Parametric Optimization of GMAW Process

"Effect of Welding speed, Welding current, Arc voltage and Torch angle on Bead geometry & Bead hardness"

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***Abstract* - In this study, the effects of various welding parameters on bead geometry and bead hardness in IS 2062 E250 B Mild steel having dimensions 120 mm x 80 mm x 6mm, welded by robotic gas metal arc welding were investigated. The welding current, arc voltage and welding speed and torch angle (travelling angle) chosen as variable parameters. Bead hardness, bead width and reinforcement was measured for each specimen after the welding operations and the effects of these parameters on bead hardness and bead geometry were researched. A plan of experiments based on Taguchi technique has been used to acquire the data. The experiments were conducted based on a four-factor, three-level. An Orthogonal array, signal to noise (S/N) ratio are employed to investigate for maximize the bead hardness and minimize the bead width & reinforcement of IS 2062 E250 B Mild steel material. Finally the conformations tests have been carried out to compare the predicated values with the experimental values confirm its effectiveness in the analysis of welding parameter.**

***Keywords* - GMAW process, MIG welding, Taguchi method, Bead geometry, Bead hardness, Mild steel**

I. INTRODUCTION

GAS-METAL ARC WELDING (GMAW) is an arc welding process that joins metals together by heating them with an electric arc that is established between a consumable electrode (wire) and the work piece. An externally supplied gas or gas mixture acts to shield the arc and molten weld pool. Although the basic GMAW concept was introduced in the 1920s, it was not commercially available until 1948. At first, it was considered to be fundamentally a high current-density, small-diameter, bare-metal electrode process using an inert gas for arc shielding. Its primary application was aluminum welding. As a result, it became known as metal-inert gas (MIG) welding, which is still common nomenclature. Subsequent process developments included operation at low current densities and pulsed direct current, application to a broader range of materials, and the use of reactive gases (particularly carbon dioxide) and gas mixtures. The latter development, in which both inert and reactive gases are used, led to the formal acceptance of the term gas-metal arc welding.

