IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified ⁜ Impact Factor 8.066 ⁜ Vol. 10, Issue 4, April 2023
DOI: 10.17148/IARJSET.2023.10414

OPTIMIZATION OF PROCESS PARAMETERS FOR VIBRATION ON MECHANICAL PROPERTIES OF DSS 2205 DURING TIG WELDING

Rahul Kumar[1], Dr. Naveen kumar[2], Dr. Pankaj Mohan Ratogi[3]

Research Scholar, Mechanical Department, Sir Padampat Singhania University, Udaipur, India,[1]

Mechanical Department, Sir Padampat Singhania University, Udaipur, India,[2]

Mechanical Department, Sir Padampat Singhania University, Udaipur, India[3]

Abstract: This research work emphasizes on the improvement in mechanical properties and provide the best combination of welding parameters to produce sound welds by the imposition of mechanical vibration during TIG welding of the DSS 2205 material.

Gas tungsten arc welding (GTAW) or tungsten inert gas welding (TIG) is an electric arc welding process in which a non-consumable tungsten electrode is used to produce the weld, an inert shielding gas (argon or helium) is generally used to protect the electrode from atmospheric contamination. This research provides the information about the problem of tensile strength reduction of DSS (duplex stainless steel) due to TIG welding. In the present work, an experimental investigation has been carried out in an industrial setup to determine and record the responses of the mechanical vibration applied for the TIG of DSS 2205 material under different parameter conditions. We have used mechanical vibration technique that uses low frequency vibrations to relieve residual stresses in weldment.In the industries, metal joints are mostly used in the form of a structural material for different manufacturing applications because it yields high strength and corrosion resistance. However, the joining process is difficult as both the materials have different mechanical and chemical properties; optimum use of the process parameters becomes utterly important. Ultimate tensile strength was used as major parameter to perform the optimization study. Mechanical joints obtained were also compared among each other on the basis of ultimate tensile strength and hardness tests. Taguchi method was used primarily for optimising the process parameters involved in welding Analysis of variance (ANOVA) method was also used for performing the optimization study and study performed by Taguchi method was validated by using ANOVA method. For welding process, gas welding process was used to create butt joint. Nine experimental runs based on L9 orthogonal array method was performed. The welding parameters to be varied are Welding current, Torch tilt angle and Motor speed. As a response Tensile strength & Hardness are being investigated in testing laboratory. Based on the results obtained, graph of mean effects plot was generated using Minitab17 software in order to study the individual effect of input variables on our outcomes, i.e. UTS and Hardness. Also residual plots are generated to study the error or variation from mean value of output variables in different runs.As a result,

Keywords: TIG welding, DSS 2205, Taguchi Method, UTS, Hardness, ANOVA.

I. INTRODUCTION

What is Welding?

Welding can be defined as the process of joining two or more materials together by fusing them using heat. When two parts to be joined are melted together, heat or pressure or both is applied with or without added metal for the formation of a metallic bond. There are many types of welding techniques used to join metals. The welding processes differ in the manner in which temperature and pressure are combined and achieved.

1) Overview of TIG Welding

TIG welding process also known as gas tungsten arc welding. This process was developed at the time of Second World War. Since its invention, welding of difficult to weld materials such as, aluminium, magnesium etc. became easier. Now-a-days with the development TIG welding process, the use of TIG has spread to a variety of metals like, SS, MS, high tensile steels, Al alloy, Titanium alloy and many more.

DOI: 10.17148/IARJSET.2023.10414

In the present scenario, out of number of welding technologies, the gas welding technique is one of the most commonly used welding practises. Gas welding is specifically utilised for the development of steel structures, joining of metals in the casting sections and fabrication and development of various structures Moreover, gas welding is also utilised for repairing of two materials' joints, which has undergone crack or damage situation. It is identified that during welding process, the welding area is being shielded by different inert gases. Thus, to prevent it from exposure to the atmospheric contaminations, this method requires constant gas and electric supply for the weld to happen in a stronger form.

In the TIG welding process, the arc is produced between work piece and tungsten electrode in an inert atmosphere. For high quality welding, the small intense arc provided by the electrode is ideal. During TIG welding process, no input heat balance is required because of the use of non-consumable electrode. Tungsten electrodes are commonly available in variety of diameters and lengths as per requirement of the welding process.

