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OPTIMIZATION OF MIG WELDING PARAMETERS ON TENSILE STRENGTH OF ALUMINUM ALLOY BY TAGUCHI APPROACH

Vivek Saxena*, Prof. Mohd. Parvez, Saurabh

* Research Scholar, Al-Falah School of Engineering & Technology. Dhauj, Faridabad,Haryana
Professor, Department of Mechanical Engineering, Al-Falah School of Engineering & Technology Dhauj,Faridabad,Haryana
Assistant Professor, Department of Mechanical Engineering, ABES Engineering College,Ghaziabad,U.P

ABSTRACT

In present days Alloy of aluminum is widely used due to its versatility especially in automotive industry. Most of the component is made by casting but some may require welding too. These components are loaded statically and dynamically as per application. Due to these reason corresponding strength is needed to be insured for the product having welded joint. This paper unveiled the influence of welding parameters on tensile strength of AM-40(EN AW 5083) aluminum alloy material during welding. A Set of experiments on MIG Welding Set up based on Taguchi technique has been used. An analysis of variance (ANOVA) accompanied with regression analysis and orthogonal array of size L9, is employed to study the characteristics of welding for a material & optimizes the welding parameters. The result computed is in form of percentage contribution factor from individual parameter, by which optimal parameters are identified for maximum tensile strength. From this study, it is observed that welding current and welding Voltage are major parameters which influence on the tensile strength of welded joint.

KEYWORDS: MIG welding, optimization, orthogonal array, ANOVA, Regression Analysis.

INTRODUCTION

The problem that has faced by the manufacturer is the control of the process input parameters to obtain a good welded joint with the required weld strength. Traditionally, it has been necessary to study the weld input parameters for welded product to obtain a weld joint with the required quality. To do so, it requires a time-consuming trial and error development method. Then welds are examined whether they meet the requirement or not. Finally the weld parameters could be chosen to acquired a welded joint that scrupulously meets the joint qualities. Also, what is not achieved or often considered is an optimized welding parameters combination, since welds can often be formed with very different parameters. In other words, there is often a more ideal welding input parameters combination, which can be used. In order to overcome this problem, various optimization methods can be used to define the desired output variables through developing mathematical models to specify the relationship between the input parameters and output variables. Design of experiment (DOE) techniques has been applied to carry out such optimization. Taguchi method have been adapted for many applications in different areas. MIG welding is carried out on weld set up that provides the power to weld the work piece at a given welding current and to feed the welding torch at specified travel speed at specified voltage. Therefore three welding parameters namely travel speed, welding voltage, welding current are need to be determined in a welding operation.

Performance evaluation of welding is based on the performance characteristics like cyclic time, power source, metal transfer technique, electrode size and composition, electrode stick out, shielding gas etc. The quality of weld surface depend upon factors that are surface finish and weld strength. Whenever two surfaces come in contact with one another, the quality of their joint plays an important role in the performance . The height, shape, arrangement and direction of these surface irregularities with the required strength of the work piece depend upon a number of factors such as:

a) Travel speed.
b) Welding current.
c) Welding Voltage.

d) Type of Power source.
e) Type of shielding Gas.
f) Electrode size and composition
g) Gas Flow rate etc.

Optimization refers to technique of allocation of scarce resources to give best possible effect. The Taguchi method is a well known technique that provides a systematic and efficient methodology for design and process optimization. This is due to the advantage of the design of experiment using Taguchi's technique that includes simplification of experimental plan and feasibility of study of interaction between different parameters. Analysis of Variance (ANOVA) is then used to determine which process parameter is statistically significant and the contribution of each parameter towards the output characteristic.

