Journal of Engineering and Sustainable Development
http://jeasd.uomustansiriyah.edu.iq/index.php
https://doi.org/10.31272/jeasd.26.1.8

Vol. 26, No. 01, January 2022
ISSN 2520-0917

EFFECT OF WELDING PROCESS PARAMETERS ON TENSILE OF LOW CARBON STEEL 283 G.C

***Hussain Hayyal[1]**   **Nadhim M. Faleh[1]**

1) Mechanical Engineering Department, College of Engineering, Mustansiriyah University, Baghdad, Iraq

Received 24/6/2021   ***Accepted in revised form 10/8/2021***   ***Published 1/1/2022***

Abstract: In this study, three welding methods are used. The purpose to investigation the effects of SMAW, SAW, and gas tungsten arc welding (GTAW) on the tensile stress of low carbon steel conforming to ASTM 283 c. 8mm thick plates are used as base material for butt welded joints. The tensile properties of the welded joints were evaluated and the results were compared by experts using the Taguchi method to design three levels of each parameter (current, voltage and displacement speed). From this research, it is found that compared to metal shielded arc welding and submerged arc welding, the pulling effect of the gas shielded welding joint of the tungsten electrode is the best. This is mainly due to the presence of The results of using analysis of variance (ANOVA) to estimate important parameters show that welding current and speed of the weld have a significant effect on tensile stress .the experimental results are in agreement with predicted results, and the maximum error is 3%..

Keywords: *SMAW, SAW, GTAW, Taguchi, ANOVA,S/N, minitab* .

1. Introduction

Welding can be thought of as a multi-input multi-output process since the quality of a weld joint is generally controlled directly by the welding input parameters during the welding process. These defects are difficult to find. Carbon steel is considered one of the most important materials that entered the oil industries, and its applications are pressure cylinders and oil tanks, as well as the structure of towers and others for ease of application and temperature tolerance during operation [1]. The aim of the current study to conduct a comparison is for the best experimentally results using three types of arc welding processes to obtain best tensile stress.] compared the SMAW and FCAW processes on the basis of microstructure and mechanical properties of ASTM A-36 steel weldments with and without PWHT. AWS E 110C-G and AWS E 11018M electrodes were used as filler metal in FCAW and SMAW, respectively. Specimens were multipass welded in flat position. The input process parameters considered were current (A), heat support (kJ/mm), voltage (V), arc time (sec), electrode diameter (mm) and number of passes Optical microscope and electron scan microscope were used for metallographic analysis. Experimental analysis showed that the lower impact resistance was observed in tubular wire process weldments as compared to the clad electrode process. Also, it was observed that the columnar region is 30% and 50% in the clad electrode and tubular wire, respectively. Humberto N. Farneze et al [2]. In this work, changes in three process factors were used to

**Corresponding Author*: EHma000@uomustansiriyah.edu.iq

investigated the influence of submerged arc welding (SAW) process parameters on carbon steel mechanical properties. Each weld condition was examined three times in total, using a full factorial design. The samples were examined using an optical microscope (OM) and a scanning electron microscope (SEM) for tensile strength and hardness (SEM). The results show that welding current, voltage and travel speed have a significant effect on tensile strength and hardness (P value <0.05). The best SAW settings are 270 amps, 33 volts, and a travel speed of 10mm / sec. Discovered fine high-density beads, thereby improving the tensile strength and hardness of the material. Prachya Peasura [3]. The tensile strength of AISI 1040 carbon steel joints welded by inert gas shielded metal arc welding was predicted using a response surface model. Other process parameters such as welding voltage, current, wire speed, and gas flow are investigated. A four-factor, three-level face-centered composite design matrix is used in the exam. The yield strength of carbon steel inert gas arc welding in AISI 1040 can be estimated using this analytical relationship. To attain the optimum performance power of the board, the response surface method (RSM) is employed to optimize the settings of the MIG welding process. Ajit Hooda et al. [4]. In the studied influence of welding parameters and joint plane on mechanical properties (retracting tension, torsional traction of the welding surface, and weld metal hardness) was examined. Create (13) examples using design of experiment (DOE) computer program and response surface technology (RSM) Method to experiment. The results show that under the welding current of (425 A) and the welding conditions of (35 cm / min), the ideal preparation parameters thrust, maximum torque limit and minimum hardness of the most extreme recoil are (202,659 MPa, 21,662 KN), respectively. Arc voltage is stable at (37 volts). Mohammad Yousif Hanna et al [5]. The mechanical properties of GMAW, SMAW and FSW welded HSLA 249 and HSLA marine grade steel joints were compared. The input process parameters considered in the GMAW and SMAW processes are current (A), voltage (V), filling diameter (mm), welding speed (mm/min), heat input (kJ/mm) and rotation speed (rpm), FSW Consider the heat input (kJ/mm), welding speed (mm/min), tool shoulder diameter (mm), pin length (mm) and axial force (kN). Follow ASTM guidelines to prepare test samples. The light microscope and SEM are used for the analysis of fractures and microstructures of tensile test samples. Experimental results show that FSW gaskets have superior mechanical properties than GMAW and SMAW gaskets. S. Raghu Nathan et al [6]. In this study to evaluate the consistency of S235JR GMAW and SMAW welded structural steel joints Used test destructive and non-destructive. The tensile experiment and the holographic interferometry process are used to study the tensile strength of facet joints and fractures. The results ofshowed that the GMAW joint has almost no or no welding defects and has superior mechanical properties, while the SMAW joint is the opposite. Giedrius Janušas et al. [7] the research plan includes: tensile strength. Upon receipt, the low-carbon steel structural rebar was cut and welded into a square shape. Two fusion welding techniques were chosen: arc welding and oxyacetylene welding because their equipment is available and can be used outdoors. The results obtained in this humble work show that from the point of view of tensile strength, oxyacetylene welding is superior to shielded metal arc welding, which has higher tensile strength. Mohamed Shaalan Abed Fathi et.al. [8].

