PARAMETRIC OPTIMIZATION OF CO_2 WELDING ON FE410 USING TAGUCHI TECHNIQUE

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Abstract – *As we know that the use of stainless steel in different sectors and sections in industries are high due to their properties such as higher tensile strength and hardness along with toughness. Therefore the time has arrived to think about stainless steel with which it is compatible and stronger. In this paper we have studied the mechanical properties of the joint of martensitic stainless steel (AISI 410) by using CO_2 welding. We have used Taguchi's method of optimization to optimize the various process parameters such as Current, Voltage, and Gas Flow Rate (GFR) which has influence on tensile strength and hardness of the joint. However, investigation is based on the Taguchi's approach of orthogonal array using analysis of variance (ANOVA) to determine influence of process parameters and to optimize them.*

***Key Words*: *Martensitic* Stainless Steel (FE410), CO_2 Welding, Taguchi Orthogonal Array, Tensile Strength, Hardness**

1 INTRODUCTION:

In the age of rising industrialization welding process is one of the most important methods in the field of manufacturing industries. Among the various welding processes CO_2 welding plays a major role in the welding of stainless steel. CO_2 welding is also mostly used in industries for better strength of weld. Kumar Rahul Anand (4) who carried out experiment on parametric optimization of Co2 welding which is done on stainless steel the process parameter where current, voltage and gas flow rate (GFR) statistically techniques analysis of variance (ANOVA) signal to noise ratio and graphically main effect plot have been used to study the effect of welding parameters on which ultimate load of weld specimen optimum parametric condition obtained by the Taguchi method.

It is there resistance to hot gases steam as this have the high tensile strength and hardness and toughness accept therefore need is to be arrived to think out in the field of the stainless steel with the other metal which are compatible stronger stainless steel till so this paper we have studied the mechanical properties of joint of the martensitic stainless steel (AISI 410) and building up stainless steel of grade AISI 410 with CO2 welding.

2. METHODOLOGY:

a) Selection of base material (AISI410).
b) Process Parameter selection (Welding current, Arc Voltage, & Gas Flow Rate).
c) Sample preparation (Cutting, Welding, Finishing, etc.).
d) Specimen for Tensile Test and Hardness Test.

3. TAGUCHI METHOD:

Genichi Taguchi a Japanese Scientist developed a technique called Orthogonal Array which is mostly used in the manufacturing industries. The aim of this technique is to provide a high quality product at very low cost. Taguchi have orthogonal array through which the mean and variance of the process parameter get affected when different parameters is applied. However he provided equal weighted to each factor by this, Taguchi showed that the variability is caused by individual factor and that can be controlled individually. Regardless of the environment in which it is used this process is designed with the aim to produce consistent output.

4 SIGNAL TO NOISE (S/N) RATIO:

Taguchi method stresses the importance of studying the response variation using the signal-to-noise (S/N) ratio are,

1.Larger the better

$$SN_L = -10\ log\left[\frac{1}{n}\sum_{i=0}^{n} {}^{1}/_{y_i^2}\right]$$

2.Smaller the better

$$SN_s = -10\ log\left[\frac{1}{n}\sum_{i=0}^{n} y_i^2\right]$$

3.Nominal is best

$$SN_{N} = 10\ log\left(\frac{\bar{y}^2}{s^2}\right)$$

Where, n= Number of trials or measurement, Y = Measured

Value of i^{th} run, $\bar{y}$= mean of measured value, s = standard deviation.

ANOVA (Analysis Of Variance), The total sum of squared deviations SS_T from the total mean S/N ratio n_m can be calculated as, $SS_T = \Sigma (n_i - n_m)^2$ where, n_i = S/N ratio of i^{th} run or experiment. n_m = total mean of S/N ratio. In this paper 3x3 parameter level are selected, So L9 orthogonal array has been selected. The arrays are given below in table 1.

Table-1. L9 Orthogonal Array:

NO.OF RUNS	CONTROL FACTORS		
	A	B	C
1	L1	L1	L1
2	L1	L2	L2
3	L1	L3	L3
4	L2	L1	L2
5	L2	L2	L3
6	L2	L3	L1
7	L3	L1	L3
8	L3	L2	L1
9	L3	L3	L2

Where A, B and C are process parameter & L1, L2 and L3 are levels of each parameter.

