

Chapter 9

Application of Artificial Neural Networks to Estimate Tensile Strength of Austenitic Stainless Steel During Metal Inert Gas Welding Process

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ABSTRACT

In the present work, artificial neural networks (ANN) have been used to model the complex relationship between input-output parameters of metal inert gas (MIG) welding processes. Four ANN training algorithms such as back propagation neural network (BPNN) with gradient descent momentum (GDM), BPNN with Levenberg Marquardt (LM) algorithm, BPNN with Bayesian regularization (BR), and radial basis function networks (RBFN) method have been used for prediction modelling. An experimentation based on full factorial experimental design has been conducted on MIG welding of austenitic stainless steel of grade-304 where welding current, welding speed, and voltage have been considered as input parameters, and tensile strength has been considered as measurable output parameter. The dataset so constituted is used for ANN modelling. Altogether, 40 different ANN architectures have been trained and tested using the above-mentioned algorithms, and 3-11-1 ANN architecture trained using BPNN with BR has been considered to show best prediction capability with mean % absolute error of 0.354%.

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INTRODUCTION

Metal inert gas (MIG) Welding is an industrially popular arc welding process which joins metal by heating them with an arc established between work and a continuous filler metal (consumable) electrode. The arc and molten weld pool are shielded by the externally supplied gas or gas mixture. The controllable input parameters for MIG welding process are welding current, welding voltage, welding speed, wire feeding rate, gas flow rate, stick out distance, electrode wire diameter, travel speed, gun angle, alternating shielding gas, mode of metal transfer, work piece plate thickness, gas mixture etc. The corresponding output parameters are such as weld strength, tensile strength, impact strength, weld hardness, elongation, effect on bead geometry etc. Quality of welding depends on variation of these welding input parameters. But as input weld parameters bear complex mathematical relationships with outputs, modelling and prediction of output parameters cannot be carried out with adequate accuracy using conventional statistical methods. Artificial neural networks can be efficiently employed to resolve this issue and estimation of output quality of the joint can be efficiently carried out for a set of input process parameters.

Artificial neural networks (ANN) are inspired from the structure of the human brain (Haykin,2006). They are massively parallel adaptive networks consisting of simple nonlinear computing elements called neurons. Each neuron receives signals as input which passes through a weighted pathway in order to generate a linear weighted aggregation of the impinging signals. It can be then certainly transformed through an activation function to generate the output signal of the neuron. The activation functions may be binary threshold, linear threshold, Sigmoidal, Gaussian etc. During training phase ANN approximate the underlying functional relationship between input-output variables of a given process to any arbitrary degree of accuracy. During testing phase prediction capability of the trained network is assessed. ANN is generally classified into two categories such as feed forward and recurrent. In Feed Forward Neural Networks (FFNN), information is passed into one direction that is starting from input layer towards the output layer through hidden layer(s). So, it does not form any cycle or loop. Among different variants of Feed Forward Neural Networks, Back Propagation Neural Networks (BPNN) is popular in the field of process modelling of welding processes.

Several research work has been conducted in the recent past based on ANN modelling of MIG welding processes. Ates (2007) estimated tensile strength, impact strength, elongation and weld metal hardness of MIG welding process using ANN while gas mixtures are considered as input parameters. In that work, ANN controller was trained using extended delta-bar-delta learning algorithm. Pal et al (2008) have employed conventional gradient descent momentum ANN to predict tensile stress (UTS) of MIG welded plates. Input parameters of ANN model are six

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