Design and Optimization of GTA Welding Process Parameter for 1.4301 Stainless Steel Plate Using Several Technique

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Abstract:

In this research work, stainless steel 1.4301 Grade metal with 5mm thick plate were used for investigating weld penetration and weld bead using GTA welding. Selecting the welding method for a particular application is a matter of concern for fabrication industry. If the selection is to be made out of the welding alternatives that are having almost equal capabilities and are to be assessed on similar criteria then this requires meticulous examination of available welding processes and the criteria of assessment. Existing studies focus on using DOE for optimizing the processes by obtaining the optimum process parameters of a method. This study investigates the best method that suits the welding of SS304 austenitic steel using analytical hierarch. The shielding gas supplied alternatively with variation of timing. The weld joint were performed with 10 mm thick plate with 12 passes of alternate supply of shielding gas with variation in timings.

Keywords:-GTA Welding, DOE, 1.4301 Stainless Steel Plate.

1. Introduction

Stainless steels are iron-based alloys that contain a minimum of 12% Cr, the amount needed to prevent the formation of rust in unpolluted atmosphere (hence the designation stainless). Few stainless steels contain more than 30% Cr or less than 50% iron. They achieve their stainless characteristics through the formation of an invisible and adherent chromium rich oxide film. This oxide forms and heals itself in the presence of oxygen. Other elements added to improve particular characteristics include nickel, manganese, molybdenum, copper, titanium, silicon, niobium, aluminum, sulfur, and selenium. Carbon is normally present in amounts ranging from less than 0.03% to over 1.0% in certain grades. Production of Stainless Steels with specific restrictions in certain types, the stainless steels can be shaped and fabricated in conventional ways.

2. Modeling and Optimization

The modeling or system analysis techniques were developed during the second world war to deploy limited resources in an optimum manner. Since these techniques were aided for military operations, these were known as operation research techniques. The popular operations research techniques include optimization methods, simulation, game theory, queuing theory etc. Among these, the popular ones in welding resources field are optimization. Analysis of Variance (ANOVA) is a statistical method used to test differences between two or more means. It may seem odd that the technique is called "Analysis of Variance" rather than "Analysis of Means." ANOVA is used to test general rather than specific differences among means.

The influence of various factors on area of penetration, heat flow rate, and micro-hardness is achieved through ANOVA techniques. For achieving, this source is constructed with various models and degree of freedom is selected for these models.

3. Optimizing The Gta Welding Parameter ForSS 304 For Weld Penetration

3.1 Estimating Working Constraints of the Process Parameters

The full factorial experiment with three sets of combinations of the gases is carried out. The four factors with three levels high, medium and low are selected. The design is called 3^4 (3 levels and 4 factors) factorial designs and nine treatment combinations. The process parameters and the range of parameters are shown in Table 1.

Table 1 Parameters and their Levels for Experiment

Parameters	Notations	Units	Low	Medium	High
Welding Current	A	A	140	180	220
Alternating shielding gases frequency	B	LPS	0.4:0.2 (Ar:He) 0.13:0.06(Lit)	0.6:0.2 (Ar:He) 0.19:.06(Lit)	0.8:0.4 (Ar:He) 0.26:0.13(Lit)
Weld gap	C	mm	1	1.5	2
Welding speed	D	mm/sec	1.5	1.75	2

Taguchi‘s orthogonal design uses a special set of predefined arrays called Orthogonal Arrays (OAs) to design the plan of experiment. Thesestandard arrays stipulate the way of full information of all the factors that affect the process performance (process responses). The corresponding OA is selected from the set of predefined OAs according to the number of factors and their levels that will be used in the experiment.

4. Conducting the Experiments

In this experimental study 5mm thick, 304 stainless steel plates are welded by GTAW. An inverter welding power source with 500 A grades is used. A solenoid valve with 4 mm diameter orifice is used to supply shielding gases to welding torch. Three sets of combination with alternate supply of shielding gases were used, to carry out the experiment. The flow of gases is controlled by solenoid valve, which is operated on timer for controlling. The timer works on 16F870 microcontroller. The micro controller is programmed for the time delay. The circuit was designated for the two types of selection mode. First valve is opened for 0.4 seconds which supplies Argonalternatively second valve opened for 0.2 seconds.

For weld penetration, L_9 orthogonal array was selected with 4 variable process parameter. Using L_9 array, the optimization model was developed with very high level of significance.