2. Experimental Procedures

2.1. Selected Material

The base material used in the welding process is a low carbon steel plate (ASTM A-283 Gr. C)[9] with a thickness of 8 mm; and tested in the located at the sample test laboratory in the state company for inspection and engineering rehabilitation (SIER) shown in the fig 1 and Table (2) describes its mechanical properties for comparison and compliance. It is generally used to produce storage tanks in the petroleum industry. All plates were in three welding used utilizing ASME the chemical composition of special welding electrode per ASME process. Table (1) Nominal and used chemical composition of the electrode wire. [10]

Figure 1. The tensile test specimens

Table 1. Chemical composition of electrode wire.[10]

Element	C	Si	Mn	Cr	Ni	Mo	V	Type process welding
E6010 Root pass	0.2	1	1.2	0.2	0.3	0.3	0.08	SMAW
E7018 Filler passes	0.15	0.75	1.6	0.2	0.3	0.3	0.08	
EH12K	0.15	0.35	1.25	0.2	03	0.3	0.08	SAW
ER701S-6 Root/Filler pass	0.15	1.15	1.85	0.4	0.15	0.3	0.08	GTAW
ASTM 283	0.056	0.036	0.549	---	0.029	0.3	----	base metal

Table 2. Mechanical properties of the used ASTM 283 Grade C plate steels.

Material	Tensile (MPa)	Yield (MPa) min	Elongation (%) max
Nominal	380–515	205	36
Used	390	320	36

2.2. Arc Welding Conditions

To study the effect of the input factors on the tensile strength resulting from the welding process, three welding factors (current, voltage and travel speed) are used as one factor, with three levels, as shown in Table (3) comprised of three tables that are divided for each welding method used. The selection of these levels is based on the actual practices used in SCOPE's oil projects.

Table 3. Process Parameters and their Levels

1- Shield metal arc welding

parameter	-level	level	+level
Current	80	98	120
voltage	24	26	28
Travel speed	8	9.2	11

2- Submerged arc welding

parameter	-level	level	+level
Current	320	350	380
voltage	26	28	30
Travel speed	25	30	35

3- Gas tungsten arc welding

parameter	-level	level	+level
Current	160	180	200
voltage	24	26	28
Travel speed	20	25	30

2.3. Welding Procedure

First, in each process, the plates are cut into (18) pieces with dimensions (300x150x8mm), and then their surfaces are cleaned to remove oxides and contaminants. Burrs are used to create V-joints in simple butt welds. All the experiments are carried out using DOE software through the matrix of the Taguchi L9 (3 ^ 3) method (Table 4) according to the design matrix, with three levels of input factors to know their effects on the voltage of traction caused by the influences of welding. Figure (2) shows a simples schematic of the type of joint design used in the experiment. Type of welding machine used (Lincoln Electric welding machine).

