

Deformation Processing Equipment



- Advanced Deformation Simulator
MTS Model 311.31
- Hot/warm/cold forming
 - Multiple deformation sequences
 - 110 Kip forging actuator
 - 220 Kip indexing actuator
 - Maximum loading rate: 120"/s
 - "Large" samples (e.g. 5" diameter)
 - Emulates industrial processes
 - Large strain deformation



- Advanced Forming Apparatus
MTS Model 866.725
- Forming limit diagrams
 - 10" punch stroke
 - 11.8"/s punch velocity
 - Dynamic punch force: 105 Kip
 - Static punch force: 150 Kip
 - Clamp actuator: 157 Kip
 - Various dies: 27" wide, 40" depth



- Rolling Mill
Fenn
- 14" rolls
 - 0.001" precision
 - Emulates industrial processes



- Extrusion
Innovare, Inc. LES
Explorer Series
- Maximum temperature: 900°C
 - 100,000 lb force
 - Extrusion dies: 1/4", 5/16", 3/8"
 - Extrusion rate: 0.5" - 1.0"/min
 - Maximum billet length: 4"
 - Vertical extrusion



- Advanced Metalworking System (AMS)
- 400,000 lb force
 - Horizontal extrusion
 - Post hot extrusion processing

The AMMRC is capable of mechanically evaluating and deformation processing materials that range in size from micrometers to bulk quantities. This unique facility enables mechanical characterization at loading rates as low as one micrometer/hour (i.e. rate of fingernail growth!) through impact (e.g. 3-4 m/sec) at temperatures ranging from -196°C (i.e. liquid nitrogen) up to 1400°C.

Monotonic as well as cyclic fatigue testing is possible via remote control and/or monitoring on some machines. In addition, evaluations of mechanical behavior and processing with superimposed pressures up to 2 GPa are possible. Deformation processing is conducted on novel forging, forming, and extrusion equipment. Materials systems that have been investigated span the range of organic and inorganic materials, including metals, polymers, ceramics, composites, electronic materials, and biomedical materials systems.

Contact

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35th
Anniversary

Advanced
Manufacturing and
Mechanical
Reliability
Center



CASE SCHOOL
OF ENGINEERING

CASE WESTERN RESERVE
UNIVERSITY

About

The Advanced Manufacturing and Mechanical Reliability Center (AMMRC) was established in 1987 to provide advanced manufacturing (e.g. deformation processing, extrusion, forming, etc.) and mechanical characterization (e.g. mechanical testing, reliability testing, fatigue, etc.) expertise to the CWRU campus, medical, industrial, legal, outside university, and government lab communities.

The AMMRC, housed in the Charles M. White Metallurgy Building, currently maintains equipment valued in excess of \$5 M and has been accessed by the local, national, and international communities.

The CWRU campus community can access the AMMRC via the use of a valid CWRU account number that will be charged at an internal rate for machine time, including set up and any technician time involved. Long term testing is available at pro-rated charges in consultation with the Laboratory Director.

Arrangements can be made to train users and reserve time for equipment use. Outside (i.e. non-CWRU) users can access the lab via a number of different mechanisms by contacting the Laboratory Director. Remote access for control/monitoring of testing is possible.

Servo-Hydraulic Equipment



Capabilities

- Tension, compression, fatigue
- Load, stroke, or strain control
- Low T and high T testing
- Low cycle, high cycle fatigue
- Fatigue crack growth
- Fracture toughness
- DCPD - FTA software



MTS Machines

- 50 Kip (2): High T alignment grips
 - Temperature: -125°C to 600°C
- 20 Kip
 - Temperature: -125°C to 225°C
- 10 Kip
 - Environmental testing
- 3 Kip
 - Fully reversed bending fatigue



Instron Machine

- 5 Kip
 - Temperature: -125°C to 600°C

Electro-Mechanical Equipment



- Instron/MTS Model 1361
 - Capable of 1 $\mu\text{m/hr}$ test rate
 - Temperature < 1500°C
 - Load, stroke, or strain control
 - Environmental testing

Universal Testing Machines



- Instru-Met/Instron Model 1125
 - Tension, compression, torsion
 - Temperature: 25°C to 1500°C
 - 100 kN capacity

Instru-Met/Instron Model 1130

- Tension
- Pneumatic grips
- 5 kN capacity

Microscale Testing Equipment



Rotating Bending Fatigue Positool Models 100/401

- R = -1
- Test frequency: 60 Hz
- Bend radius (100): 2-127 mm
- Bend radius (401): 7.2-72.2 mm
- Wire diameter: 0.05-1.0 mm
- Automatic break detection
- High cycle fatigue
- Wet or dry testing



Flex Bending Fatigue Jovil Model 3FDF

- R = -1
- Test frequency: 1-17 Hz
- Mandrel sizes: 1-31.8 mm
- Wire diameter: 0.05-1.0 mm
- Automatic break detection
- Low cycle, high cycle fatigue



