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Parametric Optimization of TIG Welding Influence On Tensile Strength of Dissimilar Metals SS-304 And Low Carbon Steel by Using Taguchi Approach

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ABSTRACT :*This study aims to optimizing and investigation in TIG welding parametric influence on tensile strength of dissimilar metals SS-304 and low carbon steel. the literature survey and experimental work has been done. The welding process has been designed using Minitab software. The best tensile test results recorded by sample No. 3, which welded by (8 gas flow rate and 120 current Ampere). The mean, Signal to Noise Ratios, and ANOVA Test have been utilizing to find out the highly effective welding parameter (current and gas flow rate).*

KEYWORDS: *Tungsten Inert Gas Welding (TIG), Gas flow rate, welding current, Investigating, and Dissimilar Metals.*

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I. INTRODUCTION

Nowadays, welding, casting, forming, machining are the most common methods that used in industry, which most of the materials are fabricated into the desired shape. Where, the shape and size of the component, cost, material, precision required and its availability are the most important factors affecting selection of a particular techniques. In some cases, it can be used one specific process to achieve the desired object. For making the end product, it is often possible to choose between the available operations. In making the final choice, different available options economy plays the decisive role [1, 2]. Quality is of most importance factor in manufacturing World today. Some references define quality as the degree of customer satisfaction when providing a purchased product. In different application areas, product quality depends on the requirements obtained in the product that meet your functional requirements. The mechanical properties of welded metals and the heat affected region (HAZ) are highly influenced by the welding quality, in the welding field. In addition to welding chemical compositions and mineral properties. On the other hand, the quality of the weld depends on the parameters of the welding process, as these mechanical properties of the weld also depend on the welding bead's geometry [3, 4].

In today's world, inert tungsten gas welding (TIG) is a very important welding process, as is TIG welding, a metal fabrication technology that has multiple goals and multiple factors in the industrial sector. The mechanical properties, weld bead geometry, the weld chemistry, and metallurgical features of produced weld can be controlled by interact by many process parameters in a complex manner, which may lead to direct or indirect effects [5]. The quality of inert tungsten gas is strong in engineering the welding bead.

In fact, to producing desired weld quality, It is needed to finding out the optimum practical condition. Such an optimize process should fulfill simultaneously all objectives that needs. This an optimization process ntechnique is called multi-response optimization. This study aims to optimizing and investigation in TIG welding parametric influence on tensile strength of dissımilar metals SS-304 and low carbon steel. Threugh theoritical and exprimental research. This study includes the litrature review and survey about Tungsten inert gas (TIG) and its parametrizes to find out the best welding parameterizes. All welding operations are mainly used in order to obtain the welding bead and weld with required parameter, and it has excellent mechanical properties with quality surface. In order to find the parameters, leading to the required mechanical properties, the application of design techniques to experiment.

The study taken its importance from title itself, which focusing on the optimizing and investigation TIG welding parametric influence on tensile strength of dissimilar metals ss-304 and low carbon steel. In addition, there are some sub-importance for this study, such as adding a new reference for the researchers those study welding process, classifying as experimental work in field of welding. This work can be extended to study the effect of parameter on other responses such as heat affected zone (HAZ) and mechanical properties.Where, this study focuses on current and welding speed parameters. In addition, studying the effect of this parameters on the tensile strength property. The experimental work divided to welding process with different welding parameters, then study the effect of this change in the produced welded.

II. MATERIALS AND METHODS

- **Materials**

Stainless steel is an ideal corrosion-resistant material. You can't distinguish between them just by looking at them, but they have different chemical properties that help us differentiate them. The chemical difference between 304L stainless steel and 316L stainless steel. From a chemical point of view, 304 stainless steel containing 8% nickel and 18% chrome. In addition, 316 stainless steel containing 2% molybdenum, 10% nickel and, 16% chrome. In fact, adding molybdenum is to arising resist corrosion and rust. Table 1, shows the chemical composition of SS-304. Table 2, shows the mechanical properties of SS-304.

Table 1. The chemical composition of SS-304.

Element	Weight (%)
Carbon	0.072
Sulfur	0.011
Silicon	0.395
Molybdenum	0.276
Phosphorus	0.041
Manganese	1.421
Chromium	17.820
Copper	0.425
Nickel	7.946

Table 2. The mechanical properties of SS-304.