Table 4. Experimental design matrix coded and actual results

No.	Current (*I*) amp	Voltage (*V*) volt	Speed (S) cm/min	Tensile test MPa		
				SMAW	SAW	GTAW
1	-1	-1	-1	401.58	405.81	401.58
2	-1	1	1	395.88	395.74	408.59
3	-1	+1	+1	392.64	386.47	418.99
4	1	-1	-1	402.41	396.93	404.88
5	1	1	1	394.64	395.74	424.90
6	1	+1	+1	411.76	436.57	436.57
7	+1	-1	-1	403.55	405.51	461.08
8	+1	1	1	413.73	436.24	479.95
9	+1	+1	+1	413.24	424.90	467.24

2.4. Design of Experiments

In current research, the Taguchi method is used to develop mathematical models based on experimental results. In the three processes, 9 experiments were carried out according to the experimental design matrix. The test is performed randomly at various levels of encoding from (-1) to (+1), and each factor is used, where each level used corresponds to the actual value suitable for encoding. Therefore, the welding input factors studied include current, voltage and travel speed. Table (4) illustrates the experimental design matrix used for the input factors and the resulting output (response) values. Use "Minitab Version 18" to establish a prediction model with 95% confidence.

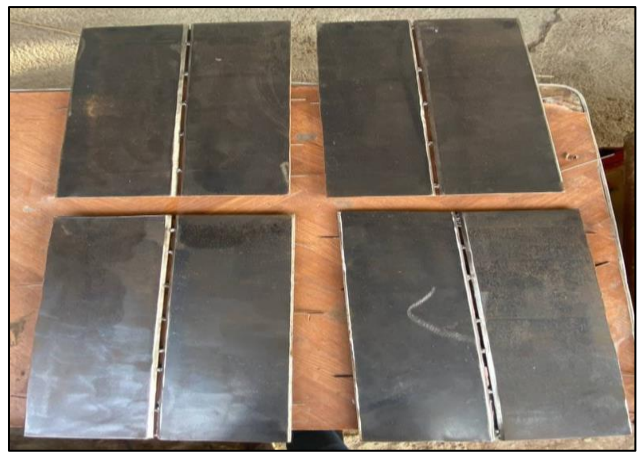

Figure 2. Simples schematic of joint design

3. Results and Discussions

3.1. Modeling of Tensile Stress

First, use Taguchi's method to select and make a suitable model, and then use response characteristics to determine the regression equation of the model. Use the experimental results given in Table (4) to establish a regression equation to discuss the influence of process factors on various response characteristics. The analysis of variance (ANOVA) of the signal-to-noise ratio of the tensile stress is achieved by eliminating the insignificant coefficients used for the results of the statistical analysis, as indicated in Table (5), (6) and (7) for each process welding used.

Table 5. Analysis of variance ANOVA for Tensile test SMAW

Source	DF	Seq SS	Adj SS	Adj MS	F	P
current	2	272.796	272.796	136.398	265.04	0.004
voltage	2	32.458	32.458	16.229	31.54	0.031
speed	2	220.369	220.369	110.184	214.10	0.005
Residual Error	2	1.029	1.029	0.515		
Total	8	526.653				

Table 6. Analysis of variance ANOVA for Tensile test SAW

Source	DF	Seq SS	Adj SS	Adj MS	F	P
current	2	1031.25	1031.25	515.63	18.34	0.052
voltage	2	262.58	262.58	131.29	4.67	0.176
speed	2	1431.21	1431.21	715.61	25.45	0.038
Residual Error	2	56.24	56.24	28.12		
Total	8	2781.29				

Table 7. Analysis of variance ANOVA for Tensile test GTAW

Source	DF	Seq SS	Adj SS	Adj MS	F	P
current	2	5956.09	5956.09	2978.04	202.58	0.005
voltage	2	583.12	583.12	291.56	19.83	0.048
speed	2	239.88	239.88	119.94	8.16	0.109
Residual Error	2	29.40	29.40	14.70		
Total	8	6808.49				

In Table 5 describes the output and points out the significant values of various input parameters. From this table, the p-value of current and speed given in the last column of the ANOVA table is 0.004, which is less than 0.05. Therefore, current is the most important factor that has the greatest impact on tensile stress. In addition, the F value given in the ANOVA table represents the meaning of current and speed. The increase in tensile strength is due to the greater melting of the material, which increases the penetration of the welded joint, while the increase in speed reduces the tensile strength, which is attributed to the effect of lower rate heat input at higher speeds all described brief in the figure (3). It can be seen from figure (4) that the most important parameter in this submerged arc welding process is the welding speed, which will reduce the tensile strength at a higher speed (lower heat input rate), followed by the welding current at the highest current (highest current). Heat input) table (6) shows the results obtained from the analysis of variance for tensile strength. Figure (5) shows the effect of current on the tensile strength of welded parts. The results showed a significant increase in tensile strength (due to increased heat generation), but this welding process resulted in a lower level of welding speed (higher rate of heat input) resulting in negligible increase in tensile strength. The p – values for current and voltage in the last column of the ANOVA table, according to table (7), are 0.005 and 0.048, respectively, which are less than 0.005. As a result, voltage is the most important element affecting tensile stress, because low current and heat produce fine grain microstructure, which has a lower tensile strength than high current flow joints. The F value in the ANOVA table also indicates the relevance of current and voltage.

