Influence of Welding Process Parameter on Tensile Properties of Butt Welded IS2062 E-250 Steel Plate Using Design of Experiment Approach

Sanjay A. Swami [1], S. M. Jadhav[2], S. Y. Gajjal[3]

***Abstract*—**
CO2 welding is one of the widely used techniques for joining of mild-steel. In this Study important process parameters namely welding current, Gas flow rate, Gas combination used for shielding were optimized using surface methodology (RSM). Experiments are conducted on specimens of single v butt welded joint, material selected for preparing the test specimen is IS2062E250 grade .The strength of the welded joint is tested by a universal te nsile testing machine and the results are evaluated.

***Index Terms*—Co2 Welding, v-butt Welds, welding current, gas flow rate, Gas combination, Tensile strength.**

I. INTRODUCTION

In many Industries of tower carinas, lifting device requires fabricated part such as jib nose, anchorage frame, lugs etc. which is used for the irrigation & support purpose .These parts fabricated by CO2 welding, and material used is mild steels. The present condition high grade material is used to archive maximum tensile strength which cost is maximum.

The present trend in the fabrication industries is the use of automated welding processes to obtain high precision production rates and high production rates. A welding process is essential to establish the relationship between process parameters to control weld quality. The MIG welding process is found in any industry whose products require metal joining process in a large scale. It establishes the weld pool, an electric arc between a continuous filler metal electrode and with shielding from an externally supplies gas, which may be an inert gas, an active gas combination or a mixture. The heat of the arc melts the end of the electrode and surface of the base metal. Co2 welding is a welding process which joins metals by heating the metals to their melting point. The arc is between a continuous, the metal being welded and consumable electrode wire. Generally, the quality of a weld joint which is directly influenced by the welding input pa parameters during the welding process; therefore, welding can be considered as a multi-input multi-output process.

Welded joints are finding applications in critical components where failures are catastrophe. Hence, the inspection methods to acceptable standards are increasing. These acceptance standards based upon test of welded specimen containing some discontinuities which is represent the minimum weld quality. Welding involves a wide range of variables such as welding speed, temperature, electrode, pulse frequency, power input, gas flow rate and gas combination that influence the eventual properties of the weld metal. There is the need to select welding parameters for a given a good weld quality.

Unfortunately, a common problem that has faced the manufacturer is control of the process input parameters to obtain a good welded joint with the required bead geometry and weld quality with maximum tensile strength and distortion.

A. Literature Review

Ibrahim et. al. [1] performed experiments in the effects of different parameters on welding penetration, The hardness measurement and micro structure was measured in mild steel that having the 6mm thickness of the base metal by using the robotic gas welding.
The changes in welding process parameters are influenced the effect of the microstructure of weld metal. As increased welding current, welding speed and arc voltage on the grain size of microstructure.
From this experiments we can conclude that depth of penetration increased by increasing the value of welding current. Also penetration influences by the factors from welding speed and arc voltage. When the variable welding parameters changed the grain boundaries of microstructures changes from bigger size to smallest size.

Sathiya et. al. [2] Investigated CO2 laser–GMAW hybrid welding process the bead geometry for microstructure and mechanical properties of AISI 904 L super austenitic stainless steel joint. The results conclude that the joint by laser–GMAW hybrid had higher tensile than the base metal. This hybrid welding is suitable for welding of AISI 904 L super austenitic stainless steel owing to their high welding speed and excellent mechanical properties of weld metal.

Hussain et. al. [3] investigated that effect of welding speed on the tensile strength. This Experiments was conducted on specimens of single v butt joint having different bevel heights and bevel angles. The material Aluminium AA6351 Alloy is selected for preparing the test specimen. The welded joint specimens are tested by a universal tensile testing machine and the results are evaluated.

Pradip et al. [4] studied for the material IS 2062 ES250 Mild steel and take input different parameter and the response was the relationships between the five controllable input welding parameters such as wire feed wire, welding voltage and weld dilution , nozzle-to-plate distance, welding speed, gas flow rate.

Srinivasulu Reddy [5] was investigated on in submerged arc welding (SAW), weld quality is affected by the weld parameters are closely related to the geometry of weld bead and this relationship which is thought to be complicated because of the non-linear characteristics.

Dr.B.K.Roy et all. [6] Was worked carried out on plate welds AISI 304 & Low Carbon Steel plates using gas metal arc welding (GMAW) process. The experimental design by Taguchi method is used to formulate. Design of experiments using orthogonal array is employed to develop the weldments.

II. MATERIAL AND EXPERIMENTAL PROCEDURE

A. Materials

Rolled Plates of IS2062 E-250 mild steel with 12 mm thickness were cut into specimens 250 x 125 x 12 by machining. Square butt joint configuration was prepared according to welding standard. Argon and co2 combination was used as shielding gas. The filler metal was an ASW classification E71T-1C with a 1.2 mm diameter electrode. The composition & mechanical properties of base metal & filler metal are listed in Table 1 & Table 2 respectively.

Table 1
Chemical composition base metal & filler metal.

