



South Dakota State University

MATERIALS EVALUATION & TESTING LABORATORY

August 24, 2009

Materials Evaluation & Testing Lab, Box 2219 SCEH 216, Brookings, SD 57007

[P] 605-688-4300 [F] 608-688-5878 [W] <http://metlab.sdstate.edu>

Background of Project

○ History

- Initial contact made March 2004
- FOS project began September 2006
- ANFO project began July 2008

○ Outcome

- METLAB created as a materials research lab for SDSU to service the needs of the DoD (U.S. Army Benet Laboratories) and local industries

○ SDSU Task

- Nondestructive evaluation and testing
- Materials and methods research
- Fatigue testing of materials and sensors
- Testing platforms for research partners

Project Personnel

Faculty:

Dr. Fereidoon Delfanian

- Professor, ME, Machine Design

Dr. Gary Anderson

- Professor, AgE & Biosystems

Dr. Zhong Hu

- Assoc. Professor, ME, Materials

Dr. Huitian Lu

- Assoc. Professor, EE, ET&M

Dr. Jikai Du

- Assistant Professor, ME, NDT

Dr. Tao Huang

- Post Doc, ME, Composites

John Feldhacker

- Research Assoc, ME, Materials

Research Partners:

American Science and Technology

- Microelectronics , circuit design, development, manufacturing

Augusta Systems

- Data correlation and fusion, bi-directional communication

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Capabilities

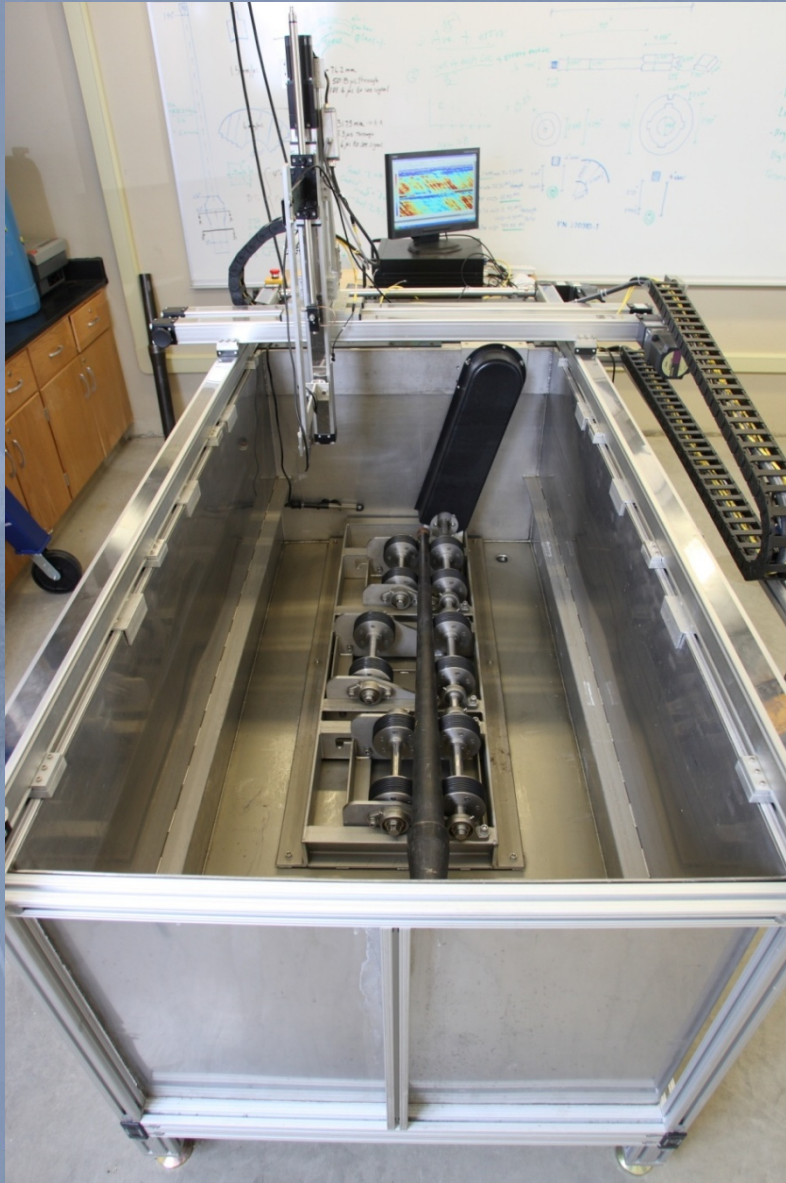
○ Nondestructive Testing

- High Speed Video
- Video Borescope
- Dye Penetrant
- Ultrasonic
- Acoustic Emission
- Eddy Current
- Magnetic Particle
- Radiographic

○ Destructive Testing

- Servohydraulic Test Systems
- Hardness Testers
- Microscopy systems

Ultrasonic Immersion Tank



- NDT Automation custom built stainless immersion tank
- High speed industrial scanner
 - 4 automated motion axis (X,Y,Z,R)
 - 4 axis PCI stepper controller
 - Resolution 0.001 in
 - Scan envelope (66 in x 36 in x 24 in)