LITERATURE REVIEW

The controlled factors in a welding process are, welding current, welding voltage and Travel Speed etc; each of which may have an effect on strength bead geometry[1,2,3,4,5]. Welding current and welding voltage were found to have differing levels of effect in each study, often playing a stronger role as part of an interaction. The controlled parameters in a welding process that under normal conditions affect tensile strength most profoundly are travel speed and welding current by patil & waghmare [2]. Prakash, S.P.Tewari, Bipin Kumar Srivastava[7] suggest that varying proportion of helium and argon may improved aluminum weld quality. Satyaduttsinh P. Chavda,Jayesh V. Desai and Tushar M. Patel[8] states the review as identifying the main factors that have significant effect on weld joint strength and weld pool geometry and compare the experimental result with FEA for optimizing parameter. S.Utkarsh, P. Neel, Mayank T Mahajan, P.Jignesh, R. B.Prajapati[9]. Sheikh Irfan and Vishal Achwal [10] investigate that Travel speed when increased while keeping voltage and current constant depth of penetration increased. H.J. Park , D.C. Kim b, M.J. Kang , S. Rhee [11] evaluated bead characteristics by optimizing wire feed rate against Welding Speed. R Quintana, A Cruz, L Perdamo and G Castelannos[12]studied transfer efficiency of alloying in material in MIG welding. Sukhomay Pal, Santosh K. Malviya, Surjya K. Pal and Arun K. Samantaray[13] studied optimization of quality characteristics parameters in a pulsed metal inert gas welding process using grey-based Taguchi method. K.Y. Benyounis and A.G. Olabi[14] The optimization methods used in this study are appropriate for modeling, control and optimizing the different welding process. P. Srinivasa Rao, O. P. Gupta, S. S. N. Murty and A. B. Koteswara Rao[15] studied the effect of process parameters and mathematical model for the prediction of bead geometry in pulsed GMA welding. arc welding by taguchi approach. Huang[16] presents the effect of each welding parameter on the weld bead geometry, and then sets out to determine the optimal process parameters using the Taguchi method to determine the parameters. S.C. Juang and Y.S. Tarng [17] studied the process parameter selection for optimizing the weld pool geometry in the tungsten inert gas welding of stainless steel. Ehsan Gharibshahiyan[18] describe effect of microstructure on surface hardness and toughness of steel.

These review demonstrate that the use of Taguchi parameter design in order to identify the optimum Tensile Strength with a particular combination of welding parameters in a MIG welding operation is considerable option to find a systematic approach.

PROBLEM DESCRIPTION

Tensile Strength is one of the important criteria for a component which is undergoing static and dynamic loading condition so optimization of parameters responsible for welding is essential so as to investigate and find improved strength. Aluminum alloy AM-40 is an alloy having good weldability, corrosion resistance and fatigue strength so it is frequently used in automotive industry.

MIG welding is best suited option for welding of Aluminum alloy. The Quality of weld Product on a MIG Welding Set up is controlled by Welding Current, Welding Voltage, Travel Speed ,Type of shielding gas Etc. which are frequently determined based on the job shop experiences. However, the Set up performance and the product characteristics are not guaranteed to be acceptable as per strength criteria . Therefore, the optimum welding conditions have to be accomplished.

PARAMETER IDENTIFICATION

The input parameters which affect the mentioned output parameters are numerous such as:

1. Welding current.

2. Welding voltage.
3. Travel speed.
4. Shielding gas
5. Metal transfer technique.
6. Electrode extension.
7. Feed wire material composition and size.
8. Operator's skill

Out of these parameters there are three parameters chosen for experimental work. The following process parameters were selected for the present work:
Welding current – (A),
Welding Voltage – (B),
Travel Speed – (C),

In combination of speed, voltage and current were the primary factors investigated while the secondary factors were not considered in the present study. In this study, $L_9(3^3)$ orthogonal array of Taguchi experiment was selected for three parameters with three levels for optimizing the objective (Tensile strength) in MIG welding .

EXPERIMENTAL PROCEDURE

Aluminum alloy work piece (ø=22 mm) is taken for analysis. It is machined up to (ø=20mm) .They are welded by considering following variation in parameters. Welding current is varied as 260,270 and 280 amp. Welding voltage is varied as 20,21,22 V. Travel Speed is varied as 7,8,9 M/min.

MIG weld set up is DC output power source. Shielding Gas is Argon –Helium mixture. Metal transfer is short circuiting metal transfer technique. After Welding is performed there are nine work pieces tested on universal testing machine up to fracture to get experimental strength value. With all the viewpoints, this study proposes "an optimization approach" using orthogonal array, ANOVA, S/N ratios to optimize precision welding condition to get improved tensile strength.

Material composition is shown in Table no .1

Material	Al	Mg	Mn
Al- Alloy	94.8%	4.5%	0.7%

Table No.1: Chemical composition of AM-40

The Welding Wire selected for the application is ER5356.
Through the examination of Tensile strength; the objectives is then obtained. The multiple objectives can additionally be integrated and introduced as the S/N (signal to noise) ratio into the Taguchi experiment. The mean effects for S/N ratios are moreover analyzed to achieve the optimum welding parameters. Through the verification results, it is shown that tensile strength from present optimum parameters are greatly improved. welding operation experiments were carried out on a MIG weld set up that provides the power to weld the work piece at a given condition of parrameters. Table For Process Parameters and their are shown in table No 2 and 4.