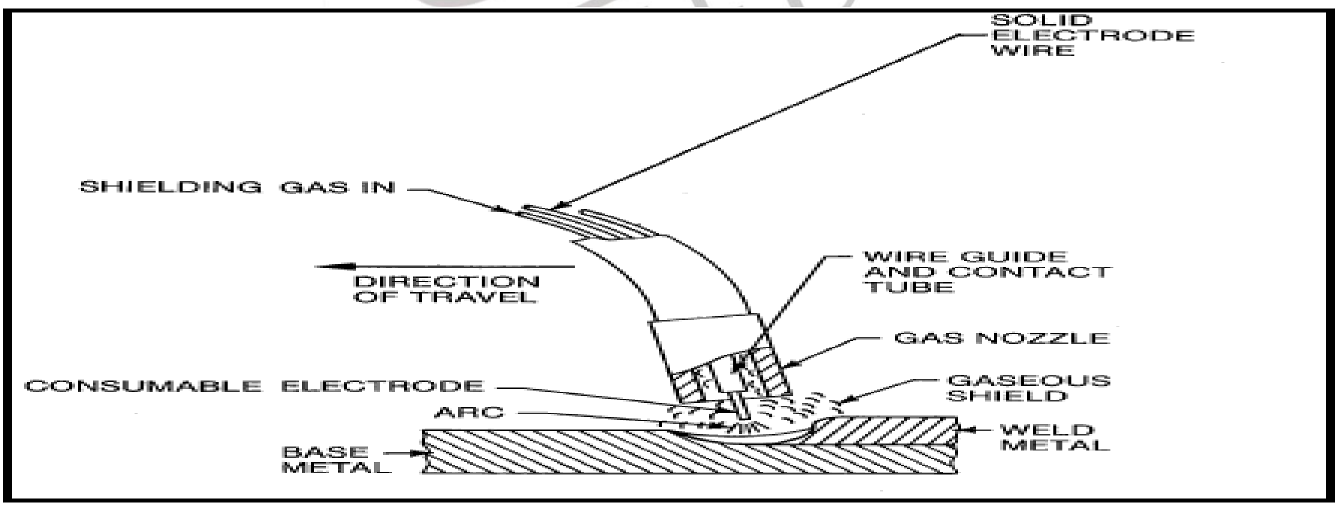

Fig 1: GMAW Process

The GMAW process can be operated in semi-automatic and automatic modes. All commercially important metals, such as carbon steel, high-strength low-alloy steel, stainless steel, aluminum, copper, and nickel alloys can be welded in all positions by this process if appropriate shielding gases, electrodes, and welding parameters are chosen. In the an arc is established between a continuously fed electrode of filler metal and the work piece. After proper settings are made by the operator, the arc length is maintained at the set value, despite the reasonable changes that would be expected in the gun-to-work distance during normal operation. This automatic arc regulation is achieved in one of two ways. The most common method is to utilize a constant-speed (but adjustable) electrode feed unit with a variable-current (constant-voltage) power source. As the gun-to-work relationship changes, which instantaneously alters the arc length, the power source delivers either more current (if the arc length is decreased) or less current (if the arc length is increased). This change in current will cause a corresponding change in the electrode melt-off rate, thus maintaining the desired arc length [1].

Design of Experiment (DOE) and statistical techniques are widely used for optimization of process parameters. In the present study the welding process parameters of GMAW can be optimized to maximize the yield strength of the work piece also reducing the number of experiments without affecting the results. The optimization of process parameters can improve quality of the product and minimize the cost of performing lots of experiments and also reduces the wastage of the resources. The optimal combination of the process parameters can be predicted. This work was concerned with the effects of welding process parameters on the bead hardness and bead geometry of IS 2062 E250 B Mild steel joints.

II. LITERATURE REVIEW

K. Abbasi, S. Alam and Dr. M.I. Khan study about An Experimental Study on the Effect of MIG Welding parameters on the Weld-Bead Shape Characteristics. From the above investigation on bright drawn mild steel of dimensions 144 ×31× 10 mm, and using a current of 165 amp and arc voltage of 16 V the following conclusions have been drawn: 1. When speed is taken as variable parameters, penetration depth increases with increase in speed up to an optimum value of 1450 mm/min, beyond that speed penetration starts decreasing. 2. When the heat input is taken into consideration the depth of penetration increases with increase in heat input up to a rate 109 J/min, beyond which the penetration depth starts decreasing. 3. Shape factor increases with increase in welding speed. An optimum shape factor was observed at a welding speed of 1450 mm/min., beyond which shape factor starts decreasing. Therefore optimum shape factor was observed at welding speed of 1450 mm/min. It can, therefore, be concluded that at a given current of 165 amp and arc voltage of 16 V as the welding speed increases the penetration depth increases until optimum value is reached, at which penetration depth and shape factor are optimum. Beyond that speed penetration depth and shape factor start decreasing.[2]

D.Katherasan , Madana Sashikant, S.Sandeep Bhat, P.Sathiya study about Flux Cored Arc Welding Parameter Optimization of AISI 316L (N) Austenitic Stainless Steel.Bead-on-plate welds were carried out on AISI 316L (N) austenitic stainless steel (ASS) using flux cored arc welding (FCAW) process. The bead on plates weld was conducted as per L25 orthogonal array. In this paper, the weld bead geometry such as depth of penetration (DOP), bead width (BW) and weld reinforcement (R) of AISI 316L (N) ASS are investigated. Taguchi approach is used as statistical design of experiment (DOE) technique for optimizing the selected welding input parameters. Grey relational analysis and desirability approach are applied to optimize the input parameters considering multiple output variables simultaneously. Confirmation experiment has also been conducted to validate the optimized parameters. Based on the Flux cored arc welding parameters (AISI 316L (N) ASS) considered in this study, the following points are deduced: The optimization of flux cored arc welding by calculating the grey relational and desirability analysis and using the recommendation of design for determining welding parameters was successful and the optimal parameter condition is WFR2 V5 TS1 TA3. Based on ANOVA results, grey relational analysis (error 4%) is more accurate than desirability approach (error 7%) to optimize the flux cored arc welding process in order to obtain the good bead profile. In both the analyses, torch angle has the most significant parameter followed by wire feed rate, travel speed and voltage. Predicted results confirmed higher depth of penetration less bead width and reinforcement.[3]

