Experimental Investigation of TIG Welding for Stainless Steel using Design of Experiment

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Abstract

Gas tungsten arc welding is a fusion welding process having broad application in industry. In this experiment selected three process parameters like current, groove angle and welding speed and range was decide for each parameters by trial and error method and distortion was the output parameters. To perform the experiment on TIG welding L27 orthogonal array has been used and based on that according to each run set experiment has performed and optimization run set was found. By Taguchi analysis and also find the regression equation for same experiment.

Keywords- TIG Welding Distortion, L27 Orthogonal Array, Taguchi

I. INTRODUCTION

The temperature distribution in the weldment is not homogeneous as a result of local heating and change that take place as welding progresses. Heat-affected zones of weld and the base metal instantly adjoining to the welded area are at a temperature significantly above that of the unaffected base metal. As the molten pool solidifies and shrinks, it begins to exert decrease stresses on the surrounding weld metal and heat-affected zone.

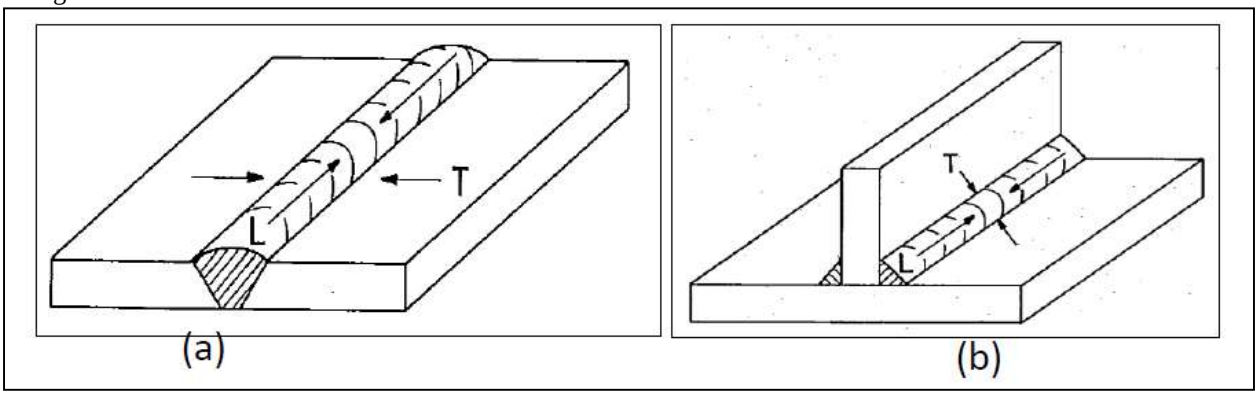

Fig. 1: Longitudinal (L) and transverse (T) shrinkage stresses Butt (a) and Fillet (b) joint

The distortion may show in butt joints as both longitudinal and transverse shrinkage and contraction, and as angular change when the face of the weld shrinks more than the root. The latter change produces transverse bending in the plates along the weld length. These effects are illustrated in figure 2

