NEMC October 2015

Missouri University of Science and Technology

Founded 1870 | Rolla, Missouri | www.mst.edu

Explosive Engineering as an Academic Program

- **Graduate Certificates**
- …
  Engineering Mechanics
  Enterprise Resource Planning
  Entrepreneurship & Technological Innovation
  Explosives Engineering (Mining Engineering)*
  Explosives Technology (Mining Engineering)*
  Financial Engineering
  Geoenvironmental Engineering
  Geotechnical Earthquake Engineering
  Geotechnics
  …

**Distance learning programs*

MS & PhD

- **Graduate Degree Programs**
- ….
- ELECTRICAL ENGINEERING (MS, PhD, DE)
- ENGINEERING MANAGEMENT (MS, PhD)
- ENGLISH (MA)
- ENVIRONMENTAL ENGINEERING (MS)
- EXPLOSIVES ENGINEERING (MS, PhD) MI
- GEOLOGICAL ENGINEERING (MS, PhD, DE)
- GEOLOGY AND GEOPHYSICS (MS, PhD)
- GEOTECHNICS (ME)
- INDUSTRIAL ORGANIZATIONAL PSYCHOLOGY (MS)
- …

Courses

- ***EXP ENG 5000 Special Problems*** **(IND 1.0-3.0)**
- ***EXP ENG 5112 Explosives Handling And Safety*** **(LEC 3.0)**
- ***EXP ENG 5512 Commercial Pyrotechnics Operations*** **(LAB 1.0 and LEC 2.0)**
- ***EXP ENG 5513 Stage Pyrotechnics and Special Effects*** **(LAB 2.0 and LEC 1.0)**
- ***EXP ENG 5514 Display Fireworks Manufacturing*** **(LAB 2.0 and LEC 1.0)**
- ***EXP ENG 5555 Computer Fired Pyrotechnic Show Design and Firing System Operation*** **(LAB 2.0 and LEC 1.0)**
- ***EXP ENG 5612 Principles Of Explosives Engineering*** **(LAB 1.0 and LEC 2.0)**
- ***EXP ENG 5622 Blasting Design And Technology*** **(LAB 1.0 and LEC 2.0)**
- ***EXP ENG 5713 Demolition of Buildings and Structures*** **(LAB 1.0 and LEC 2.0)**
- ***EXP ENG 6000 Special Problems*** **(IND 1.0-3.0)**
- ***EXP ENG 6002 Graduate Cooperative Experience*** **(LAB 3.0)**
- ***EXP ENG 6080 Industry Project*** **(LAB 3.0)**
- ***EXP ENG 6099 Research*** **(IND 0.0-15)**
- ***EXP ENG 6112 Explosives Regulations*** **(LEC 3.0)**
- ***EXP ENG 6212 Theory Of High Explosives*** **(LEC 3.0)**
- ***EXP ENG 6292 Research Methods*** **(LEC 3.0)**
- ***EXP ENG 6312 Scientific Instrumentation For Explosives Testing & Blasting*** **(LAB 2.0 and LEC 1.0)**
- ***EXP ENG 6412 Environmental Controls For Blasting*** **(LAB 1.0 and LEC 2.0)**

Explosives Camp

Two Sessions: TBA

Rising high school juniors and seniors (must be 16 years of age)

Registration: Application required.
Capacity: Space is limited to 20 participants per session

Sign up here **to join our mailing list for Summer 2016.**

At Explosives Camp you will get the unique opportunity to have hands-on learning experience with explosives: **the first and only camp of its kind!**

The program will comprise a variety of lectures, demonstrations, handling and shooting of explosives, field trips, projects and culminate in the setup and shooting of a fireworks display. It will encompass detonators, high explosives, blasting agents, rock blasting, display fireworks and demolition. You will have a behind-the-scenes look at how explosives are used in industry and in entertainment. But the number one thing that you will do at the Summer Explosives Camp is have fun!