Figure 1 Schematic layout of experimental setup with gas alternator

The gas flow was kept constant. For joint evaluation 10 mm thick, specimen were used, for better understanding of weld penetration during the jointing process, 5 mm thickness specimen were used.

Table 2 Design matrix 3^4Factorial design for conducting experiments

Exp No	Welding Current (A)	Gas flow Rate (B)	Weld gap (C)	Welding speed (D)
1	140	0.4:02	1	1.5
2	140	0.8:0.4	1.5	1.75
3	140	0.6:0.2	2	2
4	180	0.4:02	1.5	2
5	180	0.8:0.4	2	1.5
6	180	0.6:0.2	1	1.75
7	220	0.4:02	2	1.75
8	220	0.8:0.4	1	2
9	220	0.6:0.2	1.5	1.5

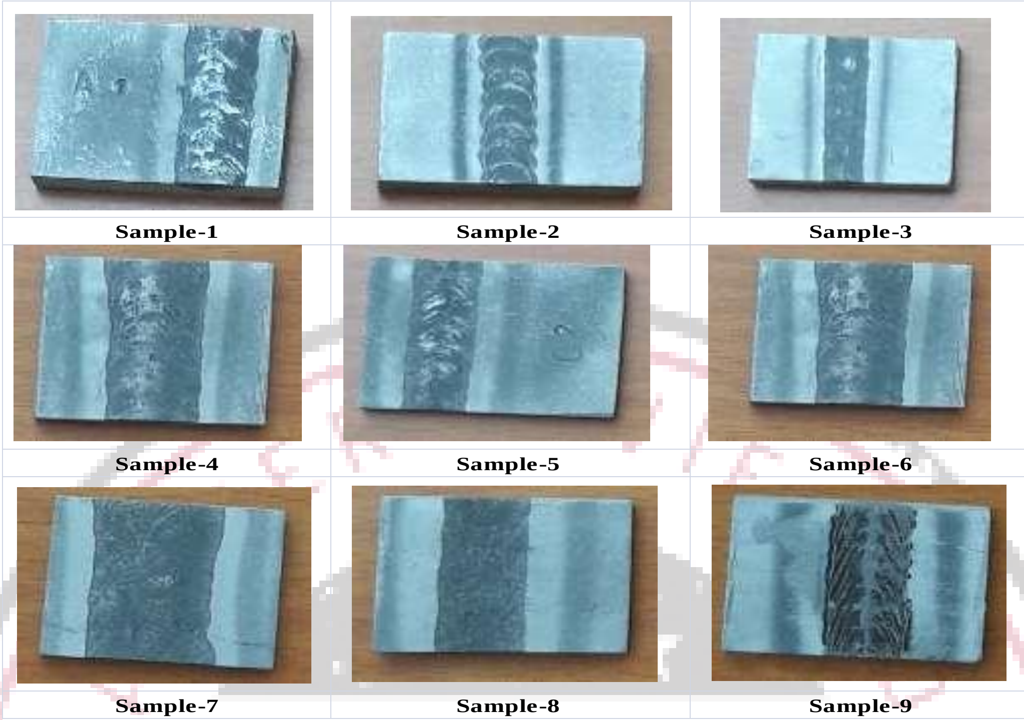

Figure 2 Experimental run1

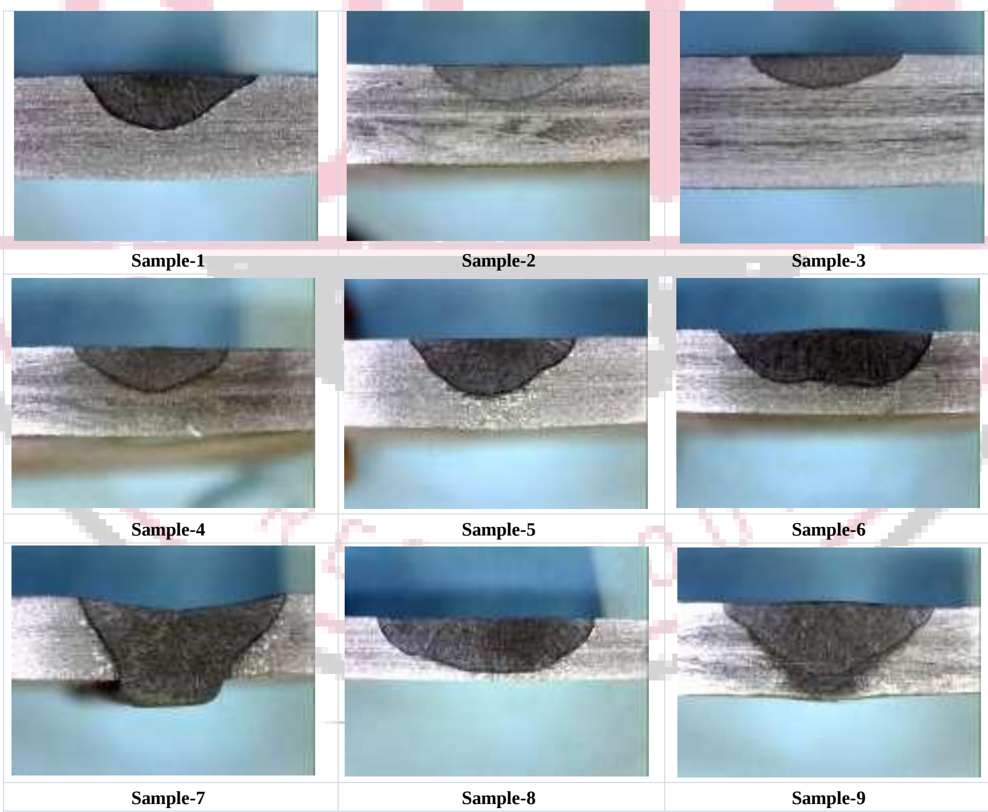

Figure 3 Experimental run2

5. Influence of Various Factors on Area of Penetration

Figure 4 shows the area of penetration influenced by the factors gas flow rate and welding current. The objective over area of penetration should be maximum. It is found out that the increase in the area of penetrationdepends upon the increase in welding current and gas flow rate.

