Weld Sequence Modeling Software Interface Development for Ship Production

NSRP Joint Panel Meeting
Cleveland, Ohio

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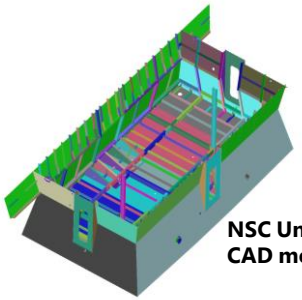
Weld Sequence Modeling Software Interface Development

- This NSRP welding panel project is designed to achieve integration between SYSWELD and ShipConstructor as shown inside the blue box on the following slide.
  - The objective of the project is to develop a streamlined, automated process that can be deployed and interfaced with ESI's SYSWELD and ShipConstructor, Ingalls' current design construction tool.
  - The CAD models from ShipConstructor will be imported automatically into SYSWELD to perform weld analysis which will compute deformation due to welding and assembly processes, and perform assembly/weld sequencing optimization to reduce distortion.
- It will improve Ingalls' production efficiency by bridging the producibility effectiveness and distortion modeling capabilities that had been developed in ALMMII LIFT Joining R1-3 Robust Distortion Control project.
- A similar interface capability between SYSWELD and Siemens NX software tool, had already been developed in a Navy ManTech project by GDEB, ESI and NSWCCD for the weld and assembly sequence process optimization in submarine egg-crate hull structural construction.
- This NSRP project will not utilize any proprietary information from Ingalls Shipbuilding.

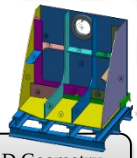
Project will provide an advanced capability to enhance ship design and construction

Weld Sequence Modeling Software Interface Development

In this NSRP project the bridge and a streamlined process will be deployed between Ingalls' current ship design and fabrication software tool, ShipConstructor, and ESI's SYSWELD to perform FAB optimization to control distortion and reduce cost.



NSC Unit 4130 imported by ESI from Ingalls' ShipConstructor CAD model from LIFT Joining R1-3 Distortion Control Project



CAD Geometry
(ShipConstructor)
- Derived from Design Model
- Joint Trajectory Lines
- No Edge Prep

Weld Process Plan (WPP)
(Excel)
- Part/Joint Information
- Weld/Assembly Sequence
- Tack Welds / Spacing

Material Database
(ESI Visual Assembly)
- Prepopulated
- HSS, HSLA, HY
- Filler Materials

Meshing
(ESI Visual Mesh)
- Automatic Bead Creation/Placement
- Semiautomatic Meshing
- Clamp Locations

Weld Process Database
(ESI Visual)
- Prepopulated with Common MIL-STD-22D Joints
- General Weld Process Information
- Shrinkage Database

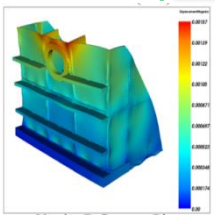
Distortion Analysis
(ESI Visual Assembly)
- Minimal User Input Req, Mainly Auto Populated
- Clamping Definitions
- External Forces
- Submit Analysis

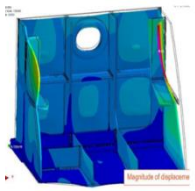
Optimization
(ESI Visual Assembly)
- Blocking and Initial Sequence from WPP
- Define Objective / Critical Tolerances
- Max Number of Iterations
- Submit Optimization

Result Visualization
(ESI Visual Viewer)
- Contours of Distortion
- Animations Showing Weld Sequence and Movement
- History Plots

Weld Sequence Plan
(CSV / Text File)
- Best Weld Sequence Obtained from Optimization
- Manually Incorporated into Work Package Instructions

Solution Approach
- Shrinkage method
- No moving heat source, no thermal calculations
- Solid elements, no shells





WSP Tool Outputs

NSRP Project Teams and Roles

• Ingalls Shipbuilding	Project lead
• ESI – North America	ICME modeling and welding software developer
• SSI – USA	ShipConstructor software developer
• NSWC – Carderock Division	Advisory Role
• ATI	NSRP Program Management
• Newport News Shipbuilding	Welding Panel Chair and PTR