 - Maximum X velocity of 20 in/sec
- Bar rotator
 - 5 ft length, 2000 lb
 - 3-10 in diameter by adjustable idler wheel
- Ultrawin 32-bit A/B/C scan software
 - Capable of pulse-echo and through transmission scanning methods

Portable Ultrasonic System



- NDT Automation Pocket UT
- Operation Modes
 - A, B, and C-scan
 - Flaw/thickness
 - Pulse-echo and through transmission
- Features
 - 2 independent gates with separated gate delay, width controls, synchronization threshold and detection threshold
 - Shortcut keypad and LCD for data entry, analysis, and review of results
 - Up to 4-hour integrated battery pack
 - 2-axis manual or automated scanner interface
 - Removable storage and USB connection for data transfer to laptop or desktop PC

Axial/Torsion Material Testing Unit



- MTS 858 flex test unit
- This machine can be used to determine
 - Yield and ultimate strength
 - Creep and Viscoelastic characteristics
 - High and low cycle fatigue characteristics
 - Fracture toughness and fracture mechanics
 - Modulus of elasticity
 - Poisson's ratio
 - Wear characteristics
 - Coefficient of thermal expansion
- Nominal dynamic capabilities
 - ± 25 kN (± 5.5 kip) axial force load
 - 250 Nm torsion force load
 - 270 (± 135) degree of travel
- Temperature Range
 - Testing at ambient or up to 2552°F (1400°C)
- Test space
 - Height – 31.1 in (78.9 cm)
 - Width – 18.1 in (46.0 cm)

Axial Material Testing Unit



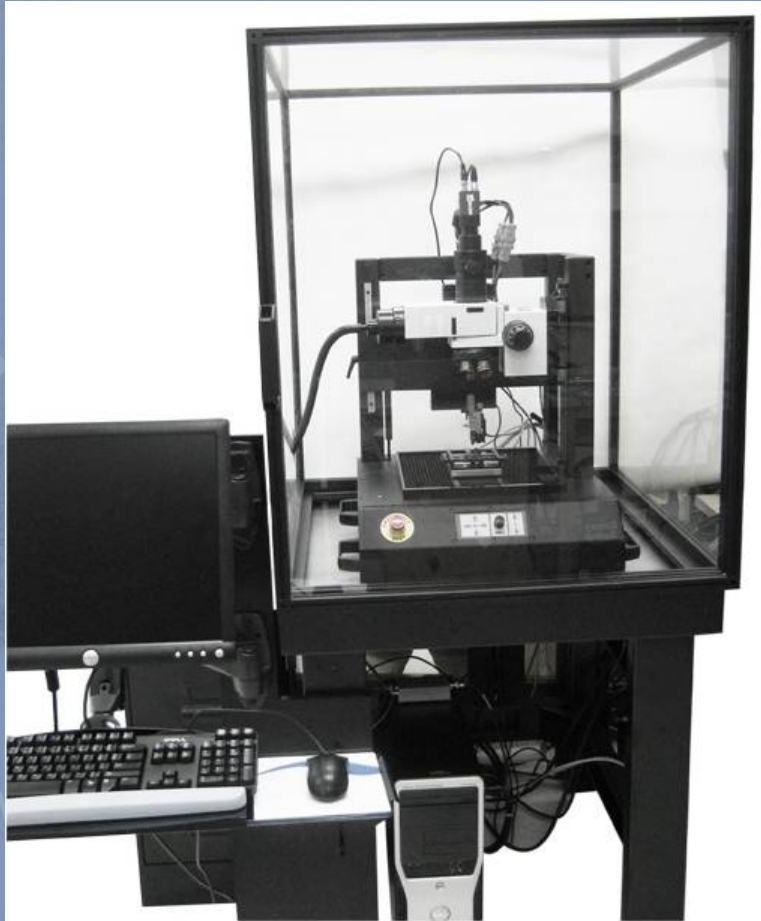
- MTS 370 Landmark test unit
- Used to determine:
 - Yield and ultimate strength
 - Creep and viscoelastic characteristics
 - Fracture toughness and fracture mechanics
 - Modulus of elasticity
 - Poisson's ratio
 - Wear characteristics
 - Coefficient of thermal expansion
- Nominal dynamic capabilities
 - ± 100 kN (± 22 kip) axial force load
- Test space
 - Height – 44.9 in (114.1 cm)
 - Width – 21.0 in (53.3 cm)