5. EXPERIMENTATION:

The specimen is prepared from the AISI 410 and MS of dimension 80*40*4mm. The welding parameters to this research are taken as current, voltage and gas flow rate. The S/N ratio for each level of process parameters is computed based on S/N analysis. Further, statistical analysis of variance (ANOVA) was performed to indicate which process parameters are significant. Thus the optimal combination of the process parameters can be obtained.

Table-2: Chemical Composition of Stainless steel 410 in wt. %.

Designation	Chemical Composition , Max wt %				
	%C	%MN	%P	%S	%FE
AISI 1024	0.2	1.3	0.045	0.045	BALANCE

Table-3: Process Parameters

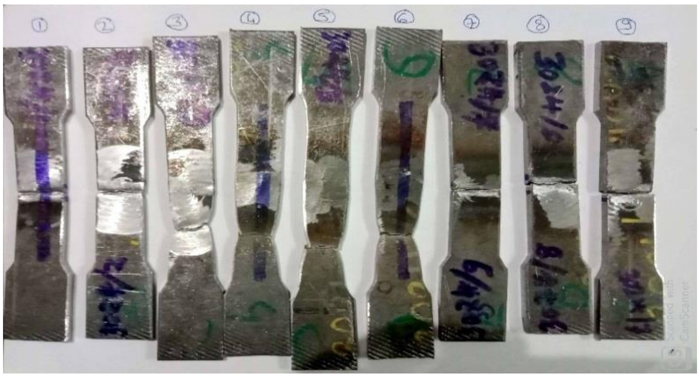

Fig-1:- Specimens after Tensile Test.

Sr. No.	Symbol	Process Parameter	Unit
1	A	Welding Current	Amp
2	B	Arc Voltage	Volt
3	C	Gas Flow Rate	L/min

Tensile test is used to determine the tensile strength of the welded joint of Austenitic Stainless Steel (AISI 410). The test is conducted on Universal Testing Machine (UTM) and the result is shown in table no - 4:

Table-4: Universal Testing Machine (UTM) Results.

Run	Current	Voltage	Gas Flow Rate	Tensile Strength (Mpa)	Hardness (HAZ)
1	125	20	14	297.33	189.6
2	140	20	17	329.26	170
3	150	20	20	424.95	169.4
4	125	25	14	430.04	167.6
5	140	25	17	425.73	172.8

6	150	25	20	427.53	171.2
7	125	18	14	227.81	172.2
8	140	18	17	215.66	188.6
9	150	18	20	295.81	170.8

$$SN_L = -10 \log \left[\frac{1}{n}\sum_{i=0}^{n} {}^{1}/_{y_i^2}\right]$$

For 1st run: n = 1 because we get the result in single trial y_i = 297.33(observed value) so, S/N = -10 log (1/ 297.33²) = 49.46 similarly we calculate S/N Ratio for every run. The response values measured from the experiments and their corresponding S/N ratio values are listed in table no -5 below.

RESULT & DISCUSSION:

FOR TENSILE STRENGTH:

Table-5: Response of Tensile Strength with S/N ratio:

Run	Current	Voltage	Gas Flow Rate	Tensile Strength (MPA)	S/N Ratio
1	125	20	14	297.33	49.46
2	140	20	17	329.26	50.35
3	150	20	20	424.95	52.56
4	125	25	14	430.04	52.67
5	140	25	17	425.73	52.58
6	150	25	20	427.53	52.61
7	125	18	14	227.81	47.151
8	140	18	17	215.66	46.67
9	150	18	20	295.81	49.42

Main Effects Graph of UTS:

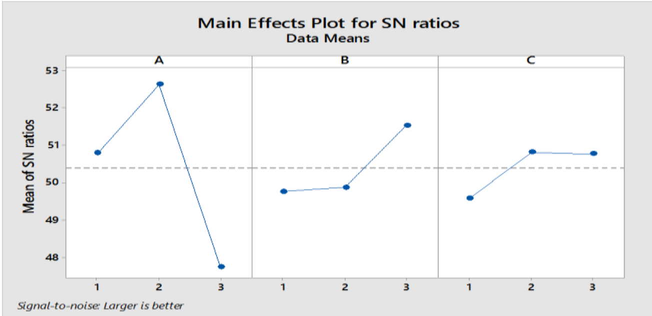

Fig-2: Graph for S/N Ratio of Different parameters For Tensile Strength

Table 6-: Mean Response Table for Signal to Noise Ratio For

Level	A	B	C
1	50.79	49.76	49.59
2	52.62	49.87	50.81
3	47.75	51.54	50.77
Delta	4.88	1.77	1.23
Rank	1	2	3

