iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** XI **Month of publication:** November 2017

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue XI November 2017- Available at www.ijraset.com

Modelling and Process Analysis of Resistance Spot Welding On Aluminium Alloy AA6063 T6 Sheets Used In Transportation Applications

B.D.Y. Sunil[1], B. Balu Naik[2], K. Sammaiah[3], KGK Murti, N. Ananth[5]
[1, 4] Department of Mechanical Engineering, Institute of Aeronautical Engineering, Hyderabad, India
[2]Department of Mechanical Engineering, JNTU Hyderabad, India
[3]Department of Mechanical Engineering, St. Martin's Engineering College, Hyderabad, India
[4]Value Innovation, Be'Rollex Pvt Ltd, Hyderabad, India

***Abstract:** In this study, resistance spot welding (RSW) process of the Aluminium Alloy 6063 T6 sheet has been modeled and optimized. The quality measure of RSW of Aluminium Alloy 6063 T6 is estimated from the tensile shear strength of the joint. The three important parameters that are considered as the factors influencing the quality of the joints are Weld Force (F), Weld Current (C) and Weld Time (T). At first, a linear regression model was utilized for developing an accurate relationship between the process inputs (3-component vectors) and the response output (tensile shear strength), but a non-linear behavior was revealed by the residual analysis. As the Artificial Neural Networks (ANNs) are capable of mapping the non-linear systems, it was proposed for the analysis. For analyzing the RSW process and the interaction effects of the parameters, a back propagation neural network model was developed. For determining a set of process parameters, a genetic algorithm with the fitness function based on the ANN model was employed as an optimization procedure. The maximum joint strength was obtained as a result of this. A high compatibility with the actual experiment data was showed by the optimization results.*
***Keywords:** Aluminium alloy AA6063 T6, resistance spot welding, weld force, weld current, weld time, artificial neural network, MATLAB*

I. INTRODUCTION

For many years, RSW is the principle joining method used in automotive industries. On an average a typical body of a car contains 4500 spot weld joints [1]. The joint in RSW method is made by the generation of heat due to the resistance offered by the work pieces for current flow and simultaneously applying the force (pressure). The electrodes are made of Copper and they conduct the weld current where the weld is to be made and they also serve to apply force on to the weld spot area to form a strong joint. The heat for joining the parts in resistance spot welding is an effect of the heat generated because of electrical resistance of welding circuits according to Joule-Lenz Law

$$Q(t) = \int_0^{\tau} I(t) \cdot R \cdot dt$$

Where
Q – generated heat,
I – welding Current,
R – electrical resistance of welding circuit,
t – welding time

To form a car body in automotive industries, the sheet metals are welded by using RSW process which is automated in the form of robotic spot welding.

The quality of the joint in RSW is directly influenced by the input welding parameters, like any other welding processes. The major problem faced by the manufacturers is to maintain the optimum welding parameters to obtain a sound joint in RSW [2]. Thus, concerned in the industrial applications, finding the relationships between the strength of weld and process parameters is of great interest. Structures in which RSW joints are usually designed are loaded with shear load even they are subjected to tension or compression loading [3]. Hence, an important index to weld quality is the tensile shear strength of the joint [4]. Because of its simplicity, the static tensile shear test is the most common laboratory test used to determine the weld strength [5].

For establishing relationship between the input welding parameters and the joint strength, various analytical and numerical methods have been employed. For modelling various welding techniques, several research works have reported the use of artificial neural

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue XI November 2017- Available at www.ijraset.com

networks (ANN). The imitation of behaviour of the biological nervous system is being done by the ANNs. They are capable of mapping non-linear and complex systems in which there are limitations in the regression methods, because of their parallel, distributed and adaptive processing [6,7]. A technique based on ANN to model gas metal arc welding parameters was presented by Ates [8]. Cevika et al. [9] proposed an ANN to determine the ultimate capacity of arc spot welding based on experimental results. To predict the tensile shear strength of 304 austenitic stainless steel RSW joints, Martín et al. [10] proposed an ANN. The effect of three process parameters namely welding time, weld current and weld force, on the tensile shear strength was investigated by them.
ANN was developed to predict the spot weld quality measure (tensile shear strength) in this study because a linear regression model, which was proposed at first, had revealed an inherent nonlinearity behavior of the RSW process. Interaction effects of RSW parameters were analyzed. For determining the optimal process parameter values for the desired tensile shear strength, a genetic algorithmic procedure has been employed. After verification of the actual experimental data with the optimization results, it has been revealed that the results are satisfactory.

II. EXPERIMENTAL PROCEDURE

A. Materials and equipment

The material used in experiments are commercially available aluminium alloy AA6063 T6 sheet widely used in transportation fabrication applications. They have excellent formability and mechanical properties due to the presence of alloying elements such as Mn and Si. The chemical composition of AA6063 T6 sheet is shown in Table 1.
The mechanical properties of AA6063 T6 sheet is shown in Table 2. The sheets thickness is 0.5 mm.

