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"OPTIMIZATION OF GMAW PROCESS PARAMETERS FOR EN8 MILD STEEL & STAINLESS STEEL USING STATISTICAL TECHNIQUES"

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ABSTRACT

Importance of optimisation is taken care of using Taguchi and ANOVA statistical approaches. Weld joints between Stainless steel and EN8 is fabricated and the tensile strength and hardness of the joints are measured in various samples. These samples are fabricated with set of values of preheat temperature, gas flow rate and welding current taking into consideration. Using Taguchi and ANOVA relations, the predicted values of tensile strength and hardness are calculated and compared with the actually observed values. Since the predicted values are within the range of observed values, the corresponding set of experimental values are considered to run the operations. Further, ANOVA results show the utilization of each process parameter in strengthening of the weld.

Key Words: *Preheat temperature, GMAW, Flow rate, Optimisation, Taguchi, ANOVA, Tensile Strength, Hardness*

I. INTRODUCTION

Welding is a process of joining two materials. It is a faster process and more economical compared to both casting and riveting. Welding find applications in the manufacture of many products around us name few ships, rail road equipment's, launch vehicles, boilers, nuclear power plants, building construction, pipelines, aircrafts, automobiles etc. Various welding methods available are: Tungsten Inert Gas (TIG) Welding, Metal inert gas (MIG) welding, Shielded Metal Arc Welding (SMAW), Plasma Arc Welding (PAW), Flux Cored Arc Welding (FCAW), Submerged Arc Welding (SAW), Gas Metal Arc Welding (GMAW), Electro Slag Welding (ESW) and Oxyacetylene (OA) Welding. Welding processes play an important role in metal fabrication industries. There are various welding techniques, but the most commonly used types are tungsten inert gas (TIG) and metal inert gas (MIG/MAG) welding process. In the TIG welding process a non-consumable electrode is used but in case of MIG welding a consumable wire is used to joining the metal. A metal inert gas (MIG) welding process consists of AC motor for heating, electrode for melting, water tube for cooling and solidification of parent metals and a filler material in localized fusion zone by a transient heat source to form a joint between the parent metals. MIG welding parameters are the most important factors affecting the quality, productivity and cost of welded joint. Factors such as arc current, arc voltage and welding speed and their interactions play a significant role in the welding process.

II. OPTIMIZATION METHOD

Taguchi Method: A Taguchi method has now a days become a powerful optimization techniques for improving productivity during research and development, so that a high quality of the product can be produced at low cost and

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also quickly. Taguchi method is one of the best method which offers the effective selection process parameters minimum no.of experiments. Thus the combination of design of experiment with the optimal welding parameters to provide a best result is achieved in Taguchi Technique. With the help of Taguchi method it possible to find out which parameter is less influence and which is more influence. Taguchi technique use a special set or design called "Orthogonal array", to investigate the entire process parameter with a small number of experiments only. Dr. Taguchi S/N ratio, which are log function of desired output, serve as a objective functions for optimization, help in data analysis and prediction of optimum results. Taguchi method use the S/N ratio to identify the control factors to optimization process first one is to find out those control factor that reduce variability and second is to find out those control parameters which have a small or no effect on the signal-to-noise ratio and which move the mean to target. The S/N ratio under different noise condition measures how the response varies relative to the nominal or target value. Depending on the goal of your experiment, you can choose from different signal-to-noise ratios. Minitab offers S/N ratios, for static design.

There are three Signal-to-Noise ratio of common interest for optimization:

Smaller-The-Better:

n= -10 Log_{10} [mean of squares of measured data]

Larger-The-Better:

n= -10 Log_{10} [mean of square of the reciprocal of measured data]

Nominal-The-Best:

n= 10 Log_{10} (square of mean/variance)

Grey Relational Analysis: In Grey relational analysis, the experimental data i.e. the measured features of quality characteristics are first normalized ranging from 0 to 1.Then, the Grey relational coefficient is calculated, based on normalized experimental data, to represent the correlation between the desired and actual experimental data. Then, the Grey relational grade is determined by averaging the Grey relational coefficient corresponding to selected responses. The overall evaluation of the multiple response process is based on grey relational grade. Hence, with this approach, optimization of the complicated multiple process responses can be converted into optimization of a single grey relational grade. Optimal parametric combination is then evaluated which would result highest Grey relational grade.