Tensile Strength is on the criteria Larger is better. From the above table we have observed that the Tensile Strength of taken specimen will be higher when the arc current is maintained at 140, arc voltage at 25V and gas flow rate at 17L/min thus we find these parameter optimum for this experiment.

Table-7: ANOVA of Variance for S/N Ratio Tensile Strength.

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
A	2	0.000386	78.90%	0.000386	0.000193	69.1	0.014
B	2	0.000065	13.22%	0.000065	0.000032	11.57	0.08
C	2	0.000033	6.75%	0.000033	0.000017	5.91	0.145
Error	2	0.000006	1.14%	0.000006	0.000003		

The ANOVA is used to investigate which process parameters have significantly affected the quality characteristics. ANOVA gives the detail about the percentage contribution made by the various process parameters and the error. Thus it helps in evaluating importance of process parameter.

FOR HARDNESS:

Table-8: Response of Hardness with S/N ratio:

Run	Current	Voltage	Gas Flow Rate	Hardness (HAZ)	S/N Ratio
1	125	20	14	189.6	45.55
2	140	20	17	170	44.60
3	150	20	20	169.4	44.57
4	125	25	14	167.6	44.48
5	140	25	17	172.8	44.75
6	150	25	20	171.2	44.67
7	125	18	14	172.2	44.72
8	140	18	17	188.6	45.51
9	150	18	20	170.8	44.64

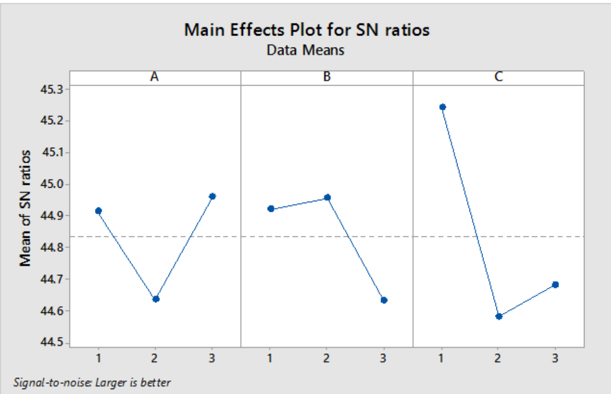

Fig-3: Graph for S/N Ratio of Different Parameters for Hardness

Table-9: Results of Optimum Parameters for Hardness

Level	A	B	C
1	44.96	44.96	45.25
2	44.64	44.92	44.58
3	44.91	44.63	44.68
Delta	0.32	0.32	0.66
Rank	2	3	1

From the above table we have observed that the Hardness of taken specimen will be higher when the arc current is maintained at 125 A, arc voltage at 20V and gas flow rate at 14 L/min thus we find these parameter optimum for this experiment and we have the ANOVA result in below table.

Table-10: ANOVA of Variance for S/N Ratio Hardness

Source	DOF	Seq SS	contribution	Adj SS	Adj MS	F-Value	P-Value
A	2	0	14.39%	0	0	1.23	0.449
B	2	0	14.52%	0	0	1.24	0.447
C	2	0	59.34%	0	0	5.05	0.165
Error	2	0	11.75%	0	0		
Total	8	0	100.00%				

CONCLUSIONS:

The present experiment can be concluded in the following steps:

1 .In this experiment Taguchi design is used for the optimization of welding parameters for the joint of stainless steel (AISI 410) and mild steel.

2 Optimized parameters for the tensile strength is

Arc Current	Level 2	140
Arc Voltage	Level 3	25
Gas Flow Rate	Level 2	17

3 Optimized parameters for the Hardness is

Arc Current	Level 1	125
Arc Voltage	Level 1	20
Gas Flow Rate	Level 1	14

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