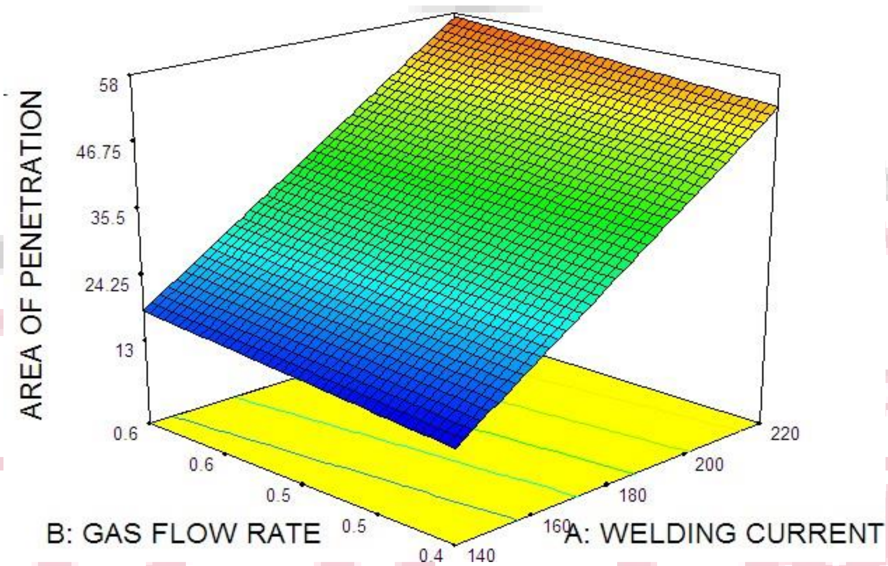

Figure 4 Effect of gas flow rate and welding current

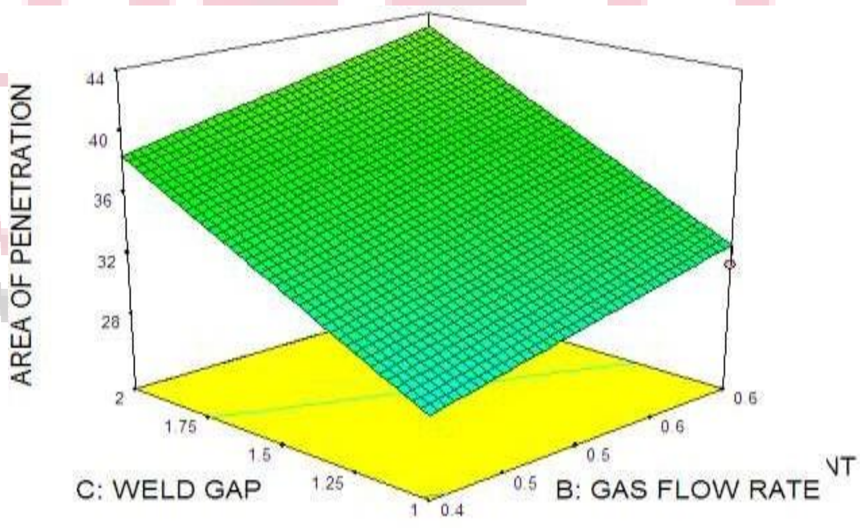

Figure 5 Effect of Weld gap and Gas flow rate

Figure 6 shows that the weld gap and gas flow rate have the contribution to the area of penetration. It reveals that the maximum area of penetration occurs when the weld gap is maximum and gas flow rate isminimum.

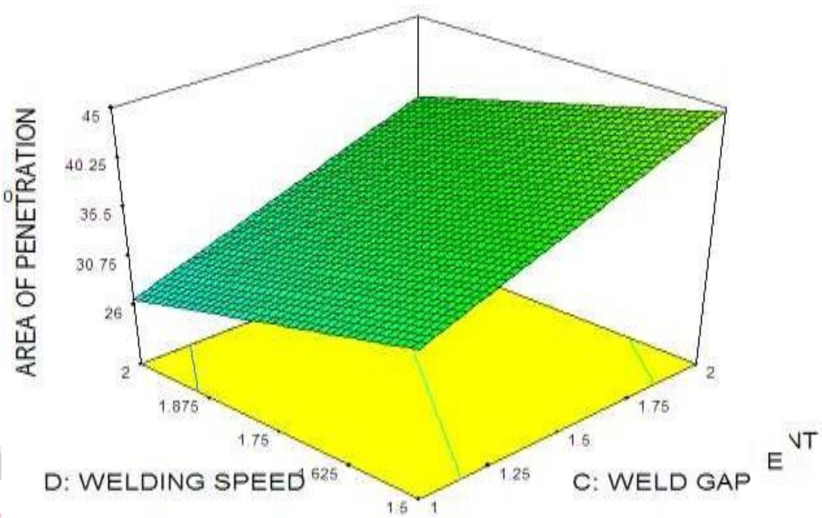

Figure 6 Effect of Welding speed and Weld gap

Figure 7 reveals the effect of welding speed and weld gap on the area of penetration. It shows that the maximum of this particular response occurs at maximum weld gap and at minimum welding speed. This figure shown the area of penetration affected by the welding current and welding speed.

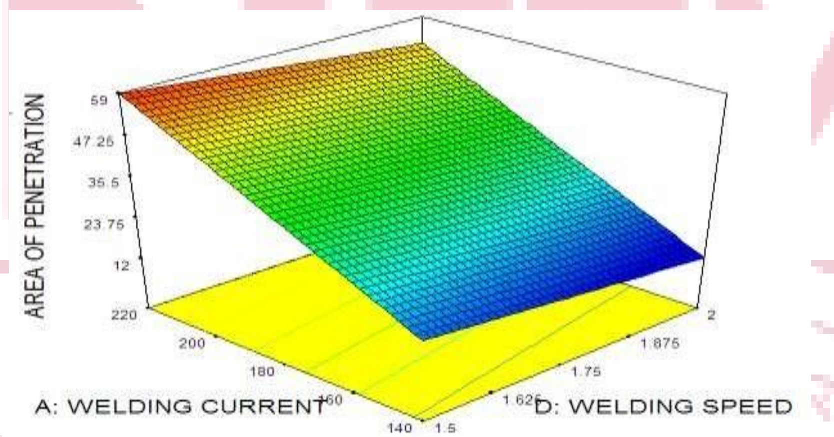

Figure 7 Effect of welding speed and area of penetration

6. Conclusion

An investigation to find the effect of alternate supply of shielding gases with time variation in SS304 plate GTA welding was carried out. The following conclusions were drawn:

- The alternate supply method with Argon and Helium compared with conventional methods of supplying pure. Ar and (Ar + 67% He) shows least degree of welding distortion.
- The 0.8-0.4 seconds of variations of timing with combinationsof alternate supply of Ar and He gases, provides better weld penetration area.

- This alternate supply of shielding gas will provide solution forincrease in gas cost and welding distortion with use in SS304.
- The weld penetration area can be improved by induction of alternate supply of shield gas composition. With variation in the supply of shielding gas timing and with rate of heat flow , arc stability is maintained, which determines the hardness of materials

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