TABLE I
CHEMICAL COMPOSITION OF ALUMINIUM ALLOY AA6063 T6 (WT%)

Element	Si	Cu	Mn	Mg	Cr	Zn	Ni
Nominal Composition	0.4	0.1	0.1	0.7	0.1	0.1	0

TABLE III
MECHANICAL PROPERTIES OF ALUMINIUM ALLOY AA6063 T6

S.No.	Details of Properties	Units
1	Tensile strength	241.31MPa
2	Yield Strength	213.73MPa
3	Elongation	12%
4	BHN	73

Trials were conducted on a 3 phase, 415 V, AC 50 Hz, 200 KVA hydraulic resistance spot welding machine at Ordnance Factory Medak, Sangareddy (Dist), Telangana State, India. The electrode was of truncated shape and water cooled with a tip diameter of 3.5 mm.

B. RSW process parameters

Using Design of Experiments (DOE), experimental data were collected. 124 different welding tests were resulted by the full factorial and central composite design table's combination. The feasible working limits of welding conditions were determined by conducting several trial tests on the sheets. In the trial runs various combinations of weld parameter values were used. The indentation and visual quality of nugget formation were inspected to identify appropriate ranges of welding parameters. While implementing such exercise, it was found observed that if the weld force is less than 1500 N and greater than 2000 N, the nugget splashed away and there was a weak joint formed. Also, if the weld time is maintained greater than 10 cycles, the parent metal got melted and holes were formed. The major observation was that the weld current should be maintained above 20 kA for the penetration of current to take place through the sheets placed as a lap joint. The weld parameter ranges that were considered for the experiment are shown in Table 3.

TABLE IIIII RANGES CONSIDERED FOR PARAMETERS

Parameter	-1 (minimum)	+1 (maximum)
Weld Force (X_1)	1765 N	1961 N
Weld Current (X_2)	21000 A	24000 A

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue XI November 2017- Available at www.ijraset.com

Weld Time (X_3)	2 Cycles	4 Cycles

C. Tensile shear test

For describing the mechanical properties and quality of the welded joints, tensile shear strength has been selected in this research. There is an eccentricity E between the two tensile axes of the overlap joints as shown in Fig. 1. Due to this eccentricity, while performing tensile shear test, the weld nugget was undergoing both tensile stress and shear stress.

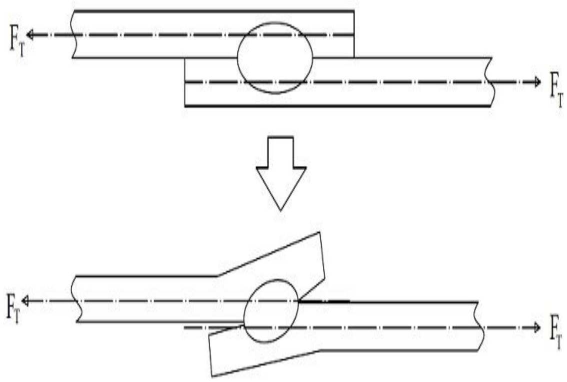


Fig. 1 Tensile shear strength definition and calculation from laboratory test.

The tensile shear test specimens were spot welded for each of the 124 welding conditions mentioned above. The specimens were prepared according to ISO14273 standards [11] as shown in Fig. 2.

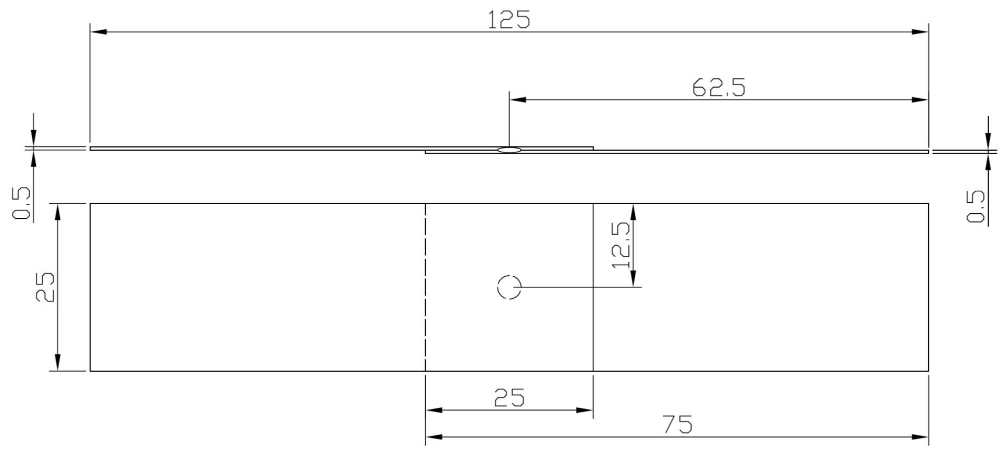


Fig. 2 Dimensions of tensile shear test specimen

The experiment related to each of the parameter combinations was carried out three times and their average value was reported as the strength of the corresponding parameter combinations for increasing the accuracy and confidence level. The test was carried out on a universal testing machine of DAK-UTB9502 make with serial no. 252/08-09 which is a 5 ton capacity 230V single phase AC machine. Three types of breaking failure were observed during the test: (1) separation; (2) knotting; (3) tearing. The samples are shown in Fig. 3.