Macro Hardness Tester



- Instron/Wilson electronic unit
- Closed loop electronic control system
- Automatic conversion of hardness scales and/or values for flat or curved specimens
- Conforms to ASTM E18, ISO 6508, DIN, EN, and all other applicable national and international specifications for hardness testing
- Specimen dimensions
 - Max height is 10.0 in (255 mm)
 - Max depth is 8.5 in (216 mm)
- Loading specifications
 - Preliminary load is 10 kg
 - Total load is 60, 100, or 150 kg
- Test scales
 - A, B, C, D, E, F, G, H, K, L, M, P, R, S, & V

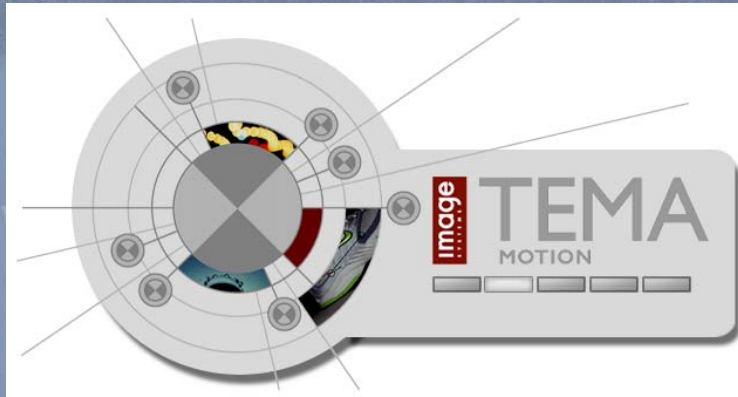
Micro/Nano Hardness Tester



- Nanovea electronic unit
- Testing capabilities
 - Microscopic and nanoscopic hardness/scratch
- Micro mechanical module
 - Loading system for 0-40 N range
 - Resolution down to 0.75 mN
 - Depth resolution of 10 nM
- Nano mechanical module
 - Loading system for 0-400 mN range
 - Resolution down to 0.003 mN
 - Depth resolution of 0.1 nM
- Microscope imaging system
 - Optical magnification of 50x, 200x, & 500x
- Scratch software package
 - Scratch at constant or increasing loads and multi-pass testing for wear evaluation
- Microhardness software capabilities
 - Depth versus load curves, hardness, modulus of elasticity, and creep calculations

High Speed Video Equipment

- Capabilities
 - Full resolution: 1,200 fps at 1024 x 1024 pixels
 - Reduced resolution: 95,000 fps at 64 x 64 pixels
- 4 GB of memory capable of capturing approximately 4 seconds of video at maximum capture rate for a specified resolution
- 10-bit image bit depth allowing for 1,024 shades of gray
- TEMA software allows for tracking of position and calculation of velocity and acceleration of multiple points in a video