Linking leaders in fabrication, technology, and manufacturing innovation

Task 1 – Interface Protocols for ShipConstructor CAD and SYSWELD

Lead Organization: SSI
Co-Lead: ESI/Ingalls

- The project team will develop an interface to read-in the exported CAD geometry, weld locations, and welding parameters from ShipConstructor to SYSWELD for distortion modeling.
  - This task will automatically build the required mesh for the assembly, populate a Weld Process Plan (WPP) with information such as which components are involved in each weld, joint types of each weld, thickness of components, initial welding sequence, sub-assemblies (components and welds), and clamping locations, types and sizes.

- Ingalls will provide a data package for an agreed-upon test unit to support the project and lead to establish interface protocols for this task.
  - Generate ShipConstructor export data for structure and weld information (where applicable) such as weld metadata as well as solid geometry objects and extended part data if applicable/available (weight, size, thickness, etc.).
  - Export samples from ShipConstructor to SYSWELD for testing using existing standards (STEP, XML, DWG).
  - Support data export requirements from ShipConstructor.
  - Develop the protocol definitions throughout this process.

ECD: February 28, 2020

Task 2 – Run Baseline Analysis of an Existing Ship Assembly

Lead Organization: ESI
Co-Lead: SSI/Ingalls

- The team will gather information on the quantity and types of welding joints and welding process parameters.
  - Number of welding joints, thickness, and grades of materials and process parameters such as heat input, number of passes, welding speed, welding sequence, and clamping conditions specific to the chosen assembly will be determined.
  - Material database containing the different materials used for this assembly will be built/upgraded in SYSWELD by ESI.
  - Series of joint level detailed analyses would be performed using ESI's SYSWELD and a process database specific to this assembly will be built.

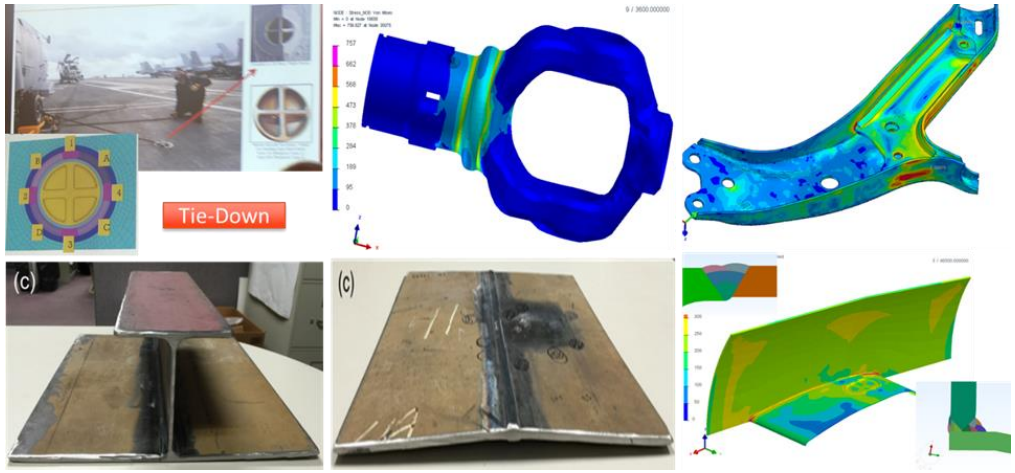
- Using developed material, process database and the welding sequence provided by Ingalls, a baseline analysis will be performed to predict the deformation of the large assembly.
  - Predicted deformation results would be compared and validated with shipyard data for this assembly.

ECD: March 31, 2020

Task 3 – Optimization of Welding Sequence

Lead Organization: ESI/Ingalls
Co-Lead: SSI

- The project team will setup and run an optimization simulation based on baseline analysis to identify potential optimum sequences.
  - Optimization criteria (ex. acceptable deformation magnitude at given locations) and optimization constraints (ex. the order of passes within a welding joint or critical joints which cannot be changed during optimization) will be identified and introduced to the optimization algorithm.
  - The outcome of the optimization run will be analyzed, compared, and validated with shipyard data.



