

Hybrid Laser Arc Welding Economic Viability Study

T.D. Huang, NGSB-Gulf Coast

td.huang@ngc.com

Joanna Carter, NGSB-Gulf Coast

jm.carter@ngc.com

Dennis Fanguy, Bollinger Shipyards

DennisF@bollingershipyards.com

Shawn Kelly, Applied Research Lab, Penn State University

smk22@arl.psu.edu

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Problem

- Hybrid laser arc welding (HLAW) has been shown to:
 - **Reduce distortion by 400%** in butt welding thin steel panel with estimated savings of **\$2.759 M per DDG-1000** (S. M. Kelly, et. al. Welding Journal 88(3), 32-36 (2009)).
 - Achieve **ABS qualification** for the fabrication of hybrid welded HSLA-80 T-beams, with potential to **save \$534 K/DDG-1000** (E. Oller, J. Ship Production, 2009).



*Distortion in 16x20 foot thin-steel panels welded using current shipyard practice (top) and hybrid (bottom) at BIW in January 2008.
Overall, the hybrid welded panel was 4-times flatter than the conventional submerged arc welded panel*

- **Despite technical success, the lack of a industry-vetted business case has impeded implementation of HLAW within the shipyard.**

Objective

- Objective: Acquire supporting data for constructing a business case to produce HLAW panels at Tier I and II shipyards by defining the following:
 1. All production and quality assurance costs associated with current panel line welding process as they are incurred through module assembly.
 2. A HLAW training program and associated cost to implement at the shipyards
 3. System specifications and ROM implementation costs for HLAW implementation at these shipyards.
- Deliverable:
 - Yard Specific business case to produce HLAW panels at Tier I and II shipyards.

Project Overview

- Task 1: Shipyard Assessment of Welding Associated Costs
 - Shipyards will document time associated with welding and rework attributed to panel line production.
- Task 2: Survey of Training Requirements
 - Shipyard welding engineers and managers will work with ARL Penn State to outline a program for training of production welders in the use of HLAW, and estimate costs.
- Task 3: HLAW System Specification
 - Based upon shipyard input on installation requirements and product needs (Task 1), ARL Penn State will develop a functional specification for a HLAW system and contact various system integrators for ROM installation costs.
- Task 4: HLAW Business Case
 - Shipyards will develop business model comparing existing capability with an improved HLAW capability.
 - The shipyards will report an ROI value.

Task 1 Scope

- Panel Types
 - Bollinger: 6-8 Panel Types, varying thickness, up to ½ inch thick.
 - NGSB: Pascagoula New Panel Line, up to ½ inch thick.
- Distortion Measurement
 - Edge Waviness at multiple steps:
 - After tacking, After butt welding, Possibly after insert welding, After stiffener welding, At PSU and/or CPSU assembly steps.
 - Reported as % not meeting MIL-STD 1689 fairness requirements
 - Compared with HLAW of large panels made in 2008.
- Non-Value Added Work
 - Artisans mark the panels where rework occurs. Sum-up the total rework for a panel and report as a percentage of linear foot of weld.
 - At PSU/CPSU, the number of strong backs and associated cost would be tracked.

Measurement Procedure

Panel Line Measurement Procedure

Relevance Key:

- HP** = Relevant to developing hybrid processing capability
- NVA** = Tracking Non Value Added Costs
- PC** = Comparison of Hybrid Welding to Existing Process
- SS** = System Specification
- QD** = Quantify Distortion
- I** = Informational

- | | | | |
|---|------------|--|------------|
| 1. Record Panel Detail | | | |
| 2. Fitting Panel Seams | | | |
| 2.1. Plate Cutting | HP | | |
| 2.2. Grinding | I | | |
| 2.3. Tacking | PC | | |
| 2.4. Rework | NVA | | |
| 2.5. Measure Post-Fitting Panel Distortion | QD | | |
| 3. Butt & Insert Welding | | | |
| 3.1. Side 1 Welding | | | |
| 3.1.1. Weld n^o | | | |
| 3.1.1.1. Record Joint Information | PC, HP, SS | | |
| 3.1.1.2. Record Pre-Weld Corrective Actions | NVA | | |
| 3.1.1.3. Record Process Information | PC | | |
| 3.1.1.4. Record Weld Rework | NVA | | |
| 3.2. Side 2 Prep ^b | | | |
| 3.2.1. Record Flip Detail | PC | | |
| 3.2.2. Record Side 2 Butt Weld Prep | PC | | |
| | | 3.3. Side 2 Welding ^c | |
| | | 3.3.1. Weld n^a | PC |
| | | 3.3.1.1. Record Joint Information | |
| | | 3.3.1.2. Record Pre-Weld Corrective Actions | |
| | | 3.3.1.3. Record Process Information | |
| | | 3.3.1.4. Record Weld Rework | |
| | | 3.4. Measure Post Butt/Insert Welding Panel Distortion | QD |
| | | 4. Longitudinal Stiffener Welding | |
| | | 4.1. Record Prep for Stiffener Welding | HP |
| | | 4.2. Stiffener Welding | |
| | | 4.2.1. Stiffener Type n^d | |
| | | 4.2.1.1. Record Joint Information | PC, HP, SS |
| | | 4.2.1.2. Record Pre-Weld Corrective Actions | NVA |
| | | 4.2.1.3. Record Process Information | PC |

