NSRP Welding Panel SP-7 Meeting

Background

Common Goals of Laser-Based Projects

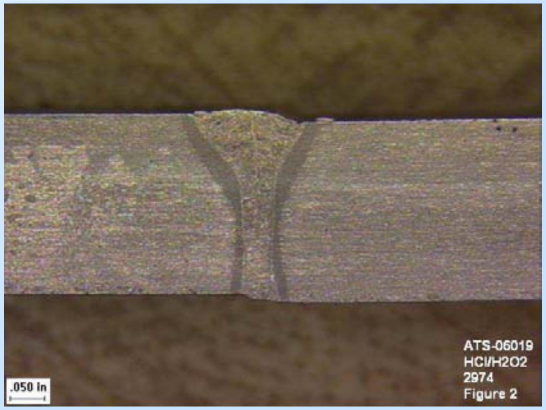
- High-speed fabrication to achieve manufacturing cost goals
- Accurate fabrication to achieve dimensional goals & reduce assy. cost
- Flexibility to achieve wide range of applications
- Design flexibility:
  - Can add to mission capability with low impact on overall vessel performance
  - Can modify Design to Suit DFA Goals
- High Accuracy Provides Significant Opportunity for Downstream Assembly Cost Savings

Current HLAW Projects

- Structural Sandwich Panels:
  - IBRC Bridge Panels - Arcelor-Mittall Durracorr
  - LASCOR Development Program – Allegheny-Ludlum 2205
  - DDG-1000 – Berms & PSB's – Allegheny-Ludlum 2003
- Structural Shapes
  - HSLA-65 – CVN Applications
  - DH-36 - DDG Applications
  - HSLA-80 – DDG Applications

Arcelor-Mittall Durracorr™

- Completed butt weld tests on 0.25-in. Durracorr-50
  - Welded with 309L-Si Filler Metal (~100 ipm weld speed)
  - Single-side butt weld
  - Tested IAW AWS D1.1
  - NDT – VT, MT, RT - Satisfactory
  - Tensiles, bends, macro & micro-hardness - Satisfactory