Therefore, the welding process parameters should be selected in such a way to obtain optimal weld pool geometry. This task of selection of parameters is usually done by experience or with the help of handbook.

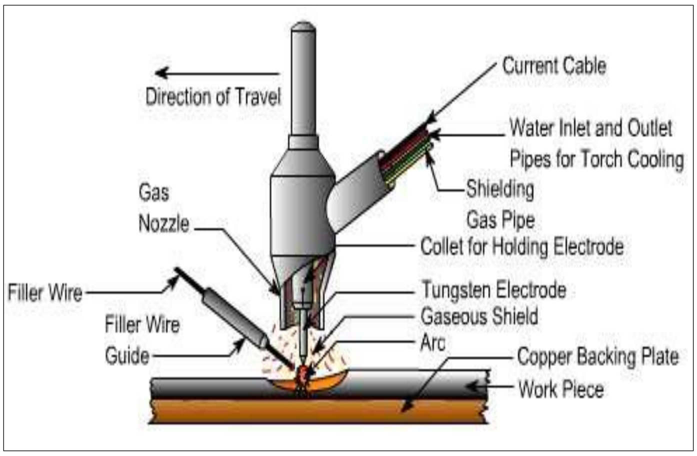


Fig. 1.: Schematic Diagram of TIG Welding

Duplex stainless steel
Duplex means two – 50% ferrite and 50% austenite.
Duplex stainless steels are called "duplex" because they have a two phase micro structure consisting of grains of ferritic and austenitic stainless steel. The picture shows the yellow austenitic phase as "islands" surrounded by the blue ferritic phase. When duplex stainless steel is melted it solidifies from the liquid phase to a completely ferritic structure. As the material cools to room temperature, about half of the ferritic grains transform to austenitic grains ("islands"). The result is a microstructure of roughly 50% austenite and 50% ferrite.

II. MATERIALS AND METHODS

2.1 MATERIAL SELECTION
DSS is emerging as structural material in marine engineering field for their excellent corrosion resistant and higher strength compared to other austenitic stainless steel. Thegeneral problems related to DSS are loss of tensile strength, corrosion resistant and toughnessdue to residual stresses developed during welding. It can cause corrosion cracking in welded structure. To overcome this problem different vibratory stress relief techniques are used. We have used mechanical vibration technique that uses low frequency vibration to relieve residual stresses in weldment.

2.2 Base Plate Material
To analyze the effect of combination of process parameters on DSS 2205 with Tungsten InertGas welding which can be effectively used to optimize the TIG welding process parameters in order to produce mechanically sound and metallurgical defect free welds.

We are using two plates of Duplex Stainless Steel as Follows:

- DSS2205 (150×40×3)

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⋇ Impact Factor 8.066 ⋇ Vol. 10, Issue 4, April 2023

DOI: 10.17148/IARJSET.2023.10414

Chemical Composition of DSS2205, wt%

The chemical composition of DSS2205 base metal should be in the limits of table 3.1. We have done chemical analysis of our base metal in METAL TEST LAB, Mumbai by Optical Emission Spectrometry method.

Table 2.1 Chemical Composition of DSS2205

Cr	Ni	Mo	Mn	Si	N	C	S	P
22.5	4.5-6.5	2.5-3.5	≤2.0	≤1.0	0.08-.02	≤0.030	≤0.020	≤0.030

The tested metal specimen is shown in that verifies that the base metal is DSS2205of thesis.