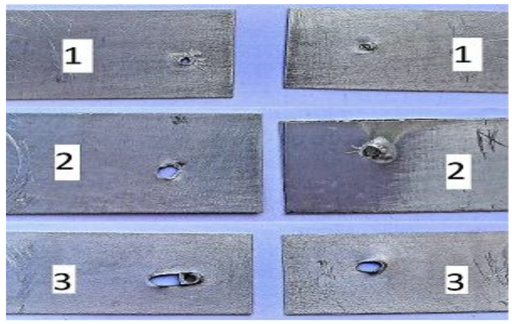


Fig. 3 breaking types observed in tensile shear test: (1) separation; (2) knotting; (3) tearing.

III.RESULTS AND DISCUSSIONS

A. *Linear regression model*

A linear regression model was developed to relate tensile shear strength of the RSW joints to the weld parameters i.e., weld force, weld current and weld time. Yates method was used for the regression analysis.

TABLE IVV

YATE'S METHOD ANOVA ANALYSIS

S.No.	Treatment Combinations	Responses (Y)	Column1	Column2	Column3 (z)	Treatment Sum of Squares (TSS) ($z^2/8$)	Calculated F-Ratio (TSS/MSS)	Significant Factors(z/8), (β coef.'s)
1	1	331	924	1876	3729	1738180	-	-
2	X_1	593	952	1853	217	5886	10.55*	27.125, (β_1)
3	X_2	467	859	280	163	3321	5.95*	20.375, (β_2)
4	X_1X_2	485	994	-63	-289	10440	18.71*	-36.125, (β_{12})
5	X_3	434	262	28	-23	66	0.12	-2.875, (β_3)
6	X_1X_3	425	18	135	-343	14706	26.36*	-42.875, (β_{13})
7	X_2X_3	524	-9	-244	107	1431	2.56	13.375, (β_{23})
8	$X_1X_2X_3$	470	-54	-45	199	4950	8.87*	24.875, (β_{123})

* in the table represents significant F-Ratio values of the β-coefficients.

Table 4 illustrates the results of the regression analysis. The coefficients which are significant were selected at 95% confidence level, can be observed in the table. The coefficient of determination and the residual analysis for this model revealed non-linear behaviour of the process. So, an ANN model was proposed.

B. *The proposed ANN model*

For model simplification, traditional modelling methods were mostly relied on assumptions and because of that consequently may lead to inaccurate results. The underlying trend of the data set presented will be captured by the ANN in the form of a complex non-linear relationship between the input parameters and output variable [7]. The ANNs characteristics make them suitable for modelling the strength of a RSW joint and therefore it was used as the modelling tool in this research.

1) *The ANN architecture:* A multilayer back propagation feed forward ANN which was implemented and trained using Neural Network Toolbox in MATLAB R2007b 7.5 version package has been used for this study. All the pattern recognition and classification tasks can be performed with a three-layer BPN, even though BPNs may have many layers [12]. For training the ANN the Bayesian regularization algorithm (called trainbr in MATLAB) was used. Bayesian regularization is a function which trains the network and updates the weight and bias values according to Levenberg-Mar-quardt optimization. It determines the correct combination by minimizing the combination of squared errors, so as to produce a network that generalizes well.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue XI November 2017- Available at www.ijraset.com

The learning system of the ANN is similar to the training of the biological nervous system. A supervised learning mechanism was utilized in the training of the ANN in this research. Thus each input should come with its respective desired output. The inputs are 3 component vectors, a component for each of the weld parameters, F, C and T. The target is the corresponding tensile shear strength of the RSW joint that is obtained from the respective input.

The overfitting phenomenon may occur in the training while the ANN is memorizing the training data instead of building an input-output mapping for the problem in question. The overfitting problem results in drop of the ability to generalize the ANN consequently. The total data which was organized in input/output pairs were 124 and was randomly divided into two subsets [13-15].

Training subset: ANN is trained with 400 input/target pairs. The synaptic weights are repetitively updated to decrease an error function in training.

Validation subset: With 20 input/target pairs for evading overfitting and attaining good generalization by means of cross validation. If the error with regards to validation subset starts to increase, then training stops (early stopping).

The performance of the ANNs depends on the number of neurons and number of hidden layers in them. By changing the number of hidden layers and also the number of neurons in each of them, many trials need to be made to find the optimum structure for the neural network. For predicting the tensile shear strength of the RSW joint, proper neural network structure was chosen by trial-and-error method. In this paper, the number of neurons in the input and output layers of the ANN are 3 and 1 respectively. There are 10 neurons which is a hidden layer. The Log-sigmoid transfer function is the transfer function for the hidden layer, called logsig in MATLAB. For the output layer the transfer function is identity function, called purelin in MATLAB.

