



National Shipbuilding Research Program SP-7
Welding Panel (SP-7) Meeting
Provo, UT

4 April 2006

Selected Friction Stir Technology Efforts for Naval Shipbuilding

- Implementation of Aluminum FSW
- Development and Implementation of FSP for Ni Al Bronze Propellers
- Development of Steel FSW

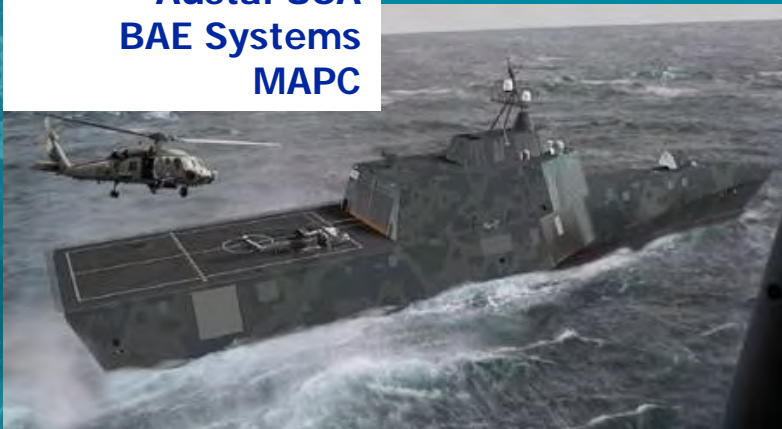


Targeted Aluminum FSW Applications (5000 and 6000 series alloys)

Lockheed Martin
Gibbs & Cox
Marinette Marine
Bollinger Shipyards



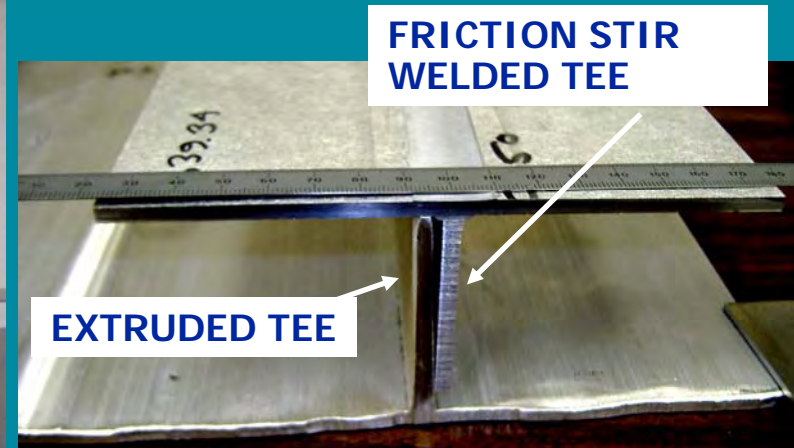
General Dynamics
Bath Iron Works
Austal USA
BAE Systems
MAPC



Ongoing activities include:

- Procedure Qualification Requirements
- Fabrication Requirements (including NDE)
- Material Selection Review Process

