E. A Neural Network Analysis of HSLA Weld Wire: A New Weld Metal Composition for 100 ksi Weld Wire

E. A. Metzbower, US Naval Research Laboratory and J. J. DeLoach, Naval Surface Weapons Center

Introduction

Models were developed for the estimation of the tensile properties (strength and ductility) and the toughness (characterized by Charpy and dynamic tear tests) of ferrous alloys intended for the welding of high-strength low-alloy steels used in the construction of ships. The method used to model the properties as a function of a large number of variables was based on a neural network within a Bayesian framework. This method is particularly useful when attempting to understand complex non-linear phenomena where the distribution of data within the input space is not obvious.

Technical Approach

The tensile properties of a series of experimental welding alloys were modeled using a neural network method within a Bayesian framework. Toughness of these same welds as measured by the Charpy V-Notch test at 0 and –60˚F were also modeled. The original research had the intention of developing welding consumables for joining high-strength low-alloy steels (HSLA) for ship construction. New weld metal compositions (a target, lean, and rich composition) have been proposed and are in test, based on the data that were used for the neural networks. This paper predicts the properties of these new compositions based on the neural networks and shows some surprising results. Based on the results of the series of tests that related composition, cooling rate and mechanical properties, an optimized weld metal was determined for 100 ksi HSAL steel plate.

Results/Discussion

The target, lean, and rich composition satisfy the minimum yield strength requirements as a function of cooling rate (25 to 110˚F/s at 1000˚F). The ultimate tensile strength is greater than that of the yield strength for the same cooling rate. The elongation decreases with cooling rate but satisfies the requirements, whereas the reduction-in-area remains relatively constant. The Charpy V-notch energy at 0˚F greatly exceeds the requirements, while the values at –60˚F meet the requirements at slow cooling rates and exceed them at faster cooling rates.

Conclusions

The neural network method within a Bayesian framework that has been used to model the mechanical properties of high strength, low alloy weld deposit (0.030C-1.50Mn-0.28Si-0.04Cr-3.75Ni-0.55Mo) has been used to calculate these properties as a function of cooling rate. The properties satisfy the requirements for a 100 ksi weld metal.