Pneumatic Multi-Mode Test Bench Bose EnduraTEC

- Tension, torsion, cyclic
- Test frequency: 1-10 Hz
- Load cells: 5, 25, 50, 500 lb
- Low cycle, high cycle fatigue

Hardness Testing



Hot Microhardness

- Nikon QM-1
 - Vickers or Knoop indenter
 - 50 g - 1 kg
 - T < 1000°C
 - High vacuum

Impact Testing



Impact Tester

- Tinius Olsen
 - Instrumentation package
 - Digital data acquisition

Mechanical Characterization



- Video Extensometer
UVID Enterprises, LLC.
- Non-contact extensometry
 - Localized strain determination
 - Frame rate: Up to 60 FPS
 - Ideal for wire, film, tissue



- Arion 1-D System
- Axial measurements
 - Scalable to >100% elongation
 - Resolution: 0.01%

- Arion 2-D System
- Axial, transverse, shear
 - Poisson's ratio
 - Scalable to >100% elongation
 - Resolution: 0.01%

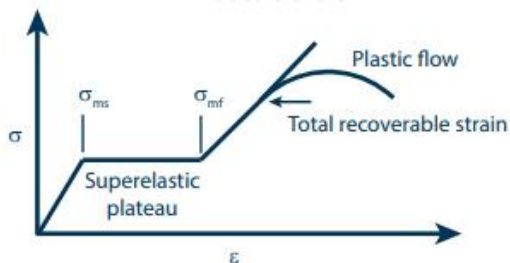
Thermal Aging



- Electric Ovens
Blue M
- Maximum temperature: 250°C
 - Long term aging

Superelastic Behavior

- Nitinol Wire
Tension response
- Strain rate: 1×10^{-3} /s
 - Wire diameter: 355 μm -508 μm
 - Stress plateau
 - Recoverable strain: < 8%
 - Ductile failure



Contact

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10th Anniversary

Nitinol Commercialization Accelerator Laboratory

2 μm

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About

The Ohio Third Frontier Wright Projects Program has funded a collaborative effort between the Cleveland Clinic, CWRU, University of Toledo, NASA Glenn Research Center, and Norman Noble, Inc. to develop a better understanding of both the metallurgical processing and mechanical characterization of Nitinol for use in medical and aerospace applications. Biomedical applications can range from orthodontia to implantable devices while other higher temperature shape memory alloys are of interest for aerospace. The collaboration is designed to create synergy amongst collaborators in the research and development of Nitinol products. CWRU has developed a facility wherein the effects of composition changes on performance can be determined.

The laboratory housed in CWRU's Materials Science and Engineering Department contains various processing and characterization (thermal, mechanical) equipment for the manufacture and analysis of Nitinol and other materials.

The CWRU campus community can access the facility via the use of a valid CWRU account number that will be charged at an internal rate for machine time, including set up and any technician time involved. Long term testing is available at pro-rated charges in consultation with the Laboratory Director(s). Arrangements can be made to train users and reserve time for equipment use. Outside (i.e. non-CWRU) users can access the facility via a number of different mechanisms by contacting the NCAL Laboratory Director.

Processing Equipment



- Vacuum Arc Melting
Thermal Technology, LLC.
Model B15 Arc Melter
- Maximum temperature: 2000°C
 - Hearth: Water-cooled Cu 9" OD
 - Bell jar: Stainless steel, water-jacketed 10" ID x 11.5" high
 - Casting: Typical sizes range from 0.5" - 3.0" diameter
 - Operating vacuum: 10^{-2} torr
 - Ultimate vacuum: $< 10^{-5}$ torr



- Hot Extrusion
Innovare, Inc. LES
Explorer Series
- Maximum temperature: 900°C
 - 100,000 lb force
 - Extrusion dies: 1/4", 5/16", 3/8"
 - Extrusion rate: 0.5" - 1.0"/min



- Additions for Phase II
Advanced Metalworking System (AMS)
- 400,000 lb force
 - Horizontal extrusion
 - Post hot extrusion processing



- Vacuum Heat Treatment
Centorr/Vacuum Industries
Series 2110 Super VII
- Stainless steel (Type 304) inner chamber, 20" ID x 30" long
 - Double wall stainless steel jacket and flanges, fully water baffled
 - W-rod elements, Mo-radiation shields and hearth plate
 - Maximum temperature: 1600°C
 - Ultimate vacuum: $< 10^{-6}$ torr

Thermal Characterization



- Differential Scanning Calorimetry
Netzsch 404 F1 Pegasus
High Temperature DSC
- Temperature range: 25°C to 1500°C
 - Heating rate: 0.1-50 K/min
 - Enthalpy range: 0-30,000 J/g
 - Specific heat: 10-5000 J/kg•K
 - Platinum furnace
 - Thermocouple: Type S
 - Protective gas: Argon

Mechanical Characterization



- Rotating Bending Fatigue
Positool Models 100/401
- R = -1
 - Test frequency: 60 Hz
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- Pneumatic Multi-Mode Test Bench
Bose EnduraTEC
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