Industrial Videoscope



- Olympus IPLEX FX Videoscope
- Capabilities
 - Still image recording
 - Movie recording
 - Image comparison
 - Measurements (Point-to-point, line, area)
- Scopes
 - 11.5 ft (3.5 m)
 - 24.5 ft (7.5 m)
 - 4 way articulation (Up/Down/Right/Left)
 - Water and dust proof
 - Operable from -13° to 212°F (-25° to 100°C) in air and 50° to 86°F (10° to 30°C) in water
- Base unit
 - Not waterproof but will operate in blowing rain conditions
 - Operable from -5.8° to 120°F (-21° to 49°C) in air

3D Laser Scanning Microscope



- Keyence VK-9700 System
- Features
 - 18000x Magnification & 0.001 μm 3D Measurement
 - High Definition and Ultra-depth
 - Examination in Real Color
 - Noncontact 3D Measurement
 - Violet laser, 408 nm wavelength
- Capabilities
 - 10x, 20x, 50x, and 150x magnification
 - 0.28 in (7 mm) height measuring range
 - 0.00004 mil (0.001 μm) height and width display resolution

Digital Imaging Microscope



- Keyence VHX-600 System
- Features
 - Clear 3-D observation with a large depth of field
 - Observation at all angles
 - Real-time image improvement
 - Recording observed images on the spot
 - Real-time measurement
 - Built-in display
- Resolution
 - 2 Megapixels: 1600(H) x 1200(V), ~1000 TV lines
 - 4 Megapixels: 1600(H) x 1200(V), ~1200 TV lines
 - 6 Megapixels : 1600(H) x 1200(V), ~1200 TV lines
 - Excellent color reproducibility
 - 8 Megapixels: 1600(H) x 3200(V), ~2400 TV lines
 - 18 Megapixels : 1600(H) x 4800(V), ~3600 TV lines
 - 54 Megapixels: 1600(H) x 4800(V), ~3600 TV lines
 - Excellent color reproducibility
- Image Format
 - JPEG (with compression)
 - TIFF (no compression)

X-ray Computed Tomography System

- NSI X-View M500 CT Unit
- Features
 - Advanced 2D X-ray inspection
 - 2D CT slice reconstruction
 - CT volume reconstruction for 3D inspection
- X-View 225 kV Microfocus X-ray Tube
 - 10 - 225 kV tube voltage
 - 0 - 3 mA amperage range
 - 320 W max power with < 0.1% ripple
 - < 3 micron detail recognition
 - < 5mm minimum focus-object-distance
- Paxscan Flat Panel Detector
 - 16 in x 11 in (40 cm x 30 cm)
 - 127 micron pixel pitch (2304 x 3200 pixels)
 - 14 bit pixel depth
- Six Axis Manual Controlled Manipulator
 - 24 in front/back, side/side and vertical travel
 - +20/-10° tilt with 360° continuous rotation
 - 100 lb load capacity



Projects Completed

○ Nondestructive Testing

- Industrial high speed video analysis
- Mortar base plate evaluation
- Explosive bonding analysis