At-A-Glance:

Two Sessions: TBA

Fee: TBA

Selection Criteria:
Space is limited to 20 participants per session

Applicants must be entering 11th or 12th grade in Fall 2016 and be at least 16 years of age by the start of the camp. Applicants must submit the following:

- One page resume
- 500 word essay on "Why I am interested in a career focusing on the application of explosives"
- Submit to a criminal background check (18 years of age or older)
- Letter of recommendation from high school teacher or counselor
- Parent contact information, including email address

Send information to:

Missouri S&T
Distance and Continuing Education
216 Centennial Hall
300 West 12th Street
Rolla MO 65409
Fax: 573-341-4992
Email: dce@mst.edu

Popular Science: THE 10 MOST AWESOME COLLEGE LABS OF 2013

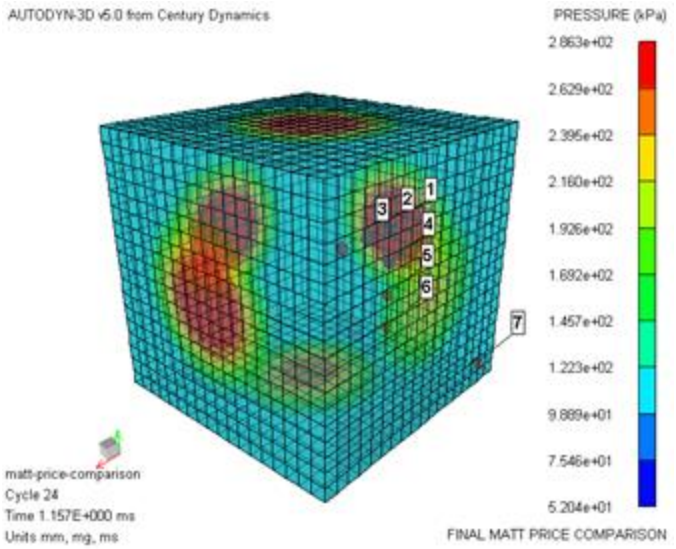
Explosives Engineering
John B. Carnett
Missouri University of Science and Technology Students in Paul Worsey's explosives program have a new class to add to their schedules: fireworks manufacturing. They grind incendiary chemicals and combine them into professional-grade fireworks; the final project is to create a five-inch pyrotechnic mortar—and set it off. Students can also take courses in commercial-firework and stage pyrotechnics, in which they learn to design, set up, and fire large public pyrotechnic displays, whether for a Fourth of July celebration, a concert, or a WWE match. **Careers: Pyrotechnics Manufacturer, Ammunition Maker, Demolition Expert**

Research Capabilties

- **Laboratory facilities**
  - Two blasting chambers (rated for 1kg and 4 kg of explosives, respectively), machine shop, computing facilities, and explosive magazines.
- **Experimental Mine facilities**
  - Two underground mines (one dedicated to research), a surface quarry, rock drills, and magazines capable of containing 3,000 LB + of explosives and detonators.

M S&T Explosives Group Capabilities

- **Testing Facilities**
  - **Blast Chamber for up to 4 Kg HE**
  - **High Speed Photography (1,250,000 fps) & (160,000 fps)**
  - **High Speed Video (up to 9000 fps & 90000 fps)**
  - **ICCD camera (55 Nanosecond exposure)**
  - **Experimental Mine/Quarry w/ explosive storage**
  - **Flash X-Ray Equipment**
  - **Data acquisition at 1MHz for pressures up to 1000 PSI for 16 channels**
  - **Multiple channels of data collection**
  - **Shock stress measurements using one time use carbon and manganin gauges**
  - **Blast modeling using AUTODYN hydrodynamic codes**



Animation created in AUTODYN of charge detonating in box.

