

C. A Thermal Method to Reduce Buckling Distortion

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Introduction

A significant problem encountered with welding thin-section stiffened steel panels for shipbuilding and other applications is unacceptable levels of distortion. Distortion along the edges of panels presents problems in fitting panels together to build larger assemblies. After final assembly, the out-of-plane distortion is often beyond specified fairness limits and, as a result, considerable time and money is spent on flame straightening distorted panels to make them acceptable. Buckling has been previously identified as the dominant form of distortion when welding thin-section steel panels. Thermal tensioning has shown promise as a technique for mitigating buckling distortion. To overcome the logistics of applying thermal tensioning to ship-size panels, moving rather than stationary heat sources were used, and no forced cooling was applied to the weld region. The auxiliary heaters travel with the welding torches and the heating is done concurrently with the welding.

Experimental Procedure

The approach used in this project was to develop and prove the concept in the lab, then to validate the method on ship-size panels in a shipyard. Development work began on small-scale mockup panels with a single stiffener, and progressed to larger panels with multiple stiffeners. Larger panels were fabricated in a shipyard with multiple stiffeners. The patent-pending transient thermal tensioning process was then applied to actual production panels in a shipyard. As an aid to strategic application of auxiliary heating, computer simulations were used to predict the susceptibility of buckling distortion prior to welding. Various auxiliary heat inputs and their placements were evaluated to determine the optimal configuration to minimize buckling.

Results and Discussion

The finite element model was effective in predicting the optimal placement and heat input of the auxiliary heaters. Optimal auxiliary heating conditions resulted in minimization of buckling distortion. The shipyard trials confirmed that transient thermal tensioning was effective on ship-size mockup panels and on actual production panels. This method of thermal tensioning works by altering the residual stress pattern in a favorable manner rather than reducing the residual tensile stress along the weld. The application of this method requires little additional cost and can be implemented on existing welding equipment in shipyards with ease. Buckling mitigation can be accomplished during welding, minimizing any need for post-weld processing.

Conclusions

Transient thermal tensioning can be used to minimize buckling distortion when welding large-scale, thin-section stiffened steel panels by altering the residual tensile stress pattern in a favorable manner. Buckling mitigation can be accomplished during welding, minimizing any need for post-weld processing.