting.
- Ralph – more presentations?
- Audience – fretting fatigue?
- Dan L. – quizs audience – wants more presentations
- Audience – take a survey of resources that FD&E members will commit
- Russ – This is a good idea but the commitment changes from day to day.
- Audience – We need to focus a lislt of target topics to help get resources. Put together a list of fastener topics.
- Darryl Taylor & Prof Sayed volunteer to help.

FD&E Planning Session called to order by Dan Morrow (new Chairman FD&E)

- John Bonnen, on Weld Fatigue
- Proposes running some tests (2-1/2") on the tube specimens reported on earlier
- How about Ralph's single weld on tension side of tube (2" OD x 1/8 wall square), as discussed on Tuesday
    - Dan L. will test some
    - Other volunteers?
- T bar testing – Peter Kurath looking at peened and unpeened, also J. Bonnen will run some peened and unpeened.
- Residual stresses need to be looked at – Dan L. said he might help on this
- Will look into other materials in this square tube
- Start analytically predicting the "field" reliability of these specimens
- Have this group start to look more into the "reliability" of specimens
- Loads -- Dan. L.
- Darryl Taylor, -- Solicit survey from group on needs and interests on fasteners to develop proposal on areas for challenges, papers etc. (fastener education).

Dan M. closed the meeting