Abstract

Fillet welding is widely used in fabrication of large stiffened panels in shipyards. Prediction of weld-residual stress and its mitigation in the structural component is a primary concern for the design engineers.

The objective of the thesis is to investigate the effect of vibrational stress reduction on the Gas metal arc welded (GMAW) stiffened plate. The primary focus is to develop a numerical model for the prediction of distribution of residual stress. One of the critical factors affecting the accuracy of the numerical results is to determine the correct dimension of the deposited bead. Prior to the study on residual stress, predictive models based on Multiple linear regression (MLR) and Artificial neural network (ANN) were developed to calculate the bead shape for GMAW fillet joints. The predicted bead parameters using ANN were found to be in good agreement with the experiments.

Finite element simulation was carried out by adopting a sequentially coupled thermal and mechanical analysis approach.The numerical set-up was validated by comparing with experimental results available in the literature, as well as through in-house measurements. The results demonstrated significant reduction of residual stress due to the vibration at critical locations in the stiffened plate. It was observed that vibrating the stiffener was more effective than vibrating the base plate with the same force. This observation could be beneficial to develop a practical and effective vibration stress relief (VSR) system for the fabrication yards where stiffened panels are manufactured.

Subsequently, an experimental assessment of the effectiveness of vibration on weld-residual stress was performed. Residual stress was significantly and consistently reduced in post-weld vibrated samples, as measured by X-ray diffraction. The study also showed that the reduction in residual stress was consistent across all of the samples. This means that post-weld vibration is a reliable method for reducing residual stress. The microstructure study revealed that VSR has significant effect on grain growth and orientation. Micro-texture study revealed that, due to VSR, an increase in strain free potential sites was noticed. In an extended study, the combined effect of various welding sequences and VSR on the large plate with multiple orthogonal stiffeners was investigated. The trend and patterns in the stress distribution revealed a strong influence of VSR on welding.

Key Words: Artificial neural network, Weld induced residual stress, Vibration stress relief, Stiffened panel, FEA, microstructure, micro-texture