Potential LCS FSW Application

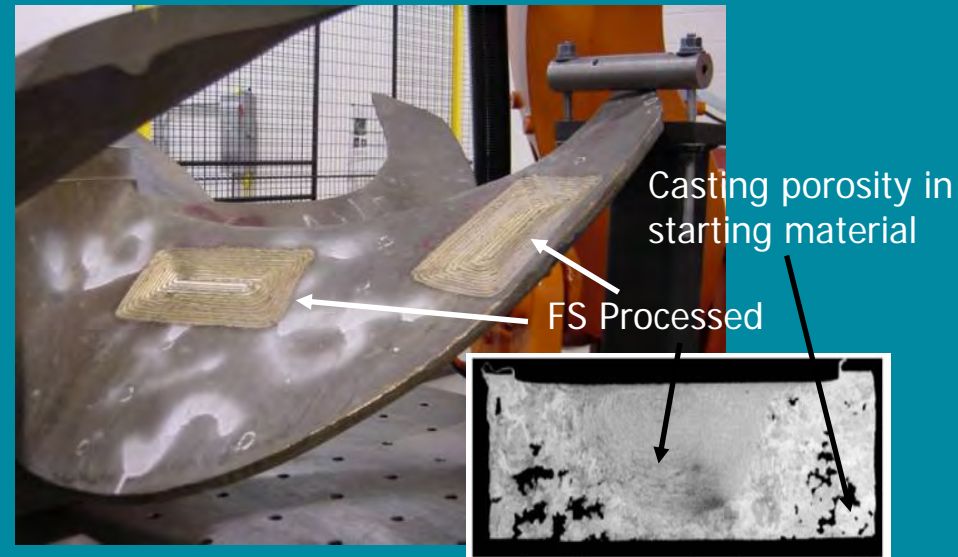
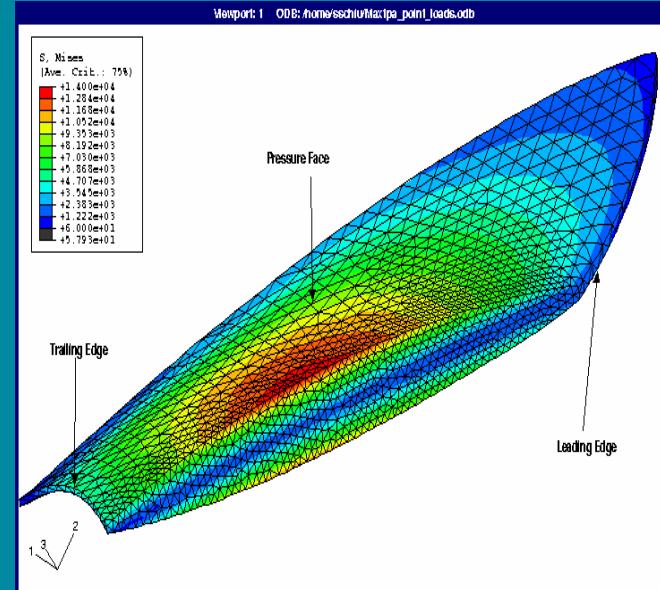


Linear FSW Extrusion
Panel Welder (Left)

Lower Distortion
associated with FSW
(Right)

Courtesy of Friction Stir Link

- Uses Ni Al Bronze Almost Exclusively
- Surface/Subsurface Defects Are Not Uncommon
- Operational Load Primarily Bending (Surface Loading)
- Static Strength in Thick, As-Cast Sections Drop Well Below Minimum Specification Values
- Conventional Fusion Weld Repairs Labor Intensive, Often Require Propeller to be Relocated to Initiate the Repair
- N/C Machines are Becoming Available in Propeller Manufacturing and Repair Facilities



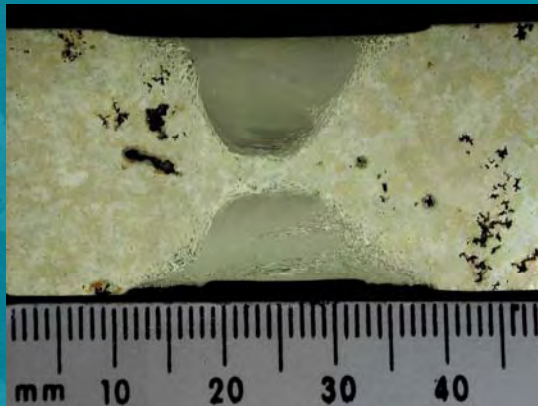
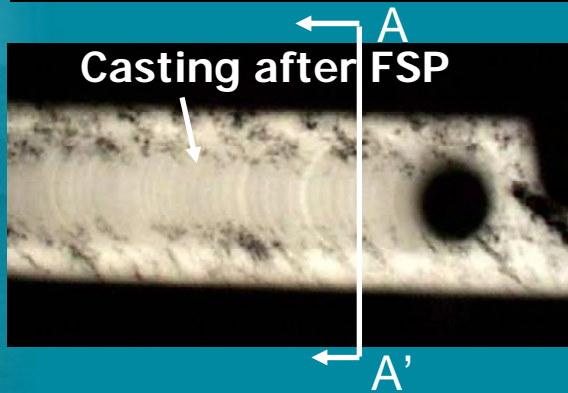
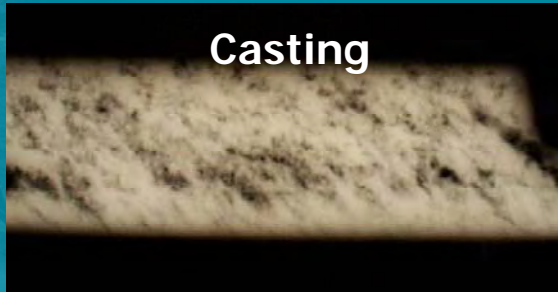