Property	Value
Density	8.21 kg/m
Yield strength	293 MPa
Tensile strength	500-750 MPa
Elastic modulus	195-210 MPa
Hardness	84 max
Elongation	50%

All steel is carbon steel. Carbon steel is used to denote carbon steel as the main alloy. The properties in carbon steel are determined primarily by the amount of carbon percentages. For these alloys, no other quantities of alloy elements such as chromium, manganese, cobalt and tungsten have been identified. Based on the carbon content, there are four types of carbon steel. Low carbon Steel (0.05–0.29% carbon), Medium carbon Steel (0.30–0.59% carbon), High Carbon Steel (0.6-0.99% Carbon), and Very High Carbon Steel (1.0 2.0% Carbon). It increases hardness and increases carbon content. They can undergo successful thermal treatment. Therefore, this is usually a very strong and difficult, but the ductility can be low. Table 3, shows the chemical composition of low carbon steel, while Table 4, shows the mechanical properties of Low Carbon Steel.

Table 3. The chemical composition of low carbon steel.

Element	Weight %
Nickel	0.021
Manganese	1.342
Carbon	0.297
Aluminum	0.031
Sulfur	0.007
Silicon	0.241

Phosphorus	0.023
Copper	0.019
Chromium	0.022
Molybdenum	0.010

Table 5. The mechanical properties of Low Carbon Steel.

Property	Value
Density	3.24 kg/m
Yield strength	260 MPa
Tensile strength	410-540 MPa
Elastic modulus	145-205 MPa
Hardness	55 max
Elongation	24%

Low carbon steel and SS-304 plates has been prepared with the dimensions of 100×25×6 mm, as well as with the bevel heights of 6 mm, and bevel angle of 45°. For welding, specimens are welded with a root gap distance 2 millimeter as shown in Figure 1.

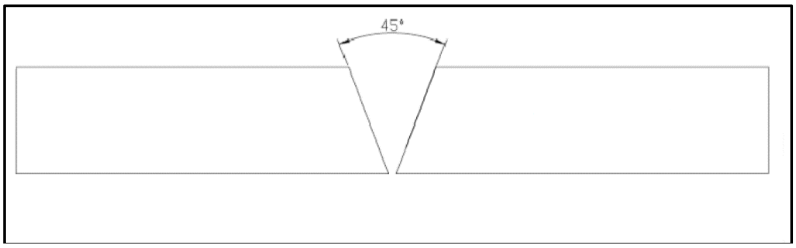

Fig. 1. Welding specimen's geometry.

- **Taguchi Method**

Welding process has been designed by Taguchi method using Minitab software. The Minitab program is one of the most powerful statistical programs with wide applications in the analysis of scientific research data in various fields. After opining software, the second step choosing taguchi design method, then selecting type of design, which is 3-level design. In addition, number of factors. the welding factors are welding current and Gas flow rate. Figure 1 shows the select Stat/DOE/Factorial/Create Factorial Design