III. LITERATURE REVIEW

Ugur Esme, Melih Bayramoglu, Yugut Kazancoglu, Sueda Ozgun [2] were carried out investigated the multi-response optimization of tungsten inert gas welding (TIG) welding process for an optimal parametric combination to yield favorable bead geometry of welded joints using the Grey relational analysis and Taguchi method. Sixteen experimental runs based on an orthogonal array of Taguchi method were performed to derive objective functions to be optimized within experiment. The objective functions have been selected in relation to parameters of TIG welding area of penetration, bead geometry; bead width, bead height, penetration, as well as tensile load and width of heat affected zone. The Taguchi approach followed by Grey relational analysis to solve the multi-response optimization problem. And also, the significance of the factors on overall quality characteristics of the weldment has also been evaluated quantitatively by the analysis of variance method (ANOVA). Optimal results have been verified through additional experiments. It shows application feasibility of the Grey relation analysis in combination with Taguchi technique for continuous improvement in product quality in manufacturing industry. Experiments were performed on 1.2mm AISI 304 thin stainless steel plate with size (25 x 240mm). 4 factor and 4 level is used i.e L16 Orthogonal array is used. Welding parameters were taken is travel speed, current, gas flow rate, Gap distance. Result of ANOVA indicates that the welding speed 52.14% contribution is most effective parameter on the responses under the multi criteria optimization (higher tensile load, penetration area, area of penetration & lower heat affected zone, bead width, bead height). The % contribution of other parameters are gap distance 20.12%, current 15.40%, shielding gas flow rate is 9.09%.

Deepak Malik, Sachin Kumar, Mandeep Saini [3] investigate that the angular distortion is a major problem in butt weld plates. Restriction of this distortion by restraint may lead to higher residual stress. In initially angular distortion in (–ve) direction is provided to reduce the angular distortion if the magnitude of distortion is predictable. For optimizing the weld parameter control ANOVA is applied. In these paper the transverse direction of TIG, welding process was

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evaluated using following as main input parameter welding current, filler rod diameter, length of plate and time gap between passes. Experiment was carried out with SS 302 & MS samples of varying length, 50mm width and 6mm thick. The stainless steel and mild steel plates were prepared with V grove design and butt weld type. With single pass filler metal, the distortion is measured with dial gauge fitted to a height gauge. 70 to 100 Amps was used as a current variation. A carbon steel filler rod of 1.5 to 2.5 used as a filler metal in these cases

In this L9 orthogonal array was selected for design of experiments towards the distortion optimization caused by welding. MATLAB 16 software is used to developed a source code to do optimization. Direct and interaction effect of the process parameters were analyzed & presented in graphical form. At the end conclusion was explain that the highest effect on angular distortion is found of diameter of electrode. The least effect on angular distortion is found of time between successive passes.

Dheeraj Singh, Vedansh Chaturvedi, Jyoti Vimal [4] this research paper discuss the optimum welding parameters for Gas tungsten arc welding. Taguchi method with an L16 orthogonal array (4-level and 4-factor) based on 16 experiment run were performed. Parameters namely used is current, gas flow rate, welding speed & gun angle is taken as a process parameters. The objective function have been chosen in relation to parameter of TIG welding bead geometry i.e. area of penetration, tensile load, , bead width, bead height, and penetration for quality target. Experiment were perform on a specimen of1.2mm 304 stainless steel plate (30 x 250 mm). The paper presented the optimization of the TIG welding process of stainless steel work piece by the grey relational theory. The optimal process parameters that have been identified the best combination of process variables for S.S are current at 40 A, gas flow rate at 5 l/min, welding speed 12m/min and gun angle at a 80 ^{o}. After the predicted optimal parameter setting with the help of (ANOVA) the most significant factor also found in this case gun angle is having max % contribution.

J.Pasupathy, V.Ravisankar [5] this paper presents the influence of welding parameters like welding speed, current on strength of low carbon steel on AA1050 materials during welding. A Taguchi method has been used to obtain the data. An analysis of variance (ANOVA), orthogonal array and S/N ratio are used to investigate the welding characteristics of dissimilar welding joint and to optimize the process parameters. Experimentally work us carried with 1mm thick low carbon steel & 2mm AA1050 aluminium alloy were used, size is (150mm width & 300mm length). In this study L9 orthogonal array is used. The experiment value that is observed from optimal welding parameters, strength is 61.37 MPa & S/N ratio is 16.45.

IV. EXPERIMENTATION

During the welding operation, parameters to be optimised are: Welding Current, Gas flow rate, Preheat temperature

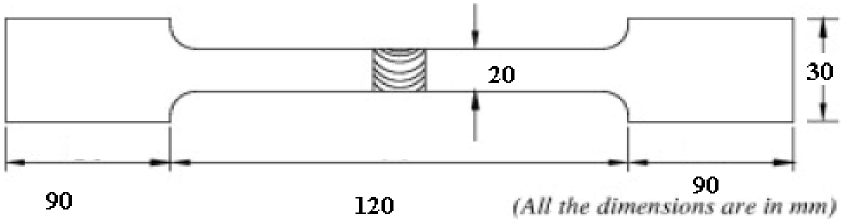

Fig. 1 Specimen

Material used in welding operation

<u>EN8</u>: EN8 is an unalloyed medium carbon steel which is used in applications where better properties than mild steel are required.