Ehsan Gharibshahiyan , Abbas Honarbakhsh Raouf , Mehdi Rahimian study about The effect of microstructure on hardness and toughness of low carbon welded steel using inert gas welding. The effect of heat input on microstructure and mechanical properties of low carbon welded steel was investigated. Results showed that by raising the voltage from 20 to 30 V the grain size number decreased from 12.4 to 9.8. It was also observed that high heat input and rapid cooling rates, in the weld metal produced fine grain austenite at high temperature, results in the formation of fine grained polygonal ferrites at ambient temperature. High heat input led to grain coarsening which was more pronounced in the HAZ, as well as reducing the impact energy and toughness. Elevation of heat input reduced the hardness in the HAZ, for instance, raising the heat input from 5 to 8 kJ/cm decreased the hardness from 160 to 148 HBN. This is considered to be attributed to a reduction in the density of dislocations and micro structural coarsening.[4]

DESIGN OF EXPERIMENT (DOE)

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 [5].

1. Signal to Noise Ratio (S/N Ratio)

Choose..	S/N ratio formulas	Use when the goal is to...	And your data are...
Larger is better	S/N = -10 Log10 [mean of sum squares of reciprocal of measured data]	Maximize the response	Positive
Nominal is best	S/N = = 10 Log10 [square of mean/ variance]	Target the response and you want to base the S/N ratio on standard deviations only	Positive, zero, or Negative

Smaller is better	S/N = -10 Log10 [mean of sum of squares of measured data]	Minimize the response	Nonnegative with a target value of zero

Table 1: Basics of S/N Ratio

III. EXPERIMENTAL PROCEDURE

The chemical composition of the test specimens are shown in Table 1, and that of the welding electrode are given in Table 2.

Material	Carbon	Manganese	Silicon	Sulphur	Phosphorous	Iron, Fe
IS 2062 E250 B	**0.210 %**	**1.490 %**	**0.210 %**	**0.024 %**	**0.024 %**	**98.042 %**

Table 2: Chemical Composition of Base Metal - IS 2062 E250 B

Material	Carbon	Manganese	Silicon	Sulphur	Phosphorous	Copper
ER 70S-6	**0.19%**	**1.63%**	**0.98%**	**0.025%**	**0.025%**	**0.025%**

Table 3: Chemical Composition of Filler wire ER 70 S-6

In the present work, AISI 1045 specimens was prepare with dimensions of 120 mm × 80 mm × 6mm of each were used as the work piece. Optical emission spectroscopy (OES) has been done to find out the chemical composition of the base metal, is shown in Table 1. These specimens were prepared with V Shaped groove as shown in Fig. 2, where groove angle, root face and root gap were 60°, 1.5 mm and 1.5 mm, respectively.

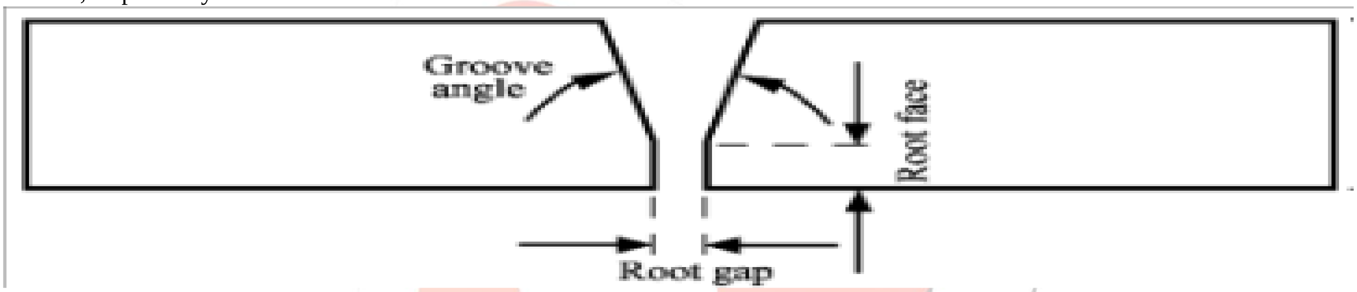

Figure 2: work material edge profile of the V-groove.