Laboratory Development stage 1

Before:

Now:

Development stage 2

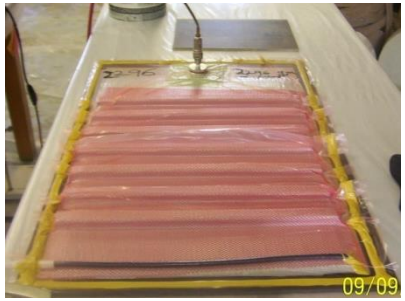
- Transforming from → to

Now:

Next:

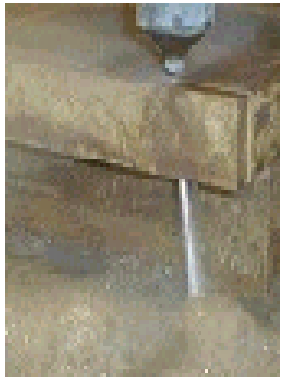
Capabilities from Manufacturing Engineering

- Composites Processing
- Additive Manufacturing (Direct Digital Manufacturing)
- Assembly Simulation & Analysis
- Friction Stir Joining
- Titanium Machining

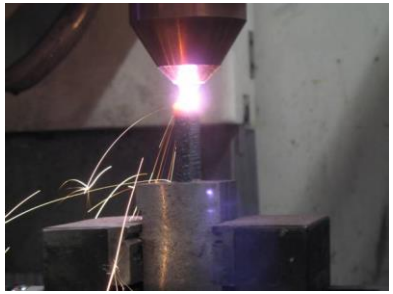


Composites Fabrication and Evaluation

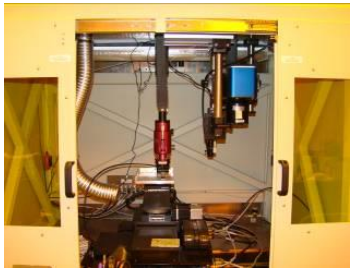
Titanium Machining



Abrasive Slurry Cutting



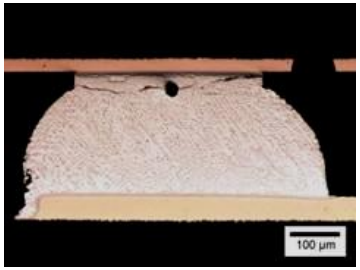
Rapid Prototyping & Manufacturing



Laser Materials Processing

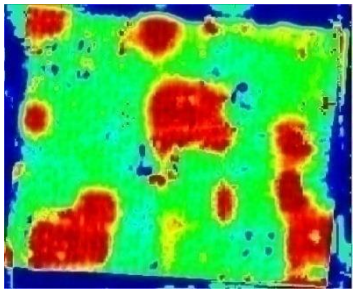
Assembly Modeling & Simulation

Friction Stir Processing



Lead-Free Soldering

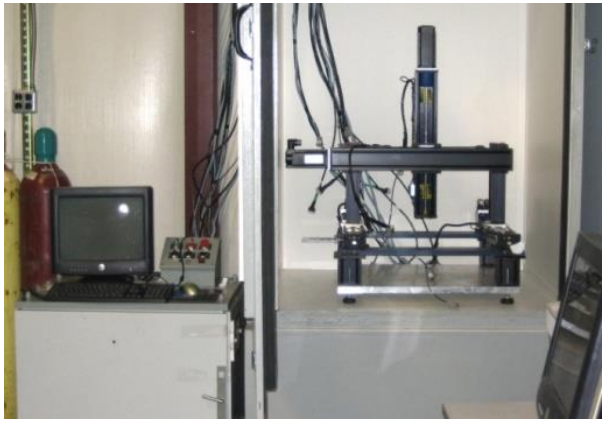
Non-Chrome Coating



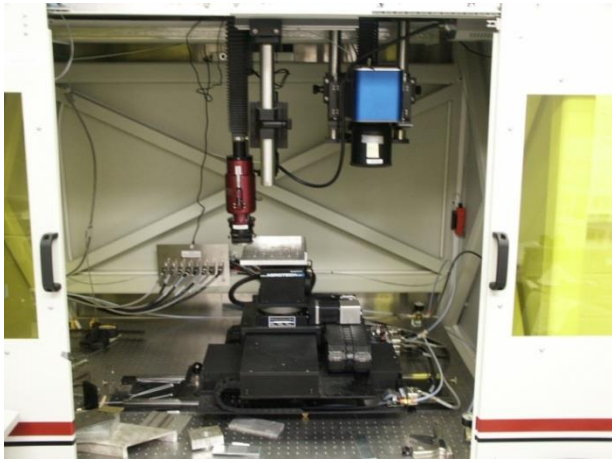
Non-Destructive Evaluation

Hybrid Manufacturing Machine

Selective Laser Sintering Machine



Freeze Extrusion Fabrication Machine



Laser Micromachining Machine

Abrasive Slurry Cutting Machine

Vertical Machining Center

5-axis Friction Stir Processing Machine

Autoclave

Fatigue Testing Machine

Computer Automated Virtual Environment (CAVE)