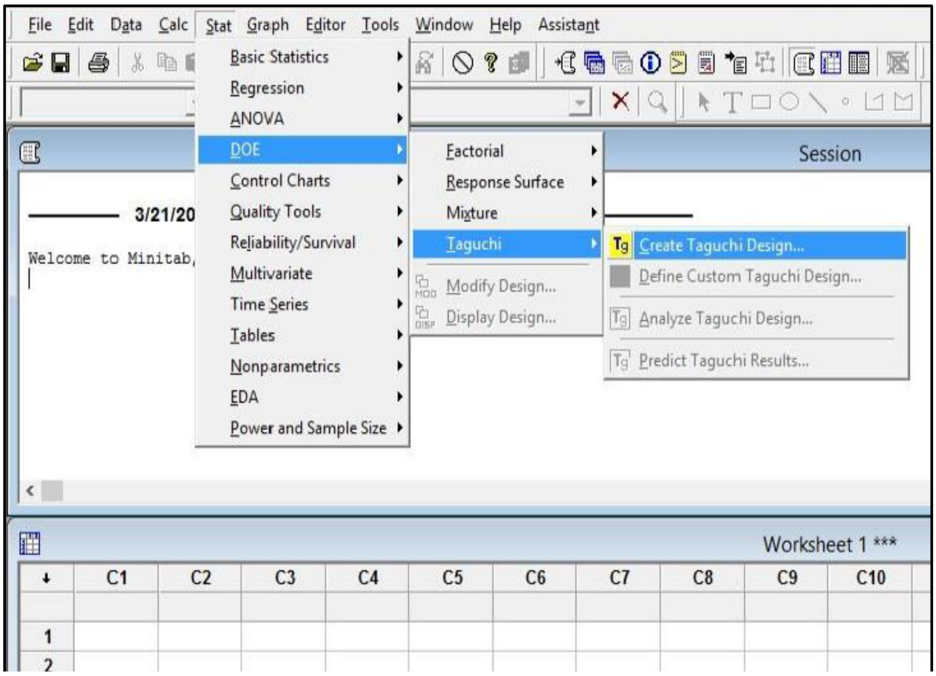

Fig. 2. Select Stat/DOE/Factorial/Create Factorial Design.

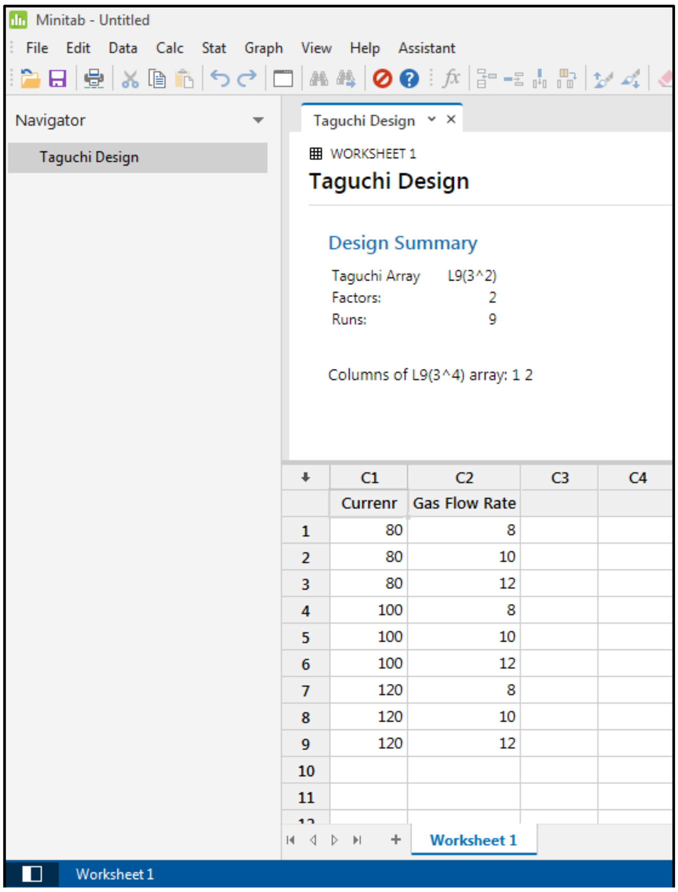

Fig. 3. Welding parameters design by Taguchi method.

Welding parameters as resulted by Minitab software shown in Table 5. Table 6 shows welding process parameters.

Table 5. Welding process parameters by Taguchi method

Experiment no.	Gas flow Rate (Lit/min)	Current (Amp)
1	8	80
2	8	100
3	8	120
4	10	80
5	10	100
6	10	120
7	12	80
8	12	100
9	12	120

Table 6. Welding process parameters.

Parameter	Range
Distance from tip to contact	4 mm
Voltage	10-15
Tungsten electrode	2.4 Diameter
Filler rod SS-304	1.6 mm Diameter
Gas flow rate Argon	8-12 L/M

III. RESULTS AND DISCUSSIONS

The tests have been done utilizing the Servo-hydraulic load frames – HB series, 2-column tensile test machine, all results have been investigated by Taguchi Analysis with Minitab software. Table 7 shows the tensile test results.

