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Total Error Analysis Role of Predicting Mechanical Properties By Friction Stir Welded Aluminum pipes

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Abstract : *Aluminum can't successfully be arc welded in an air environment, due to the affinity for oxygen. If fusion welded in normal atmosphere oxidization readily happens and this outcome in both slag inclusion and porosity in the weld, greatly reducing its mechanical properties. To overcome these problems one of the most common ways of welding aluminum has been to a suggestion the friction stir welding. To work in this area needs to do a tremendous amount of experience and this thesis has provided general Specification of the process of friction stir welding pipes using three methods regression analysis (RA),Response surface methodology(RSM) and artificial neural networks (ANN) to infer the mechanical properties has this Specification so for the thickness of 2 to 4 mm, depending on the rotational speed from 485 to 1800(RPM) travel speed from 4 to 10 (mm/min to work comparative between three method ((RA), (RSM) and (ANN)) through total error.*

Keywords: *Friction stir welding, Aluminum pipe, total error.*

I. INTRODUCTION

Solid-state welding is the process whereby coalescence is produced at temperatures below the melting point of the base metal without the use of any filler metal. There are fewer defects in solid-state welding because the metals do not reach their melting temperatures during the welding process. However, the base metals being joined retain their original properties, and the Heat Affected Zone (HAZ) is small when compared with the fusion welding techniques (O'Brien and Guzman, 2007). Friction Stir Welding is a variant of friction welding that produces a weld between two or more workpieces by the heating and plastic material displacement caused by a rapidly rotating tool that traverses the weld joint (Thomas et al., 1991).
The advantage of hydroforming of FSW tubes is the tailoring of the starting materials that can vary in thickness and/or composition to optimize weight or performance. This tailoring is typically carried out in stamping by welding sheets of different thickness together. The blank is then stretch formed and drawn, resulting in a part with optimized weight (Davies et al., 2005; Ambrogio et al., 2006; Grant et al., 2006; and Buffa et al., 2007).
Recently more, attempts have been made to weld dissimilar aluminum alloys, which ultimately could provide flexibility in design as well as optimize strength, weight, and corrosion resistance (Kou and Le, 1984; Lammlein et al., 2010; Longhurst et al., 2010a and 2010b; and Schneider, 2011). To date, no work has been reported on the welding of tailor welded tubes for hydroforming.
The study shows the preliminary results on Friction Stir Welding (FSW) of 2024-T3 aluminum alloy tubes and the impact of the welding process on weld quality. Welding was performed on tubes with similar thickness. The mechanical properties of the welds were assessed by hardness and tensile measurements on as-welded and heat treated tubes (Zeng et al., 2006).
This study will focus on the total error on predicted mechanical properties of the welded joints of 6061 pipes after friction stir welding for pipes.

II. EXPERIMENTAL WORK

Aluminum was used for aluminum 6061 pipes -style experiments friction stir welding.[14-13]
The design tool used in the generation of heat between to pipes have also been outfitted design is placed on the machine friction stir welding for the completion and implementation of experiments[15-16].

III. RESULT AND DISCUSSION

It was conducted experiments Technical Institute for Advanced Industries - Training sector - the Ministry of Military Production – Alslam city -Egypt.
The results obtained from pipes welding aluminum 6061 and rotational speed from 485 to 1800 RPM, different travels speeds from 4 to 10 mm / min and various thickness aluminum pipes from 2 to 4 mm[15-16]

MATHEMATICAL MODELING

Regression analysis

RA it is one of the systems forecasting. the Regression analysis gives the ability to rely on real data in the conclusion of theoretical data, but this work will use this method to predict the scope of deliberate data which inferred difference in the wrong exists between real data and corrected to predict the line for adoption in the conclusion of the true values of specific coefficients for equations which gives the highest accuracy in the equations to predict the required values depending on the data.

The tensile strength , elongation and hardness of the joints are the function of rotational speed, welding speed, and axial force and it can be expressed as

$$Y = f(N, T, F)$$

Where

Y-The response.

N- Rotational speed (RPM).

T- material thickness,

F – travel speed (mm/min).

For the three factors, the selected polynomial (regression) could be expressed as

$$Y = k + aN + bT + cF$$

Where k is the free term of the regression equation, the coefficients a, b, and c are linear terms [16]

The validity of regression models developed is tested by drawing scatter diagrams. Typical scatter diagrams for all the models are presented [16]. The observed values and predicted values of the responses are scattered close to the 45° line, indicating an almost perfect fit of the developed empirical models [16].

Response surface methodology

RSM is known as a combination of statistical and mathematical methods for experimental model structure. Response surface methodology gives the ability to rely on real data in the conclusion of theoretical data, but this work will use this method to predict the scope of deliberate data which inferred difference in the wrong exists between real data and corrected to predict the line for adoption in the conclusion of the true values of specific coefficients for equations (Quadratic) which give the highest accuracy in the equations to predict the required values depending on the data.

