Optimization of Welding Parameters to Reduce Distortion in Welding of SA 203 GRADE-E by ANOVA

Prashant A. Kapse
PG Student
Department of Production Engineering
V.J.T.I. Mumbai, India

Dr. Sachin A. Mastud
Professor & Head of Dept.
Department of Production Engineering
V.J.T.I. Mumbai, India

Abstract

Tungsten Inert Gas (TIG) welding is widely used in fabrication industries. Distortion is major problem due to which reworks and time, cost gets affected. So it has to be controlled. The main objective of this research is to optimize the TIG welding parameters to reduce distortion in plate to plate butt weld joint of material SA203 GRADE –E. An experiment is conducted to study the effect of three TIG welding control parameters as welding current, WEP angle, preheat temperature on welding distortion. Here root gap is taken constant and welding position is same through the experiment. The Experiments were planned using the strategy of DOE. The levels of input parameters were selected and experiments were carried out. The results obtained under the combination of these parameter were analyzed by using ANOVA (analysis if variance), statistical method to investigator the critical parameter affecting the distortion in welding and their contribution.

Keywords: ANOVA, Distortion, DOE, TIG Welding, SA203 Grade-E

I. INTRODUCTION

Welding is major joining technique in fabrication industries for the welding of steels for manufacturing of different structures, pressure vessels, aerospace, shipping, and heat exchangers applications. TIG is arc welding used for smaller fillet and butt welds. In this process the arc is formed between a pointed on consumable tungsten electrode and the work piece, in an inert atmosphere of argon or helium for shielding & electrode replace by filler material. The major design and industry constraints are weld strength and cost competitive.

In optimization of TIG welding processes, parameters play an important role for the final product quality in terms of weld distortions, welding defects, joint efficiency and mechanical properties. As welding process involves the heating and cooling process in non-uniform, uneven manner, the distortions are unavoidable. The weld process contributes to the development of several kinds of distortions like longitudinal, transverse or angular distortions and defects like porosity, cracks, lack of penetration, lack of fusion, undercut, and spatter. Various factors affecting the quality of weld are weld current, consumable size, gas flow rate and the weld speed, preheat temperature weld edge preparation angle, inter pass temperature and transfer speed of consumable. Optimization of these parameters can avoid the major rework and saves production time and cost.

II. EXPERIMENT SET UP AND DETAILS

A. Factorial Design

Design of experiment is technique of defining and investigating all possible combinations in an experiment involving multiple factors and to identify the best combination. Here the different factors and their level are identified. We have used factorial design, and used full factorial design. The three parameters are varied at three different levels so the no of iteration goes to 27

B. Welding Arrangement

Here the sample of material selected is taken for welding , with proper welding arrangement including , TIG welding machine , heating cylinder with burner, temperature measuring chalk, spirit level grinding machine etc , here we have carried out welding with proper welding position 3G welding position

Fig. 1: Welding Equipment

Fig. 2:.Experiment set-up

Fig. 3: Sample of plate to plate set up

Fig. 4: Distorted samples

C. Material Selection

Here we have selected material as, SA 203 GRADE E with plate of 10mm thick. We have chosen this material as it normally used n fabrication of pressure vessel , heat exchangers , also having good corrosive persistence , resistance to oxidation ease of cleaning and easily available with low cost. The chemical composition is as shown

Table - 1
Chemical Composition

Elements	*C*	*Mn*	*P*	*S*	*Si*	*Ni*	*Fe*
Composition	*0.20*	*0.70*	*0.035*	*0.035*	*0.15*	*3.25*	*Balance*

D. Process Parameter

In this study there are three parameters as welding current, weld edge preparation angle and preheat temperature. Each process parameter has here level of values as mentioned in below table
Constant parameter: welding position and work piece thickness, root gap (4mm)

Table - 2
Input parameters at different levels

Parameter	*Unit*	*Level 1*	*Level 2*	*Level 3*
		Low	*Medium*	*High*
Current	*Ampere*	*100*	*150*	*200*
WEP angle	*Degree*	*45*	*60*	*75*
Preheat temp	*Celsius*	*50*	*100*	*150*

E. Response Parameter

Here all experiments were conducted; distortion was measured, as shown below

Table - 3
Experimental results

Sr	*Welding Current*	*WEP*	*Preheat Temp*	*Distortion*
1	*100*	*45*	*50*	*3.75*
2	*100*	*45*	*100*	*3.55*
3	*100*	*45*	*150*	*3.4*
4	*100*	*60*	*50*	*3.8*
5	*100*	*60*	*100*	*3.6*
6	*100*	*60*	*150*	*3.5*
7	*100*	*75*	*50*	*4.1*
8	*100*	*75*	*100*	*4*
9	*100*	*75*	*150*	*3.9*
10	*150*	*45*	*50*	*4.15*
11	*150*	*45*	*100*	*4.5*
12	*150*	*45*	*150*	*4.3*
13	*150*	*60*	*50*	*4.7*
14	*150*	*60*	*100*	*4.4*
15	*150*	*60*	*150*	*4.2*
16	*150*	*75*	*50*	*5.25*
17	*150*	*75*	*100*	*5*
18	*150*	*75*	*150*	*4.9*
19	*200*	*45*	*50*	*5.5*
20	*200*	*45*	*100*	*5.4*
21	*200*	*45*	*150*	*5.3*
22	*200*	*60*	*50*	*6.5*
23	*200*	*60*	*100*	*6.3*
24	*200*	*60*	*150*	*6.2*
25	*200*	*75*	*50*	*6.9*
26	*200*	*75*	*100*	*6.7*
27	*200*	*75*	*150*	*6.1*