Per ASTM standard has been used to tensile test, where size of the work piece is decided as per ASTM A370. Figure 1 shown welding sample prepared after machining. Table 7 shows tensile test results according to welding parameters. As showing, the best tensile test results recorded by sample No. 3, which welded by (8 gas flow rate and 120 current Ampere). Followed by sample No. 9 that welded by (12 gas flow rate and 120 current Ampere), while the lowest tensile results recorded by sample No. 8 which welded by (12 gas flow rate and 100 current Ampere).

Table 7. The tensile test results.

Experiment	no. Gas flow Rate Lit/min	Current Amp	Tensile Strength N/MM2
1	8	80	449.82
2	8	100	465.21
3	8	120	596.59
4	10	80	488.56
5	10	100	479.11
6	10	120	456.81
7	12	80	519.64
8	12	100	440.62
9	12	120	556.19

- **Taguchi Analysis of Tensile Test**

Table shows the S/N ratios and Mean 1 of Tensile Strength resulted by Minitab software. Which Includes mean, signal-to-noise ratio, and ANOVA test.

Table 8. Taguchi Analysis of Tensile Test.

Experiment	no. Gas flow Rate Lit/min	Current Amp	Tensile Strength N/MM2	SNRA1	MEAN1
1	8	80	449.82	53.0608	449.82
2	8	100	465.21	53.3530	465.21
3	8	120	596.59	55.5135	596.59
4	10	80	488.56	53.7784	488.56
5	10	100	479.11	53.6087	479.11
6	10	120	456.81	53.1947	456.81
7	12	80	519.64	54.3141	519.64
8	12	100	440.62	52.8813	440.62
9	12	120	556.19	54.9045	556.19

1. Mean

Table 9 shows the graph of the main effects of the signal-to-noise ratios of the tensile strength, as shown in Table 4.5, while Table 4 shows the means response table. Figure 4.7 shows the main media effects according to gas and current flow. From Figure, it can be note that gas flow rate is highly effective as compared to the current.

Table 9. Response Table for Signal to Noise Ratios
Nominal is best (10×Log10(Ybar^2/s^2))

Level	Current	GAS Flow Rate
1	*	*
2	*	*
3	*	*
Delta	*	*
Rank	1.5	1.5

Table 10. Response Table for Means

Level	Current	GAS Flow Rate
1	503.9	486.0
2	474.8	461.6
3	505.5	536.5
Delta	30.7	74.9
Rank	2	1

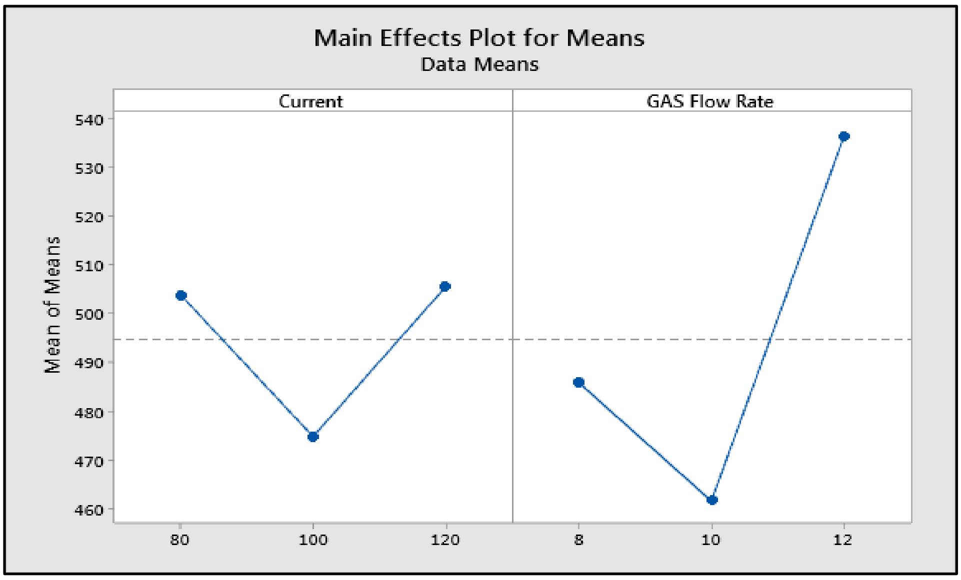

Fig. 3. The main effects of means.

