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PARAMETRIC OPTIMIZATION OF MAG WELDING PARAMETERS FOR IMPROVING STRENGTH & HARDNESS OF WELDED JOINT OF TWO DISSIMILAR METALS BY TAGUCHI METHOD

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Abstract: The purpose of this study is to propose a method to decide near optimal settings of the welding process parameters in MAG welding. The properties of the welded joints are affected by a large number of welding variables/ parameters. Properties include Tensile strength, Hardness, Impact force etc. In an attempt, this article focuses on an approach based on the Taguchi method for optimizing the process parameters for tensile strength and hardness of weld with multiple performance characteristics considering influence of input welding parameters current, Voltage, Root Gap and Gas flow rate. Input parameters play an important role in maintaining the better quality of welding along with its weld strength and hardness MAG welding process, considering the effects of main variables on weld strength & hardness. By using Taguchi and ANNOVA technique an optimal solution is find out, which provides us an optimal results of the varying condition. Using these characteristics, the process parameters, including Current, Voltage, Root Gap and Gas Flow Rate are optimized. The Experimental results show parameter Voltage & current has the most significant effect on the multiple performance characteristics

I. INTRODUCTION

Welding is a manufacturing process, which is carried out for joining of metals. All welds will be prepared by MAG welding technique. .GAS METAL ARC welding (GMAW)/MAG is a process that melts and joins metals by heating them with an arc established between a continuously fed filler wire electrode and the metals This is often done by melting the work pieces and adding a filler material to form a pool of molten material (the weld pool) that cools to become a strong joint, with or without the help of pressure. I have studied Design of Experiment method for this work and by use of the experimental data have optimized by Taguchi technique. In which input parameters for MAG welding are Gas Flow rate, Voltage and root gap between plate and the output parameter is hardness & tensile strength. We were used Mild Steel and Stainless Steel (SS-304) material for welding. It is a plain carbon steel and also known as “soft” or mild steel. Small scale trial welding experiments, in the light of field joint of plate have been planned to perform on 10 mm plate thicknesses of mild steel IS 2062 E250 double V-groove joint is used. Experimental design, we were used Taguchi method to find out number of readings. By using DOE method, the parameters can be optimize and having the best parameters combination for target quality. The analysis from DOE method can give the significance of the parameters as it give effect to change of the quality and strength of product or does not. A plan of experiments based on Taguchi technique has been used to acquire the data. An Orthogonal array and analysis of variance (ANOVA) are employed to investigate the welding characteristics of to find out percentage contribution of each input parameter for obtaining optimal conditions, we were used analysis of variance (ANOVA) method. The objective of this work is to investigate parametric optimization of MAG welding method can be used to weld sheet metals (structural and stainless steels) in Butt joint in a single pass with different air gaps, Current, Voltage & Gas flow rate. To better assess this method to weld these sheet metals so that conclusion can be drawn from the results obtained. Panasonic-400 was used as the welding equipment.

II. METHODOLOGY

Taguchi Method is used to arrange the experiments. The Taguchi technique has become a powerful tool for improving productivity during research and development work, so that higher quality products can be produced rapidly and at minimum cost. Dr. Taguchi of Nippon Telephones and Telegraph Company, Japan has introduced a method based on "ORTHOGONAL ARRAY" methods which give much reduced "variance" for the experiment with "optimum settings" of control parameters. So the marriage of Design of Experiments with optimization of control parameters to get best results is achieved in the Taguchi Method “Orthogonal Arrays" provide group of well balanced (least) experiments and Dr. Taguchi's Signal-to-Noise ratios (S/N), they are log functions of desired output, serve as objective functions for optimization, help in data analysis and prediction of optimum results.

1) Signal-to-noise ratio

1) Larger the better: $SN_L = -10\log\left[\frac{1}{n}\sum_{i=0}^{n}\frac{1}{y_i^2}\right]$

2) Smaller the better: $SN_s = -10\log\left[\frac{1}{n}\sum_{i=0}^{n} y^2\right]$

3) Nominal the better: $SN_N = 10\log\left[\frac{y^{-2}}{S^2}\right]$

Where, η - Signal to Noise(S/N) Ratio,
Yi - it’s observed value of the response,

n - no. of observations in a trial,

y - Average of observed values (responses)

B. Analysis of Signal to Noise Ratio

In the Taguchi Method the term 'signal' represents the desirable value (mean) for the output characteristic and the term 'noise' represents the undesirable value (standard Deviation) for the output properties. Therefore, the S/N ratio to the desirable value of the S. D. S/N ratio used to calculate the quality characteristic variable from the desired value. The S/N ratio S is defined as

S = - 10 log (Mean of sum square of reciprocal of measured Data)

Regardless of the category of the quality, a greater S/N ratio corresponds to better quality characteristics. Therefore, the optimal level of the process parameters is the level with the greatest S/N ratio.