Focused Ion Beam (FIB) Inspection system

Works

- Improved wall breaching methods utilizing explosive systems (Army Corps of Engineers)
- Explosive-driven pulsed electrical power
- Explosive testing & safety
- Blast effects on structures and structural elements
- Formulation of new ANFO-type products
- Design, test and production of special application explosive devices
- Lightweight steel Anti-EFP armor (Leonard Wood Institute)
- Explosively-hardened armor(Leonard Wood Institute)

Works

- Quench of detonation via EMP (ONR)
- Blast-resistant structural design; coupling of continuum physics with laboratory-based high impulse tests with structure explosive tests (ALERT/Department of Homeland Security)
- Anti-blast attack education (ALERT/Department of Homeland Security)
- Explosion instrumentation & evaluation
- Taggants for high explosives
- Research & development of explosives systems and subsystems
- Instruction - short courses and seminars
- Airborne dust explosion evaluation (CNS)
- Mild Traumatic Brain Injury (DoD).

Blast-Resistant Design and Testing

- Reinforced concrete and retrofitted reinforced concrete slab and wall units.

Blast-Resistant Design and Testing

- design consultation and blast testing of polyurea (“truck bed liner”) reinforcement of CMU walls:

Blast-Resistant Design and Testing

- design consultation, ballistic and blast testing of sand filled and unfilled fiberglass barriers:

Blast-Resistant Design and Testing

- design consultation and blast testing on Range 26D Fort Leonard Wood Army base

Blast-Resistant Design and Testing

TSWG– blast defense group Projects

- Assisted TSWG in three different problems for the NY Port Authority
- Analysis and test of terrorist blasts within tunnels
- Analysis and test of concrete and steel bridges exposed to intentional blasts
- “flip book” for bridge vulnerability and defense analysis

High-Speed Imaging Capability – Cordin Camera

Explosive-driven pulsed power experiment

- Test of Ferromagnetic Generator seeding Loop Flux-compression Generator (2006 Army Grant w/UMC EE)

10 microseconds into shot

12 microseconds into shot

22 microseconds into shot

Photos at ½ million frames per second; camera capable of 1.5 million frames per second.

High-Speed Imaging Capability – Cordin Framing Camera

•2000 grains per foot copper linear shaped charge (LSC) (top).

•Bottom three photos taken of LSC detonation at 1 million frames per second.