For estimating the ability to generalize the previously trained ANN 20 input/target pairs used for cross validation were also employed as well. An experimental output was attained for each input by presenting the 20 inputs to the ANN, Table 5.

TABLE V
TRAINING INPUTS – 8 EXPERIMENTAL DATA

F	C	T	Experimental value
1765	21000	2	331
1961	21000	2	593
1765	21000	4	434
1961	21000	4	425
1765	24000	2	467
1961	24000	2	485
1765	24000	4	524
1961	24000	4	470

Fig. 4 depicts the plot of the network outputs (ANN-output) versus the experimental outputs (E-output) as red colored spots. The perfect fit (network out-puts equal to experimental outputs) is indicated by the continuous line. The ANN has a high performance, and it can accurately map the relationship between the tensile–shear strength of the RSW joint and the process parameters is indicated by the result.

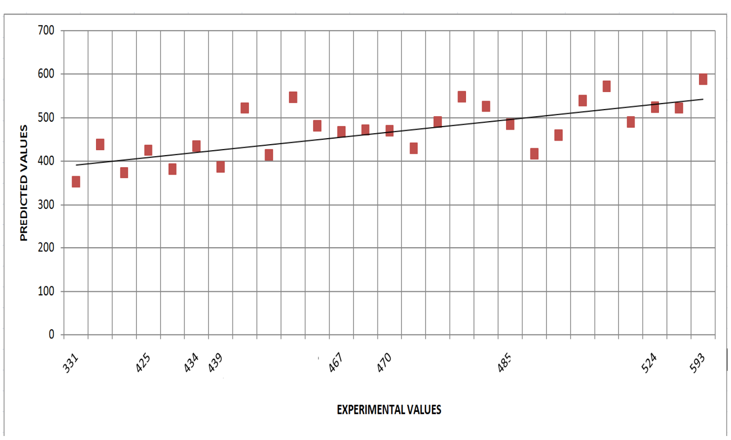


Fig. 4 Plot of 27 ANN predicted vs experimental outputs

C. Analysis of process parameters

The major advantage of ANN is that the interaction effects of process parameters are also accounted by it. It is important to pay more attention to the marching of process variables during the welding process de-sign due to complicated effects of interactions [16]. In this regard, to predict the tensile shear strength in RSW joints, ANN model has high capability to evaluate the interaction effects of parameters and hence it was employed. The mathematical function developed by the ANN was extracted and the effect of the process parameters and their interactions on the tensile–shear strength was illustrated by 3D surfaces and their contours for this purpose. The effects of interactions were showed in Figs. 5-8.

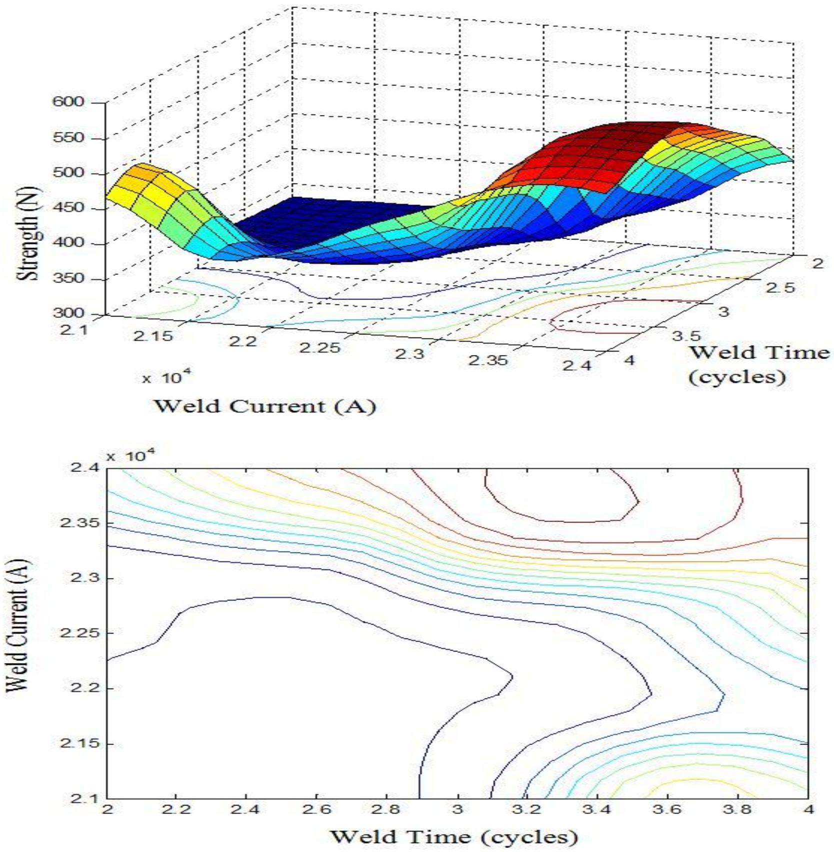


Fig. 5 Interaction of weld current and weld time when weld force is 1765 N

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue XI November 2017- Available at www.ijraset.com