Parameters	Symbols	Units	Level – 1	Level – 2	Level – 3
Welding current	A	Amp.	260	270	280
Welding Voltage	B	V	20	21	22
Travel Speed	C	M/min.	9	8	7

Table 2: Parameters and their levels

Experimental Layout design is shown in Table no 3

Exp No.	Welding Current (A)	Welding Voltage (B)	Travel Speed (C)
1	+1	+1	+1
2	+1	0	0
3	+1	-1	-1
4	0	+1	-1
5	0	0	+1
6	0	-1	0
7	-1	+1	0
8	-1	0	-1
9	-1	-1	+1

Table No.3: Experimental Design

Exp. No.	Process Parameter& their levels		
	Welding Current A(Amp.)	**Welding Voltage B(V)**	**Travel Speed C(M/Min.)**
1	280	20	9
2	280	21	8
3	280	22	7
4	270	20	7
5	270	21	9
6	270	22	8
7	260	20	8
8	260	21	7
9	260	22	9

Table No.4: Experimental Layout Using an L-9 Orthogonal Array

RESULTS

The results have shown in the tables below

Exp. No.	Factor			Results	
	Welding Current (A)	WELDING voltage (B)	travel speed (C)	Tensile Strength (N/MM^2)	S/N Ratio
1	280	20	9	224	47.0050
2	280	21	8	221	46.8878
3	280	22	7	225	46.9661
4	270	20	7	224	47.0050
5	270	21	9	222	47.1205
6	270	22	8	227	47.1587
7	260	20	8	226	47.0050
8	260	21	7	230	46.8878
9	260	22	9	227	46.9271

Table 5: Experimental Results For Tensile Strength and S/N Ratio

Interpretation of plots

The following graphs have been obtained by the use of MINITAB-17 software:

1) Main Effect plots for Means for Tensile Strength shown in Fig No.1
2) Main Effect plots for S/N ratios for Tensile Strength shown in shown in Fig No.2

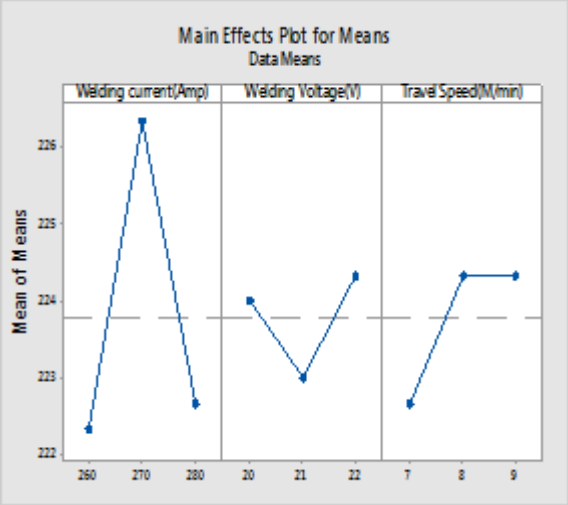

Fig No.1 Main effect plot for means

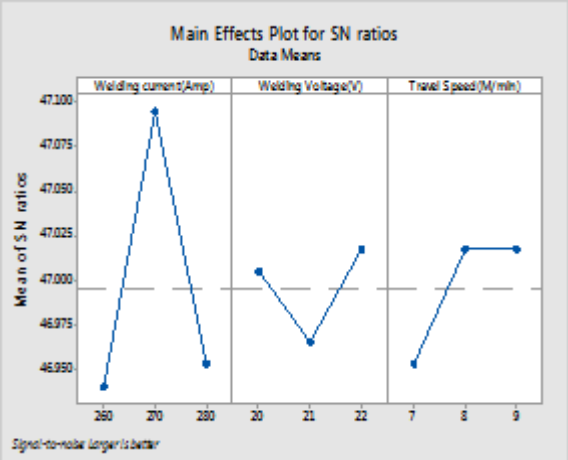

Fig No.2Main effect plot for S/N Ratio
Deformed Work piece shown in Figure No.3

Fig No.3 Deformed Work piece

Influence of the parameters

The influence of the parameters are listed below

Sr. No	Factor	Sum of Square	DOF	P	%
1	A	0.04581	2	0.34	67.70
2	B	0.01047	2	0.69	15.43
3	C	0.01019	2	0.70	14.73
4	Error	0.2401	2		2.14
5	Total	0.9048	8		100

Table 5: Result of analysis of variance for Tensile Strength

CONCLUSION

The above work, experimently verify that the combined approach of Taguchi and ANOVA gives us the optimal parameters in MIG Welding process using optimum set of Parrameters.The failure of welded product problems encountered by Static and dynamic loads were successfully addressed by application of Taguchi Method. The most affecting parameters having the impact of 67.70%(Percentage influance factor) is Welding current latter Welding voltage and Travel speed.Remaining percentage for the influece on this experiment will definetly associated with welding condition and other parameters.

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