Prediction of structural elements lifetime of titanium alloy by neural network

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Abstract

Prediction of fatigue crack growth rate (FCG) is an important problem in fracture mechanics, which is of great practical importance for ensuring the reliability and safety of structures subjected to cyclic loading.

It is known that experimental data often have a certain scatter, and traditional models do not always accurately describe all aspects of the crack growth process. In particular, neural networks allow us to build models based on large amounts of data and consider various factors that affect crack growth. The dependence of crack length on the number of a-N loading cycles is an important tool for assessing the material lifetime and predicting its failure. Understanding the behavior of such cracks allows for making informed decisions regarding the operation and maintenance of engineering structures.

The study aimed to create a model that would accurately predict how the crack length increases with the number of loading cycles under different stress ratios. During training, the dataset was divided into two unequal parts - training and test samples. The training data were the number of loading cycles N and the stress ratio R. The neural network was trained on the experimental data, which allowed the model to recognize patterns and predict the crack length. It is important that in Fig. 1, the points are located quite close to the bisector of the first coordinate angle, which indicates the consistency of the predicted and experimental data.

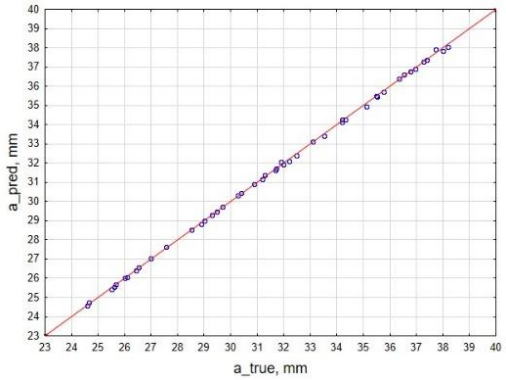

Figure 1. Comparison of experimental crack length a and predicted

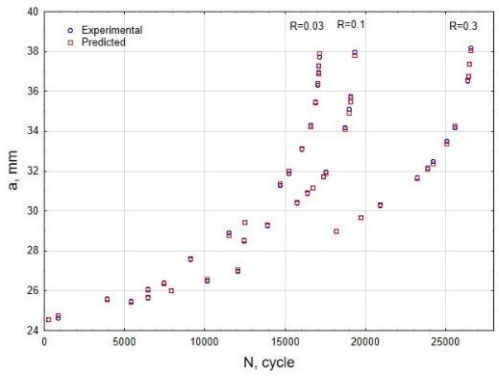

Figure 2. Fatigue crack growth curve of titanium alloy under different stress ratios: a-N curves

Therefore, integrating traditional models with machine learning methods allows for the achievement of high prediction accuracy and ensures the reliability of engineering systems. The prediction results are in good agreement with the experimental ones. The error of 0.2% was obtained by the neural network method in the test sample.

Keywords: fatigue crack growth; stress ratio; neural network; machine learning