III. RESULTS AND DISCUSSION

ANOVA is carried out to analyze the effect of control parameter on reponse with the aid of trial version of MINITAB 16 software

A. ANOVA Results

General Linear Model: Distorion versus Welding Curr, WEP, Preheat Temp

Factor	Type	Levels	Values
Welding Current	fixed	3	100, 150, 200
WEP	fixed	3	45, 60, 75
Preheat Temp	fixed	3	50, 100, 150

Analysis of Variance for Distorion, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Welding Current	2	25.8067	25.8067	12.9033	514.70	0.000
WEP	2	2.7239	2.7239	1.3619	54.33	0.000
Preheat Temp	2	0.4550	0.4550	0.2275	9.07	0.009
Welding Current*WEP	4	0.8211	0.8211	0.2053	8.19	0.006
Welding Current*Preheat Temp	4	0.0400	0.0400	0.0100	0.40	0.804
WEP*Preheat Temp	4	0.0994	0.0994	0.0249	0.99	0.465
Error	8	0.2006	0.2006	0.0251		
Total	26	30.1467				

S = 0.158333 R-Sq = 99.33% R-Sq(adj) = 97.84%

Fig. 5: Minitab result for Analysis of Variance

B. Main Effects Plot

Main effects plot shows that welding current is the main significant parameter then WEP and preheat temperature.here as welding current and WEP angle increses the distotion also gets increses but as preheat temp increses ,the distortion get decreses

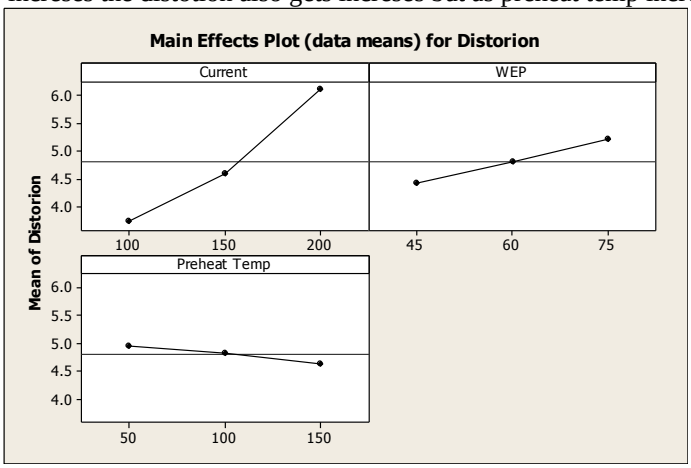

Fig. 6: Main Effects Plot (Data Means) For Distortion

C. Interaction Plot

Interaction plot shows there is no significant interaction among the parameters. Each parameter contribute indivisualy towards output.here we have seen thet there is interaction between WEP and welding current but has no more significance.

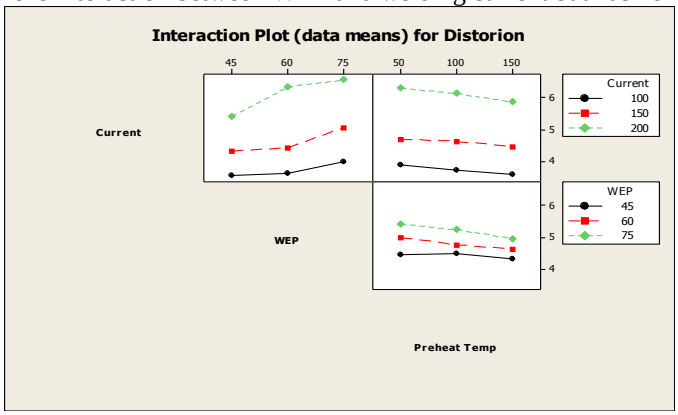

Fig. 7: Interaction Plot (data means) for Distortion.

Table -3
Manual ANOVA results of parameters and their interaction

Symbol	***Parameter***	***DOF***	***Sum of sq.***	***Mean sq.***	***P (%)***
C	*Current*	*2*	*25.80667*	*12.90335*	*85.60*
A	*WEP angle*	*2*	*2.723889*	*1.3619445*	*9.03*
T	*Preheat temp*	*2*	*0.455*	*0.2275*	*1.50*
*C*A*	*Current*WEP*	*4*	*0.82112*	*0.20528*	*2.72*
*A*T*	*WEP*Preheat temp*	*4*	*0.09942*	*0.02486*	*0.0824*
*C*T*	*Current*preheat temp*	*4*	*0.04*	*0.01*	*0.132*
Error	-	*8*	*0.199*	*0.0249*	*0.660*
Total	-	*26*	*30.146667*	-	*100*

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IV. CONCLUSION

Distortion in welding is very important in fabrication industries, welding current is moistly affecting parameter for distortion From the experiments on work piece plate by TIG welding and analysis by statistical tool ANOVA, welding current is the most influencing parameter to the distortion on weld joints than WEP angle and preheat temperature. Here distortion is directly proportional with thwe welding current and WEP angle , it means as welding current or WEP angle increases the distortion gets also increases , but the preheat temperature having inversely with distortion

The percentage contributions for welding current, WEP angle and Preheat temperature are 85.60%, 9.03% and 1.50% respectively.

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