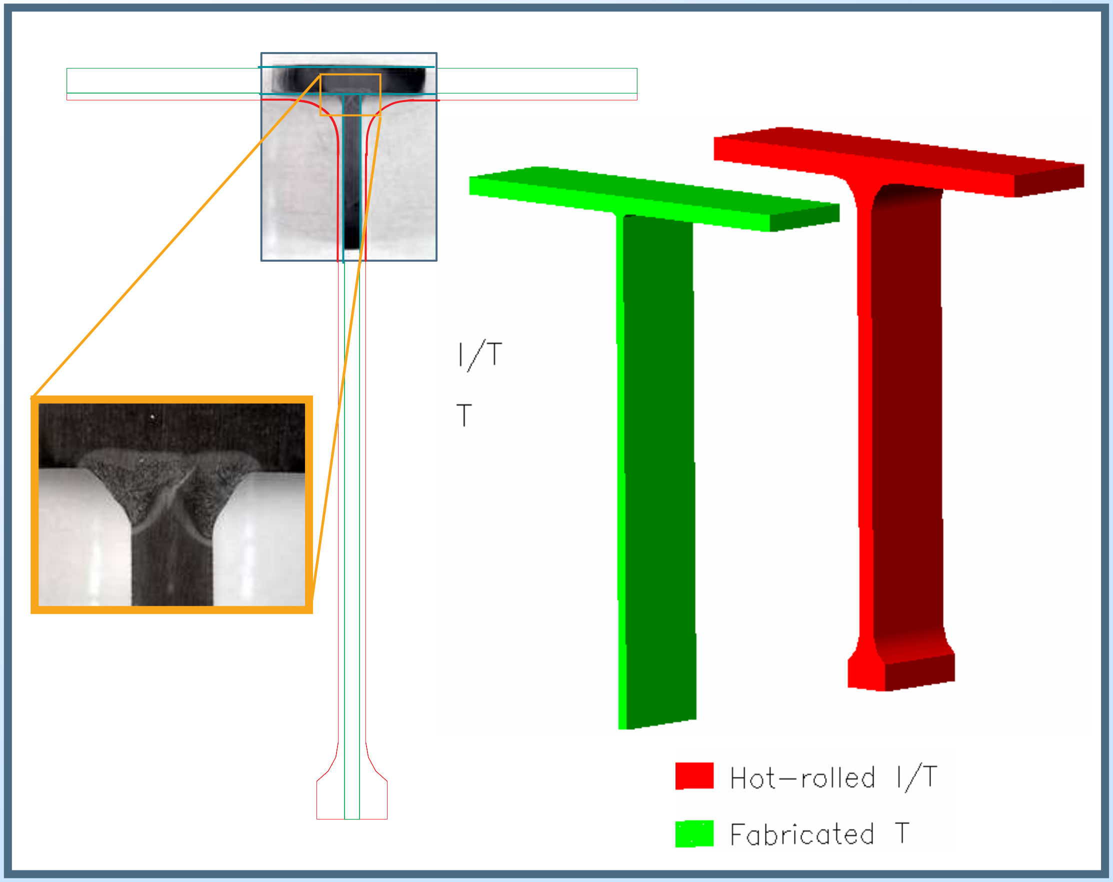
Fabricated Structural Shapes

The Shape you need for the ship you want?

The ship you get with the shape they got?

PICK *ONE!*

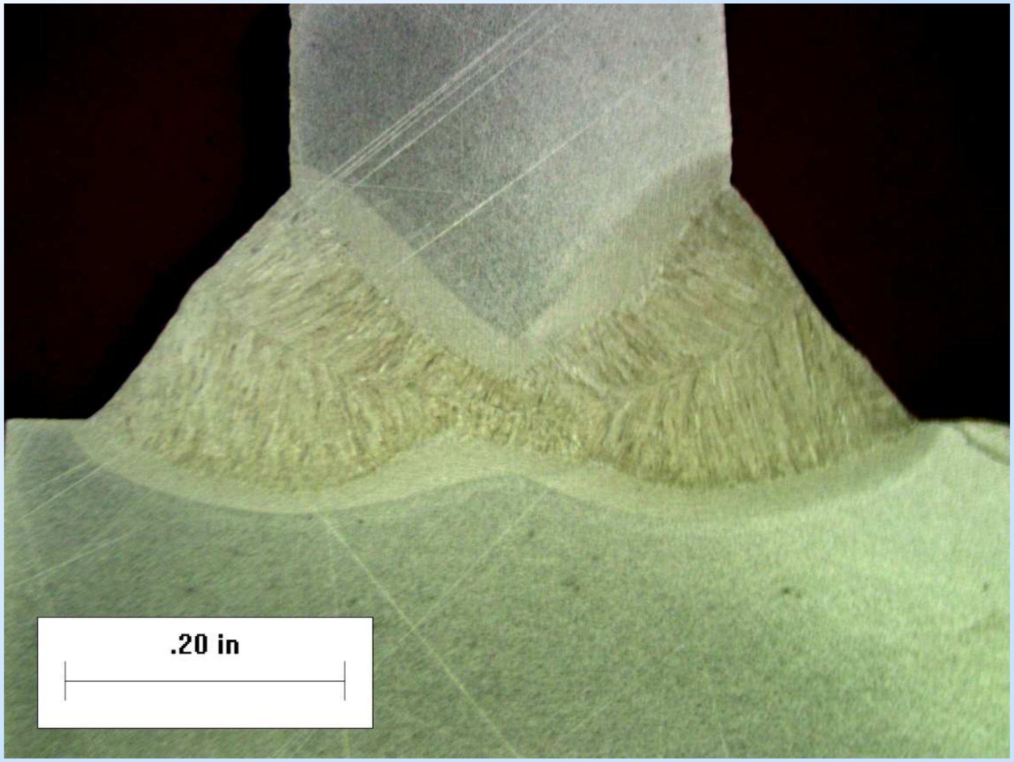
Benefits of Fabricated Shapes



9.0# DH-36 I/T Replaced by 6.3# DH-36 Fabricated Tee (33% wt. savings)

HLAW Process Qualification

- Target Weld:



Potential Shipbuilding Market

CVN Product Needs:	**~600,000'**
CVN Material:	**HSLA-65**
CVN Web Thickness:	**3/16" – 1"**
CVN Web Distribution:	**~90% < 3/8"**
CVN Weight Savings:	**>480 Tons**
DDG-1000 Product Needs:	**69,000+**
DDG-1000 Alloys:	**HSLA-80 & DH-36**
DDG-1000 Web Thickness:	**5mm – 20mm**