Table 2.2 Physical Properties of DSS2205

Density	7800Kg/m3
Elastic Modulus	200 Gpa
Thermal conductivity (at 100 °C)	19.0 W/m-k
Mean Coefficient of Thermal Expansion (0-100°C)	13.7 μm/m/°C
Specific Heat (0-100°C)	450 J/Kg-K
Electrical Resistivity	850 nΩ-m

Table 2.3 Mechanical Properties of DSS2205

Ultimate tensile strength	655 Mpa
Yield Strength 0.2% Proof (min)	450
Elongation (min)	25%
Harness Rockwell C (max)	31 HR C
Hardness Brinell(max)	293HB

The experimental setup is selected comprising of a set of machineries and work piece material required for completion of the work. The requirements of experimental setup required for the present work is as follows:

- TIG welding machine
- Sample Work piece
- Non-consumable Electrode
- Filler rods
- Universal Testing Machine (UTM)
- Vickers hardness tester

Experimental procedure

A Vibration table has a vibratory motor attached below it is joined with Variac which is helpful in changing input Voltage of the motor. A multi meter is coupled with variac so that exact voltage input to the motor can be seen digitally and accurately. The variac is connected to the AC supply lines. TIG welding used in our experiment has a argon gas supply and its pressure is maintained constant to 8 bar during all experiments. C-clamp is used to fix the weld plates with Table top. Moreover, wooden sheets are used to isolate the welding current from table top so that the motor may not damage. A steel table top is fixed in notch such that it may not vibrate to amplitude more than 1 mm. The setup is as shown in fig. 4.6.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁂ Impact Factor 8.066 ⁂ Vol. 10, Issue 4, April 2023

DOI: 10.17148/IARJSET.2023.10414

Fig. 2 Experiment setup

With the help of variac, motor voltage is adjusted and RPM has been measured by tachometer. Different experiment has been performed by changing motor RPM, Torch tilt angle and Welding current.

Weld joint preparation

- Square butt welding
- Root gap: 1 mm
- Double sided without root backing but with root grinding
- No preheat required
- Polarity: DCEN
- TIG Electrode:
- Ø 2.4
- Thoriated (Pure, Ceriated, Lanthanated, Zircoriated, Rare earth)
- Pointed (Ball, Truncated)
- Filler wire: Er2209
- Ø 1.2

Experimental Parameter:

Table 3.1 Process parameters and levels

DESIGNATION	FACTORS	LEVEL 1	LEVEL 2	LEVEL 3
A	Welding current (A)	80	90	100
B	Torch tilt angle (°)	60	75	90
C	Motor speed (RPM)	1400	1450	1500

Experimental Responses

Following responses will be study after the welding is performed they are as follow:

1) Ultimate Tensile Strength.
2) Hardness

Experimental data of L9 runs for Tensile testing and Hardness

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁒ Impact Factor 8.066 ⁒ Vol. 10, Issue 4, April 2023

DOI: 10.17148/IARJSET.2023.10414

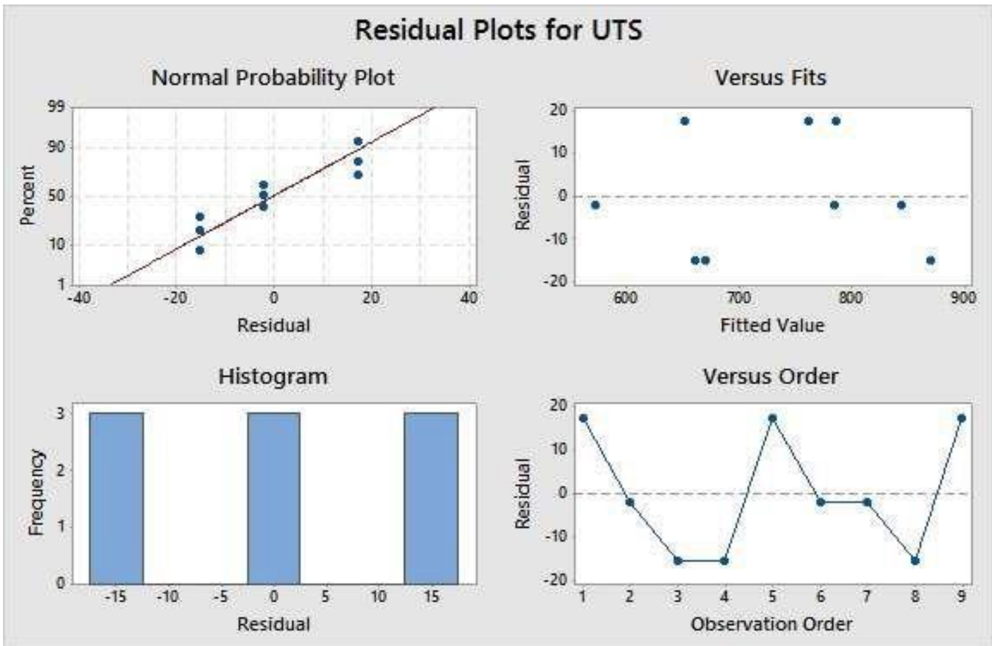
Based on the TAGUCHI, for 3 different factors and 3 levels, 9 experimental run is carried outand the responses ultimate tensile strength and hardness has been tested. The results from tensile testing and Vickers hardness test has been shown in table Also a single run without vibration was carried to compare the tensile strength with vibration conditions.