C. Analysis of Variance

The purpose of the analysis of variance (ANOVA) is to investigate which design parameters significantly affect the quality characteristic. This is to be accomplished by separating the total variability of the S/N ratios, which is measured by the sum of the squared deviations from the total mean S/N ratio, in contributions by each of the design parameters and the error. First, the total sum of squared deviations SST from the total mean S/N ratio can be calculated.

III. EXPERIMENTAL DETAILS & PLAN

The experimental design was according to an L'9 array based on Taguchi method, while using the Taguchi orthogonal array would markedly reduce the number of experiments. A set of experiments designed using the Taguchi method was conducted to investigate the relation between the process parameters and response factor. Minitab 15 software is used for optimization and graphical analysis for obtaining data.

Process Parameters	Parameter	Level-1	Level-2	Level-3
Current	A	120	140	150
Arc voltage	B	30	35	38
Root Gap	C	2	3	4
Gas Flow Rate(CFH)	D	8	10	12

Table-1

Layout using L9 orthogonal array

Run	Current	Voltage	Root Gap	Gas flow rate
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

Table-2

For this research purpose on MAG welding, we have chosen the material IS 2062 E250 (mild steel)& SS-304(stainless steel).Specimen was made of size 100x50 x10mm with the help of power hacksaw. A grove of 60° was made with the help of bench grinder. All samples were finished for welding supported by fixture.L9 orthogonal array is used for analysis purpose and standard table of four variables with three different levels of input parameters and the output characteristic is hardness and tensile of welded joint is shown in table 1.

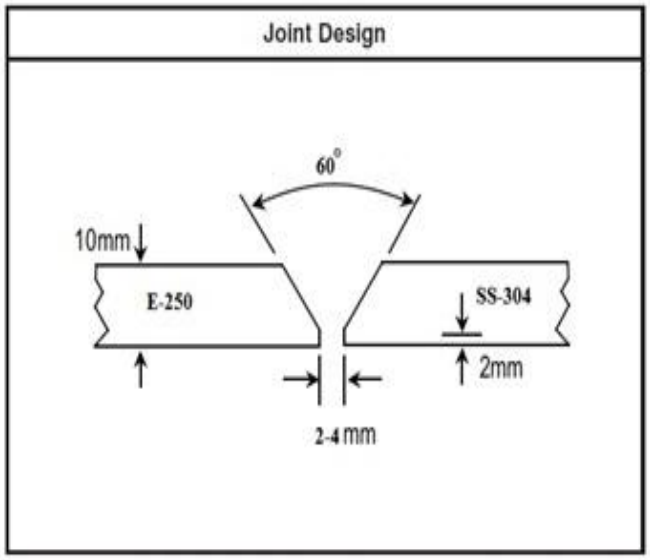

Fig.1 Joint Design

Fig. 2 Welding of Stainless Steel and Mild Steel

Experimental layout using L9 orthogonal array

Run	Current	Voltage	Root Gap	Gas flow rate
1	120	30	2	8
2	120	35	3	10
3	120	38	4	12
4	140	30	3	12
5	140	35	4	8
6	140	38	2	10
7	150	30	4	10
8	150	35	2	12
9	150	38	3	8

Table-3

IV. WELDING RESULT & ANALYSIS:

TAGUCHI ANALYSIS FOR TENSILE STRENGTH

Tensile Strength Readings & S/N Ratio

Run	Current	Voltage	Root Gap	Gas Flow Rate	Tensile Strength	SNRA
1	120	30	2	8	466.39	53.3750
2	120	35	3	10	302.59	49.6171
3	120	38	4	12	357.35	51.0619
4	140	30	3	12	493.73	53.8698
5	140	35	4	8	428.75	52.6441
6	140	38	2	10	378.27	51.5560
7	150	30	4	10	501.67	54.0084
8	150	35	2	12	446.28	52.9921
9	150	38	3	8	390.12	51.8240

Table-4

Response Table for Signal to Noise Ratios: Larger is better

Response Table for signal to Noise ratio

Level	Current	Voltage	Root Gap	Gas Flow Rate
1	51.35	53.75	52.64	52.61
2	52.69	51.75	51.77	51.73
3	52.94	51.48	52.57	52.64
Delta	1.59	2.27	0.87	0.91
Rank	2	1	4	3