Material	C	Si	Mn	p	S	Cr
IS2062 E250	0.12	0.25	0.60	0.005	0.05	
E71T-1C	0.042	0.38	1.39	0.008	0.007	0.014

Table 2
Mechanical Properties of base metal & Filer metal.

Material	Yield stress	Tensile stress	Elongation (%)
IS2062 E250	210	300	28
E71T-1C	490	560	26.4

B. Welding procedure

Twenty pairs of specimens were CO2 welded based on parameters designed. The gas flow rate and welding current were measured by using a regulator and an anemometer. The gas combination cylinder are used as per design (argon & Co2). Each butt weld was formed by two passes of CO2 welding, one over the other. Single ‘‘V’’ butt weld (welded only one sides) preparation was used. Fig. 1 shows representation of the weld joint preparation that was performed by machining. All welds of specimen were inspected and approved by visual inspection.

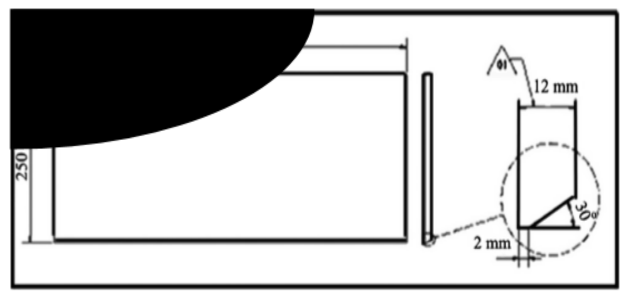

Fig.1Representation of weld joint preparation.

C. Tensile test

Tensile test specimens were prepared in accordance with ASME Section 9). Tensile test were carried out at a strain rate of 0.1 S^{-1} by digital compression tensile tester machine.

III. RESULTS AND DISCUSSION

The geometry of grove fig.2 observed that the welding penetration is good and the ‘‘V’’ groove is uniform in width and width.

Fig.2 Geometry of groove

A. Working limits of parameters

A large number of trial of sample were carried out using 5 mm thick rolled plates of IS2062 E250 Grade to find out feasible working limits of CO2 welding parameters. Different welding parameters were used to carry out the trial runs. The visual inspection were used to identify the working limits of the welding parameters. By trail the results obtained are as following. If the current is less than 170A, there will be lack of fusion and incomplete penetration. For current greater than 210 A, spatter and undercut will be observed on the weld bead surface. If the gas flow rate of shielding gas is lower than 13 l/min, porosities and inclusions will be observed and flow rate of shielding gas combination more than 17 l/min will lead to porosities generation due to agitated flow gas. Considering all the conditions above, feasible limits of the parameters were selected in a manner that the E250grade mild steel is welded without any weld defects. Among a wide range of parameters, central composite design matrix were selected three parameters and five levels to optimize the experimental conditions.

Table 3
Important Co2 welding parameters and their working range

Parameters	Notation	Level				
		-2	-1	0	1	2
Current	I	170	180	190	200	210
Gas flow	G	13	14	15	16	17
% of Co2	M	100	80	50	20	0

Table3 lists the range of selected parameters

Table4 shows 20 sets of coded conditions used to prepare the design matrix. The convenience of recording and processing experimental data by considering upper and lower levels of the parameters were coded as +2 and -2, respectively. The effects of welding parameters namely gas flow, welding current and Gas combination on the tensile strength be explained.

The results of tensile testing performed on welded specimens are tabulated below Table 4.

The tensile testing of the weld is influenced by the weld joint design gas flow rate, welding current & Gas combination.

The effect of the input process parameter on the responses of tensile strength is plotted as.

Table 4
Central Design Matrix and Experimental Result

Ex. No.	Coded value			Actual Value			U.T.L KN	U.T.S N/mm^2
	I	G	M	I(A)	G (L/Min)	M		
1	-1	-1	-1	180	14	80%	77.64	339.811
2	1	-1	-1	200	14	80%	63.72	279.18
3	-1	1	-1	180	16	80%	65.42	286.628
4	1	1	-1	200	16	80%	72.96	320
5	-1	-1	1	180	14	20%	71.94	312.565
6	1	-1	1	200	14	20%	70.16	306.429
7	-1	1	1	180	16	20%	51.24	225.687
8	1	1	1	200	16	20%	74.24	325.272
9	-2	0	0	170	15	50%	72.24	316.842
10	2	0	0	210	15	50%	58.36	225.965
11	0	-2	0	190	13	50%	67.04	294.035
12	0	2	0	190	17	50%	62.64	274.737
13	0	0	-2	190	15	100%	64.36	282.281
14	0	0	2	190	15	0%	15.4	67.544
15	0	0	0	190	15	50%	76.42	333.77
16	0	0	0	190	15	50%	76.36	334.912
17	0	0	0	190	15	50%	77.94	340.409

18	0	0	0	190	15	50%	76.42	333.77
19	0	0	0	190	15	50%	77.94	340.409
20	0	0	0	190	15	50%	76.36	334.912

1. The effect of welding current on Tensile strength.

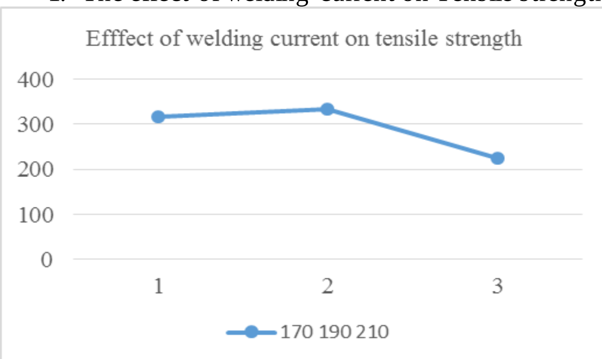

Fig. 3

From Fig.3 it is observed that Welding current directly proportional to tensile strength up to certain limit utter that decreases with increasing welding current.