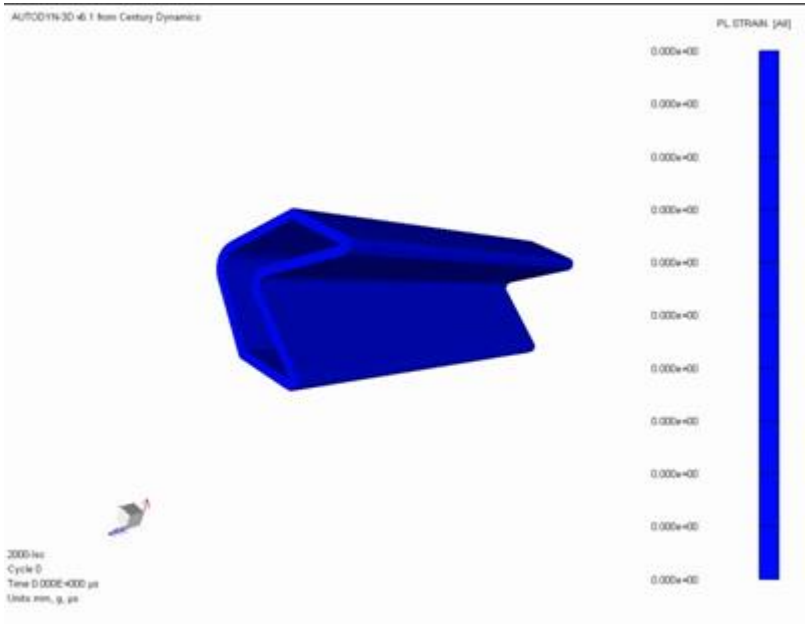
8 μsec > detonator firing

14 μsec > detonator firing

18 μsec > detonator firing

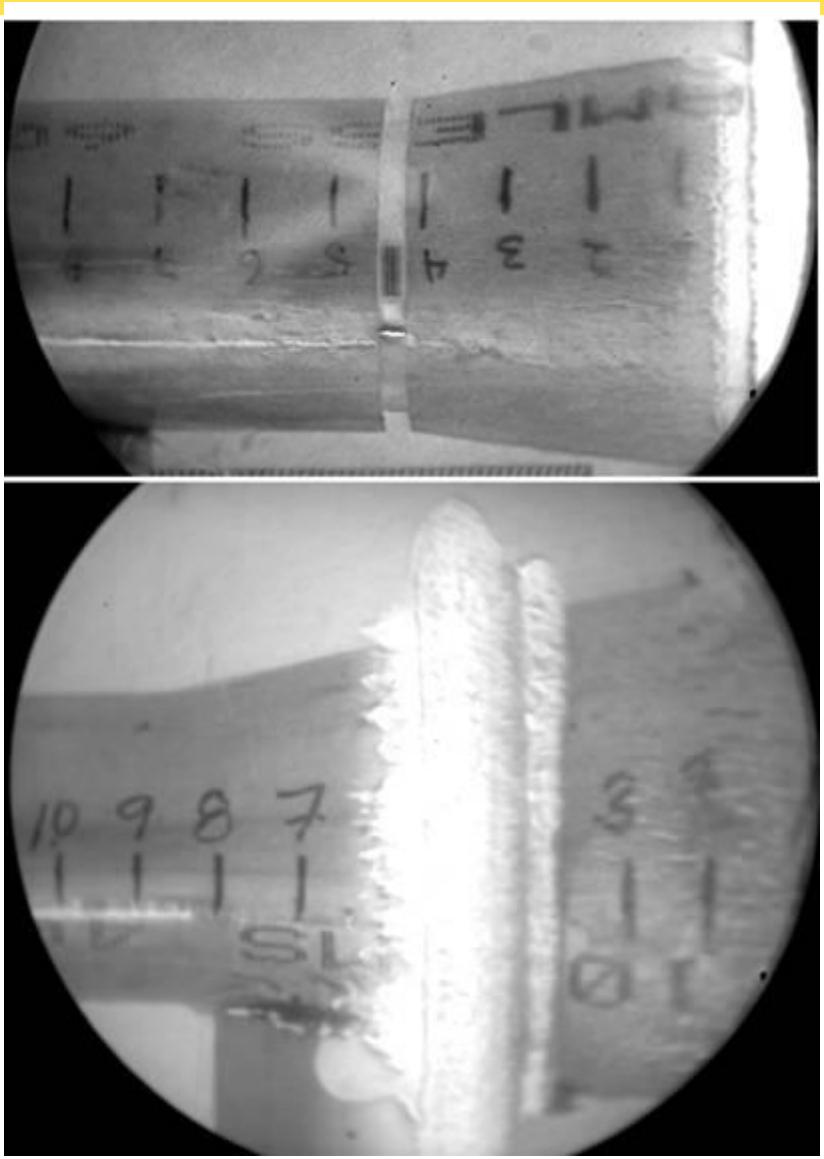
Advanced Modeling Techniques

- AutoDYN 3D – closely coupled CFD-CSD code, capable of modeling blast + structure interactions.