Table-5

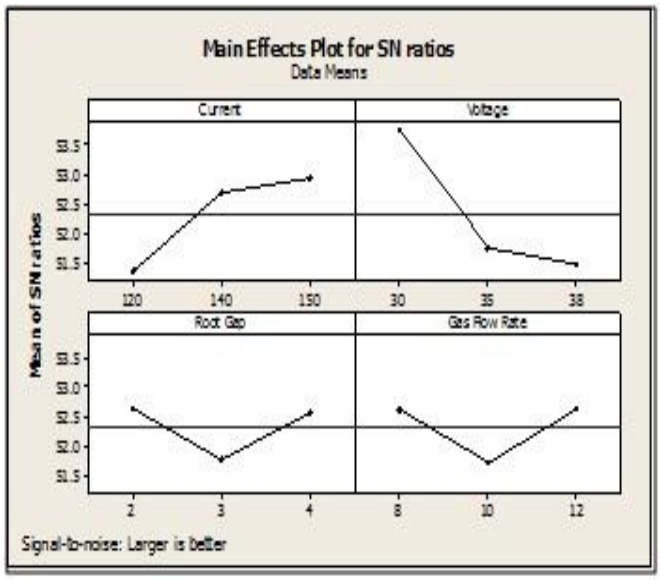

Fig-3

Regardless of the category of the performance characteristics, Agreater S/N value corresponds to a better performance. Therefore, the optimal level of the welding parameters is the Level with the greatest S/N value. Based on the analysis of the S/N ratio, the optimal welding performance was obtained at 120A arc current (level 3), 30 V arc voltage (level 1), 2mm root gap (level-1) and 12 L/Min. gas flow rate (level 3).Fig. 3 shows the main effects plot for S/N ratio of all three parameters and table 5 shows the result of optimum parameters for max.tensile strength.

TAGUCHI ANALYSIS FOR HARDNESS TESTING

Hardness Reading & S/N Ratio

Run	C	V	RG	GFR	WZ	HAZ	PM	SNRA5
1	120	30	2	8	87	88	85.5	36.78
2	120	35	3	10	87	86	87.5	41.11
3	120	38	4	12	82.5	90	88.5	26.81
4	140	30	3	12	89.75	79.5	83.75	24.28
5	140	35	4	8	86.5	87	80	26.70
6	140	38	2	10	80.5	82.5	84	33.42
7	150	30	4	10	88.5	89	87.5	41.26
8	150	35	2	12	86	87	90	32.49
9	150	38	3	8	82	85.5	89	27.76

Table-6

Response Table for Signal to Noise Ratio: Nominal is best

Response Table for Signal to Noise Ratio

Level	Current	Voltage	Root Gap	Gas Flow Rate
1	86.89	86.50	85.61	85.61
2	83.72	86.33	85.56	85.83
3	87.17	84.94	86.61	86.33
Delta	3.44	1.56	1.06	0.72
Rank	1	2	3	4

Table-7

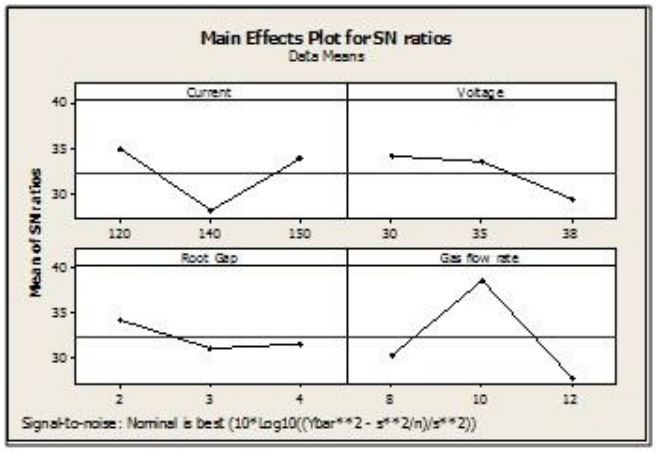

Fig-4

Regardless of the category of the performance characteristics, a greater S/N value corresponds to a better performance. Therefore, the optimal level of the welding parameters is the level with the greatest S/N value. Based on the analysis of the S/N ratio, the optimal welding performance was obtained at 150A arc current (level 3), 30 V arc voltage (level 1), 2mm root gap (level-1) and 12 L/Min. gas flow rate (level 3). Fig. 5.7 shows the main effects plot for S/N ratio of all three parameters and table 5.8 shows the result of optimum parameters for man hardness.

V. RESULT &CONCLUSION:

The study found that the control factors had varying effect on the response variables.Taguchi method has been very successful in optimizing process variable considering technical as well as economic aspects. The strategic analysis on the effect of signal to noise ratio is superior to conventional procedures. There may be numerous of controlling factors on which the welding can be optimized. The taguchi method is used to find the optimal solution for the controlled process variables.

From Taguchi technique

1. We find the optimum parameter for tensile strength:

Gas Flow Rate	Level 3	20
Voltage	Level 2	38
Root Gap	Level 1	0.5

2. we find the optimum parameter for Hardness:

Gas Flow Rate	Level 2	15
Voltage	Level 3	40
Root Gap	Level 3	2.5

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