OFFICE OF RESEARCH & DEVELOPMENT

2012 R&D REVIEW

BAA-2010-1
Edison Welding Institute (EWI) High-Speed Rail Projects

U.S. Department of Transportation
Federal Railroad Administration

STEPHEN LEVESQUE
Project Manager, EWI
Office of Research and Development
Office of Railroad Policy and Development

Who is EWI?

- Mission

  Advance our customers' manufacturing competitiveness through innovation in joining and allied technologies

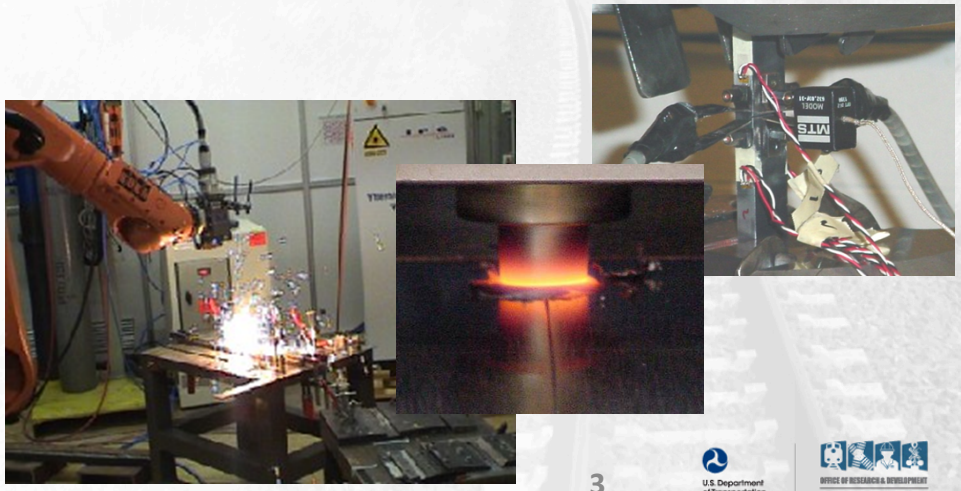
- Not-for-profit 501(c)(3) organization
  - ~$28M annual revenue and more than 130 employees
  - ~$25M in capital equipment
  - 132,000 square foot facility in Columbus, Ohio
  - More than 240 corporate members at over 1200 locations

Applied Research Services

- **Joining process capabilities**
  - Full range of arc and resistance
  - Laser processing
  - Plastics welding
  - Adhesives bonding
  - Micro-joining
  - Friction stir welding

- **Supporting technologies**
  - Design & structural integrity
  - Materials, mechanical testing
  - Materials engineering
  - Computational modeling
  - Advanced NDE
  - Weld tooling design

- **Allied & Emerging Tech**
  - Additive manufacturing
  - High power ultrasonic processes
    - Additive mfg., machining, etc.
  - Thermal forming
  - Electro-magnetic joining
  - Electro-magnetic forming/ trimming
  - Forming simulation



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2012 R&D REVIEW

The Use of Translational Friction Welding (TFW) for Constructing and Repairing Rails

U.S. Department of Transportation
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Project Manager, EWI
Office of Research and Development
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The Use of TFW for Constructing and Repairing Rails

- **Problem**
  - Joining of continuously welded rail is currently performed using the flash welding or thermite welding processes. Each process has drawbacks in price and quality.

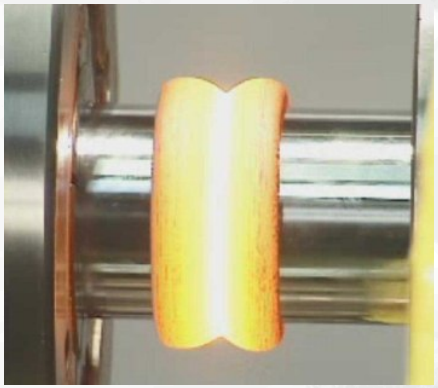
- **Solution**
  - Translational friction welding can provide welds with near parent metal strength with bonding times of less than a minute.