2. Signal to Noise Ratios

The signal-to-noise ratio was calculated using Minitab, as Table 11 shows the response-to-noise-response schedule. Figure 4 illustrates the main effects of SN ratios for a tensile test. It can be note that gas flow rate is highly effective as compared to the current. Figure illustrates the main effects of SN ratios for a tensile test. It can be note that gas flow rate is highly effective as compared to the current.

Table 11. Response Table for Signal to Noise Ratios
Larger is better

Level	Current	GAS Flow Rate
1	53.98	53.72
2	53.53	53.28
3	54.03	54.54
Delta	0.51	1.26
Rank	2	1

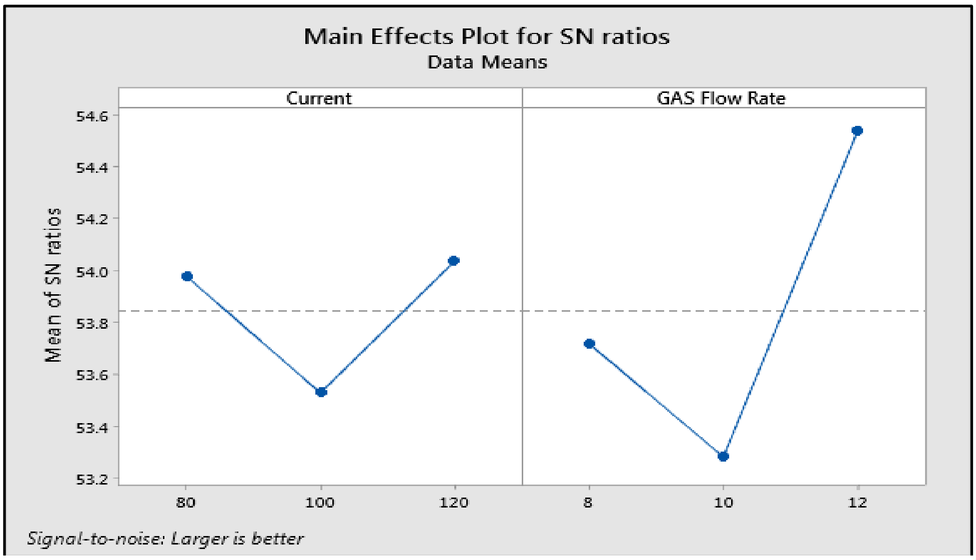

Fig. 4. The main effects of SN ratios.

3. ANOVA Test

As same as Mean and S/n ratio, the ANOVA test has been done to carried out the highly effective factor (current or gas flow rate). Table 12 shows the factor information of tensile test, which is found that welding current is highly effective by recording 0.754 as P-Value, while gas flow rate recorded 0.329.

Table 13 shows the factor information of tensile test, which is found that welding current is highly effective by recording 0.754 as P-Value, while gas flow rate recorded 0.329.

Table 12. The Factor Information of tensile test.

Factor	Type	Levels	Values
Current	Fixed	3	80, 100, 120
GAS Flow Rate	Fixed	3	8, 10, 12

Table 13. Analysis of Variance of tensile test by ANOVA Test.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Current	2	1786	893.1	0.30	0.754
GAS Flow Rate	2	8754	4376.8	1.49	0.329
Error	4	11770	2942.5		
Total	8	22310			

IV. CONCLUSION

This study aims to improve and verify the parametric effect of TIG welding on the tensile strength of various metals SS-304 and low carbon steel. This process was carried out using theoretical and experimental work. In addition, the study aimed to study various metal connections using the metal filling process. In general, different welding is used to make thermal power plants, pressure vessels and tubes in nuclear reactors and heat exchangers, and therefore, failure often occurs due to low tensile strength. The process designed by Taguchi Analysis using Minitab software. After survey and experimental work, the best tensile test results recorded by sample No. 3, which welded by (8 gas flow rate and 120 current Ampere). In mean and Signal to Noise Ratios of Tensile Strength, it can be note that gas flow rate is highly effective as compared to the current. while in ANOVA Test of Tensile Strength is found that welding current is highly effective by recording 0.754 as P-Value, while gas flow rate recorded 0.329. Generally, the study adds new references in welding dissimilar metals for student and researchers.

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