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Complex-Panel Weld Shrinkage Data Model for Neat Construction Ship Design Engineering

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Stock-side construction practices are still widely used in US shipbuilding, largely due to the lack of accurate and reliable weld shrinkage and distortion allowance data. The National Shipbuilding Research Program (NSRP) initiated a two-year project in 2010 to provide a comprehensive weld shrinkage and distortion solution method that enables neat construction capabilities across the U.S. shipbuilding industry. A key component of the project is a predictive weld shrinkage model based on current ship designs, materials, and construction practices that can be directly interfaced with ship CAD design tools. In the first year of the project, a weld shrinkage data model was developed for 'simple' panels, which has been presented in the 2011 SNAME conference. In the second year of the project, weld shrinkage data model was developed for complex panels, i.e. those containing mis-matched shapes, cut-outs, inserts, and irregular shape. This paper introduces the complex-panel weld shrinkage data model and demonstrates its application in ship panel design and production.

The complex-panel weld shrinkage data model was developed by regression analysis of data collected from 18 production panels and 3 shipyard test panels. The data were used to update the simple model developed in the first phase of the project. By analyzing the measured data, it was found that there was no clear indication that a cutout affected the panel shrinkage. A cutout does not need to be input in the shrinkage calculation. However, a complex panel including cutouts has more out-of-plane distortion, resulting in additional shrinkage, which was considered by having a different shrinkage model than a simple panel. During the investigation, it was observed that the inserts induced additional butt joint across-weld and along-weld shrinkage and did not affect the fillet-weld shrinkage resulting in additional shrinkage. Therefore, the additional butt joints along the inserts were input during butt-joint shrinkage calculations.

The complex-panel weld shrinkage data model has been embedded in the first-year developed Microsoft Excel spread sheet for ease of use. The spreadsheet permits the user to input the panel design parameters including material type, plate thickness, stiffener shape, spacing, and length, and overall panel dimensions. The user can also provides fabrication details, such as the welding process, weld sizes, welding parameters, and the use of fixtures. The Excel spread sheet was enhanced to allow a user to input complex-panel features, inserts, multiple plate thicknesses, and non-rectangular-shape panel. In addition, the complex-panel shrinkage data model has been implemented into ShipConstructor to calculate shrinkage from a software library file.

In addition, this paper also includes the results of 34 laboratory panels. The laboratory panels were fabricated to study the effect of materials and heat input on weld shrinkage. It was found that higher strength materials have less shrinkage than lower strength materials. A material multiplier has been developed to consider the effect of material during shrinkage calculation. Additionally, a relationship has been established between heat input and weld shrinkage.