Potential Advantages of FSP for Ni Al Bronze Propeller Repairs

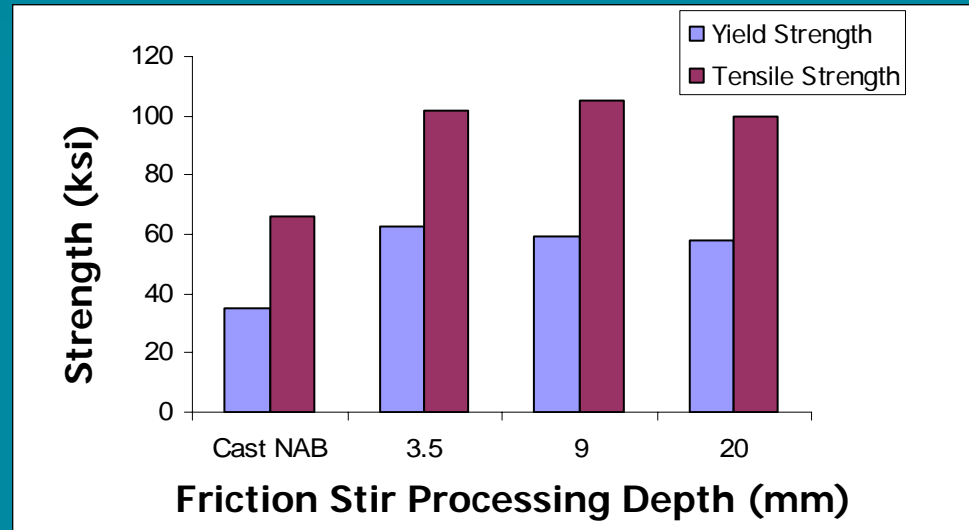
- Solid State (No Melting)
- Reduced Temperature Profile
- Heals Surface and Subsurface Defects
- Processed Area Shows Increased Strength Compared to Substrate
- FSP Equipment - Milling Machine Technology
 - » Automated
- Potential Less Time and Resources Needed to Effect Repair



Quality and Strength of Processed Regions in NiAl Bronze



Cross-section A-A' of FSP Repair



Left: Radiographs of NiAl Bronze before and after FSP. Demonstrates FSP ability to heal porosity.

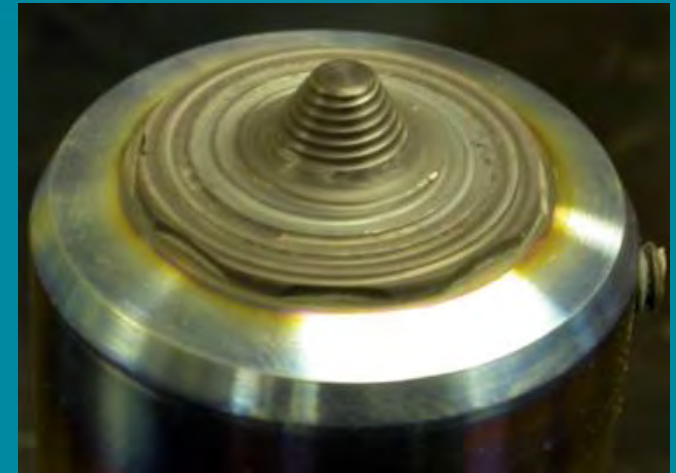
Above: Influence of FSP on strength of NiAl Bronze. Demonstrates that FSP can increase strength by >50%.