<u>Stainless Steel</u>: It is a family of iron-based alloys that contain a minimum of approximately 11% chromium, a composition that prevents the iron from rusting, as well as providing heat-resistant properties.

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Table 1. Welding Parameters

Parameters/Factors		level		
		1	2	3
A	Welding Current (Amp)	100	112	124
B	Gas Flow Rate (cu. mm/min)	10	15	20
C	Preheat Temperature (°C)	275	285	300

Table 1 shows the parameters to be optimised viz. welding current, preheat temperature and gas flow rate while Table 2 exhibits the designed set of experiments as per the degree of freedom calculated.

Table 2. Design of Experiments of welding parameters

Exp. no.	Welding current (Amp)	Gas flow rate (mm^3/min)	Preheat temperature (°C)
1	100	10	275
2	100	15	285
3	100	20	300
4	112	10	285
5	112	15	300
6	112	20	275
7	124	10	300
8	124	15	275
9	124	20	285

Table 3. Tensile strength against each set of experiment

Exp. no.	Preheat temperature (°C)	Gas flow rate (mm^3/min)	Welding current (Amp)	Tensile strength (MPa)
1	275	10	100	93.58
2	285	15	100	93.67
3	300	20	100	91.74
4	285	10	112	94.65
5	300	15	112	92.34
6	275	20	112	87.25
7	300	10	124	89.14
8	275	15	124	91.04
9	285	20	124	86.44

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Table 4. Hardness against each set of experiment

Exp. no.	Preheat temperature (°C)	Gas flow rate (l/min)	Welding current (Amp)	HRC
1	275	10	100	72.36
2	285	15	100	83.54
3	300	20	100	71.12
4	285	10	112	82.07
5	300	15	112	83.45
6	275	20	112	74.14
7	300	10	124	83.21
8	275	15	124	82.74
9	285	20	124	84.07

Table 3 and Table 4 contains the tensile strength and Rockwell hardness values of each set of experiments measured.

Table 5. S/N Ratio against each set of experiment

S. No.	S/N Ratio	
	Tensile Strength (Higher-the-Better)	Rockwell Hardness (Higher-the-Better)
1	22.9203	21.2919
2	20.7612	19.3222
3	21.5343	18.4534
4	24.1615	22.991
5	19.5651	18.3302
6	20.9705	19.8713
7	18.2323	17.0602
8	18.7887	20.2332
9	21.5602	23.4951