3.2. Multiple Regression Analysis (MRA)

MRA is carried out with the help of Minitab18 software. The traction regression equations (models) obtained using MRA are given in equations 1 to 3. The p-value of (I, V, and S) is 0.000, which is less than 0.05. The R-squared value (tensile stress) of the model indicates the suitability of the model for prediction. The fact that the regression model has a p-value of 0.000 supports the inference that the regression model can be used for prediction (traction).

The regression equation (model) of the shield metal arc welding (SMAW) is:

$$Tensile\ stress = 385.7 + 0.3365\ (I) + 0.842\ (V) - 4.011\ (S) \quad (1)$$

The regression equation (model) of the submerged arc welding (SAW) is:

$$Tensile\ stress = 254.7 + 0.4368\ (I) + 3.307\ (V) - 3.030\ (S) \quad (2)$$

The regression equation (model) of the gas tungsten :arc welding (GTAW) is

$$Tensile\ stress = 51.9 + 1.493\ (I) + 4.61\ (V) - 0.44\ (S) \quad (3)$$

Where, I = Current (amp) . V = Voltage (volt).

S = Speed (cm/min)

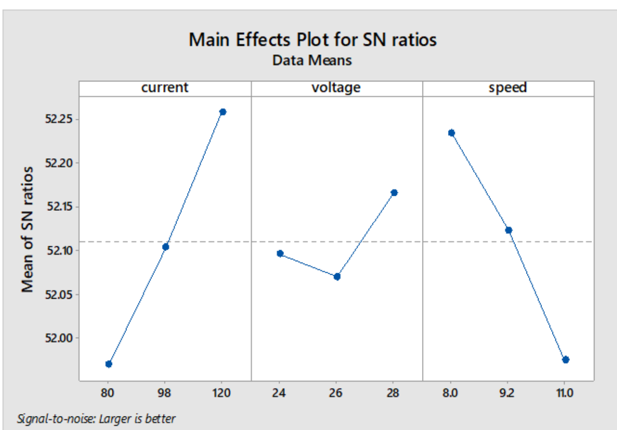

Figure 3. Plot Main effects for S/N ratios for tensile result IN smaw

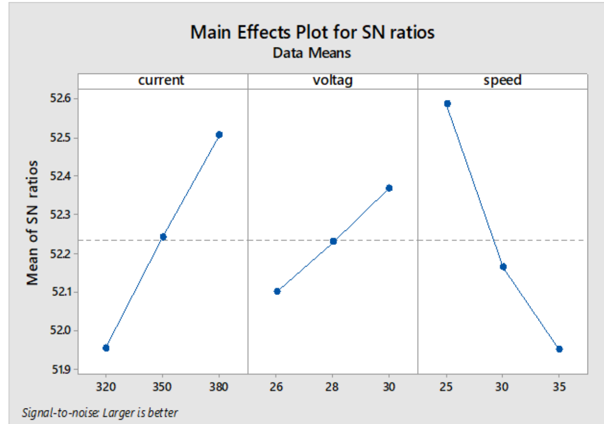

Figure 4. Plot Main effects for S/N ratios for tensile result in saw

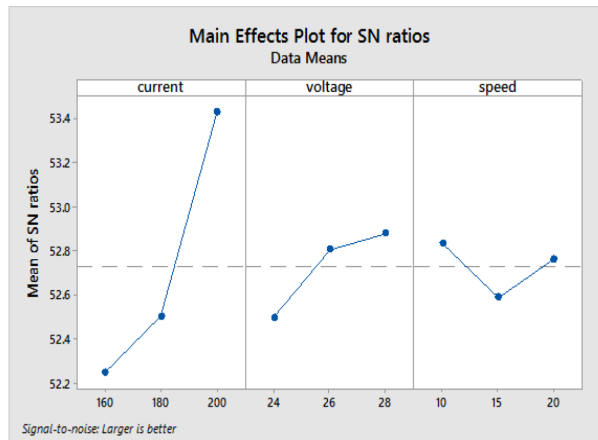

Figure 5. Plot Main effects for S/N ratios for tensile result in GTAW

3.3. Optimization for the Arc Welding Process Parameter

Repeat the welding experiment. By using the instruction to produce the figures (5),(6)and(7)for each welding process in the Taguchi method and take the highest parameter value for each level and then take the highest value for each parameter of current, voltage and speed and we repeat the experiment in practice and check it and take the optimal value and after using the linear regression equation that depends on the practical experimental results 9 for each method Welding, as in Table 1, predicts a linear equation that is considered a theoretical equation, and the comparison between them is made and the error ratio between scientific and theoretical is read. the larger the selection, the better the quality, because it is the ideal attribute of the welded joint and is calculated by formula (4) [11]. The optimal parameters setting for welding process is in listed table (8). Each predicted response was calculated from equation (1) (2) and (3) in MRA.

Table 8. Optimal welding process parameters

Response	**Optimum parameter**			**Optimum response**		
	I	***V***	***S***	***Experimental***	***Predict***	***Error***
Tensile in SMAW	120	28	8	416.11	417.52	1%
Tensile in SAW	380	30	25	461. 08	444.19	3%
Tensile in GTAW	200	28	10	485.95	475.03	2%

$$S/N = -10 \times log\ (\sum (1/y^2)/n) \quad (4)$$

S / N = the relationship between the average value (signal = S) and standard deviation (noise = N).

y = response to a given combination of factor levels.

n = the number of responses in the combination of factor levels.

Table 5.22: Optimal SMAW process parameters

4. Conclusions