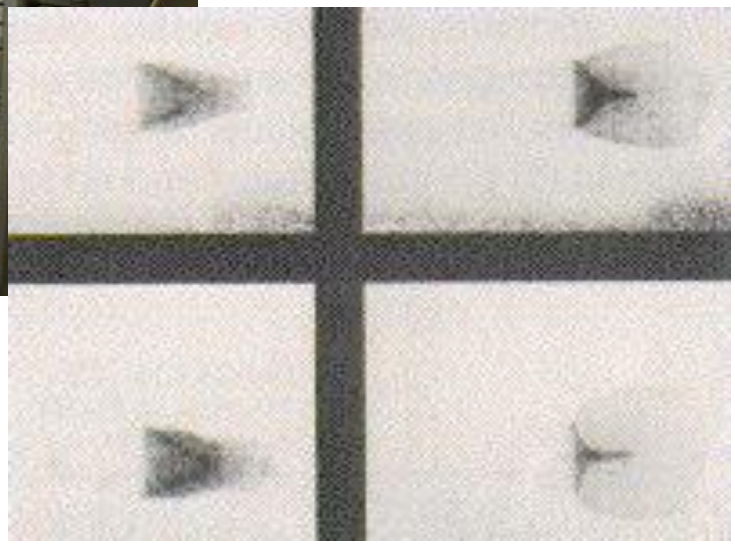
High-Speed Imaging Capability – Gated ICCD Camera

Single-frame capability; images taken at 55 nanosecond exposures



High-speed Imaging Capability – Flash X-Ray

Flash X-ray Equipment



Flash X-Ray of Shaped-Charge Jet Formation

People Explosives

Stewart Gillies
University of Missouri
Professor and Director Rock ...
Mining & Nuclear Engr

(573) 341-4365 Work
gilliesst@mst.edu
226 McNutt Hall
Rolla, MO 65409

Paul Worsey
University of Missouri
Prof of Mining Engineering ...
Mining & Nuclear Engr
(573) 341-4317 Work
(573) 467-0011 Mobile
pworsey@mst.edu
226 McNutt Hall
Rolla, MO 65409

Jimmie Taylor
University of Missouri
Supervisor Experimental Mine
Mining & Nuclear Engr

(573) 341-6406 Work
jtaylor@mst.edu
226 McNutt Hall
Rolla, MO 65409

Johnson, Catherine E.
University of Missouri
Assistant Professor
Mining & Nuclear Engr
(573) 341-4258 Work
(859) 221-0689 Mobile
johnsonce@mst.edu
226 McNutt Hall
Rolla, MO 65409

Jason Baird, Ph.D., Lt. C...
University of Missouri
Assoc Professor Emeritus
Mining & Nuclear Engr
(471) 746-4262 Work
(573) 308-5783 Mobile
jbaird@mst.edu
226 McNutt Hall
Rolla, MO 65409

People AM

Leu, Ming C.
University of Missouri
Keith and Pat Bailey Distingui...
Mechanical & Aerospace Engin
(573) 341-4482 Work
(573) 308-6360 Mobile
(573) 364-5991 Home
mleu@mst.edu
320 Engineering Research Lab
Rolla, MO 65409

Fuewen Liou
University of Missouri
Prof of Mech Engr, Director o...
Mechanical & Aerospace Engin

(573) 341-4603 Work
liou@mst.edu
292 B Toomey Hall
Rolla, MO 65409

Joseph Newkirk
University of Missouri
Assoc Prof of Met Engr & Res...
Materials Science & Eng

(573) 341-4725 Work
jnewkirk@mst.edu
282 McNutt Hall
Rolla, MO 65409

Presenter

Tuppers@mst.edu

(573) 329-8515

Steve Tupper works in the Office of Sponsored Programs at Missouri S&T and serves as the University Liaison to Fort Leonard Wood. Tupper is a graduate of the US Military Academy, holds a MSEE from Georgia Tech as well certificates from various Army and Corps of Engineer educational programs. Tupper served in the US Army Corps of Engineers for 26 years at various capacities and levels. He has been a Professor of Military Science at WPI and an Associate Professor of Electrical Engineering at the Military Academy.