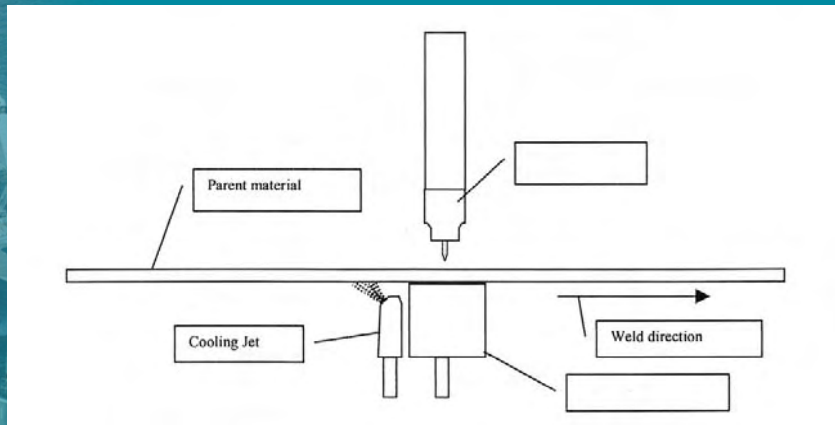
Welding of HSLA-65 (Tool optimization, parameter optimization, distortion control)



W-Re Tools



PCBN Convex Scroll
Shoulder Tool

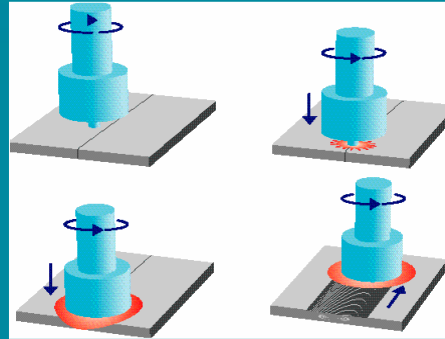


Conceptual approach
to minimize weld
distortion (RSC)



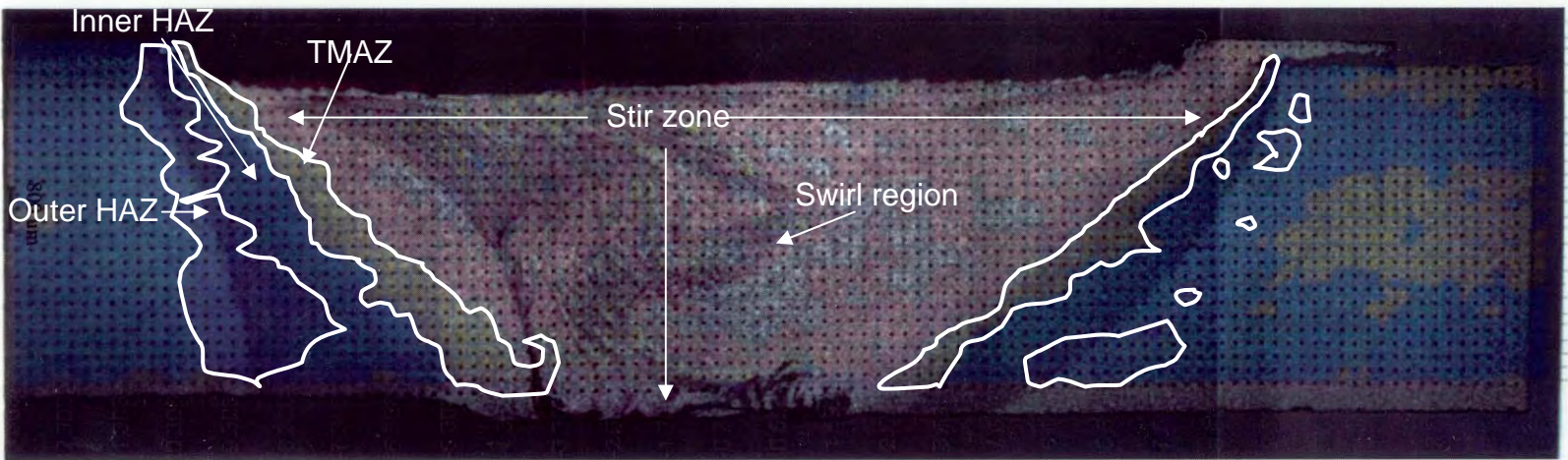
Defect free
HSLA-65 FSW

$(\epsilon, \dot{\epsilon}, T)$



Weldment
Performance

Load, RPM, Travel Speed



5 distinct regions in the steel friction stir weld cross-section