Table 3.2 Experimental runs and their responses

PARAMETERS				READINGS
Welding Current(A)		Torch tiltangle (°)	Motor(RPM)	Variac Voltage (V)
1	80	60	1400	18.16
2	80	75	1450	24
3	80	90	1500	263.6
4	90	60	1450	25.70
5	90	75	1500	266.50
6	90	90	1400	18.25
7	100	60	1500	260.30
8	100	75	1400	18.20
9	100	90	1450	25.72
10*	90	90	0	0

A single run without vibration for comparison purpose.

Analysis of Variance (ANOVA) for UTS



IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁜ Impact Factor 8.066 ⁜ Vol. 10, Issue 4, April 2023

DOI: 10.17148/IARJSET.2023.10414

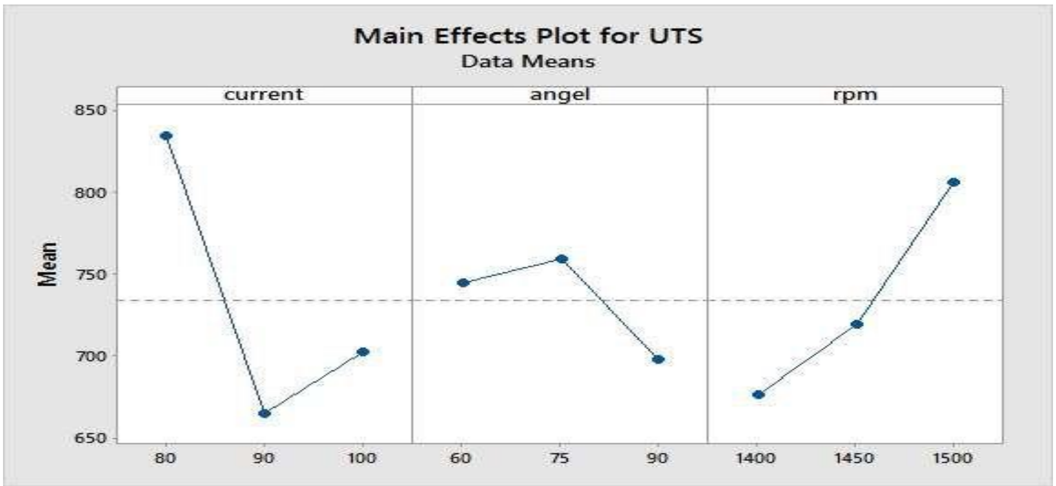


Fig. 3 Main effects plot for UTS

Fig. 6.2 clearly suggests a dominant influence, in a quantitative sense, of the Welding current,Torch tilt angle and Motor RPM. The result of ANOVA represented in response diagrams shown in Fig. 6.2 suggest that the optimal combination of welding parameter levels, which gives the highest value of the UTS is C1A2R3.

Table 3.3 ANOVA table for UTS

Source	DOF	Sum of Squares(SS)	Mean of Squares(MS)	F-value	P-value
Current	2	47091	23545.3	29.09	0.033
Torch tilt Angle	2	6062	3031.0	3.75	0.211
Motor RPM	2	26145	13072.3	16.15	0.058
Error	2	1619	809.3		
Total	8	80916			

Table 3.4 Model Summary for ANOVA UTS

S	R-sq	R-sq(adj)	R-sq(pred)
28.4488	98.00%	92.00%	59.49%

Analysis of Variance (ANOVA) for Hardness

ANOVA was used to identify the optimal welding parameter levels so as to maximize Hardness

