# ANN Tool Approach for Parametric Optimization of Friction Stir Welding on Al-6063

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*Abstract*— Aluminum alloy 6063 is used in engineering design like automotive connector stock, and structural members due to their lightweight better machinability, strength properties, and braze ability. Friction stir welding is a solid-state joining process in which material is welded without melt and recast. This research presents the effects of parameters on TS (KN/mm$^2$) and hardness during friction stir welding of aluminum alloy 6063. The friction stirs welding parameters such as tool rotational speed (950-1450 rpm), welding speed (20-40 mm/min), and tilt angle (0-1 degree) have been used. ANN tool was used in MATLA software for simulation and validation purposes. It was noted that for the friction stir welding of aluminum alloy 6063, the tensile strength and hardness values are 0.08625 KN/mm$^2$ and 53.9375 VHN respectively. The common parameters combination for maximum tensile strength was 1175 rpm, 40 mm/min, and 0 degrees for transverse, welding speed, and the tilting angle of the tool.

***Keywords:*** FSW, Al-6063, ANN, VHN, TS

## I. Introduction

As we look back in decades, welding can be assumed to be a for-all-time joining process (1). Welding utilizes physical and metallurgical conditions to combine two or more materials as one (2). That shows nothing but another cycle. Right off the bat, produce welding is used as a similar or dissimilar metal joining process (3). The metal is joined by warming and hammering in forge welding, the current scenario shows that the bunches of welding processes are accessible. The vital contrasts between welding systems are a strategy that can be utilized to create heat to liquefy the metals (4). The welding covers many aspects. Welding is used as a creation cycle for little and huge ventures. Welding is practical and productive interaction. This cycle is utilized in air, space and submerged working conditions also (5).

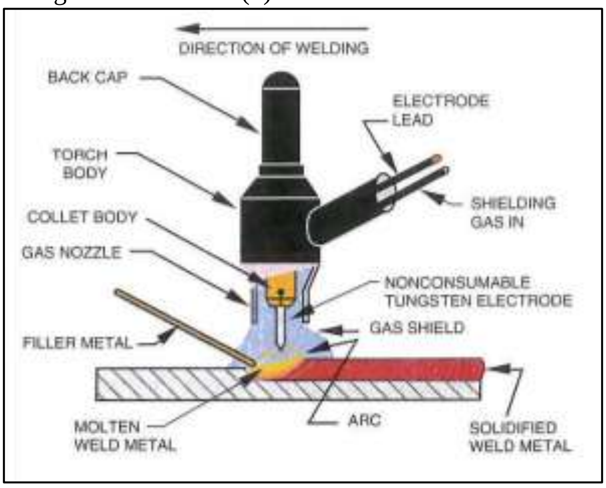


Fig. 1: Principle of FSW Process (6).

Solid-state and fusion welding, are the two kinds of welding. In fusion welding, there is no pressure applied but a filler material is always used. In solid-state welding, pressure is applied along with heat. No filler materials are used (7). Friction welding is a form of the solid-state welding process, which depends on the flow of metal, and deformation and on the formation of the molten bridge (8). The basic principle of friction welding involves the simultaneous application of pressure, and relative motion, generally in a rotational mode, between the components to be joined. Friction welding which requires pressure, relative motion, and time, is an efficient thermal energy source for the welding of material (9–11).

### A. *Artificial Neural Network*

The feed-forward back propagation neural network (FFBPNN) is a common ANN architecture that is used in this study. Here, the weights and biases of neurons in each layer are carried forward as neuron outputs (12,13). These weights and biases are tuned or adjusted to minimize the error between the actual class and the predicted class. This model is extremely capable of understanding the patterns and is very versatile. The optimal ANN architecture is application dependent (14). Therefore, setting the number of hidden layers is challenging and heuristic methods are often adopted to reach the optimal ANN structure (15–17).

