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Modelling of Weld Microhardness Using an Artificial Neural Network

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The aim of this paper is about modelling microhardness in function of welding speed and position around the welded joint. The obtained model is then able to predict this characteristic without need of further experiments.

Key words: welding, neural network, microhardness.

Метою цієї роботи є моделювання мікротвердости залежно від швидкости зварювання та положення навколо зварного з'єднання. Одержаний модель здатний передбачити цю характеристику без необхідности подальших експериментів.

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Ключові слова: зварювання, нейронна мережа, мікротвердість.

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1. INTRODUCTION

Welding is a process that plays an important role in industrial field [2]. We find welding in uncountable domains. Studying of welding process and understanding its features is of big interest.

There are different parameters that can influence welding properties such as metal type, speed of welding. It is difficult to find mathematically a model for such process. Artificial neural network is chosen as solution to find a model describing relations between the studied characteristics.

Microhardness (and subsequently mechanical resistance) along metal and weld joint is an important characteristic that are studied in a welding process [3, 4]. Understanding those characteristics could help in predicting the behaviour of weld in the first step of designing a structure before passing to realization phase.

The metal BS2 is chosen for this study due to its important role in industry and thus economy, this study contributes to the security, economy and industry.

2. EXPERIMENTAL TEST

2.1. Arc Welding

First, the metal is prepared in four samples of length 8 mm. Each sample is welded in different speeds (30, 35, 40, 45 mm/min). The obtained samples are then prepared for the laboratory tests.

2.2. Laboratory Test

Each sample undergoes a series of test of microhardness. The points are chosen around the weld and distances are taken in the length of the piece symmetrical to the centre welded joint.

2.2.1. Microhardness Test

The microhardness is measured at different points along the sample [3], passing through the different regions (base metal BM, fusion zone ZF, and thermally affected zone ZAT). The obtained results are shown in figure (Fig. 1).

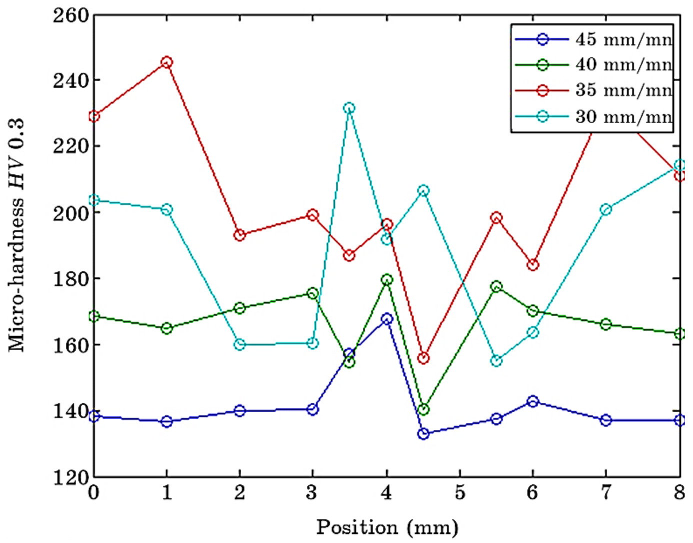

Fig. 1. Microhardness versus distance for different welding speeds.

From the above results, it is clear that microhardness curves are highly non-linear and are therefore difficult to find simple models to represent the evolution. This leads us to choose the artificial neural network as a tool to predict the above values as a function of welding speed and distance.

3. ARTIFICIAL NEURAL NETWORK

Artificial neural networks (ANN) are biologically inspired [2, 6]. They are used in many fields due to their features. ANNS is composed of

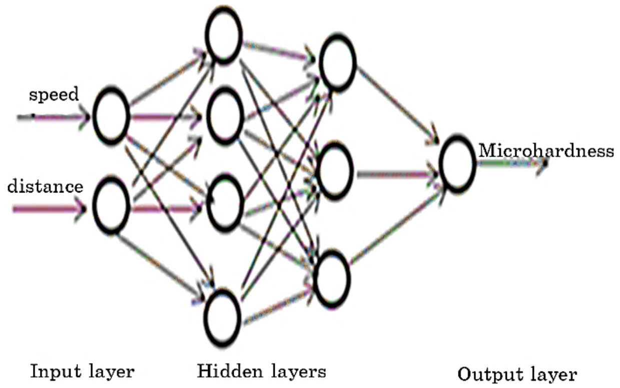

Fig. 2. ANN architecture.

elements (neurons) that are interconnected to form a neural network. The advantage of the use of ANN for prediction is that they are able to learn from examples only [5] the trained network is then able to predict values even for nonlinear process.

