A Review of Asian Shipyard Robotic and Automated Welding Technology

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VISIT OBJECTIVES

• Assess current state of world-class automation and robotics used in both commercial and combatant ship construction
  – Review the role of hull design processes in maximizing use of robotic construction

• Understand cost and quality benefits associated through use of robotics

• Discuss robotic arc welding procedure and operator qualification requirements

• Identify mutual areas for robotic welding R&D collaboration
SHIPYARDS VISITED

Japan

• **IHI Marine United** – build naval, coast guard, ferries and support ships, as well simple bulk carriers. 12 to 14 ships/year.

• **Universal Shipbuilding, Ariake** – builds VLCCs, VLOCs, and Bulk Carriers. 8 ships/year.

• **Oshima Shipbuilding** – build only bulk carriers and is the most productive shipbuilder in the world. 36 Ships/year.

South Korea

• **Hyundai Heavy Industries** – build commercial and naval ships, floating production storage, offloading platforms, and rigs. 114 ships/year.

• **Daewoo Shipbuilding & Marine Engineering (DSME)** – build tankers, LNG, containerships, FPSOs and offshore rigs. 70 ships/year

• **Samsung Heavy Industries** – build commercial, tankers, LNG, containerships, FPSOs and offshore rigs. 70 ships/rigs per year.
SHIPYARDS VISITED

a) IHI Marine United, Yokohama
b) Universal, Ariake Shipyard
c) Oshima Shipbuilding
d) Hyundai Heavy Industries, Ulsan
e) DSME
f) SAMSUNG Heavy Industries
SHIPYARDS VISITED

- DSME
- Samsung
- Hyundai
- Oshima
- Universal Ariake
- IHI Marine United
ROBOTIC WELDING TECHNOLOGY

- 5 of the 6 shipyards visited are using welding robotics
- Robotic welding and cutting is being used in panel line assembly, sub-assemblies, assembly block construction, pipe-to-flange fillets, 3D curved panel butt joints, painting/coating, plasma cutting, and induction plate forming
- Each shipyard has its own robotics departments
- 4 of the 5 shipyards build their own NC robots
- Majority of robotic welding is CO$_2$ shielded FCAW, fillet welds
ROBOTIC WELDING TECHNOLOGY

• All robotic programming is conducted off-line (OLP), automatically through CIM systems that couple the 3D CAD model with specialized CAM software

• Touch sensing, laser vision, and through arc seam tracking is used to adjust to robot part variation

• Precision NC plasma cutting is used to obtain 1.00 - 0.08 mm gap tolerance for butt joints and a 0-2 mm gap tolerance of flange-to-web fillet joints, necessary for robotic welding

• One shipyard, 68% automated and robotic welding of hull structure with a goal of 80%

• Typical robot ROI is 5 years with at least 2 robots/operator
AUTOMATED BLOCK
ASSEMBLY
LINE-WELDING

- NC controlled 7 welding heads/14 electrodes
- 7 longitudinal frames are weld to the skin plate simultaneously
- Seam tracking and end detection sensing
PORTABLE WELDING ROBOT

Universal Shipbuilding, Proprietary 5-Axis Robot “HIROBO”

HIROBO system has been delivered to a number of foreign shipyards that include Odense Steel Shipyard – Denmark, Dan Yard – Denmark, Chantiers De L’Atlantique – France, Kvaerner Masa-Yards Turku Shipyard – Finland, Hyundai Heavy Industry – Korea, and Samsung Heavy Industry – Korea.
• Robots are automatically lowered into place by an NC overhead gantry system
• Sensors are used to position the robots with respect to the weld joints
- At this shipyard, 16 robots are operated by 2 workers in this application
AUTOMATED, OFF-LINE PROGRAMMING

- CAD interface
  - Seam abstraction
- CAD to VRML 3D model transformation
- Welding information from welding D/B

Robot program generation for an assembly
- Welding seam nesting
- Work document
  - If needed, robot program verification using simulation
  - If needed, robot program calibration to adjust assemblies’ real position
  - Transfer robot program to robot’s controller

Off-line programming
- Standard programs
  - On-site industrial computer
  - Downloading job programs
  - Monitoring
  - Control

Robot body
Controller and welding equipment
ROBOTIC WELDING QUALIFICATION

Asian Shipyard Procedure Qualification

- Commercial Standards
  - ABS, NS, Japanese Welding Society, ASME, AWS, BS
    - Unlike MA, ME, or AU welding this is no guidance for how to qualify a robotic welding or operator procedure
  - Customer Specification

- Robot Operator Qualification
  - Internal company qualification
    - 1 Day Robot Class Training
    - 1 Day OJT
    - Typically, not even welders as robot operators
  - Or, use skilled welders
Navy Robotic Welding Qualification

- No standard exists for robotic welding procedure qualification
- Engaged AWS D16 Robotic Welding Committee
  - AWS D16.4, Certification Standard (CRAW, like CWI)
  - New D16.5, Robot Arc Welder Training Document – DRAFT in process
- NSWCCD Requirements Development System
  - ABB 6-Axis Robotic Welding System
    - Determine/Validate robotic welding essential elements for operator and procedure qualification
CARDEROCK CAPABILITIES

Robotic Arc Welding System
- Welding, cutting, and grinding
- Adaptive welding

Robotic Friction Stir Welding/Processing
- Material homogenization
- Improved material performance
INTEGRATION OF ROBOTICS IN US NAVAL SHIP CONSTRUCTION

– Paradigm Shift Needed
  • Automotive model of hard fixturing and 1 million widgets doesn’t work in ship construction
  • “Bring the robot to the part, not the part to the robot”

– Design for robot manufacturing
  • Increased part commonality between ship cases
  • CAD systems with integrated robot and automation planning (e.g., Siemens NX: Tecnomatix)
  • Defining the as-built part condition (metrology enhanced robotics)
  • Flexible open robot integration architectures

– Simpler Robot Programming

– Increase Use and Development of Adaptive Welding Technologies
  • Sensors for positioning, locating, and closed-loop controls

– Technology Champion and Education
QUESTIONS/DISCUSSION