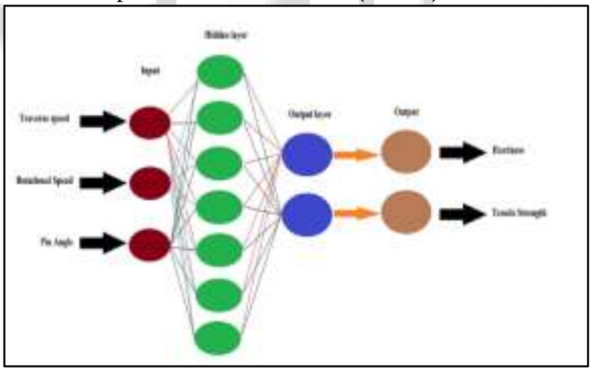

Fig. 2: ANN Structure

## II. Material and Methods

The aluminum alloy Al-6063 was used as workpiece material in the research work. The Friction stirs welding process was utilized for the joining of workpiece plates (18). The plates were prepared in 150 x 100 x 8 mm.

The Universal testing machine and hardness tester were used for the analysis of tensile strength and hardness respectively (19,20). After recording the response parameters then artificial neural network tool was used for simulation and validation of the response variable (21). MATLAB software was used for the ANN tool (22).

## III. RESULTS FOR MECHANICAL TESTS

### A. *Tensile Strength (TS)*

The most extreme pressure that a material can endure although being pulled or extended prior to breaking or falling flat (23–25).

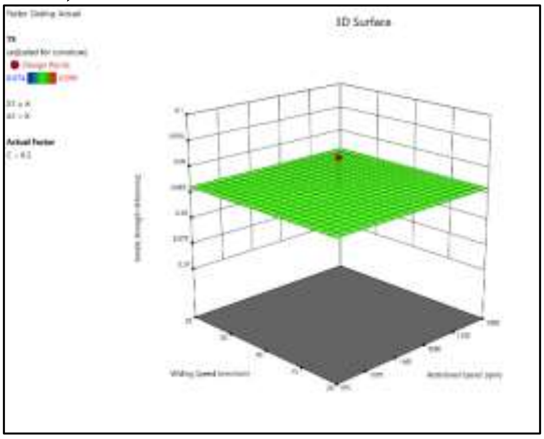

Fig. 3: 3D Surface Plot for Tensile Strength

### B. *Hardness Measurement*

The hardness measurement is also significant for the material which is developed or produced. The improvement in hardness is also beneficial for every industrial need to meet their requirement (26–28).

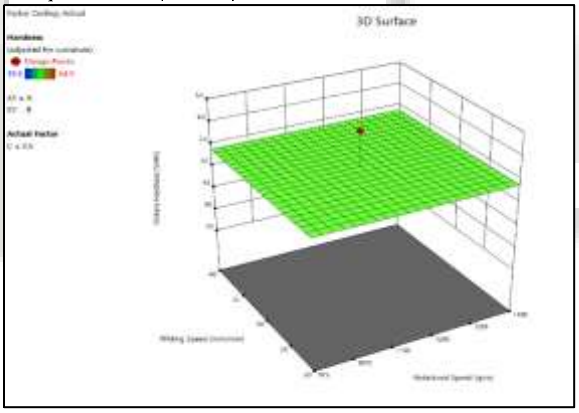

Fig. 4: 3D Surface Plot for Hardness

### C. *Analysis of Response by ANN Tool*

This model is extremely capable of understanding the patterns and is very versatile. The optimal ANN Model is application dependent (21).

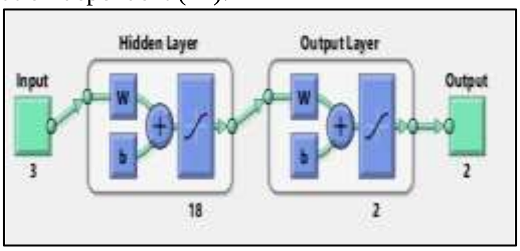


Fig. 5: Designing ANN Model

Therefore, setting the number of hidden layers is challenging and heuristic methods are often adopted to reach the optimal ANN structure. So, the architecture of ANN becomes 3-18-2, 3 corresponding to the input values, 18 to the number of hidden layer neurons, and 2 to the outputs as shown in figure 5.