The surface of the plates was grind to remove the dust and other foreign particles. In order to obtain a strong bonded joint the properties of the base metal and the welding wire must comply with each other. The type of material of welding wire total depends upon the material that is required to be welded. So ER 70S-6 was selected as welding wire with a diameter of 1.2 mm was selected, shielding gas was 80% carbon and 20% argon use in same experiment.

The effect of the process parameters is Arc voltage, Welding current, Welding speed and Torch angle (travel angle) focusing position on the weld joint bead geometry and bead hardness has been investigated. OTC FD-B4L Robotic arm and OTC DP 400 Power source was used to join the 6mm plate which have high accurate performance.1st bead parameters is same for all experiment and this optimization is taken for 2nd bead process parameters.1st bead was taken at 125 A current, 18.5 V Arc voltage, 30 cm/min welding speed and 90° torch angle (travel angle).this parameter is constant for each and every experiments 1st bead passes. After then 2nd bead experiment was designed based on orthogonal array L9.

FACTOR	Welding current	Arc voltage	Welding speed	Torch angle
LEVEL 1	190 A	18 V	25 cm/min	70°(push angle)
LEVEL 2	220 A	21 V	30 cm/min	90° (Normal)
LEVEL 3	250 A	24 V	35 cm/min	110°(drag angle)

Table 4: Factors and Their Level

No	Welding current (A)	Arc voltage (V)	Welding speed (cm/min)	Torch angle (degree)
1	190	18	25	70°
2	190	21	30	90°
3	190	24	35	110°
4	220	18	30	110°
5	220	21	35	70°
6	220	24	25	90°
7	250	18	35	90°
8	250	21	25	110°

9	250	24	30	70°

Table 5: Orthogonal Array L9 of Taguchi Method using Minitab-16 Software

IV. RESULT AND DISCUSSION

Effect of welding current: hardness is decrease and bead width & reinforcement is increase with increment of current from 190 to 250 A. which value shown in Fig 3,4 and 5 based on Taguchi analysis.

Effect of Arc voltage: Arc voltage increase from 18 to 24 V, Bead hardness decrease and bead width increase within this range of arc voltage. But Reinforcement is decrease with decrease of arc voltage 18 to 21 V and again increases reinforcement up to 24 V.

