Optimization of Process Parameters of Multi-Response Tungsten Inert Gas Welding of AISI 304L

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Abstract- *The objective of this research work is to study influence of TIG welding parameters on AISI 304L.Parameters like welding current, gas flow rate, welding speed and filler material are considered for study. Response variables are tensile strength and bending strength. Experimentation is carried out according to L18 orthogonal array. ANOVA technique is used to find out influence of each parameter on strength of material. Results showed that welding current has the highest influence on tensile strength and bending strength.*

Keywords- Tungsten Inert Gas (TIG),

I. INTRODUCTION

TIG welding is also called as Gas Tungsten Arc Welding. It was developed in 1940 at the start of Second World War [1]. TIG welding uses non-consumable tungsten electrode to produce the arc and shielding gas to protect the weld pool, heat affected zone, tungsten electrode from atmospheric contamination. Argon and helium are most commonly used shielding gas [2]. Stainless steel also called as the corrosion resistance steel are family of iron base alloys having excellent corrosion resistance properties. Stainless steel consists of minimum 10.5% chromium [3]. Also molybdenum and nickel are added to increase the corrosion resistance property. Stainless steel are again classified as ferrite, austenite, martensite and duplex stainless steel.304L is austenite stainless steel consisting minimum 18% chromium and less than 0.03% carbon [4].

Taguchi method is one of the best and power fool technique which uses special design to study the effect of parameters with less number of experiments [5]. This technique provides simple and effective approach for optimization. Problem can be solved with the help of orthogonal array. Percentage contribution of each parameter can be obtained with the help of ANOVA [6].

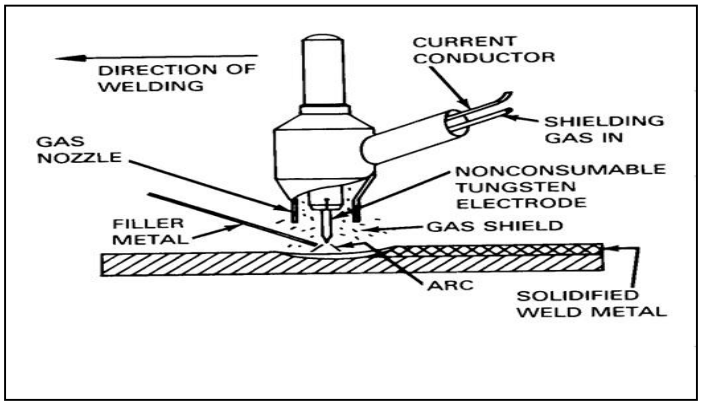

Fig.1Basic mechanism of TIG welding [5]

Literature review, modeling and analysis of plasma arc cutting process presented below

II. METHODOLOGY

Experimentation and analysis work is carried out by following way

a) Design and perform the experiments for pilot readings
b) Decide the each level of process parameters from pilot experimentation
c) Design and perform orthogonal array with the help of level of each parameters
d) fter performing orthogonal array experimentation Taguchi and ANOVA analysis technique is used is used to find percentage contribution of each process parameter for respective response variables

1] Material specifications:

Material	: 304L Austenite stainless steel
Thickness	: 4mm
Size	: 100mm*50mm
Weld type	: Butt weld

ELEMENT	WEIGHT PERCENTAGE
Carbon	0.0168
Manganese	1.70
Phosphorus	0.0217
Sulphur	0.005
Silicon	0.353
Chromium	18.41
Nickel	8.10
Molybdenum	0.218

Table1 Chemical composition of 304L

2. Critical parameters and their levels:

LEVELS	1	2	3
FILLER	308L	309L	-
Current	80	100	120
Gas flow(LPM)	4	8	12
Speed(mm/min)	100	120	140

Table 2 Parameters and their levels

III. EXPERIMENTATION

Taguchi method is used for design of experiments. Since one parameter having two levels so mixed design is used. L18 orthogonal array and respective responses are listed in table.