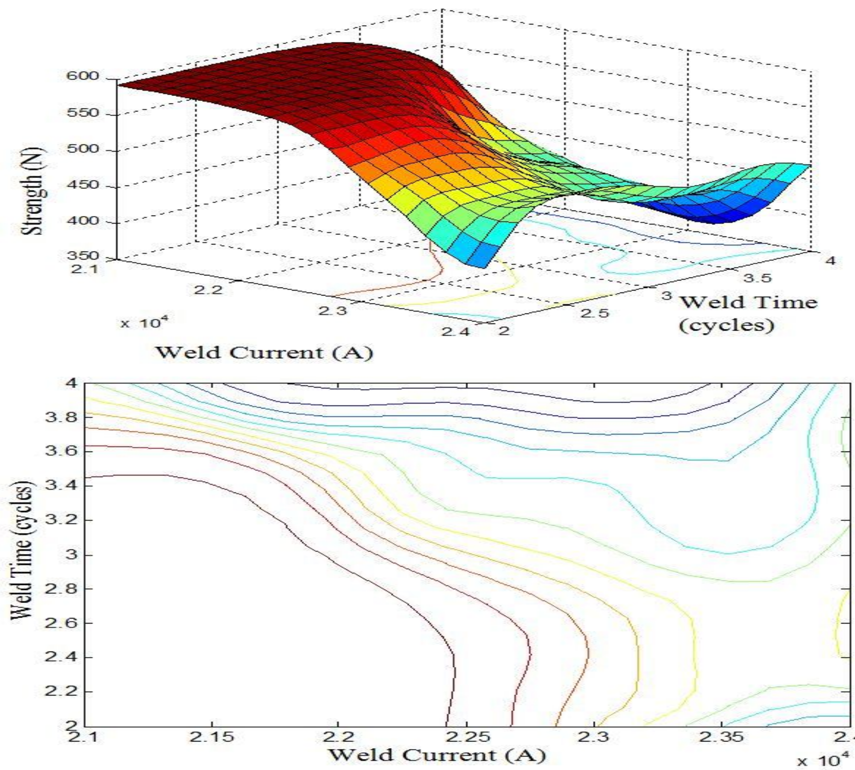


Fig. 6 Interaction of weld current and weld time when weld force is 1961 N

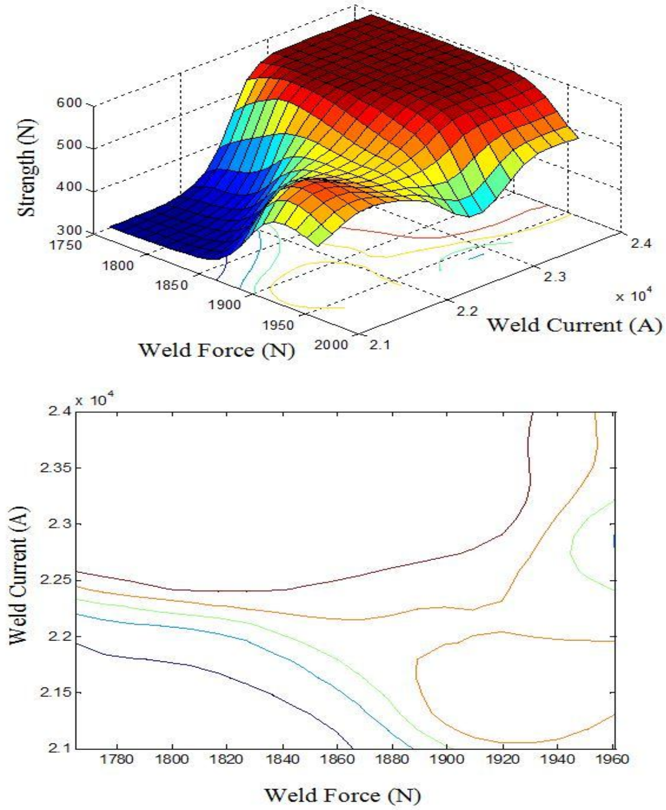


Fig. 7 Interaction of weld current and weld force when weld time is 2 cycles

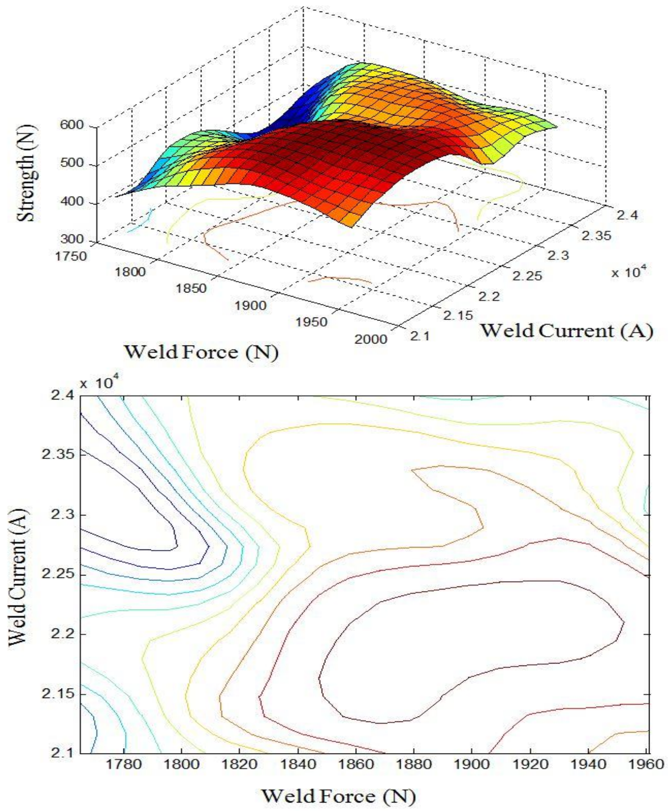


Fig. 8 Interaction of weld current and weld force when weld time is 4 cycles

The surfaces and their contours reveal the variations in the tensile–shear strength by the actions of two variables (one out of the three parameters remained constant).

The physical welding attributes such as fusion zone size, weld penetration and electrode indentation are the most important parameters governing the mechanical performance of resistance spot welds. It has been shown that weld current and weld time significantly affect these characteristics [17]. For instance, volume of melted metal is a function of heat input which is governed by the welding parameters including weld current and weld time. Fig. 5 demonstrates the interaction effect of weld current and weld time (weld force is 1765 N). As illustrated, within the range of 2–3 cycles, by increasing the weld current the strength increases at a sharp ascending rate and then remains constant in the 22.5 kA–24 kA weld current range. On the other hand, at higher weld times (3–4 cycles), by increasing the weld current to 24 kA the strength increases and then decreases. This happens due to the fact that by increasing the weld current and time more resistance heat is generated. Moreover, under the action of the excessive resistance heat generated by the large weld current and weld force, the liquid metal during nugget formation is crushed to turn into a spatter, there-by decreasing the nugget size. The input heat melts and softens the sheets and if the weld force remains constant, a deeper indentation is created. A spike in electrical current results in a large indentation and a potential burn through effect on thin metal plates [18]. Also, particularly on the high condition where the spatter is excessive, the appearance of the weld is important [19]. Furthermore, as a result of significant resistance heat, the overheating microstructure is generated in the heat affected zone and then the mechanical properties of the spot weld decreases [16].

Fig. 6 demonstrates the interaction of weld current and weld time (weld force is 1961 N). The role of the weld force in forming nugget in the RSW process is crucial, especially regarding the aluminium sheets. As can be seen, in general, by increasing the weld current, at first the strength increases and after reaching a maximum amount, it decreases. At higher weld force there is a further decrease in strength because of excessive weld force leading to accumulate a coat around the electrode to enlarge the contact area between work pieces and electrodes. Thus with this phenomenon, the resistant heat decreases because of lower current density, and then the nugget size decreases with this effect, which is also unfavorable to the quality of RSW because of the decrease in effective area to load and mechanical properties of spot weld. Another important reason for increase in strength at higher weld currents is the excessive heat generated and the liquid metal spatter. Due to the penetration of the electrodes into the work piece and the work piece crushing under these circumstances, the strength decreases.