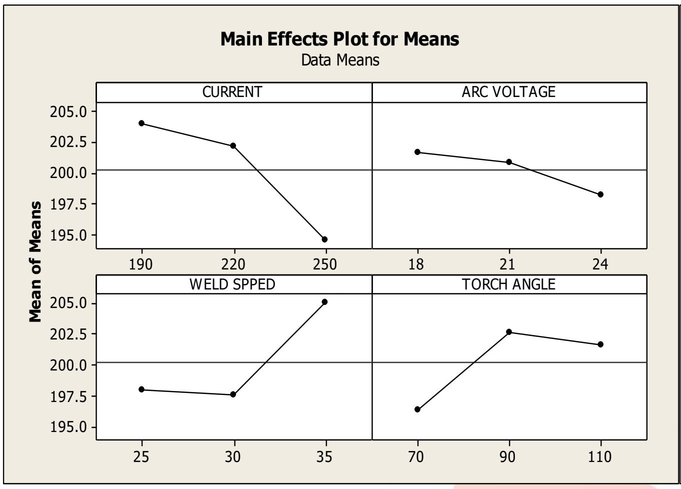

Fig 3: Graph for Means Hardness HV 10

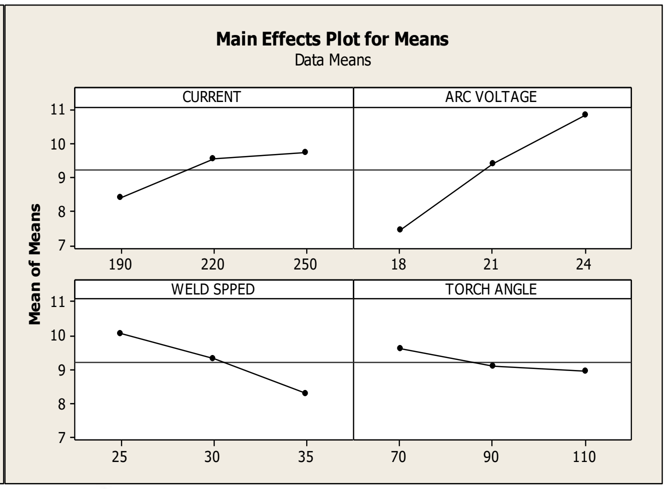

Fig 4: Graph for means Bead width

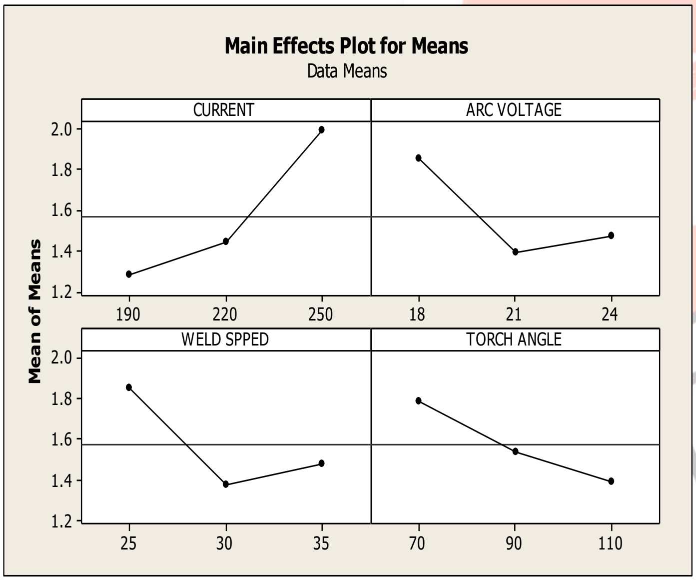

Fig 5: Graph for Means Reinforcement

	For maximization Bead Hardness	For minimization Bead width	For minimization Reinforcement
Welding current	190	190	190
Arc voltage	18	18	21
Welding speed	35	35	30
Torch angle	90°	110°	110°
S/N Ratio	46.5398	-15.6825	1.82974
Mean value	**211.887**	**5.39667**	**0.73**
Actual value	**211**	**5.42**	**0.76**

Table 6: Taguchi analysis based optimum set

Effect of welding speed: As welding speed is increase from 25 to 30 cm/min in this range bead hardness & reinforcement both decrease. After that point again both parameter is increase up to 35 cm/min. Bead width is continuously decrease in the range of 25 to 35 cm/min.

Effect of Torch angle (Travel angle) : Bead hardness is increase with increments of torch angle from 70° to 90°.but bead hardness again decrease from torch angle 90° to 110°.bead width and reinforcement both decrease with a increment of torch angle 70° to 110°

V. CONCLUSION

1. Welding current 190 A, Arc voltage 18 V, welding speed 35 cm/min and 90° torch angle at this condition we can achieve maximum bead hardness.
2. Arc voltage 18 V, Welding current 190 A, 110° torch angle and welding speed 35 cm/min at this condition we can achieve minimum bead width.
3. Welding speed 30 cm/min ,Welding current 190 A, Arc voltage 21 V and 110° torch angle at this condition we can achieve minimum reinforcement of bead.

VI. REFERENCES

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