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Estimation of Residual Stress in Welding of Dissimilar Metals at Nuclear Power Plants Using Cascaded Support Vector Regression

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ABSTRACT

Residual stress is a critical element in determining the integrity of parts and the lifetime of welded structures. It is necessary to estimate the residual stress of a welding zone because residual stress is a major reason for the generation of primary water stress corrosion cracking in nuclear power plants. That is, it is necessary to estimate the distribution of the residual stress in welding of dissimilar metals under manifold welding conditions. In this study, a cascaded support vector regression (CSVR) model was presented to estimate the residual stress of a welding zone. The CSVR model was serially and consecutively structured in terms of support vector regression modules. Using numerical data obtained from finite element analysis by a subtractive clustering method, learning data that explained the characteristic behavior of the residual stress of a welding zone were selected to optimize the proposed model. The results suggest that the CSVR model yielded a better estimation performance when compared with a classic support vector regression model.

Keywords: Cascaded Support Vector Regression (CSVR); Dissimilar Metal Welding; Primary Water Stress Corrosion Cracking (PWSCC); Residual Stress; Subtractive Clustering (SC)

1. Introduction

Factors such as the mechanical attributes of a material, stress concentration, macro- and micro-structure, and residual stress have influences on the structural fatigue life. Among these factors, residual stress is a critical factor that has an impact on the life of parts in operating nuclear power plants (NPPs). The residual stress is a tension or repression that exists in a material even when external loadings are not imposed, and this residual stress in parts or structures is generated by incompatible permanent internal strains. Various industrial substances typically involve residual stresses generated by heterogeneous plastic deformation due to heterogeneous heat treatment by welding.

Welding is a major factor that induces residual stress and typically generates high tensile stresses. The residual