Weight Savings: TBD

Process Development & Qualification

Approach

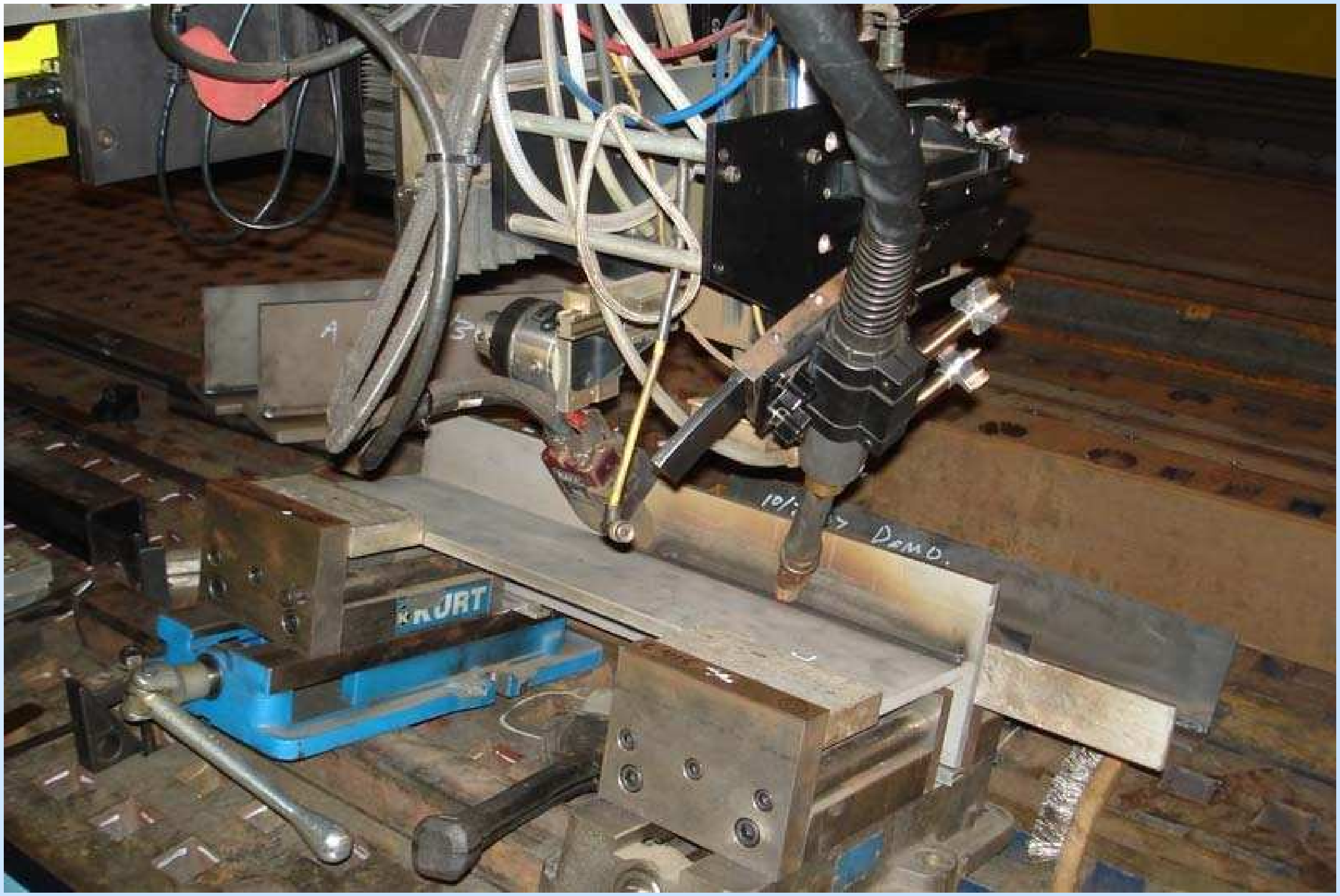
- Determine Maximum Thickness of Web
- Initial Parameter Screen
- Limited Testing to Validate
- Detailed Parameter Development
- Selection of Conditions for PQR Testing
- Completion of PQR Test Specimens
- NDT & Mechanical Testing
- Generation of Submittal Documents
- Submit for approval

Procedure Qualification

HSLA-65 Strategy:

- Tested 3 heat-input conditions: operating range, lowest, highest;
- Butts and tees, each of 4 thicknesses (0.19, 0.25, 0.31, 0.38 in.)
- Followed guidelines of “TP-248, Special Weld”
- Butt weld tests used web thickness instead of flange thickness
  - Test for “quench effects” due to thick flanges
- “All Weld Tensile” - not representational, not performed
- Added “Tee-Tension” testing
- Added micro-hardness scans (both butt & tee)
- Performed “informational” CVN testing (not required for <0.5 in.)