- **Project team**
  - EWI and APCI

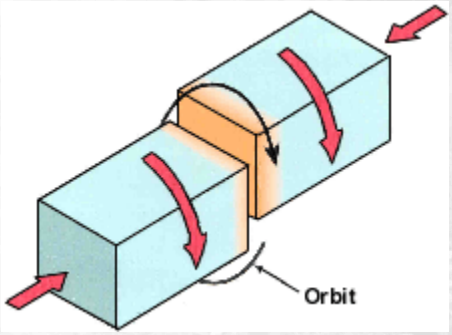
100 Ton Mechanical System
APCI Translational Friction Welder

History of Friction Welding

- **Inertia rotational welders 1960's**
  - One part chucked in spindle, other part in fixed tool
  - Energy stored in rotating flywheel
  - Parts pressed together heating and forging
- **Direct Friction Drive**
  - Similar to Inertia but energy comes from continuous motor drive
  - Stopping by brake and clutch reducing torque to parts
- **Orbital welding machines**
  - Demonstrated but not known to be applied in production
- **Hydraulic oscillators**
  - No stored energy
  - Very high cost compatible with only high value added assemblies
  - Very large incompatible with in-field applications
- **Mechanical oscillators**
  - Fixed amplitude
  - Low physical and operating cost
  - Small compatible with in-field applications



Rotating Friction Weld
Courtesy of MTI.com



Orbital Friction Weld Concept
Courtesy of TWI

Phase 1 Results

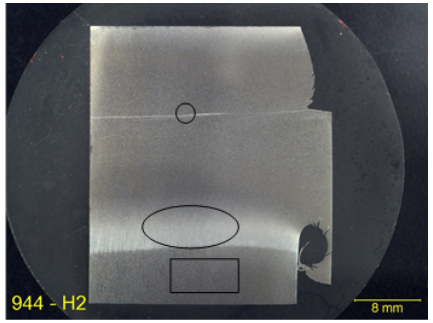
- Several welds conducted on 136RE rail

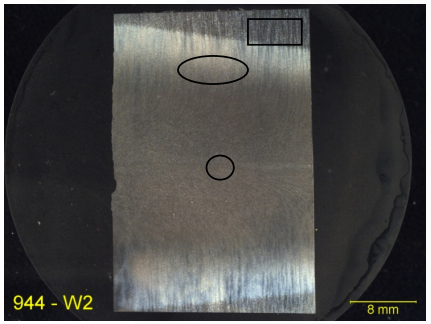
- Weld sample 944
  - Full interface weld
    - 70-80 second weld time
    - 3.8mm burnoff

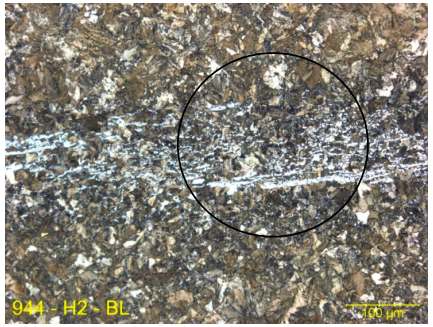
- Mechanical testing
  - Tensile
  - Bend
  - Hardness
  - Metallurgical evaluation