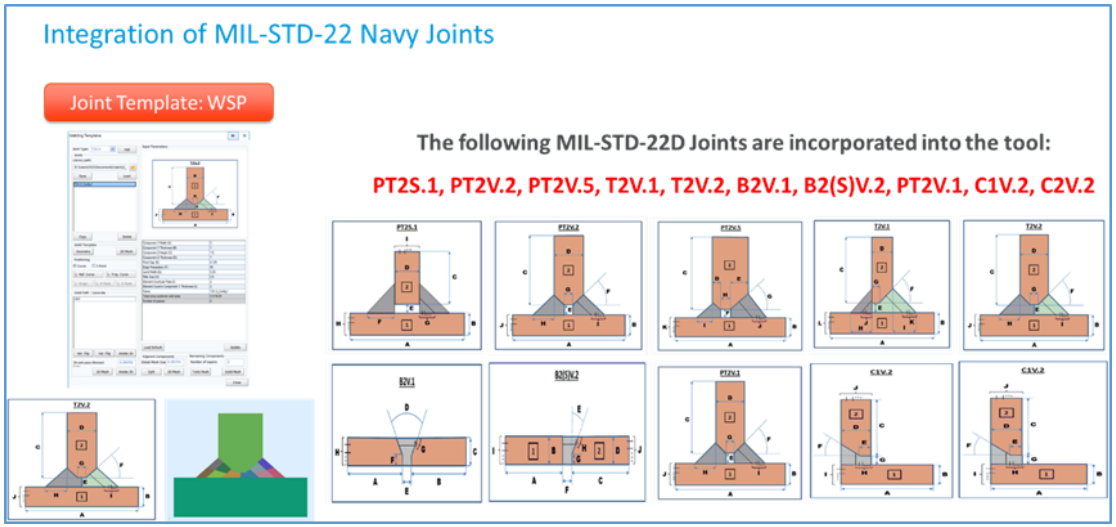
Typical Assemblies analyzed using the Transient Moving Heat Source Approach

ECD: April 30, 2020

Task 4 – Demonstration of Software Applicability

Lead Organization: ESI/Ingalls
Co-Lead: SSI

- The team will develop a beta version of the "Welding Modeling Process" and demonstrate the approach, workflow and simulation results.
  - The U.S. Coast Guard National Security Cutter (NSC) unit 4130, or other available parts representative of typical Ingalls production, will be used in the demonstration.
  - The demonstration will include welding the stiffened assembly using existing processes and weld sequences, as well as the optimized weld sequence approach.



MIL-STD-22 Welding Joints Configurations Integrated in Weld Sequence Planning Tool

ECD: May 31, 2020

Task 5 – Develop Technical Specifications

Lead Organization: Ingalls
Co-Lead: ESI/SSI

- The project team will build technical software specs and gather required features to develop a fully automated comprehensive software package suitable for the shipyard, which will allow for the prediction and optimization of deformation of large assemblies.

- Ingalls will use the developed specs to determine a return on investment (ROI).

ECD: June 15, 2020

Task 6 – Final Report

Lead Organization: Ingalls
Co-Lead: ESI/SSI

- The project team will prepare a final report that documents the work performed and will provide a plan for the development of the software package, as well as the implementation of the software in the shipyard.

- The report will include detailed technical software specs and features.

ECD: June 29, 2020

Technology Transfer and Implementation Approach

- Project results will be posted to the NSRP website to be accessed by authorized recipients and presented at relevant NSRP technology transfer events.

- List of the implementation approach at participating shipyards along with expected implementation timeline (if applicable) will be provided.

- SSI will work with Ingalls to continue the development of a weld module in their existing software package. Weld data will be input into 3D ship construction models which can be updated as new rulesets are issued. The results of the project will be made available to the industry at large.

- Follow-on work will be done to incorporate the integration into PEMA's robotic welding software and allow for seamless integration and optimized weld paths in ship production.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