2. Effect of Gas flow rate on tensile strength.

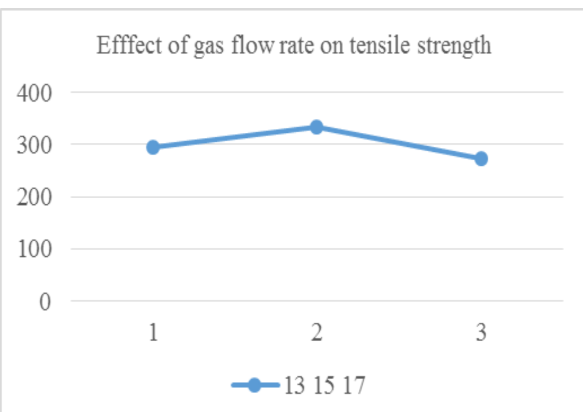

Fig.4

From fig.4 It is observed that the gas flow rate also affect same as welding current.

3. Effect of Gas Combination on tensile Strength.

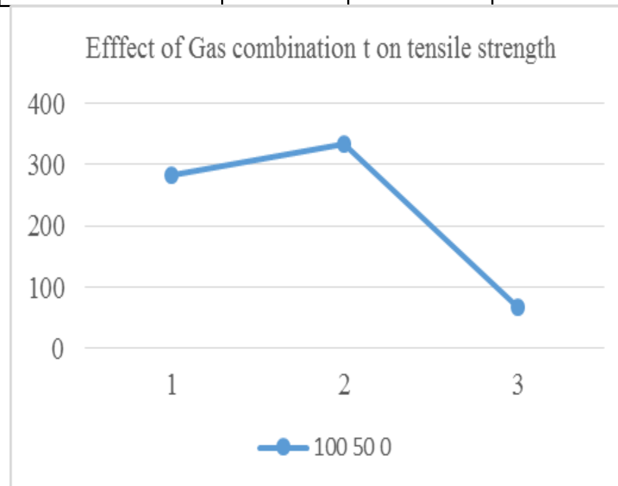

Fig.5

Fig. 5 shows that the effect of gas combination on tensile strength, the tensile strength increase with increasing the Co2 % up to 50% & decreases with decreasing the tensile strength.

B. Development of an empirical relationship

In this experiment, the response the response function of weld joint, Tensile strength (σ) is function of Welding current (I), gas flow (G) and gas combination (M) and it can be expressed as.

$\sigma = f(I, G, M,)$

Second order polynomial equation that represents the response surface 'Y' is:

$$Y = b_0 + \sum b_i x_i + \sum b_{ii} x_i^2 + \sum b_{ij} x_i x_j$$

Selected polynomial could be expressed by considering three parameters,

$$\sigma = b_0 + b_1(I) + b_2(G) + b_3(M) + b_{11}(I^2) + b_{22}(G^2) + b_{33}(M^2) + b_{12}(IG) + b_{13}(IM) + b_{23}(GM)$$

Where, σ, I, G and M. are tensile strength (MPa), current (A), flow rate of shielding gas (l/min) and Gas combination, respectively.

C. Validation of the developed relationship

The adequacy of the developed relationship will tested using the analysis of variance technique (ANOVA). In this technique, if we will the calculated 'F' ratio of the developed model is less than the standard 'F' ratio (from F-table) at a desired level of confidence (95%), the model is adequate within the confidence limit.

IV. CONCLUSION

The effect of welding Input process parameters such as welding Current e, gas flow rate and gas combination influences on mechanical properties i.e. tensile strength shows in the above graph.
The max tensile strength is at 50% Co2 + 50% argon gas combination at 190 A welding current & 15 l/min Gas flow rate.

V. ACKNOWLEDGMENT

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AUTHORS

First Author- Sanjay A. Swami, PG Scholar in Mechanical (Design Engineering), NBN Sinhgad School of Engineering, Ambegaon(Bk), Pune-41.
Email: Sanjayswami75@gmail.com

Second Author- Prof. S.M. Jadhav, Assistant Professor, (Mechanical Design Engineerin), NBN Sinhgad School of Engineering, Ambegaon(Bk), Pune-41.
Email- sainand.jadhav@sinhgad.edu

Third Author- Prof.(Dr.)S.Y. Gajjal, Associate Professor& Head of M.E. Mechanical (Design Engineering)t, NBN Sinhgad School of Engineering, Ambegaon(Bk), Pune-41.
Email: shekhar.gajjal@sinhgad.edu