Sr. No	Filler	Current (A)	GF	WS (mm/min)	Tensile (MPa)	Bending (MPa)
1	308L	80	4	100	552.85	740.25
2	308L	80	8	120	507.43	621.32
3	308L	80	12	140	562.69	525.5
4	308L	100	4	100	582.91	898.4
5	308L	100	8	120	599.7	908.25
6	308L	100	12	140	584.29	621.37
7	308L	120	4	120	596.42	1252.5
8	308L	120	8	140	565.34	782.46
9	308L	120	12	100	577.86	815.85
10	309L	80	4	140	580.33	1089.48
11	309L	80	8	100	533.41	775.56
12	309L	80	12	120	581.4	845.12
13	309L	100	4	120	655.28	1218.75
14	309L	100	8	140	551.37	687.34
15	309L	100	12	100	570.76	1019.61
16	309L	120	4	140	590.9	1248.5
17	309L	120	8	100	566.66	970.51
18	309L	120	12	120	630.91	1065.14

Table 3 L18 orthogonal array

Tensile test:

Dimensions of tensile specimens are prepared according to AWS standard. Tensile specimens are prepared on milling machines. Tension test is carried out on the universal testing machine.

1] Design of Tensile specimen:

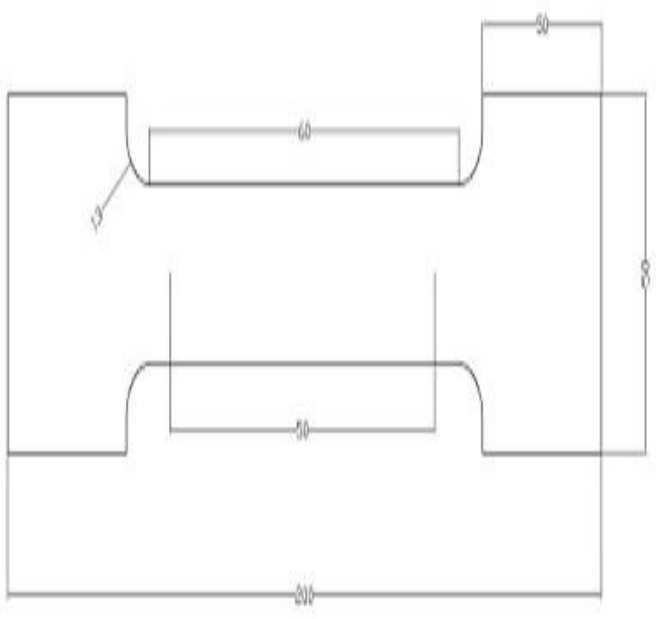

Fig.2 Tensile specimen design

2] Preparation of tensile specimen

Fig.3Preperation of tensile specimen

3] Bending test

Bending test is mainly conducted to check the ductility and soundness of the weld. Bend test is again classified as root bend and face bend. If the root is outside and it is in tension then it is called as root bend test

Fig.4Three point bend test

Fig.5 Root bend

Fig.6 Bend Test Specimens

IV.RESULT AND DISCUSSION

1] Analysis of Variance

Analysis of variance (ANOVA) is a statistical model which can be used to find out effect of independent parameter on single dependent parameter and also can be used to find out the significant parameters and the percentage contribution of each parameter. MINITAB17 is statistical software used.

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Filler	1	352.8	12.36	12.36	0.09	0.776
Current	2	2614.1	2750.18	1375.09	9.61	0.007
Gas flow	2	3322.9	3018.32	1509.16	10.55	0.006
Speed	2	5867.6	5867.42	2933.8	20.51	0.001
Residual error	8	1144.4	1144.43	143.05	-	-
Total	15	13301.9	-	-		--

Table 4 ANOVA for tensile strength

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Filler	1	161738	161738	161738	18.23	0.002
Current	2	184991	184991	92495	10.43	0.004
Gas flow	2	279455	279455	139727	15.75	0.001
Speed	2	88062	88062	44031	4.96	0.032

Residual error	10	88704	88704	8870	-	-
Total	17	802950	-	-		--

Table 5 ANOVA for bending strength

2] Percentage contribution:

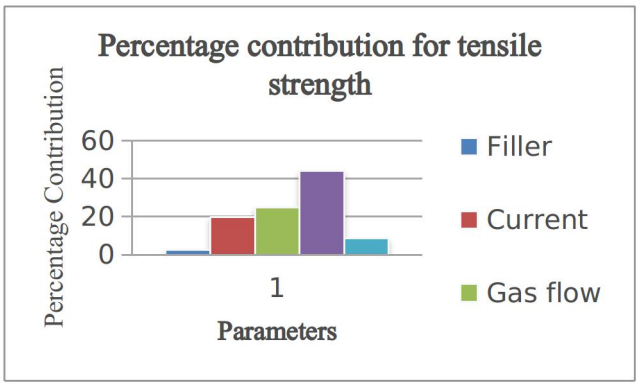

Fig.7 Parameter contribution for tensile

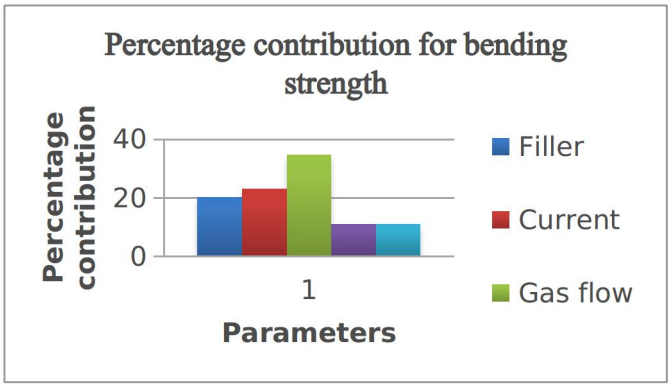

Fig.8Parameter contribution for bending

Welding speed has the highest contribution (44.11%) followed by the welding current (24.98%) for the tensile strength while gas flow rate has the highest contribution (34.8%) followed by the welding current (23.03%) for bending strength.

3] Main effect plots.

Fig.9 Main effect plot for tensile strength

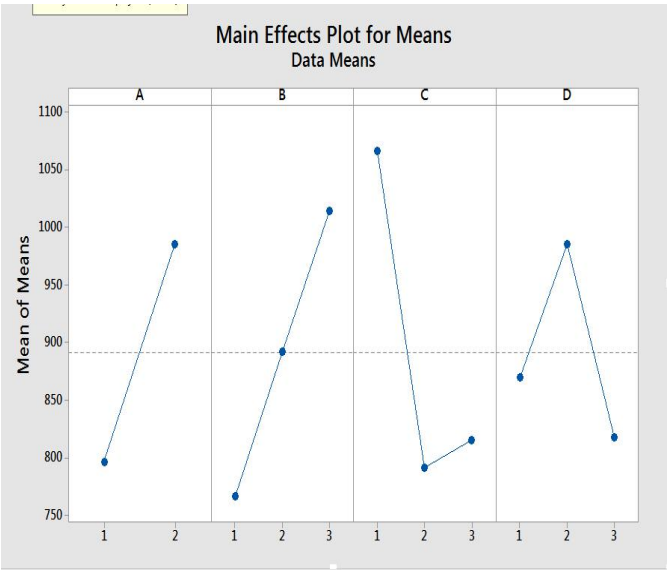

Fig.10 Main effect plot for bending strength

Welding speed is one of the most critical parameters to obtain the good quality weld. Also the current and gas flow rate has the dominant contribution in weld quality and strength of the weld. Proper control of these parameters yields in good weld quality.

V. CONCLUSION

To get maximum tensile strength optimum parameters obtained are current 100A, filler 309L, gas flow rate 4lpm and welding speed 120 mm/min.

Maximum bending strength can be obtained by current 120A,gas flow rate 4lpm,filler 308L,and speed 120mm/min. 309L filler gives good quality welds. From ANOVA welding speed and current has the more influence on the weld strength followed by gas flow rate.

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