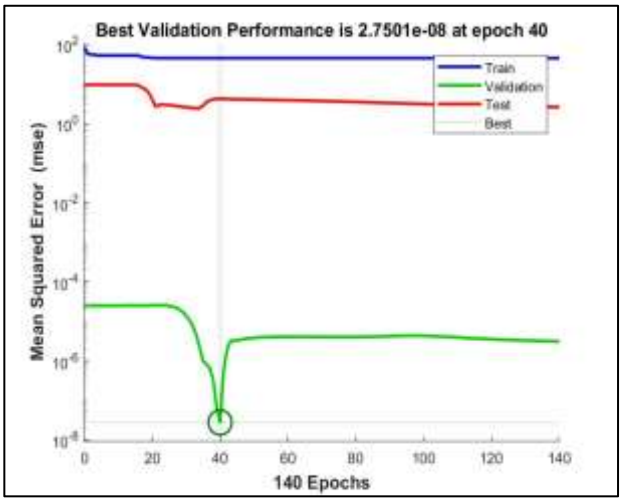


Fig. 6: Variation of MSE w.r.t. epoch

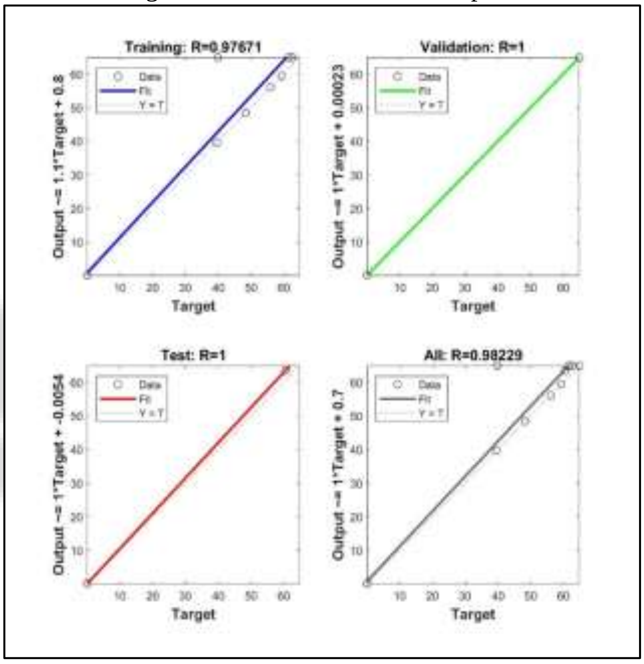


Fig. 7: Regression plot of Trained ANN Model

The iteration was applicable to the response variable and figure 6 shows the 40 epochs or iteration that gives the best performance for the prepared model.

A feed-forward back proliferation calculation is chosen for the ongoing prescient model. The information dataset comprises of three info boundaries (rotational, welding speed, and tilt angle), and two separated reaction boundaries (Tensile strength and hardness) as shown in figure 7.

| Responses | Predicted | Observed | Error | % Error |
|---|---|---|---|---|
| Hardness* | 53.9375 | 52.7831 | 1.1544 | 2.14% |
| TS* | 0.08625 | 0.08563 | 0.0062 | 7.18% |

Confidence = 95%  Population = 99%

Table 1: Optimum Value prediction of Responses

## IV. CONCLUSION:

The hardness value raised increment with the increment in the transverse speed. The hardness is fundamentally affected by the welding speed (29). The curve shows that after achieving an elevated hardness, it gets decreases with an increment in the welding speed. The same trends can be seen with the tilting angle.

The ANN predicted results show that maximum tensile strength and hardness values are 0.08625 KN/mm$^2$ and 53.9375 VHN respectively. The common parameters combination for maximum tensile strength was 1175 rpm, 40 mm/min, and 0 degrees for transverse, welding speed, and the tilting angle of the tool. This is the optimal combination and solution for the problem.

## V. FUTURE SCOPE

Though a systematic experimental study has been carried out for the tensile strength and hardness of aluminum alloy 6063 using FSWM, ample scope is there for carrying out further research in the area.

1) In this investigation only three parameters (rotational speed, welding speed and tilt angle) were included as input factors. Study of other parameters such as axial force, shoulder diameter and pin diameter can be included.
2) The study can be extended to other Taguchi of aluminum alloy and harder materials.
3) In the present research response tensile strength and hardness are selected. Further investigations can be done to find out other responses like Yield Strength, Impact Strength, and % Elongation etc.
4) The tool made of other material can also be used for further investigation.

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