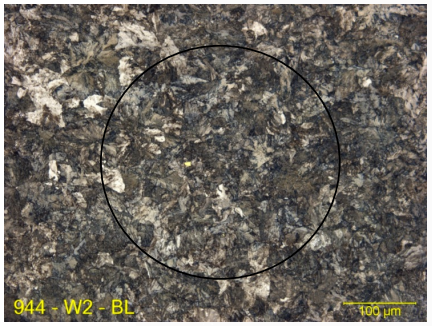
Mechanical Test Results

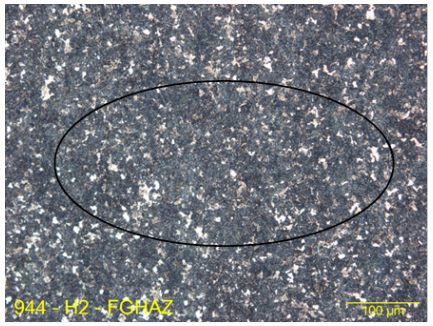
Head **Web**

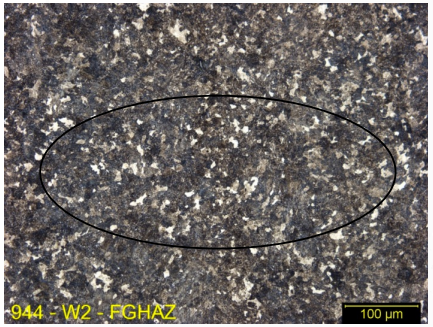


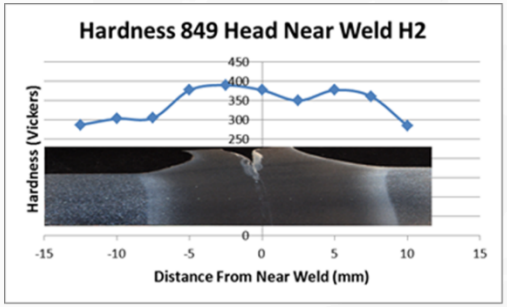


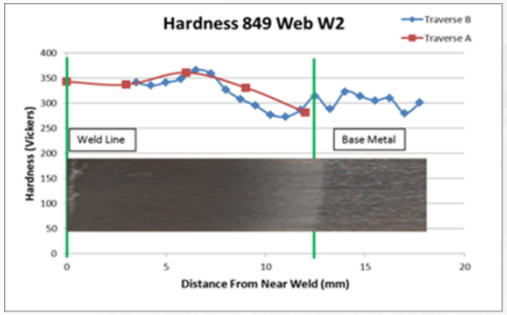


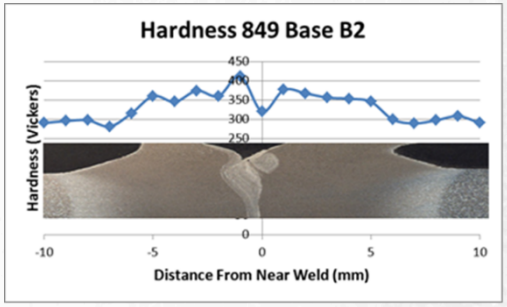


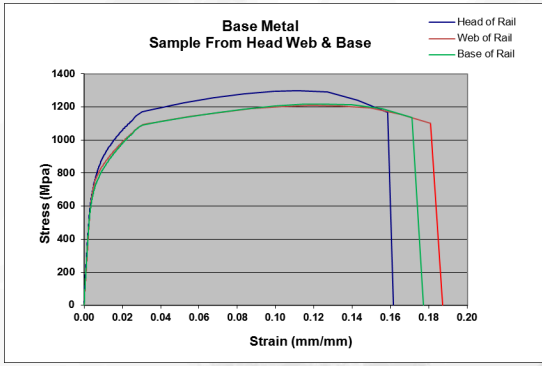


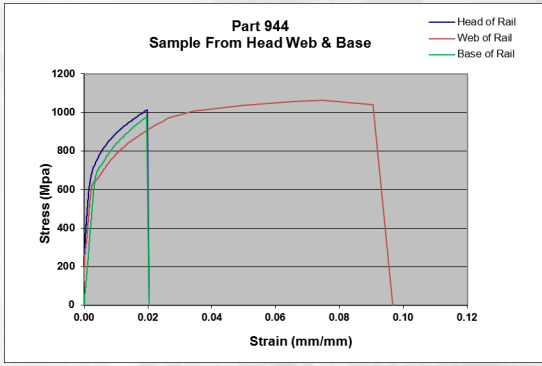












Results and Conclusions

- TFW of 136RE (8597mm^2 / 13.33in^2) rails were conducted using a direct drive/programmable cam concept machine
  - Eliminates the need for very large hydraulic oscillation systems
    - More compact equipment
    - Facilitates portable systems
  - These welds offer advantages over thermite and flash welding
- Subsequent evaluations being considered on improved welder

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Developing a Reliable Method for Attaching Signaling Wires to Rail

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Developing a Reliable Method for Attaching Signaling Wires to Rail

Problem

The present methods of rail/wire attachment have shortcomings that are creating reliability problems for the railroads.