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁘ Impact Factor 8.066 ⁘ Vol. 10, Issue 4, April 2023

DOI: 10.17148/IARJSET.2023.10414

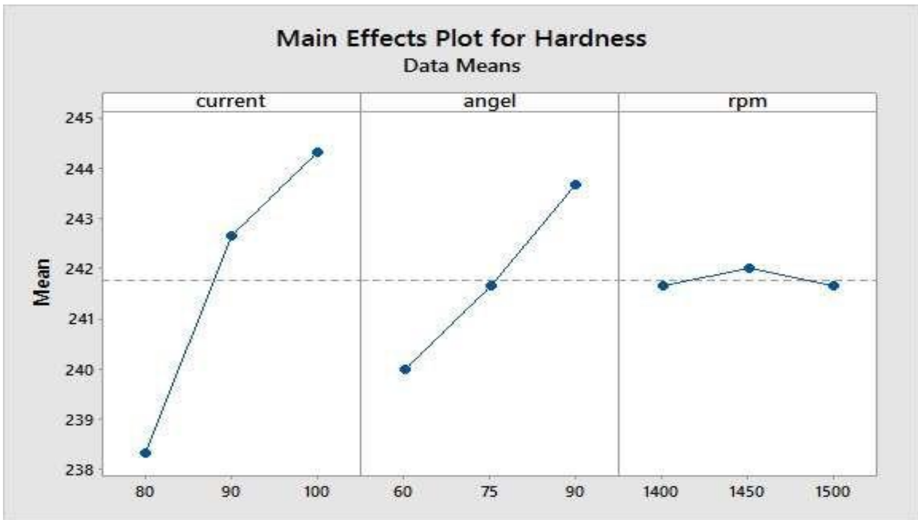


Fig. 4 Main effects plot for Hardness

Fig.4 clearly suggests a dominant influence, in a quantitative sense, of the Welding current,Torch tilt angle and Motor RPM. The result of ANOVA represented in response diagrams shown in Fig.suggest that the optimal combination of welding parameter levels, which gives the highest value of the Hardness is C3A3R2.Residual plots are used to evaluate the data for the problems like non normality, non-random variation, non-constant variance, higher-order relationships, and outliers. It can be seen from Fig. that the residuals follow an approximately straight line in normal probability plot.

Histogram is the special case because skewed-right data have a few large values that drive themean upward but do not affect where the exact middle of the data is (that is, the median). Residuals possess constant variance as they are scattered randomly around zero in residuals versus the fitted values. Since residuals exhibit no clear pattern, there is no error due to time or data collection order.

Table 3.5 ANOVA table for Hardness

Source	**DOF**	**Sum of Squares(SS)**	**Mean of Squares(MS)**	**F-value**	**P-value**
Current	2	57.5556	28.7778	37.00	0.26
Torch tilt Angle	2	20.2222	10.1111	13.00	0.71
Motor RPM	2	0.2222	0.1111	0.14	0.875
Error	2	1.5556	0.7778		
Total	8	79.5556			

Table 3.6 Model Summary for ANOVA Harness

S	R-sq	R-sq(adj)	R-sq(pred)
0.881917	98.04%	92.18%	60.41%

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified ⁜ Impact Factor 8.066 ⁜ Vol. 10, Issue 4, April 2023
DOI: 10.17148/IARJSET.2023.10414

Signal-to-Noise ratio

There are 3 Signal-to-Noise ratios of common interest for optimization:

Table: 3.7 Selecting S/N ratio formula for particular application.

Choose	S/N ratio formulas	Use when the goal isto	And data
Larger is Better	$\frac{S}{N} = -10 * \log\left(\frac{\sum 1/Y^2}{n}\right)$	Maximize the response	Positive
Nominalis Best	$\frac{S}{N} = -10 * \log \sigma^2$	Target the response and you want to basethe S/N ratio only onstandard deviations	Positive, zero, orNegative
Nominalis best (default)	$\frac{S}{N} = 10 * \log\left(\frac{y^2}{\sigma^2}\right)$	Target the response and you want to basethe S/N ratio on means and standard deviations	Non-negative withan "absolute zero"in which the standard deviationis zero when the mean is zero
Smaller is Better	$\frac{S}{N} = 10 * \log\left(\frac{\sum Y^2}{n}\right)$	Minimize theresponse	Non-negative with target value of zero

Table: 3.8 S/N ratio values Calculated by Minitab 17.