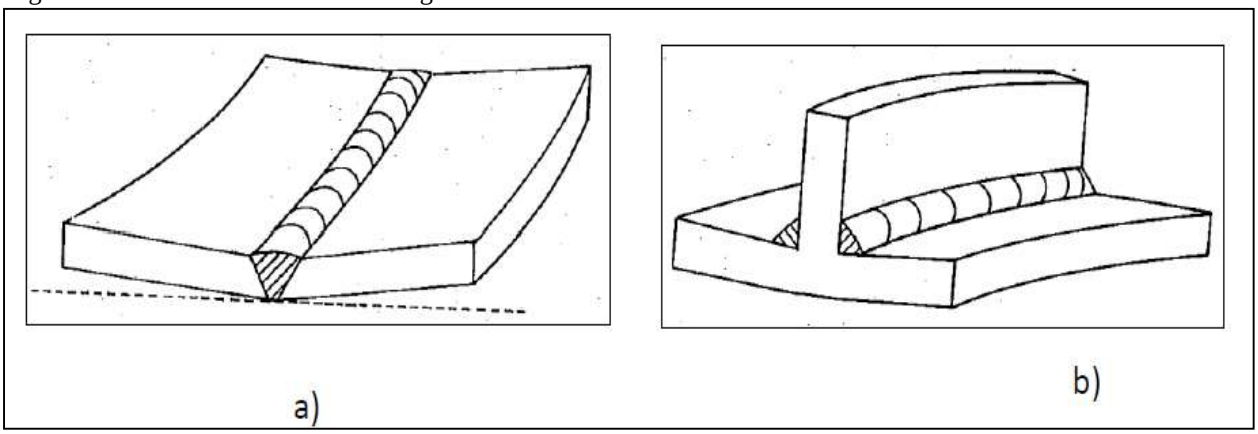

Fig. 2: Distortion in Butt (a) and Fillet (b) joint

II. LITERATURE REVIEW

Rakesh Prajapati et.al was experimented on the GMAW welding by L9 orthogonal array where the process parameters are welding speed current and gas flow rate and the response parameters is the UTS. He was perform the experiment for 9 run set by using design of experiment. [1]. Asifa Khurram ET always developed f.e model for predict the weld distortion and residual stresses in but joint. Nonlinear FE transient thermal analysis is performed using surface heat source model with Gaussian distribution to compute highest temperature in mild steel plates. [3]. V. J. PAPAZOGLOU et.al studied The development of analytical means for predicting and controlling distortion in welded aluminum structures is summarized in Part I. Experimental and analytical studies on transverse shrinkage, longitudinal distortion, out-of-plane angular distortion and buckling distortion are presented. Methods for reducing weld distortion. [4]. Ramani.S et al. was studied angular distortion in which four factors and five level factorial centre composite rotatable design is used to develop a mathematical model to predict angular distortion with MIG welding process parameters. Mathematical model developed to optimize the process parameters. The experiment perfume by MIG welding over AI6061 plates [5].

III. EXPERIMENTAL SETUP

The experiments have been conducted using a Unitor UWI 400 Power Source and an Automated Welding Set up. In this welding machine automated Tungsten Inert Gas torches as well as automatic feeler wire feeding units are provided. For experimentation, servo motors are used for maintaining welding speed during actual welding. This would be rather diverse with hand held manual torch. While using automated TIG torch welding speed can be set to specific value directly on this machine as it is a controlled automation. As the stainless steel is classified in different categories like austenitic, ferrite, martens tic etc. from this we have chosen austenitic stainless steel (304) because of its low cost, easy accessibility in the market. Austenitic is the broadly used type of stainless steel. It has a nickel content of at least of 7%, which makes the steel structure fully austenitic and gives it ductility, a large scale of service temperature, non-magnetic properties and good weld capability. Stainless steel is selected for transport out the experimental analysis because of its many advantages and easy availability in the market.

Table 1: Typical Room Temperature Mechanical Properties

Material	*UTS Mpa*	*0.2 % Mpa*	*Elongation in 50.8 mm*	*Hardness Roclwell*
304	*89 – 579*	*52-290*	*55*	*80*

Table 2: Chemical composition of filler metal

	C	*Cr*	*Ni*	*Mo*	*Mn*	*Si*	*P*	*S*	*Cu*
	0.08	*19.5- 22*	*9 – 11*	*0.75*	*1-2.5*	*0.30 – 0.65*	*0.03*	*0.03*	*0.75*

Table 3: Process parameters and their level. [2]

Parameters	*Unit*	*Level 1*	*Level 2*	*Level 3*
		Low	*Medium*	*high*
Current	*Ampere*	*175*	*200*	*225*
Groove angle	*Degree*	*45*	*60*	*75*
speed	*Mm/sec*	*2*	*3*	*4*

Table 4: L27 Orthogonal array. [2]

Experiment No.	*Process parameter*		
	Current (Ampere)	*Groove angle (Degree)*	*Welding speed (mm/sec)*
1.	*1*	*1*	*1*
2.	*1*	*1*	*1*
3.	*1*	*1*	*1*
4.	*1*	*2*	*2*
5.	*1*	*2*	*2*
6.	*1*	*2*	*2*
7.	*1*	*3*	*3*
8.	*1*	*3*	*3*
9.	*1*	*3*	*3*
10.	*2*	*1*	*2*
11.	*2*	*1*	*2*
12.	*2*	*1*	*2*
13.	*2*	*2*	*3*
14.	*2*	*2*	*3*
15.	*2*	*2*	*3*
16.	*2*	*3*	*1*
17.	*2*	*3*	*1*
18.	*2*	*3*	*1*
19.	*3*	*1*	*3*

20.	*3*	*1*	*3*
21.	*3*	*1*	*3*
22.	*3*	*2*	*1*
23.	*3*	*2*	*1*
24.	*3*	*2*	*1*
25.	*3*	*3*	*2*
26.	*3*	*3*	*2*
27.	*3*	*3*	*2*

Welding specimen has been prepared for TIG welded joints. SS 304 specimen with dimension 200mm x 150mm x 5mm was considered for welding with different angle Vee butt joints. Welding process has been carried out in TIG welding machine.