○ Destructive Testing

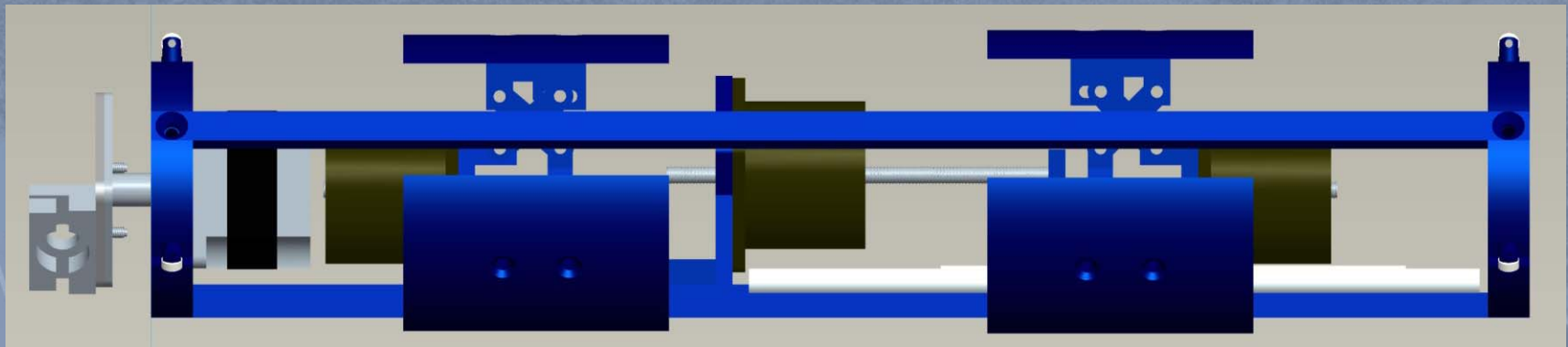
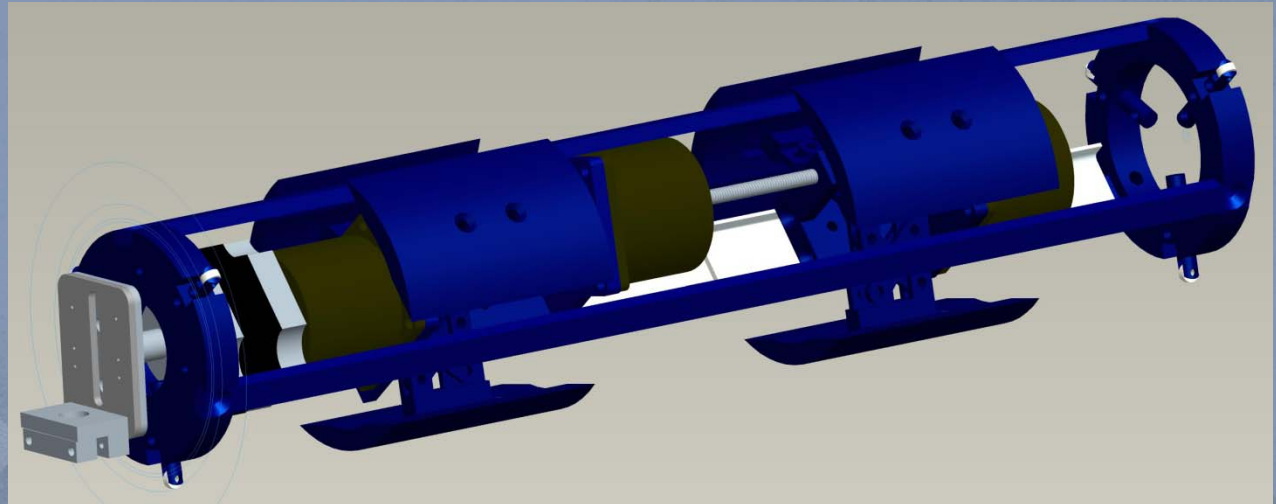
- E4340 steel elevated temperature fatigue
- Composite material analysis
- Turbine blade adhesive analysis
- Motor housing screw testing
- Explosive bonding analysis

○ Other Projects

- Field inspection vehicle (FIV)
- Cannon barrel simulation

NDT Conceptual Design

- Rotating Platform
 - Videoscope
 - Transducers



*Prototype done by ME senior design team and electronic controls and software to be completed by AST team

Future Testing Acquisitions

○ Nondestructive testing

- Computed Tomography Scanner
- Additional transducers for ultrasonic equipment
- Phased array ultrasonic equipment
- Eddy current equipment
- X-ray diffraction equipment

○ High speed video equipment

- New camera with additional speed and resolution
- Additional video equipment

References and Helpful Links

- North Star Imaging
 - <http://www.4nsi.com/>
- NDT Automation
 - <http://www.ndtautomation.com>
- MTS Systems Corporation
 - <http://www.mts.com>
- Instron Corporation
 - <http://www.instron.com>
- Nanovea
 - <http://www.nanovea.com>
- Vision Research
 - <http://www.visionresearch.com>
- Olympus
 - <http://www.olympus-ims.com>
- Keyence
 - <http://www.keyence.com>

Thank You

o Questions?