Sr.	Welding Current (A)	Torch tiltAngle (°)	MotorRPM	Ultimate Tensile Strength (MPa)	Hardness (HV)	SNRA-1
1	80	60	1400	804	237	50.1434
2	80	75	1450	843	238	50.2088
3	80	90	1500	855	240	50.2851
4	90	60	1400	646	241	50.0847
5	90	75	1450	780	243	50.3201
6	90	90	1500	570	244	50.0274
7	100	60	1400	783	242	50.2904
8	100	75	1450	655	244	50.1937
9	100	90	1500	670	247	50.3108

Average response for each combination of control factor levels in the design. When performing a statistical analysis, one of the simplest graphical tools at our disposal is a main effects plot. This plot shows the average outcome for each value of each variable, combining the effects of the other variables as if all the variables are independent. the main effect of plot for means where the optimum parameters will be based on the highest peak at each parameter. From the figure, the optimum parameter is determined. The best parameter according to the graph shows the welding current 80Aapproximately, the torch tilt angle should be 75° approximately and the vibration motor speed should be 1500RPM.

DOI: 10.17148/IARJSET.2023.10414

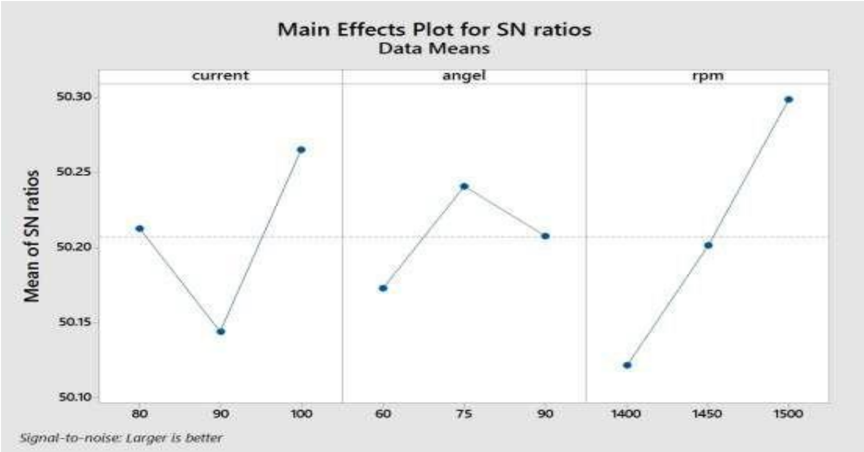


Fig. 5 Main effects plot for S/N ratios

The Signal-to-noise ratio shows how the response varies relative to the nominal or target value under different noise conditions. We have chosen Larger is better Signal-to-noise ratio as we require maximum value of response parameters.

III. CONCLUSION

The following Conclusions are arrived at from the above investigations:

1. From the experimentations, it is found that it is impossible to achieve any desired response just by Trial and Error because of a large number of variability among the collected data. Thus, an in-depth analysis is needed to achieve the final response.
2. It is identified that, both the response parameters i.e. UTS and hardness have highly non-linear relationships with welding parameters as shown in Table 4.1.
3. It can be concluded from the previous literature reviewed that the design of experiment approach is proven to be a best choice for researchers because it involves all the possible combination of parameters thus resulting in accurate and exact results and response values can be obtained to close level of accuracy and precision.
4. The auxiliary vibrations induced into the weld pool resulted in increased hardness and the yield the welded joint which indicates the orientation of the crystal and refinement of grains took place.
5. RPM of vibration motor is varied during the welding so that weld pool could be mechanically stirred in order to induce favorable micro structural effects.
6. The tensile strength of the weld with vibration was larger than that without vibration. Especially, the tensile strength was remarkably increased when the combination of certain parameters takes place.