3.1. The Proposed Neural Model

We use a feed-forward neural network with two inputs (speed, distance) and one output (microhardness).

The first problem to solve is the number of layers and neurons in each layer. After tests we choose a feed forward ANN with 2 hidden layers and (8, 3) neurons.

3.2. ANN Training

Once the ANN designed, it should be trained. Experimental data are used to establish neural network, which are able to predict the Vickers microhardness [1].

The database is divided randomly in 3 parts: two thirds for training, third for testing, and third for validation. The results are shown in figure (Fig. 3).

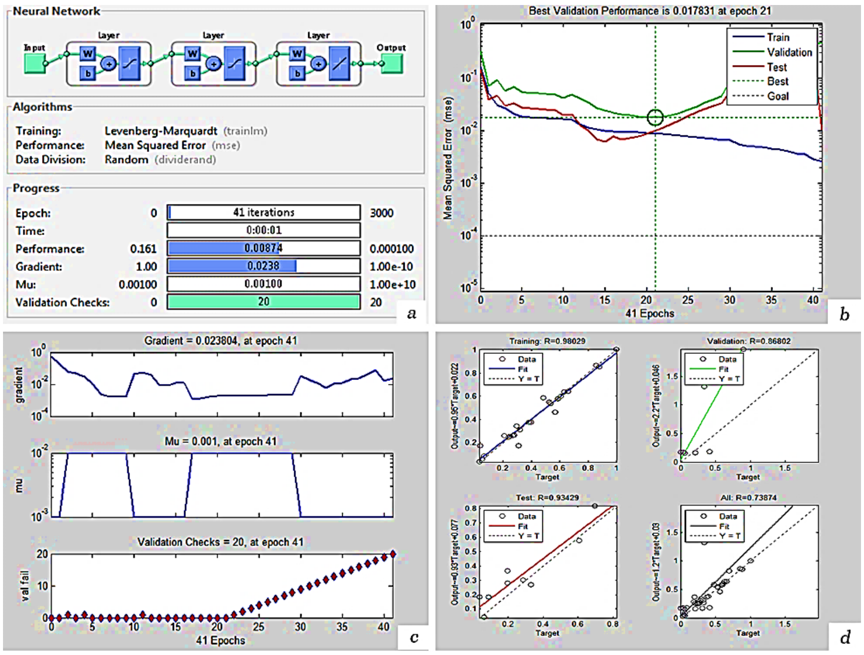

Fig. 3. ANN training, test and validation.

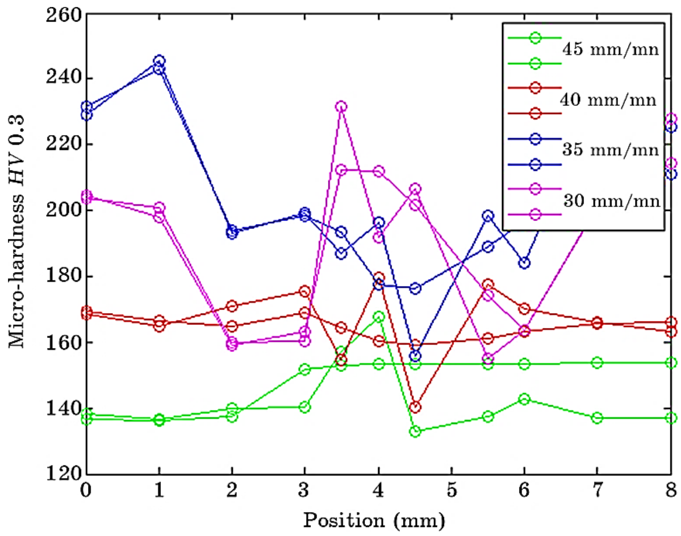

Fig. 4. Results calculated by the ANN model and experiments.

4. RESULTS AND DISCUSSION

From the results, it is clear that the obtained neural network gives good results with an overall correlation coefficient $R = 0.9220$ and a mean square error $MSE = 0.0108$ (Fig. 4).

The difference between experimental data and predicted ones can be reduced and the results could be improved by adding more experiments to database with more accurate devices.

5. CONCLUSION

As the correlation coefficient R and the mean square error MSE are good, the obtained neural network can be used as a model to predict the microhardness values for any speed or position around the weld joint. This feature of trained ANN allow user to use it as a model that predict microhardness along the welded metal without any further experiments.

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