The tensile strength, elongation, and hardness of the joints is the function of rotational speed, welding speed, and axial force and it can be expressed as

$$Y = f(N, T, F)$$

Where

Y-The response.

N- Rotational speed (RPM).

T- Material thickness,

F – Travel speed (mm/min).

For the three factors, the selected polynomial (regression) could be expressed as

$$Y = K + aN + bT + cF + a^2N^2 + b^2T^2 + c^2F^2 + + abNT + ac NF + bc TF$$

Where k is the free term of the regression equation, the coefficients a, b, and c are linear terms [15] Design-Expert 6.0.8 Software Packages is used to calculate the values of these coefficients for different responses. After determining the coefficients, the mathematical models are developed [15]. The developed final mathematical model equations in the coded form are given [15].

Artificial Neural Network (ANN)

ANN is computational models, which duplicated the function of the network, composed of neurons which used in solving complex functions in many applications. Neural networks composed of simple synchronous processing elements that are inspired by the nervous systems. The basic unit in the artificial neural networks is the neuron. Neurons are associated with each other by links known as synapses; by a weight factor. The neural network modeling details approach is given somewhere.

The results acquired after exercise and testing on artificial neural networks are shown in this [15]

The trend in the modeling using RSM, RA and ANN has a low order non-linear behavior with a regular experimental domain and relatively small factors region, due to its limitation in building a model to fit the data over an irregular experimental region. Moreover, the main advantage of RSM and RA is its ability to exhibit the factor contributions from the coefficients in the regression model. It is noted that ANNs perform better than the other techniques, especially RSM and RA.

The ANN model leads to comparatively accurate tensile strength predictions, elongation% predictions and hardness predictions. The error against observation order of both the models is compared in fig (1, 2 and 3).

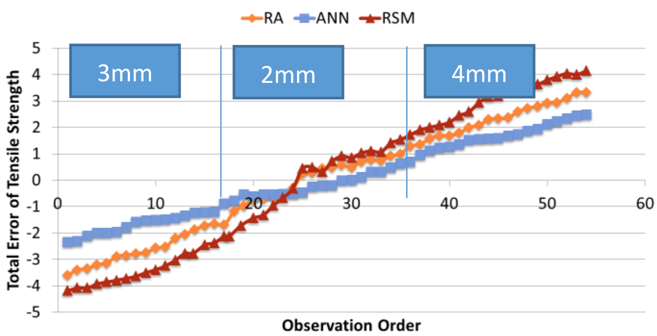

Fig. (1) The relation between total error of tensile strength (RA,ANN and RSM) and sample test

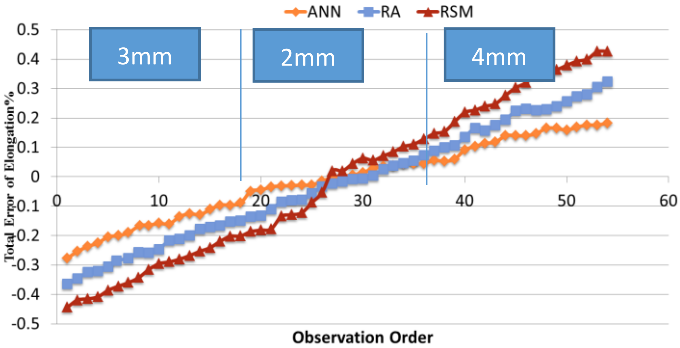

Fig. (2) The relation between total error of elongation (RA, ANN and RSM) and sample test

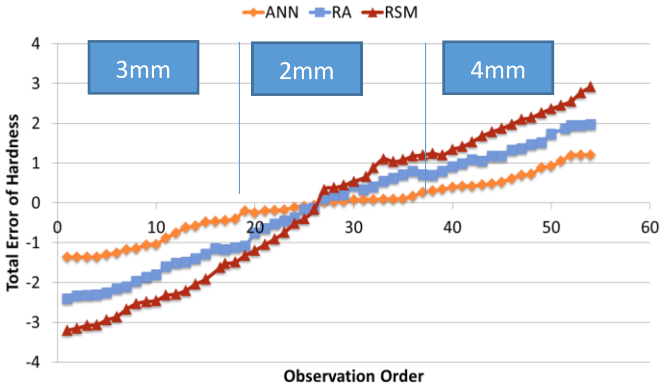

Fig. (3) The relation between total error of hardness (RA,ANN and RSM) and sample test

CONCLUSION

The predictive ANN model is set up to be masterful of best predictions of tensile strength The outcome of the ANN model signalize it is much more durable and exact in appreciate the values of tensile strength when compared with the response surface model and regression analysis model

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