Table 5: Experimental run set with response

Experiment No.	*Process parameter*			*Distortion (mm)*
	Current (Ampere)	*Groove angle (Degree)*	*Welding speed (mm/sec)*	
1.	*175*	*45*	*2*	*9.78*
2.	*175*	*45*	*2*	*8.25*
3.	*175*	*45*	*2*	*9.45*
4.	*175*	*60*	*3*	*8.25*
5.	*175*	*60*	*3*	*8.45*
6.	*175*	*60*	*3*	*8.63*
7.	*175*	*75*	*4*	*9.25*
8.	*175*	*75*	*4*	*9.56*
9.	*175*	*75*	*4*	*9.75*
10.	*200*	*45*	*3*	*8.85*
11.	*200*	*45*	*3*	*7.45*
12.	*200*	*45*	*3*	*9.25*
13.	*200*	*60*	*4*	*9.45*
14.	*200*	*60*	*4*	*8.65*
15.	*200*	*60*	*4*	*8.52*
16.	*200*	*75*	*2*	*9.25*
17.	*200*	*75*	*2*	*9.65*
18.	*200*	*75*	*2*	*9.36*
19.	*225*	*45*	*4*	*9.78*
20.	*225*	*45*	*4*	*8.65*
21.	*225*	*45*	*4*	*9.45*
22.	*225*	*60*	*2*	*8.45*
23.	*225*	*60*	*2*	*9.63*
24.	*225*	*60*	*2*	*8.80*
25.	*225*	*75*	*3*	*8.25*
26.	*225*	*75*	*3*	*9.20*
27.	*225*	*75*	*3*	*8.56*

After performing the experiment with the L27 run set which has been prepared by the Taguchi techniques can carried out the response for each run set and found optimize run set which has lowest distortion value. At 200 amp current 45^0 degree groove angle and 3 mm/sec welding speed, can find 7.45 mm welding distortion .distortion can be find out by the dial gauge in which at different pre decided spot dial gauge set and take the reading of whole work piece to check the distortion.

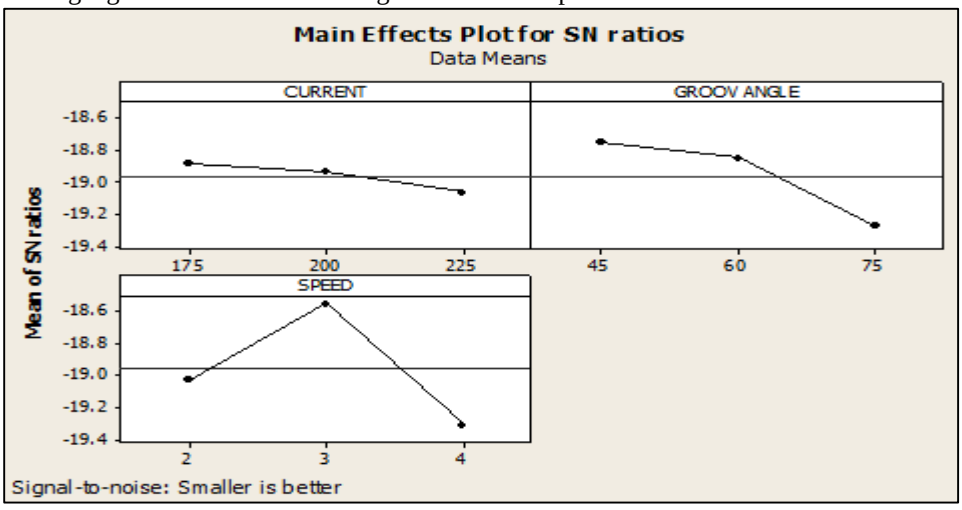

Fig. 1: Main effect plot for SN ratio

Figure 1 indicating the main effect plot of single to noise ratio in which we can find the effect of different parameters on the distortion main effecting parapets was the welding speed which can show in table no.6 as seen in the graph welding speed is the most effective parameters.

Table 6: Response Table for Signal to Noise Ratios

Level	*Current*	*GOOVE ANGLE*	*WELDING SPEED*
1	*-18.18*	*-18.76*	*-19.03*
2	*-18.94*	*-18.85*	*-18.55*
3	*-19.07*	*-19.28*	*-19.31*
	0.18	*0.52*	*0.75*
	3	*2*	*1*

Regression Equation for Distortion = 7.70148 + 0.0036 CURRENT + 0.147778 SPEED by using this equation can find out the different predicted value of distortion.

IV. CONCLUSION

In this experiment Taguchi technique was used to optimize the process parameters where the process parameters are current, groove angle and welding speed and the response parameters was distortion.L27 orthogonal array used to perfume the experiment and it was found the run no.11 gives the optimum result for the distortion. After that regression equation developed for prediction the number of result and also check the validation of regression equation by comparing the result with experimental result.

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