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V. RESULTS AND DISCUSSION

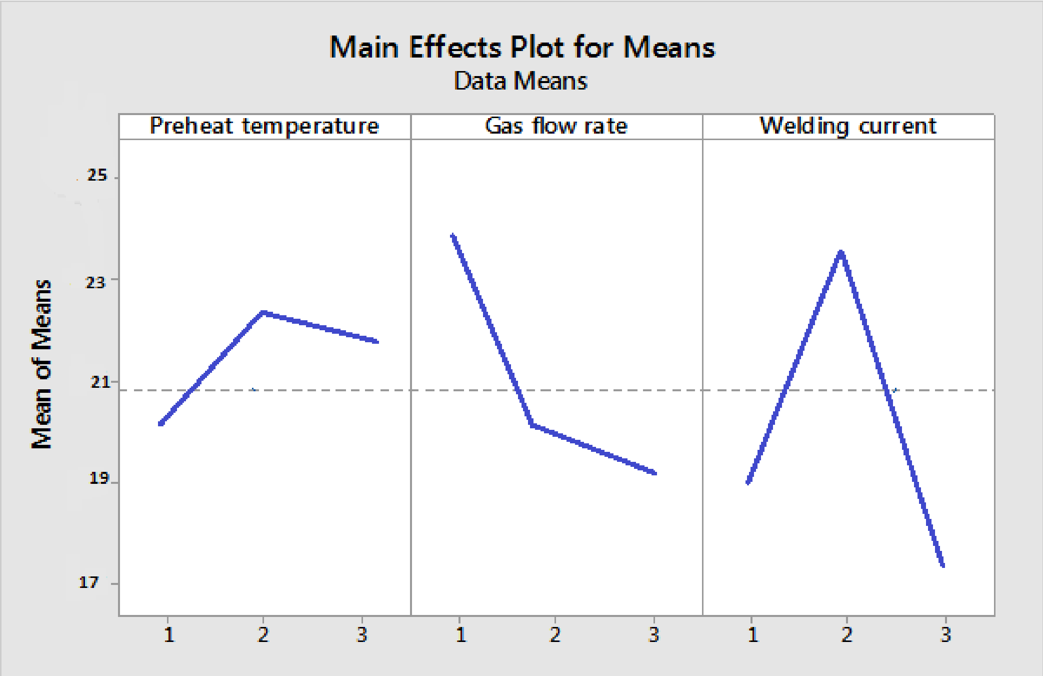

Fig. 2. Statistical Result of Tensile strength

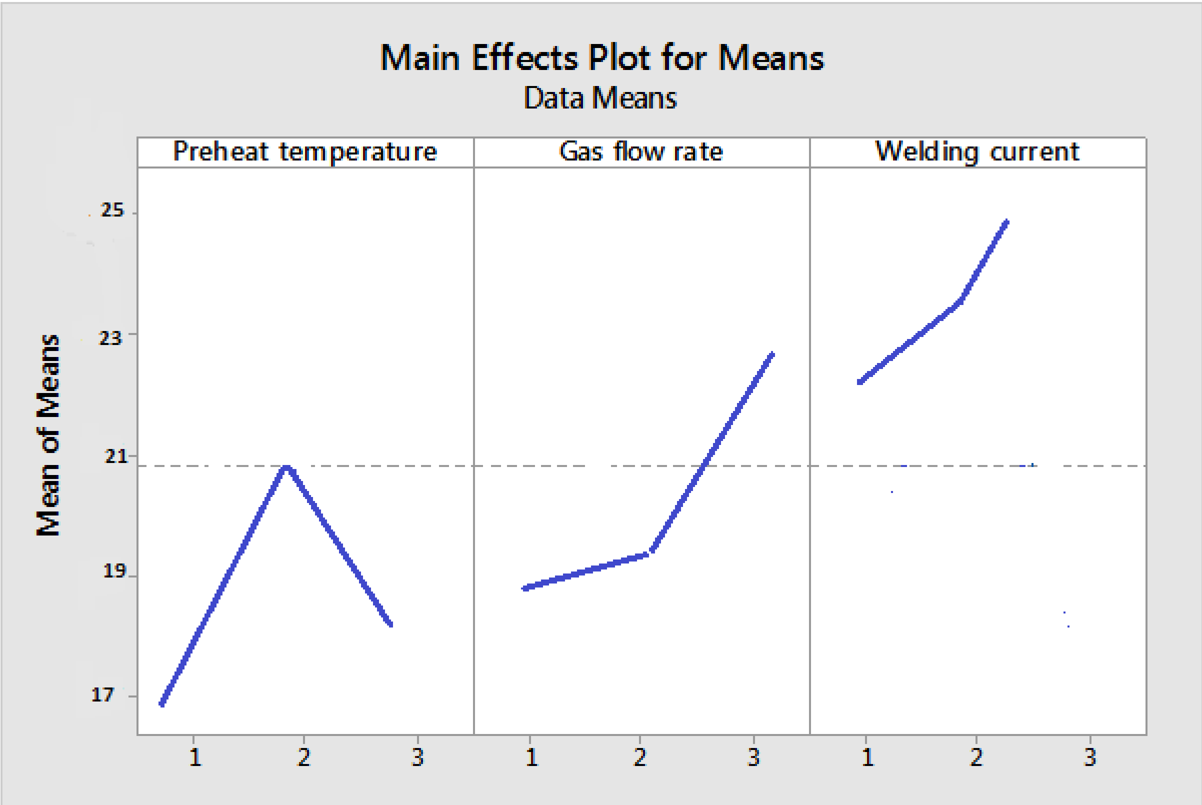

Fig. 3. Statistical Result of hardness

Fig.2 and Fig. 3 display the results graphically and it is clearly evident that for tensile strength the set of experiment A2B1C2 is the optimised experiment and for Rockwell hardness A2 B3 C3 is the optimised experiment.

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VI. CONCLUSION

Table 5 Results of tensile strength and Rockwell hardness

Tensile Strength			
Optimized Experiment	**Predicted Value**	**Observed Value**	**Percentage Deviation**
A2B1C2	88.78 MPa	94.65 MPa	6.20%
Rockwell Hardness			
Optimized Experiment	**Predicted Value**	**Observed Value**	**Percentage Deviation**
A2B3C3	75.56 HRC	84.07 HRC	10.12%

Experiments are conducted and finally the optimized set of experiments are obtained for both tensile strength and Rockwell hardness. It is observed that A2B1C2 is the optimized set of experiment for tensile strength of the weld joint while in case of Rockwell hardness the weld joint has hardness value of 84.07 HRC for A2B3C3. When compared the actual measured values with the Taguchi results, a deviation of 6.2% and 10.12% is observed as shown in Table 5. Due to smaller deviation in observed and predicted values, the optimized set of experiments are considered.

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