Advanced Fabrication System



View of Tee in fixture ready for welding

Applied Thermal Sciences
PO Box C - 1861 Main Street - Sanford, Maine 04073
www.appliedthermalsciences.com

Advanced Fabrication System

Weld head in position to weld toward left of picture

Process Qualification – HSLA-65 Results

Attribute	Thickness	Results
Visual Inspection	0.188, 0.250, 0.313, 0.375	Satisfactory
Magnetic Particle Inspection	0.188, 0.250, 0.313, 0.375	Satisfactory
Radiographic Inspection	0.188, 0.250, 0.313, 0.375	Satisfactory
Transverse Tensile	0.188, 0.250, 0.313, 0.375	Satisfactory
Root Face & Side Bends	0.188, 0.250, 0.313, 0.375	Satisfactory
Nominal Heat Input	0.188, 0.250, 0.313, 0.375.	10-12 kJ/in. (3 Heat inputs represent High, Mid, Low bounds)
Macro-section Evaluation	0.188, 0.250, 0.313, 0.375	Satisfactory
Micro-hardness	0.188, 0.250, 0.313, 0.375	Informational (Avg. < 350 VHN)
Tee-Tension Test	0.188, 0.250, 0.313, 0.375	Informational (Sim. to ASTM A-769) - Sat
Charpy V-Notch Evaluation @ -20F	0.313, 0.375 Sub-size specimens	Informational: Weld (Avg. ~ 145 ft-lb. @ -20F) HAZ (Avg. ~50 ft-lb. @ -40F)

Process Approval

DEPARTMENT OF THE NAVY
PROGRAM EXECUTIVE OFFICER
AIRCRAFT CARRIERS
614 SICARD STREET SE STOP 7007
WASHINGTON NAVY YARD DC 20376-7007

IN REPLY REFER TO
9074
PMS378/twm
Ser 07-1135
13 Aug 07

Subj: CVN 78 PRECISION LIGHT SYSTEMS WELDING PROCEDURE QUALIFICATION RECORDS IN SUPPORT OF HYBRID LASER/GMA WELDING OF HSLA-65 BUILT-UP T-BEAM AND I-BEAM FABRICATION; APPROVAL

3. NAVSEA Action. NAVSEA approves reference (a). The weld procedure qualification records listed in enclosure (1) meet the requirements of reference (b) and are approved. The corresponding weld procedure specifications listed in enclosure (1) are acceptable for welding in accordance with reference (c).

First Approval of Laser-Based Welding Process on Primary Hull Structure of Naval Combatant Vessels

HSLA-80 Tees, 25-ft. Demonstration Set

HSLA-80 Tee Fabrication

Hybrid Laser Arc Welding of HSLA-80

Project Team:

- Concurrent Technologies
- Applied Thermal Sciences
- NSWC-Carderock
- ABS
- Bath Iron Works
- Northrop-Grumman Shipbuilding
  - Pascagoula
  - Newport News

