Evaluation of Factors Affecting IASCC of Reactor Internal

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1. Introduction

Reactor internal of PWR is highly irradiated. The main damage mechanism of reactor internal has been considered as irradiation assisted stress corrosion cracking (IASCC). The effect of neutron irradiation on material has been studied by many researcher[1-4]. Neutron irradiation depletes Cr content in grain boundary, induces hydrogen and helium, makes vacancy and dislocation loop. And the resistance of IASCC is decreased by neutron irradition. These effects are different with materials and environment condition. To reduce IASCC, it is necessary to investigate which factor is the most important to IASCC. In this study, the relative importance of factors affecting IASCC is studied by artificial neural network method.

2. Experimental procedure

2.1. Experimental

To investigate the effect of chemical composition and environment condition on IASCC in austenitic stainless steel, the contents of Cr, Si, P, S, Mn, C, N, Ni are changed and the neutron fluence, conductivity, PH, ECP, oxygen concentration in environment are changed. Irradiation fluence was changed from 0 to 3 dpa. Oxygen concentration was from 7 to 9.7 ppm, ECP is 124-292 mV SHE, conductivity is 0.06-0.12 μS/cm, PH at 25℃ is 3.35-7.37. The effect of IASCC was investigated by slow strain rate tensile (SSRT). These experimental data was referenced[5].

2.2. Artificial neural network (ANN)

In analysis of artificial neural network, the value of R^2 is from 0 to 1. The closer is to 1, the better prediction is given. Average error is the difference between actual and prediction. Correlation is the measure of how the actual and predicted correlate to each other in terms of direction. MSE is a statistical measure of the difference between the values of the outputs in the training set and the output values the network is prediction. RMSE is the square root of MSE.

3. Results

3.1. Relative importance with environment condition

The IASCC was measured by the amount of intergranular SCC (IGSCC). The relative importance according to many factors such as rradiation fluence, oxygen concentration, ECP, conductivity, PH was shown Fig. 1. R^2 was 0.533781, average error was 9.01687, correlation was 0.730804, MSE was 181.8154, RMSE was 13.46389.

In this prediction, R^2 value indicates the poor prediction but irradiation fluence of input data was the most important factor.

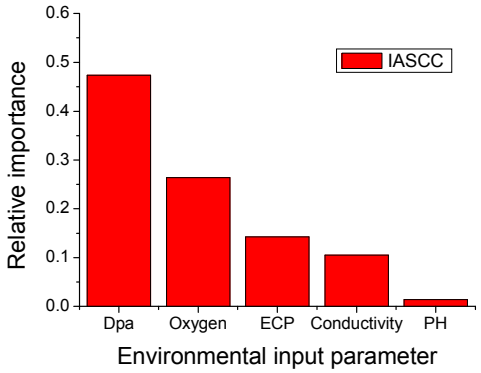

Fig. 1. Relative importance of factors with environmental condition

Yield stress was added as input data. The result was shown Fig. 2. R^2 was 0.72104, average error was 6.737157, correlation was 0.849147, MSE was 108.7884, RMSE was 10.43017. This prediction with yield stress was better than that without yield stress. In this prediction, yield stress was the most important and irradiation fluence was less important.

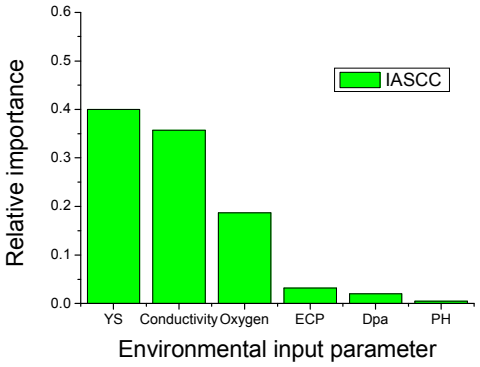

Fig. 2. Relative importance of factors with environmental condition and mechanical property

3.2. Relative importance with chemical composition

The effect of chemical composition on IASCC was evaluated. Relative importance was shown Fig. 3. Input data was 11. Nb and sulfur were very important. R^2 was 0.556998, average error was 7.34043, correlation was 0.746339, MSE was 212.6272, RMSE was 14.58176.

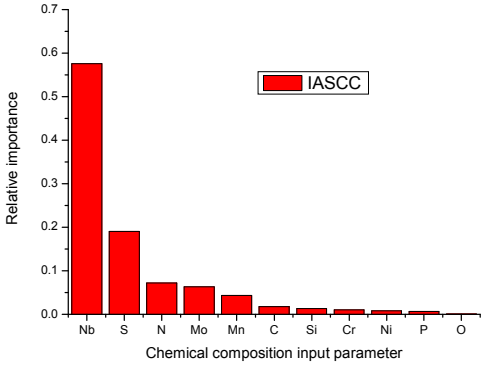

Table 3. . Relative importance of factors with chemical composition

Yield stress and elongation were added as input data. R^2 value was 89%. In this case, yield stress and Nb were very important. This result was shown in Fig. 4. R^2 was 0.897227, average error was 4.533696, correlation was 0.947222, MSE was 49.32787, RMSE was 7.023382. The prediction with yield stress and elongation was better.

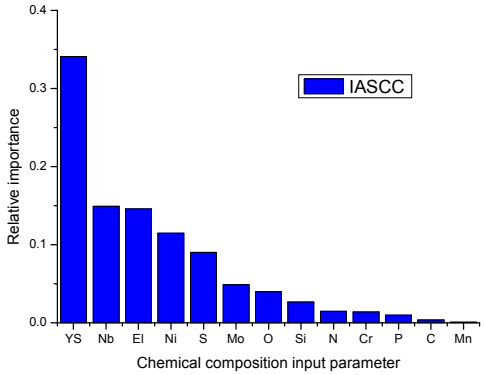

Fig. 4. . Relative importance of factors with chemical composition and mechanical properties.

4. Conclusion

Relative importance of factors affecting IASCC is changed with the selection of input factors. Yield stress is more important to IASCC than neutron irradiation. The accuracy for prediction of relative importance is in the range of about 50% to about 90%.

Reference

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