Optimization of MIG welding parameters using Artificial Neural Network (ANN) and Genetic Algorithm (GA)

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**Abstract**

There are many mathematical models by which we can control the quality of weld properties in welding. We can use neural network which express some relationship between input and output. Now a days neural network is very useful tool by which we can interrelate input and output parameters compare it with that of the value which is given by the neural network and we can optimize the value. An artificial neural network and genetic algorithm is use to optimize the parameter. An Artificial Neural Network is a mathematical model inspired by biological neural networks. Here we are using ANN model for MIG (metal inert gas welding) welding. Two dissimilar type of work piece (stainless steel grade 304 and stainless steel grade 316) was taken and the welding experiment was performed and the result was analyse by using artificial neural network and genetic algorithm and it was find that ANN was given the batter result argon was taken as shielding gas and experiment was done on full factorial. Genetic Algorithm (GA) used to optimize the value of output. And it is concluded that Artificial Neural Network (ANN) successfully integrated as other regression model.

**Keywords**: Welding, Neural, Genetic algorithm.

**Introduction**

There are lot of mathematical model by which we can control the quality of weld. Artificial neural network (ANN) can be used in optimization of welding parameter. The area of Artificial Neural Network is very vast it can be used in various field in today generation. It is used in agriculture, welding technology, group technology, soil water conservation etc. Artificial neural network play a very important role to develop model which express the interrelationship between input and output parameter react with the metal and forms a layer on the metal surface and there is chance of corrosion.

**Butt welding**

The experiment are conducted on the 3mm thick sheet of stainless steel of grade 304 and stainless steel of grade 316 and electrode of stainless steel of grade 309L was used the chemical composition is given in the table the butt welding was performed on the work piece. Experiment are conducted on full factorial in which 3 input parameter are taken and 27 sample of work piece are taken for observation. Argon used for shielding gas to prevent the welding from the atmospheric contamination.

**ANN architecture**

A neural network consists of an interconnected group of artificial neurons, and it is very important and useful tool for develop models which express the interrelationship between input data and output data. There are so many benefits of ANN in the Engineering design and GT (group technology) because it can store a large set of parameter In most cases a neural network is an adaptive system that changes its structure during a learning phase. Learning of Neural network is very important we have to learn

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Neural networks are used to model complex relationships between inputs and outputs or to find patterns in data.

Neural networks are similar to biological neural networks in that functions are performed collectively and in parallel by the units it is very important point because the biological neurons are perform the function in parallel artificial neural network are not work accurately like biological neuron, rather than there being a clear delineation of subtasks to which various units are assigned. The term "neural network" usually refers to models employed in statistics, cognitive psychology and artificial intelligence. Neural network models which emulate the central nervous system are part of theoretical neuroscience and computational neuroscience. Neural network models in artificial intelligence are usually referred to as artificial neural networks (ANNs); these are essentially simple mathematical models defining a function or a distribution over or both and but sometimes models are also intimately associated with a particular learning algorithm or learning rule[2]. A common use of the phrase ANN model really means the definition of a class of such functions (where members of the class are obtained by varying parameters, connection weights, or specifics of the architecture such as the number of neurons or their connectivity). Artificial neural networks proved useful in a various of real application that deal with highly interactive and complex processes [10].

Welding
Welding is a process of joining of two metals (can be similar or dissimilar) with the application of heat with pressure with or without filler rod. Sometime filler metal is required. In today’s technology welding technology is used in every branch of industries, mechanical industries etc.

Methodology
Artificial neural network (ANN) used for classification and genetic algorithm (GA) used for optimized to data.

Table 1 Welding parameters levels.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage (volt)</td>
<td>100</td>
<td>110</td>
<td>120</td>
</tr>
<tr>
<td>Current amp</td>
<td>16</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>Velocity (cm/min)</td>
<td>40</td>
<td>45</td>
<td>50</td>
</tr>
</tbody>
</table>
### Table 1: Experimental Data collection

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Curr. (A)</th>
<th>Vol. (V)</th>
<th>TS (cm/min)</th>
<th>UTS (MPa)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>16</td>
<td>40</td>
<td>715.76</td>
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<tr>
<td>2</td>
<td>100</td>
<td>16</td>
<td>45</td>
<td>725</td>
</tr>
<tr>
<td>3</td>
<td>100</td>
<td>16</td>
<td>50</td>
<td>656</td>
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<tr>
<td>4</td>
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<td>730.65</td>
</tr>
<tr>
<td>6</td>
<td>100</td>
<td>18</td>
<td>50</td>
<td>650.45</td>
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<tr>
<td>7</td>
<td>100</td>
<td>20</td>
<td>40</td>
<td>650</td>
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<tr>
<td>8</td>
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<td>20</td>
<td>45</td>
<td>670</td>
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<tr>
<td>9</td>
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<td>600.67</td>
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<tr>
<td>10</td>
<td>110</td>
<td>16</td>
<td>40</td>
<td>755</td>
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<td>110</td>
<td>16</td>
<td>45</td>
<td>756.89</td>
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<td>110</td>
<td>18</td>
<td>40</td>
<td>687.32</td>
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<td>110</td>
<td>18</td>
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<td>738.43</td>
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<td>110</td>
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<td>50</td>
<td>751.67</td>
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<tr>
<td>15</td>
<td>110</td>
<td>18</td>
<td>50</td>
<td>680.43</td>
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<td>110</td>
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<td>40</td>
<td>678.33</td>
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<td>27</td>
<td>120</td>
<td>20</td>
<td>50</td>
<td>571.73</td>
</tr>
</tbody>
</table>

Normalization of data done by the formula: $X_i = \frac{X_i}{X_{max}}$
Where $X_i$ is value at $i^{th}$ column and $X_{max}$ is max value in that column.