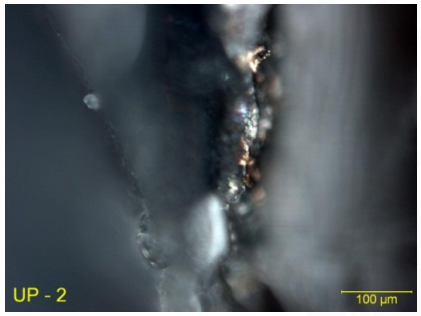
- Exothermic Weld Bonds
  - Portable, martensite possible
- Pin Brazing
  - Portable, martensite possible
- Plug Bonds
  - Mechanical solution, may loosen over time
- Bolted Contacts
  - Drilling required, excellent attachment/detachment
- Adhesive Bonds
  - Portable, multi-step procedure

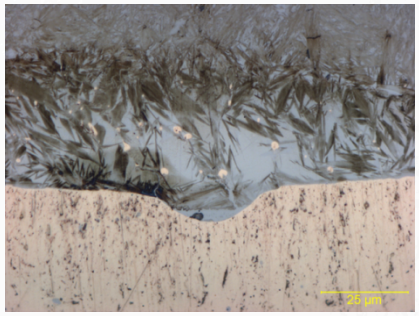
Solution

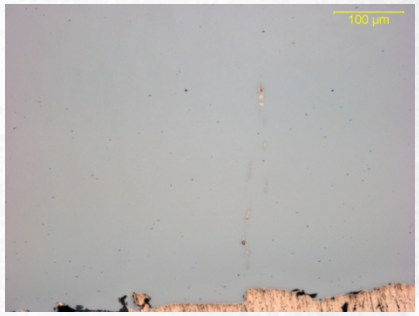
Portable friction welding of signal wires to the head of the rail.

Previous Research and Railroad Interviews/Feedback

- Reviewed over 5 years of research conducted by TTCI
- Tamaroa, IL, NTSB Railroad Accident Report
- Contacted Amtrak, Union Pacific, BNSF, CSX, CP, and NS
  - Improved reliability of signal wire attachment methods still exists
  - Biggest concern for implementation is process complexity
    - Keep it simple, yet robust and field deployable
    - Preheat or additional process steps is objectionable
- Rail with UT indication near RWI joint was evaluated
  - Crack face analysis showed evidence of martensite and potential for liquid metal embrittlement