In order to investigate the interaction effect of weld current and weld force more accurately, Fig. 7 is presented. By comparing Fig. 5 with Fig. 6, it can be concluded that the effect of the weld force at higher weld currents depends greatly on the weld time because at the higher weld time (4 cycles) the increase in the weld force contributes to a decrease in strength. However, by decreasing the weld time (2 cycles - Fig. 6) the decrease in strength is not observed any more. In other words, by decreasing the weld time the weld force parameter causes much fewer variations in the strength. Fig. 7, which illustrates the interaction effect between weld current and weld force (weld time is 2 cycles), also confirms this fact.

Fig. 8 demonstrates the interaction effect of weld current and weld force (weld time is 4 cycles). As can be seen, by increasing the weld current from the lowest level, the strength increases and it decreases after reaching to a maximum amount. This is because of the overheating microstructure which is generated in the heat affected zone.

It is still impossible to find out how to adjust the process parameters in spite of the analysis and investigations conducted on the proposed ANN, to reach the highest strength level. In other words, in the defined boundary restrictions, due to the existence of various parameters and their interaction effects, the estimation of the optimized combination of the process parameters to achieve the highest strength level of the RSW joints is a demanding task. Thus, it is essential to utilize a capable tool for obtaining the optimized combination of the process parameters. For this purpose, a Genetic Algorithm (GA) approach has been devised to obtain the optimum combination of the process parameters to reach the highest strength level in this research.

No more than 3 levels of headings should be used. All headings must be in 10pt font. Every word in a heading must be capitalized except for short minor words as listed in Section III-B.

D. Process parameters optimization using combined ANN/GA method

Genetic Algorithm is a general-purpose optimization tool which is capable and widely used for solving optimization problems in the mathematics, engineering, etc. In this research, Genetic Algorithm was employed to optimize the process parameters to obtain a set of desired values for tensile shear strength during RSW welding experiments. The aim of the process optimization is to find the optimal control variables in RSW under certain given constraints, in order to obtain the best quality of RSW joint made. On the basis of proposed ANN model the fitness function was used in the optimization procedure.