### Table 2: Normalized data

<table>
<thead>
<tr>
<th>Current Voltage</th>
<th>Travel Speed</th>
<th>UTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.833</td>
<td>0.8</td>
<td>0.946</td>
</tr>
<tr>
<td>0.833</td>
<td>0.8</td>
<td>0.958</td>
</tr>
<tr>
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<td>0.8</td>
<td>0.867</td>
</tr>
<tr>
<td>0.833</td>
<td>0.9</td>
<td>0.939</td>
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<tr>
<td>0.833</td>
<td>0.9</td>
<td>0.965</td>
</tr>
<tr>
<td>0.833</td>
<td>1</td>
<td>0.859</td>
</tr>
<tr>
<td>0.833</td>
<td>1</td>
<td>0.859</td>
</tr>
<tr>
<td>0.833</td>
<td>0.9</td>
<td>0.885</td>
</tr>
<tr>
<td>0.833</td>
<td>1</td>
<td>0.794</td>
</tr>
<tr>
<td>0.917</td>
<td>0.8</td>
<td>0.998</td>
</tr>
<tr>
<td>0.917</td>
<td>0.9</td>
<td>0.993</td>
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<tr>
<td>0.917</td>
<td>0.9</td>
<td>0.993</td>
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<tr>
<td>0.917</td>
<td>1</td>
<td>0.899</td>
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<tr>
<td>0.917</td>
<td>1</td>
<td>0.896</td>
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<tr>
<td>0.917</td>
<td>0.9</td>
<td>0.929</td>
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<td>0.917</td>
<td>1</td>
<td>0.779</td>
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<tr>
<td>1</td>
<td>0.8</td>
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<td>0.9</td>
<td>0.947</td>
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<tr>
<td>1</td>
<td>0.8</td>
<td>0.888</td>
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<tr>
<td>1</td>
<td>0.9</td>
<td>0.896</td>
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<tr>
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<td>0.9</td>
<td>0.909</td>
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<tr>
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<td>0.900</td>
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<tr>
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<td>0.9</td>
<td>0.824</td>
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<tr>
<td>1</td>
<td>1</td>
<td>0.890</td>
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<tr>
<td>1</td>
<td>1</td>
<td>0.901</td>
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<tr>
<td>1</td>
<td>1</td>
<td>0.755</td>
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</tbody>
</table>
Mathematical Model for UTS by Genetic Algorithm (GA)

A regression analysis has been used for developing the second order regression models for response UTS. In order to understand the effect of control factors on the responses, first order, second order and interactions between different control factors have been considered. The general equation for regression model may be given as:

\[ y_j = b_0 + \sum_{i=1}^{n} b_i x_i + \sum_{i=1}^{n} b_{ij} x_i^2 + \sum_{i=1}^{n} b_{ij} x_i x_j \]

Where b's are coefficients. The final model for the UTS obtained as follows –

\[ f = \text{function } f = \text{UTS}(x) \]

\[ f = -7883 + 69.9x(1) + 148x(2) + 168x(3) - 0.051x(1)x(2) - 0.475x(2)x(3) - 0.0708x(3)x(1) - 0.301x(1)x(1) - 3.81x(2)x(2) - 1.76x(3)x(3)) \]

where

\[ x(1) = \text{Current} \]
\[ x(2) = \text{Voltage} \]
\[ x(3) = \text{Travel Speed} \]
Objective value (UTS): 775.1137 MPa

<table>
<thead>
<tr>
<th>Current</th>
<th>Voltage</th>
<th>Travel speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>109.641amp</td>
<td>16.001volt</td>
<td>43.362 cm/min</td>
</tr>
</tbody>
</table>

**Figure 5:** Variation between Fitness value and Generation

**Figure 6:** General optimization procedures using a genetic algorithm

Ref: Optimization of laser butt welding parameters with multiple Performance characteristics. [4]

**Figure 7:** Effect of current on UTS

The graph shown in fig. 4.1 is plotted between current levels at 100A, 110 A, 120 A, and ultimate tensile strength. The voltage and speed level varies here from 16 V to 20 V and 40 to 50 cm/s. It is observed from the graph that the maximum possible values of strength are obtained with current at level 110 A. The value of strength obtained from the genetic algorithm is confirm that the optimum strength is obtained at current level 109.641A.

**Figure 8:** Effect of voltage on UTS

Here the value of voltage are kept constant at each nine experiment and the value of current and speed is varies from 100A to 120A and the 40cm/s to
50 cm/s respectively. The optimum value of strength is obtained at 18 V. Genetic algorithm also shown that the value of voltage for optimum output is comes out to be at 16.001 V.

**Effect of travel speed on UTS**

![Graph showing the effect of travel speed on UTS](image)

Value of UTS is fined maximum between 40 to 45 and it is clear by the Genetic Algorithm that the optimum value of the travel speed is 43.362 cm/min at which the value of the Ultimate Tensile Strength is found 775.1137 MPa which is optimum value coming from Genetic algorithm.

**Conclusions**

In MIG welding process we use stainless steel of grade 304 and stainless steel of grade 316. Three parameters are taken as input parameters (welding voltage, current, and travel speed of welding) and one parameter is taken as output parameters (ultimate tensile strength). Data is classified by using Artificial Neural Network and optimized by using Genetic Algorithm successfully integrated. The developed Artificial Neural Network model is successfully integrated with optimization algorithms like Genetic algorithm to optimize the welding parameters. The optimized welding parameters given by the GA, the metal inert gas (MIG) welding joints were processed. Joints exhibit better quality. After performing the experiment we found that stainless steel grade 304 has better strength than stainless steel grade 316. Argon gas work satisfactory for stainless steel because we cannot used such gas which react with the work piece and form metal oxides.

**References**

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