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ISSN 0543-5846
METABK 58(1-2) 91-94 (2019)
UDC – UDK 620.193:669.715:621.791.052:621-41:517.1=111

OPTIMAL CORROSIVE BEHAVIOUR ON THE WELDMENT OF AA6063 ALUMINUM ALLOY BY TUNGSTEN INERT GAS (TIG) WELDING PROCESS WITH BACKING PLATES

Received – Primljeno: 2018-06-18
Accepted – Prihvaćeno: 2018-09-20
Original Scientific Paper – Izvorni znanstveni rad

Pertaining on the present work on improving the corrosion resistance of AA 6063 aluminum alloy is found to weld with many backing plate materials like stainless steel, copper, marble and brass in accordance to the welding process that inherits itself with TIG. Utilizing the Orthogonal array L16, experiments were carried out. The corrosion resistance was improved by optimizing the pulsed TIG welding process parameters like current (A), gas flow rate (B), backing material (C) and backing thickness (D) using Genetic Algorithm (GA). Results proved that the GA shows a better corrosion resistance rate that was obtained to about 0,0408 mm/year with the backing material as copper.

Key words: corrosive, AA 6063 alloy, welding, backing plates, Taguchi method

INTRODUCTION

In days of recent, sectors such as the defense, automobile and aerospace, the need of high strength to weight ratio is obtained in the joining process [1]. When it comes to conventional methods in welding titanium alloys, it adapts tungsten inert gas (TIG) welding, friction welding, electron beam welding and laser welding. Out of these titanium adapts to the TIG welding that is commonly used for alloys that come in sheet form. One of the major pull back of the TIG welding is that it has a high input of heat, high risk of contamination and severe distortion [2].

The Tungsten inert gas has been used for quite a couple of years although the fusion welding of aluminum portrays a great challenge. Thick aluminum alloy plates were joined using the process of double sided TIG welding [3]. The main cause of the defect formation in stir zone is due to a small summed diameter resulted in insufficient heat generation and flow of materials that are plasticized of smaller contact area. These parameters can be rectified and controlled with the help of a suitable back plate [4]. Completion of welding in a successive way owes itself to the back plate material diffusivity. The input process parameter depends to the quality of the weld joint. It was found a problem to the manufacturer within the control of input process parameters to get a good welded joint with a withstanding quality. Operators and engineers who were skilled chose the parameters which consumed more time like the trial and error method that took time for every new product to obtain a welded joint according to expectations. it is then examined whether welds meet the required specifications or not [5]. The corrosion of the welded resistance of various regions formed during welding do not result the same. Earlier related studies state that the welded zones of most points are susceptible to corrosion. Cases relating the causes of resistance to the corrosion are incorrect design of the edges, wrong selection of filler, residual stress, crack and porosity. [6]. These days the adaptation of design of experiment (DOE). Computational network and evolutionary algorithms are used to up bring mathematical relationships between the welding process that relates the input parameter and the output variables of the weld joint, so that the determination of the welding input parameters lead to a desired weld quality [7]. Mathematical models develop in many ways to bring about the control of welding quality, production, weld properties in weld process and micro structure [8]. The genetic algorithm has become popular in the years of recent where it helps useful tools to develop models that express an interrelationship between the input and output of the complicated system [9].

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EXPERIMENTAL METHODOLOGY MATERIAL SELECTION

Relating this study, the commercial availability AA 6063 aluminum alloy was utilized in this process. Designing of base metal is fabricated to the size about 100 mm in length, 50 mm width and 6 mm in thickness plate.

EXPERIMENTAL PROCEDURE

In the experimental process, current (A) gas flow rate (B) Backing material (C) and backing thickness (D) are the parameters for the key control process. The four different backing plate materials such as brass, marble, stainless steel and copper are carried out through the process of Gas Tungsten arc Welding (GTAC). It is carried out in order to examine the corrosion resistance of work piece. The backing plates are done at a length of 140 mm, width of 50 mm and with a difference of thickness of 3 mm, 6 mm, 9 mm with the assistance of a round nose milling cutter 5 mm diameter groove 1 mm depth was taken on the upper side of the backing plate. Taking the principles of Taguchi method, sixteen samples were prepared by combinations of current (A) gas flow rate, current (B) backing material (C) and backing thickness (D). The Linear Polarization Resistance, commonly known as the electro chemical technique is taken into adoption to measure the resistance of corrosion for the samples in terms of mm/year. The process parameters are listed in Table 1 and the experimental values with responses that are measured is also shown in Table 2. The samples that were welded are shown in Figure 1.

Table 1 **Ranges of process parameters**

Parameters	Level			
	1	2	3	4
A / amp	125	135	145	155
B / l/min	5	7	9	11
C	Cu	Stainless Steel	Marble	Brass
D / mm	0	3	6	9

Taking notification from the experimental analysis of sample no 11, the average gas flow rate and the average above current provides good corrosion resistance to the welded specimen. The measurement in corrosion resistance utilizing Linear Polarization Resistance (LPR) is portrayed in Figure 2

RESULTS AND DISCUSSION OF OPTIMIZATION

Analysis of variance is said to be a standard statically technique used to analyze each process parameters in order to provide confidence. In terms of calculation

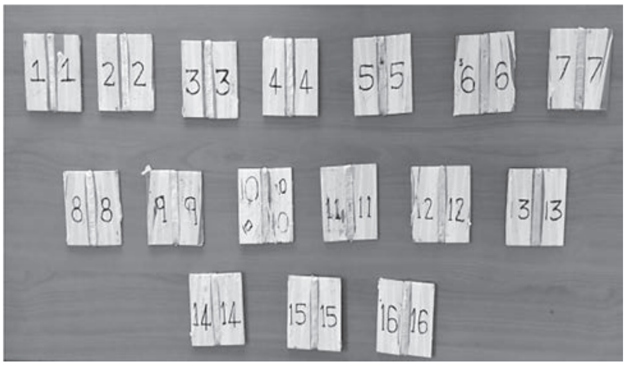

Figure 1 Welded samples

Table 2 **Experimental values**

A / amp	B / l/min	C	D / mm	Corrosion rate / (mm/year)	Signal to noise (S/N) Ratio
1	1	1	1	0,23456	12,5949
1	2	2	2	0,05457	36,7308
1	3	3	3	0,16578	15,6094
1	4	4	4	0,97164	0,2499
2	1	2	3	0,78907	2,0577
2	2	1	4	0,34666	9,2019
2	3	4	1	0,15158	16,3872
2	4	3	2	0,57537	4,8011
3	1	3	4	0,86758	1,2338
3	2	4	3	0,77963	2,1622
3	3	1	2	0,16028	15,9024
3	4	2	1	1,0987	-0,8176
4	1	4	2	0,45894	6,7649
4	2	3	1	0,43157	7,299
4	3	2	4	0,52189	5,6484
4	4	1	3	0,61906	4,1653

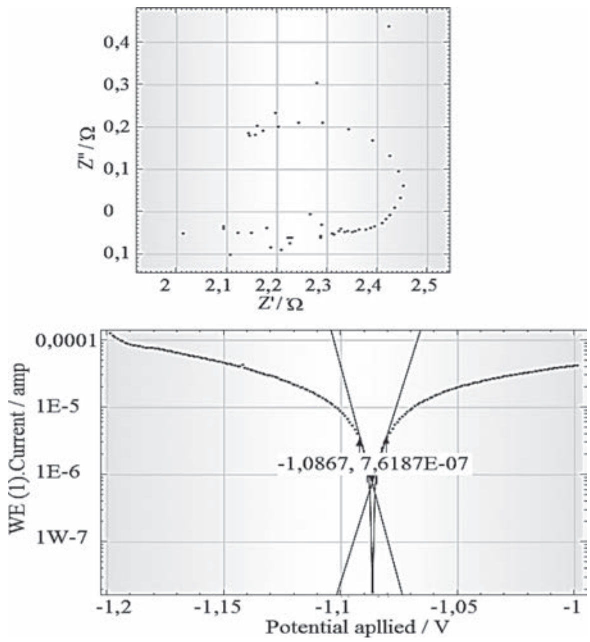

Figure 2 Linear polarization and impedance

of contribution of corrosion rate, the method of ANOVA is adopted. To this investigation the contribution in percentage of each parameter is shown clearly in Figure 3 which obtains the parameters most influencing parameters to the corrosion rate and it is done by means of MINTAB software. The process considered to be important at the most in calculating the percentage is backing thickness 60 % (mm) falling with backing material which is about 20 % current (amp) about 12 % and finally gas flow rate (l/min) is about 19 %. The corrosion rate that is a part of the output parameter measures the mean and the signal to noise ratio to get the quality of the welded work piece that is idolized by the process parameter. Figures 4, 5, 6 and 7 shows the mean and ratio of S/N of corrosion resistance. From this it is understood that the corrosion rate of the joint of the welded sample is achieved by the S/N ratio value in smaller proportion. Taguchi analysis states that, the state of corrosion stood minimum at a process parameters welding current 125 amp, gas flow 7 l/min, stainless steel lies as the backing material with the backing thickness of 3 mm. The value of square that stand in correlation coefficient (R) are (R^2) (91,6 %) and adj R^2 (85,1 %) towards the modeling equation of average corrosion resistance. The closeness of the model that represents the process is indicated by the value R^2. To obtain the optimal corrosion rate the deriving method of regression analysis if further used for the investigation. Formation of the regression equation is assisted by Taguchi L_{16} orthogonal array. It uses the input and output parameters. The factor A, B, C, D undergoes correlations between themselves and is further obtained by multiple linear regression that are given below in equations.

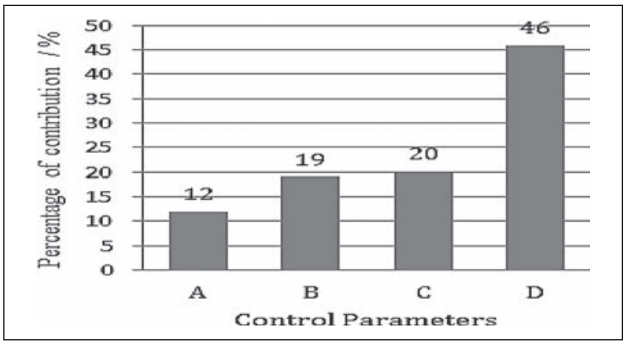

Figure 3 Percentage contribution

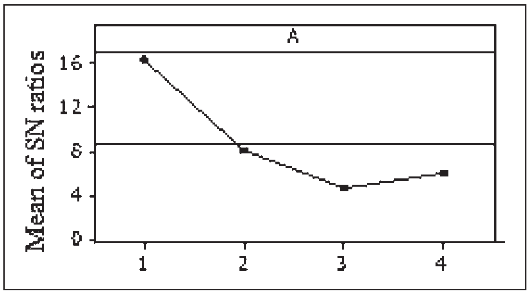

Figure 4 Mean of S/N ratios for current

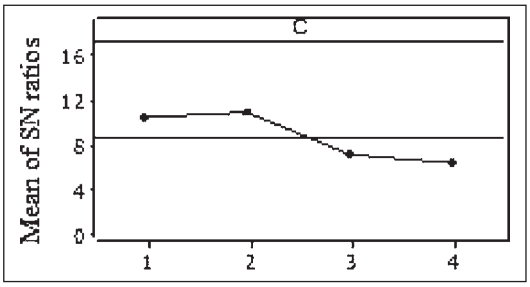

Figure 5 Mean of S/N ratios for gas flow rate

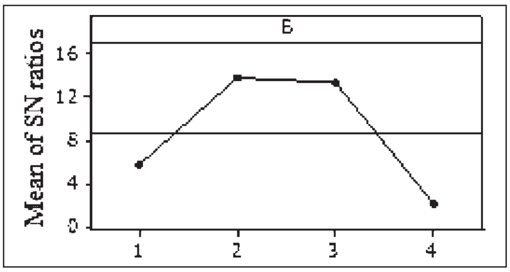

Figure 6 Mean of S/N ratios for backing material

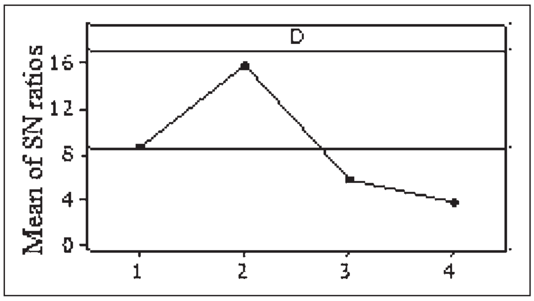

Figure 7 Mean of S/N ratios for backing thickness

$$\text{Corrosion rate} = -1{,}66212 + 3{,}61714\,A - 1{,}63234\,B + 4{,}02121\,C - 3{,}61780\,D - 0{,}89112\,A^2 + 0{,}19018\,B^2 - 0{,}44973\,C^2 + 0{,}42337\,D^2 + 0{,}22259\,AB + 0{,}08911\,AC - 0{,}13905\,BC - 0{,}71405\,B\,C + 0{,}80669\,BD \quad (1)$$

OPTIMIZATION USING GENETIC ALGORITHM

With limited constraints taken into consideration the investigation of genetic algorithm is employed for optimization. The predicting of optimal relationship between welding process parameters and corrosion rate has been employed through the genetic algorithm which works through the development regression model. This kind of functioning was carried to the GA toolbox of MATLAB 2010 as the objective function. In the portrayal of Figure 8, it shows that the distributed points generate itself from the optimization of responses. Crossover fraction (0,08), population size (100) and population fraction (0,35) were selected with the critical parameters that conjoined with GA. In results it was found that better corrosion rate 0.0408 mm/year was obtained for optimum process parameters like current 155 amp, gas flow rate 5 l/min, copper as backing material and backing thickness of 6 mm.

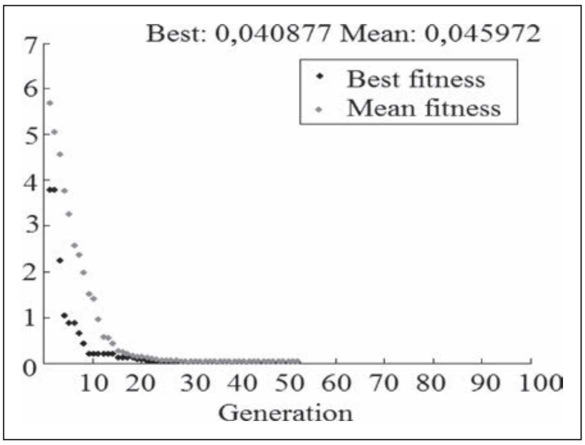

Figure 8 GA predicted result

EXPERIMENTAL VALIDATION

When comparing the predicted versus actual, observations show that the percentage of error lies within ± 5,95 % towards Taguchi results and ± 4,68 % towards genetic algorithm results. Thus the results of validation show that the model carries a good agreement between the responses and process parameters.

CONCLUSION

Conclusions states that Taguchi analysis and GA predicted corrosion rate by optimizing parameters of welding from this investigation results are as follows.

- The most important process parameters from calculations shows that backing thickness (mm) of 60 % shows that backing material is about 20 %, current (amp) of 12 % and finally gas flow rate (l/min) is about 19 %.
- Valuable data that is predicted from the vast range if experimental database provided by the quadratic regression model that is developed.
- Findings from Taguchi analysis states that corrosion rate is minimum at process parameter welding current 125 amp, gas flow rate 7 l/min, backing material is stainless steel and the thickness is 3 mm.
- Results showed by GA states that a better corrosion rate of 0,0408 mm/year was obtained towards optimum process parameters like current 155 amp, gas flow rate 5 l/min, backing material as copper and backing thickness 6 mm.
- The Taguchi and GA results that are validated to the developed model has positive agreement when it relates process parameters and responses.

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Note: The responsible translator for English language is Mr.Fabian Netto, HOD of Languages, Peepal Prodigy Groups, Coimbatore, India.