The ANN model has been implemented as the objective function of the optimization problem in this research. The boundary constraints that were used for the process window as given below:

21 kA $\leq$ weld current $\leq$ 24 kA

1765 N $\leq$ weld force $\leq$ 1961 N

2 cycles $\leq$ weld time $\leq$ 4 cycles

TABLE VV

GA PARAMETERS

GA Parameters	Value
No. of generations for evolution	200
Population size	50
Type of selection	Stochastic uniform
Probability of cross over	0.95

The GA parameters used to optimize the process parameters are listed in Table 6. The reciprocal of the objective functions were used as the fitness functions as the objective functions were the maximum values of the strength of the RSW joints. The proposed ANN model presented in this research was optimized by GA code. The neural network prediction of the tensile shear strength of the RSW joint, under the optimized process conditions, was 588.79 N. This value is higher than all of the train and test samples. This is
An actual experiment was carried out based on the optimized process parameters in order to evaluate the correctness of the value predicted by the proposed GA and the obtained result was compared with that of the GA predicted result. The results given in Table 7 show that the modeling approach presented in this study can accurately predict the strength values of RSW joints. In determining the optimal set of process parameters the developed optimization approach had showed a desired performance.

TABLE VII

PREDICTED TENSILE–SHEAR STRENGTH OF THE RSW JOINT UNDER OPTIMUM PROCESS PARAMETERS AND EXPERIMENT VALUE

F (N)	C (kA)	T (cycles)	Predicted value by GA	Experiment value
1961	21	2	588.79	593

IV. CONCLUSIONS

The regression analysis reveals that there is a non-linear relationship between the weld parameters and the tensile shear strength of the RSW joints. For modeling the complex relationship between the process parameters and the quality index (tensile shear strength) of the RSW, the proposed ANN 4-10-1 was an effective tool.

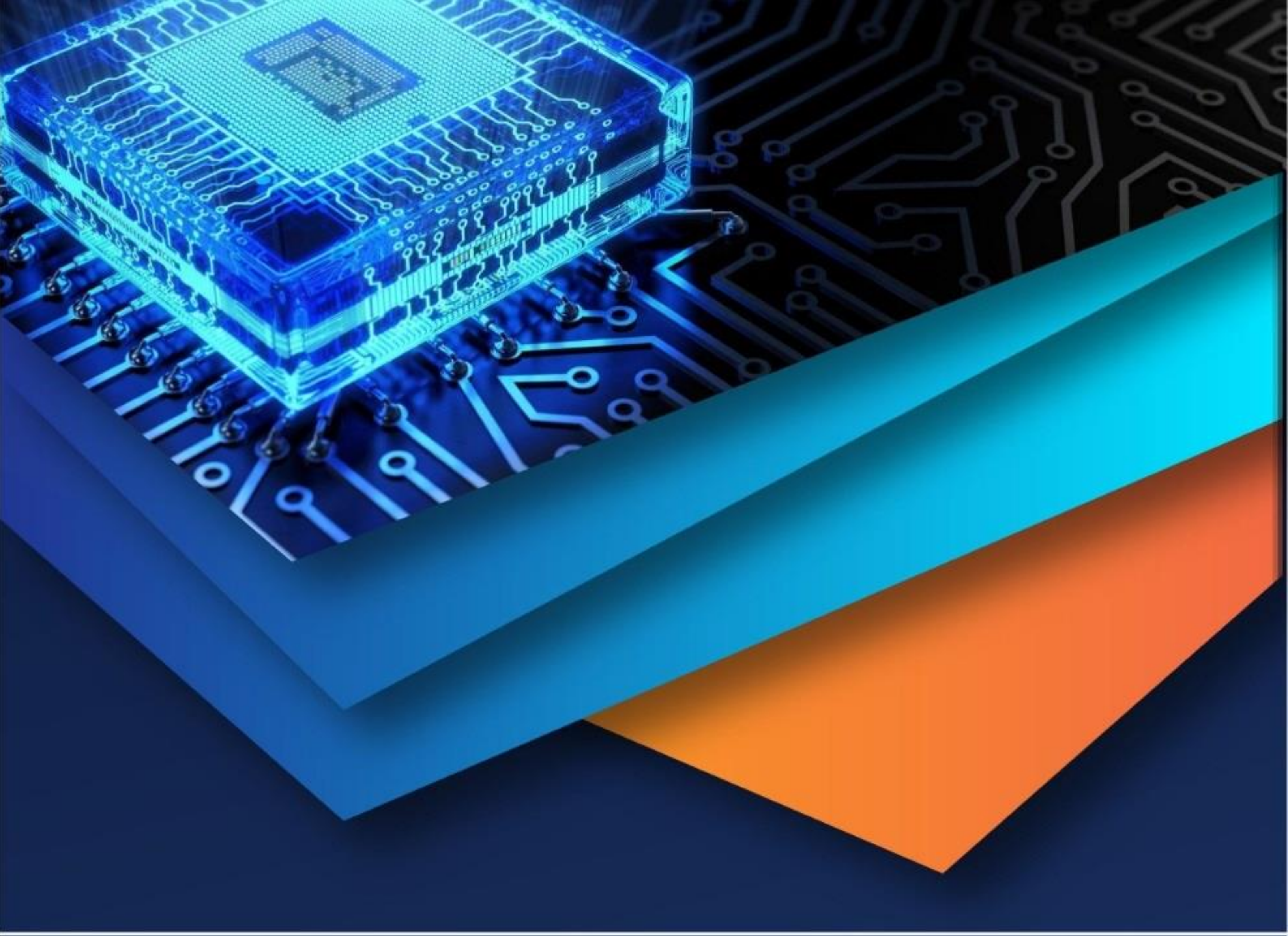
On the basis of the ANN model, the effects of weld parameters and their interactions on the tensile shear strength were analyzed. This can provide a beneficial reference for the RSW process of aluminium alloy sheets. The combined ANN / GA optimization procedure proposed in this paper provides decent results for the optimization of the RSW process. The results obtained by the optimization parameters from GA were successfully verified against the actual experimental data.