In this study, the tensile strength of SMAW, SAW and GTAW joints of ASTM 283 Gr.C low carbon steel were evaluated and compared.

1- Welding current and welding speed have the greatest influence on welding tensile strength, followed by welding voltage and the three welding processes used.
2- Among the Three processes used for the welded joints, the joint manufactured by the GTAW process exhibits the highest value. In Compared to base metal, the tensile strength of GTAW process welded joints is better than SMAW and SAW process joints, which are respectively 19%, 15% and 6% higher.
3- The experimental results of tensile stress, of SMAW, SAW and GTAW agree well with the predicted results, with a maximum error of 3%.

Conflict of Interest

The authors stated that they have no known competitive economic interests or personal relationships that may affect the research presented in this study. Through this research the following conclusions are drawn.

4. References

1. Metals Handbook, "Welding and Brazing", ASM (American Society for Metals) International, Vol. 6, Metals Park, Ohio, USA, 2000.
2. Humberto N. Farneze, Jorge Carlos F. Jorge, Luís Felipe G. de Souza, Ivaní de S. Bott. Comparative study of high-strength steel weld metals obtained by the SMAW and FCAW processes for offshore applications and mooring chains. Welding International,2010.
3. Prachya Peasura "Investigation of the Effects of Submerged Arc Welding Process Parameters on the Mechanical Properties of Pressure Vessel Steel ASTM A283 Grade A " Hindawi Journal of Engineering. 2017,
4. Ajit Hooda, Ashwani Dhingra, Satpal Sharma " Optimized MIG welding processes parameters to predict maximum throughput in AISI 1040" International Journal of mechanical Engineering and robotics research. Vol. 1, No. 3, October 2012 .
5. Mohannad Yousif Hanna and Samir Ali Amin and Abdulaziz Saud Khider "Study

of Mechanical Properties of Carbon Steel Plate SA-516 Gr. 70 Welded by SAW Using Square-Shape Joint Design "Journal of University of Babylon for Engineering Sciences, Vol. (27), No. (3): sept 2019.

6. S. Raghu Nathan, V. Balasubramanian, S. Malarvizhi, A. G. Rao. Effect of welding processes on mechanical and microstructural characteristics of high strength low alloy naval grade steel joints. Defence Technology. Vol 11(3) pp308-317 .2015.
7. Giedrius Janušas, Audrius Jutas, Arvydas Palevičius, Darius Žižys, Arvydas Barila. "Static and vibrational analysis of the GMAW and SMAW joints quality" Journal of Vibrio engineering; vol 14:pp1220-1226. 2012.
8. Muhammad Shaalan Abed Fathi, Qish Hazem Ismail and Khaled Abbas Saleh. Effect of welding type on the mechanic Welding joint properties. Vol. 9, Issue 4, pp699-708.Aug 2019,
9. ASTM A285M/A285, Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength Test Methods and Definitions for Mechanical Testing of Steel Products.2015.
10. Boiler and Pressure Vessel Code (ASME) (Section II, Part C) by American Society for Mechanical Engineers (ASME) International, 2010.
11. M. F. Triola, "Essentials of Statistics", 2nded, Pearson Education Inc., USA, 2005.