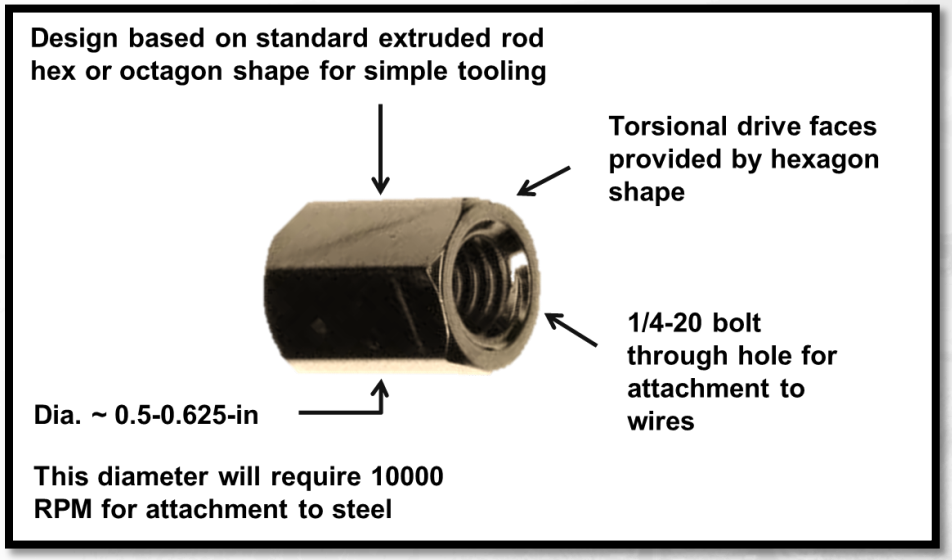






Selection of Stud Materials

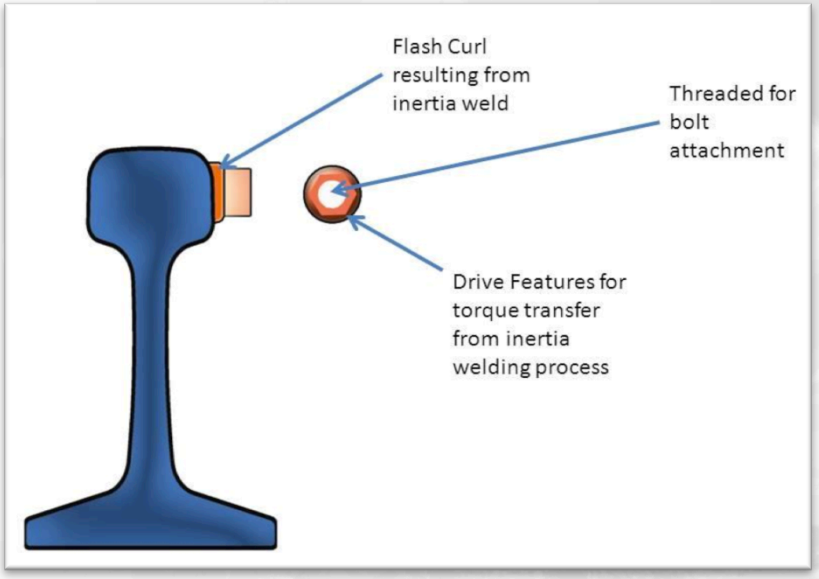
- Must be forgeable in friction welding process at temp < 870 C
- Close proximity to steel in galvanic series
- > 50-ksi UTS
  - 1000-lb load
- Affordable and commercially available
- Machinability
- Surface velocity factors for friction welding



Next Steps

Develop a portable inertia welding process

- Conduct welding trials
  - 3 alloys
- Preliminary analysis
- Process robustness
- Reparability study
- Design criteria for portable equipment



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Rail Base Corrosion and Cracking Prevention

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Rail Base Corrosion and Cracking Prevention

Problem:

Rail sections succumb to bottom rusting with stresses leading to cracking and fracture

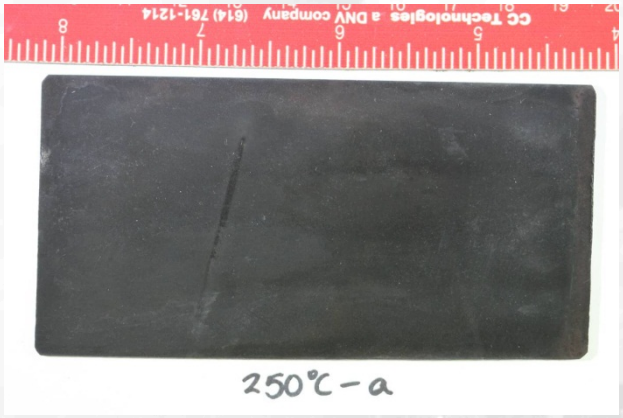
Solution:

EWI's corrosion mitigation system for steel

- Originally investigated for nuclear plant water feeds
- Appears to have rust-healing properties
- Simple application techniques
- Possibly can be used for remediation

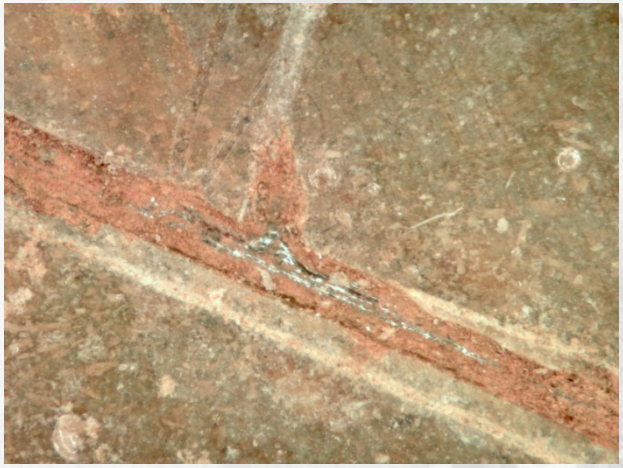
EWI Corrosion Protection System

- Three-step, sequential topical application
  - Passivates and seals steel surface
  - Treatments can be done in a shop environment – possibly in the field



Autoclave in Water: 250C / 72 hr

- Treated, then scribed to bare metal
  - Cycled in salt water / dry / humidity for 3 weeks
  - Initial surface rust was loose and non-adherent; little bleed
  - Underlying metal was shiny



Proposed Project Plan

- **Team**
  - EWI & Volpe National Transportation Systems Center
- **Budget**
  - $265,537
- **Duration**
  - 9 months

- **Small scale studies**
  - Surface change or chemistry
  - Corrosion studies
- **Medium scale studies**
  - Cyclic corrosion
  - Fatigue life with and without corrosion
  - Effect on crack formation
- **Large scale studies**
  - With and without corrosion
  - Impart pre-stress resonant fatigue
  - Examine results