V. ACKNOWLEDGMENT

The authors would like to thank the authorities of Ordnance Factory, Medak, for their permission to conduct the experimental work on the Hydraulic RSW machine (200KVA). The authors would like to thank the Principal; and the Head of the Department of Mechanical Engineering of Institute of Aeronautical Engineering for their encouragement, support and granting permission to publish this work. The authors also express their sincere thanks to the authorities of JNTU Hyderabad for their support and permission to present this work.

REFERENCES

[1] Y.CHO, W. LEE and S.J. HU, “Design Of Experiment Analysis and Weld Lobe Estimation for Aluminium Resistance Spot Welding”, Welding Research Journal, March 2006.
[2] Kolahan Farhad, Heidari Mehdi. Modeling and optimization of MAG welding for gas pipelines using regression analysis and simulated annealing algorithm. J Sci Ind R 2010;69:177–83.
[3] Özyürek. An effect of weld current and weld atmosphere on the resistance spot weldability of 304L austenitic stainless steel. J Mater Des 2008;29: 597–603.
[4] Zhou M, Zhang H, Hu SJ. Relationships between quality and attributes of spot welds. Weld J 2003;4:72s–7s.
[5] Zhou M, SJ Hu, Zhang H. Critical specimen sizes for tensile–shear testing of steel sheets. Weld J 1999;78(9):305s–13s.
[6] Hornik K, Stinchcombe M, White H. Multilayer feedforward networks are universal approximators. J Neural Network 1989;2:359–66.
[7] Mathew MD, Kim DW, Ryu WS. A neural network model to predict low cycle fatigue life of nitrogen-alloyed 316L stainless steel. J Mater Sci Eng, A 2008;474:247–53.
[8] Ates Hakan. Prediction of gas metal arc welding parameters based on artificial neural networks. J Mater Des 2007;28:2015–23.
[9] Abdulkadir Cevika M, Kutuk Akif, Erklig Ahmet, Guzelbey Ibrahim H. Neural network modeling of arc spot welding. J Mater Process Technol 2008;202:137–44.
[10] Martín Óscar, Tiedra PilarDe, López Manuel, San-Juan Manuel, García Cristina, Martín Fernando, et al. Quality prediction of resistance spot welding joints of 304 austenitic stainless steel. J Mater Des 2009;30:68–77.
[11] ISO 14273. Specimen dimensions and procedure for shear testing resistance spot, seam and embossed projection welds; 2000.
[12] Woll SLB, Cooper. Pattern-based closed-loop quality control for the injection molding process. J Polym Eng Sci 1997;37:801–12.
[13] Bishop. Neural networks for pattern recognition. New York: Oxford University Press; 1995.
[14] Haykin. Neural networks: a comprehensive foundation. 2nd ed. Upper SaddleRiver, (NJ): Prentice-Hall; 1999.
[15] Guessasma Coddet. Microstructure of APS alumina–titania coatings analysed using artificial neural network. J Acta Mater 2004;52:5157–64.
[16] Yi L, Jinhe L, Huibin X, Chengzhi X, Lin L. Regression modeling and process analysis of resistance spot welding on galvanized steel sheet. J Mater Des 2009;30:2547–55.
[17] Goodarzi M, Marashi SPH, Pouranvari M. Dependence of overload performance on weld attributes for resistance spot welded galvanized low carbon steel. J Mater Process Technol 2009;209:4379–84.
[18] Florea RS, Solanki KN, Bammann DJ, Baird JC, Jordon JB, Castanier MP. Resistance spot welding of 6061-T6 aluminum: failure loads and deformation. Mater Des 2011;34:624–30.
[19] Weiss KE. Paint and coatings: a mature industry in transition. J Prog Polym Sci 1994;22:203–45.



10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY