

Corrosion Studies Of Diffusion Bonding On Aluminium -Fly Ash (ALFA) Composites By Taguchi Technique

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Abstract. In this study, the corrosion behaviour of Diffusion Bonding (DB) on Aluminium Fly Ash (ALFA) composites was investigated. Bonding parameters were optimized for maximization of corrosion resistance on Taguchi design of experiments (L9 orthogonal array) with three bonding parameters such as temperature, pressure, and time. The corrosion behaviour of bonded ALFA composites was investigated using polarization in 3.5 wt% NaCl solution. Analysis of variance (ANOVA) was used to examine the results. The optimum bonding parameter combination for minimum corrosion behaviour is A1B1C3, which is 450°C (temperature), 8MPa (pressure), and 20 minutes (time). The corrosion resistance of bonded ALFA composite is predicted to be optimal at 0.04387. A confirmation test is used to validate the results.

Keywords— Diffusion bonding, Aluminium – Fly ash, Taguchi technique, ANOVA

1. INTRODUCTION

Diffusion bonding is one of the promising techniques to join alloys as there is no melting occurs during bonding and absence of contamination at the

weld joints. The metals are brought in close proximity to each other with heating and the metal surface is subjected to compressive pressure to near plastic state and by giving upset pressure to get the diffusion bonding [1]. Diffusion bonding has exhibited superior joint strength when joining dissimilar materials [2]. In

recent years nonferrous metal aluminum alloys drawn more attention in application to marine, aerospace and automobile industries due to high strength to weight ratio, together with its natural ageing characteristics. Diffusion bonding process involves application of different parameters like bonding Temperature, bonding pressure, holding time to get the formation of the bonding of the samples. It is carried out at high pressure, shorter processing time and temperature below melting point [3]. The aim of the present work is to study the effect of diffusion bonding process parameters such as bonding temperature, bonding pressure and bonding time for corrosion rate while bonding of Aluminum fly ash composites. By the application of Taguchi method, optimum process parameters are identified. the corrosion studies carried out at the diffusion bonded zone might be useful & appropriate. The corrosion evaluations were carried out by electro chemical method. Polarization resistance measurements are done to measure the general corrosion rate.

2. Design of Experiments

Taguchi technique is used to improve the process to make a quality product. It is utilized to minimize the number of experiments and satisfy all possible combination of process parameters. Taguchi L9 orthogonal array is utilized in this study. It has 3 process parameters and 3 levels of the orthogonal array as L9 . It has 9 sets of process parameters combine to optimize bonding parameters for getting maximizing corrosion resistance of bonded ALFA composites. Taguchi is utilized to find optimal parameter design and significant factor(4). Taguchi approach uses Signal to Noise (S/N) ratio is used to find out the quality characteristics for engineering applications. S/N ratio has three criteria such as Lower the better (LB), Higher the better (HB) and Nominal the best (NB). In this study, our requirement is the minimization of corrosion density alone for that LB criterion was chosen. LB criteria were calculated by the equation 1

$$S/N \text{ ratio}_{LB} = -10 \log \left[\frac{1}{n} \sum_{i=1}^n Q_i^2 \right] \dots\dots (1)$$

From the response table for optimal parameter combination to select by the higher average value of each level.

3. Materials and Experimental Procedure

AA6061 Aluminium alloy used in this study and its chemical composition are presented in the table. 1. Reinforcement used in this study was fly ash (type 'c') and its size 1-100 μm . The chemical composition of fly ash is tabulated in Table 2. The aluminum reinforced with fly ash (6%) was prepared by stir casting process. The fabricated aluminum fly ash composite samples (45mmX45mmX8mm) were joined by the diffusion bonding process and the machine setup as shown in Fig. 1The polished and chemically treated specimens were stacked one over the other in a die made of H-13 AISI Tool Steel and the entire diffusion bonding setup, shown in bonding machine, and inserted into a vacuum chamber (vacuum pressure of 29 mm of Hg was maintained). The specimens were heated up to the bonding temperature using induction furnace with a heating rate of 25°C/min. Identical soaking timings were given for all the pairs of the alloy subjected to diffusion bonding. After the completion of process, the samples were cooled to room temperature before removal from the chamber. The results of the test conducted for the specimen are given in TABLE 4. Based on the tested values nine samples were selected for further corrosion studies.

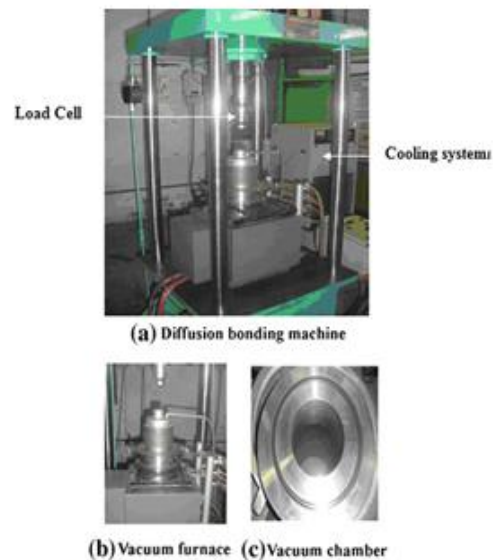


Fig.1. Diffusion Bonding machine setup



Fig 2 Stir casting machine set

Table. 1 Chemical composition of Aluminium AA6061 alloy by % wt.

Mg	Si	Fe	Mn	Cu	Cr	V	Al
0.9	0.6	0.2	0.03	0.2	0.1	0.01	Bal

Table.2 Chemical Composition of Fly ash by % wt.

SiO ₂	Al ₂ O ₃	CuO	K ₂ O	CaO	MgO	TiO ₂	FeO
51.4	29.65	4.86	1.57	2.87	1.72	2.54	5.39

Table.3 Process parameters and their levels

Control Factor	Unit	Factor	Level		
			1	2	3
Bonding temperature	°C	A	450	475	500
Bonding pressure	MPa	B	8	9	10
Bonding time	Min	C	45	30	20

Table.4 L9 orthogonal table for corrosion current density

Experiment	A	B	C	i_{corr} ($\mu A/cm^2$)	S/N ratio
1	1	1	1	0.044	27.072
2	1	2	2	0.072	22.817
3	1	3	3	0.054	25.433
4	2	1	2	0.099	20.114
5	2	2	3	0.066	23.636
6	2	3	1	0.085	21.391
7	3	1	3	0.099	20.070
8	3	2	1	0.102	19.803
9	3	3	2	0.128	17.890

Taguchi approach is efficient method to optimize the process parameters and it reduces number of experiments (5,6). Taguchi analysis to be achieved through signal to noise (S/N) ratio. The aim of this study is to achieve corrosion rate for that S/N ratio of smaller the better criteria is used. The response table was developed by the application of Taguchi approach. It is used to find the optimal parameters to achieve high yield of responses. Values of the response table to calculate by the average value of each level of the column in the orthogonal array. Table.5 shows the response table for corrosion rate (S/N ratio). Table.5 shows the response table for bonding strength (S/N ratio). Optimal bonding parameters for high yield of bonding strength (S/N ratio) are A1B1C3. such as 450°C of temperature, 8MPa of pressure and 20 minutes of time.

Table .5 Response table for S/N ratio
(Smaller is better)

Level	Factor		
	A	B	C
1	25.11	22.42	22.76
2	21.71	22.09	20.27
3	19.25	21.57	23.05
Delta	5.85	0.85	2.77
Rank	1	3	2

Table.6 Results of ANOVA

Control Factor	Dof	Sum of Squares	Mean squares	F - Test	% Contributi
Bonding temperature	2	51.829	25.915	15.37	73.8
Bonding pressure	2	1.093	0.546	0.32	1.6
Bonding time	2	13.930	6.965	4.13	19.84
Error	2	3.372	1.686		4.80
Total	8	70.224			

ANOVA is used to investigate process parameters and identify which process parameters are significantly affecting bonding strength. ANOVA calculated and presented the table .6. From the ANOVA table, most significant parameter is bonding temperature it

influences 73.8% followed by 19.84 % of bonding time and 1.6% of bonding pressure. Both Taguchi and ANOVA analysis identify bonding temperature most significant factor than the others.

4. Conclusion

In this investigation, corrosion studies diffusion bonded Aluminium Fly ash composites analyzed by the Taguchi approach. The results were summarized as follows:

The L9 Taguchi orthogonal designed experiments of diffusion bonding of AFA composites were successfully conducted.

The optimum bonding parameter combination for minimum corrosion behavior is made as A1B1C3 such as 450°C (temperature), 8MPa (pressure), and 20 minutes (time). The predicted corrosion current density is 0.04387.

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