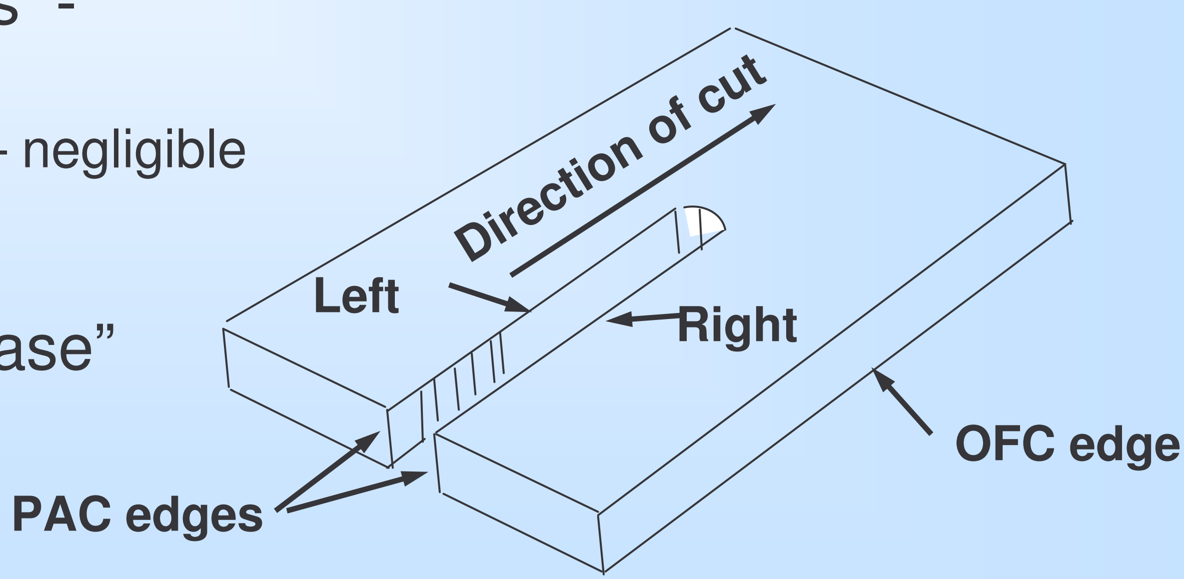
Hybrid Laser Arc Welding of HSLA-80

Plan:

- Extend qualification to HSLA-80
- Extend qualified thickness for both HSLA-65, DH-36 & HSLA-80
- Establish suitability of alternative laser sources
  - Does change of laser require re-qualification?
  - Test one set of conditions with two lasers (Trumpf & IPG)
- Establish suitability of OFC & PAC edge preparation
- Evaluate diffusible hydrogen values
- Examine fume emissions

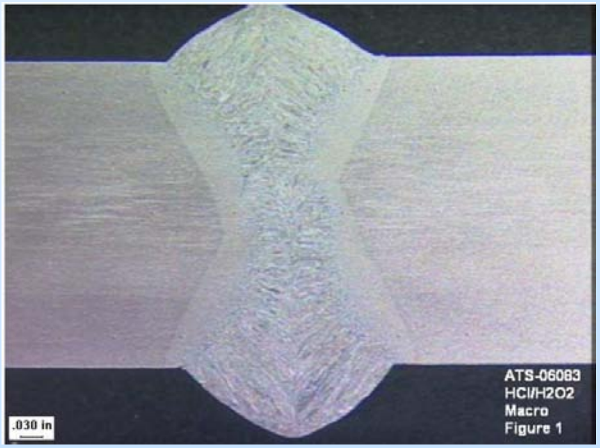
Method of Edge Prep

- Examined re-cast effects
  - Mechanized LBC, PAC, & OFC; also semi-auto PAC
  - M-LBC-Bender; M-PAC – BIW; M-OFC – Ronson
  - Semi-Auto PAC - CTC
- Multiple specimens -
- Results:
  - M-LBC & M-PAC – negligible
  - M-OFC - ~100 μm
  - SA-PAC - variable
- M-OFC is "worst case"



OFC vice Machined Edge Prep

- Welded two test plates
  - 0.375-in. HSLA-80, Mil-100S-1 filler, same parameters
  - One set w/machined edges; 1 set w/OFC edges
- NDT & mechanical testing – Satisfactory
  - Micro-hardness values identical (~200-300 HV-1000)
  - Tensile tests – base metal fracture
  - Bends – OK
  - CVN's – similar
    - Extreme variation
    - Evaluation underway
- Additional tests planned



Charpy Impact Testing

- Welded several test plates:
  - 0.5 & 0.375-in. HSLA-80, Mil-100S-1 filler, 92Ar-8CO2 gas
  - Three sets w/machined edges; one set w/OFC edges
- Variation in Charpy values
  - Ranges from 8-300 ft-lb.
- Review of specimens underway:
  - Centering of notch on weld
  - Visual appearance of surfaces
  - SEM of fracture surfaces
  - EDAX of fracture surfaces
- Additional tests planned

Questions?