REFERENCES

[1] A.Balaram Naik, A.Chennakesava Reddy, "Experimental Analysis of TIG Welding and Comparison between Activated-TIG and TIG on Duplex Stainless Steel (2205)"International Journal of Scientific & Engineering Research, Volume 7, Issue 6, June-2016
[2] S. Parvez, M. Abid, D. H. Nash, H. Fawad and A. Galloway, "Effect of Torch Angle on Arc Properties and Weld Pool Shape in Stationary GTAW" journal of engineering mechanics © ASCE/September 2013.
[3] Pravin Kumar Singh, D. Patel, S.B. Prasad, "Optimization of process parameters during vibratory welding technique using Taguchi's analysis", ElsevierGmbH.
[4] S.P.tewari and A. shanker, "Effects of Longitudinal Vibration on Tensile Properties ofWeldments" Welding research supplement November 1994.
[5] P.Govindarao,Dr.P.Srinivasarao, Dr.A.Gopalakrishna and C.V.Sriram, "Improvement of Tensile Strength of Butt Welded Joints Prepared By Vibratory Welding Process" International Journal of Mechanical Engineering and Technology (IJMET), Volume 4, Issue 4, July – August.
[6] M. Saravanan, D. Praveen Kumar, K. Naveen, " Effect of Vibration on Macro and Micro Properties of SMAW Weldment" International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET), Volume 5, Issue 5, May-2016.
[7] Munish Kainth, Deepak Gupta, Vivek Kumar Sharma, "Experimental Investigation Of The Effect of Vibration on

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁜ Impact Factor 8.066 ⁜ Vol. 10, Issue 4, April 2023

DOI: 10.17148/IARJSET.2023.10414

Mechanical Properties of Aisi 1018 Mild/Low Carbon Steel Welded Joint Using SMAW" International Journal of Mechanical Engineering (IJME), Vol. 2, Issue 2 (July, 2015)

[8] Marco Arturo García Renteríaa, Víctor Hugo López Morelosb, Rafael García Hernándezc, Francisco Curiel Lópezd, and José Lemus Ruíze "Effect on the microstructure and mechanical properties of the electromagnetic stirring during GMA welding of 2205 DSS plates." Materials Science Forum Vol. 755 (2013) pp61-68© (2013) Trans Tech Publications, Switzerland.

[9] Murugan N, Parmar RS. Effect of welding conditions on microstructure and properties of tupe 316L stainless steel submerged arc welding cladding. Weld J, AWS 1997;76(5):210-s–20-s, May.

[10] Gunaraj V, Murugan N. Application of response surface methodology for predicting weld bead quality in submerged arc welding of pipes. J Mater Process Technol 1999;88:266–75.

[11] Gunaraj V, Murugan N. Prediction and comparison of the area of the heat-affected zone for the bead-on-plates and bead-on-joint in submerged arc welding of pipes. J Mater Process Technol 1999;95: 246–61.

[12] Ajit Khatter, Pawan Kumar, Manish Kumar, "Optimization of Process Parameter in TIG Welding Using Taguchi of Stainless Steel-304" IJRMET Vol. 4, Issue 1, Nov2013 - April 2014.

[13] Nirmalendhu Choudhury, Ramesh Rudrapatiand Asish Bandyopadhyay, "Design optimization of Process Parameters for TIG Welding based on Taguchi Method" International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN2347 – 5161.

[14] Dheeraj Singh, Vedansh Chaturvedi, Jyoti Vimal, "Application of Signal to Noise Ratio Methodology for Optimization of Tig Process Parameters" International Journal of Engineering and Innovative Technology (IJEIT) Volume 3, Issue 1, July 2013.

[15] M. Balasubramanian, "Prediction of optimum weld pool geometry of PCTIG welded titanium alloy using statistical design" Engineering science and technology, an international journal 19(2016) 15-21.

[16] A.Sivasankaran, Taguchi Optimization of TIG Welding for Maximizing Weld Strength of Aluminium 8011" International Journal of Innovative Research in Science, Engineering and Technology, Vol. 4, Special Issue 6, May 2015.

[17] Ravinder, S., K. Jarial, "Parametric Optimization of TIG Welding on Stainless Steel
(202) & Mild Steel by using Taguchi Method" International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463 Vol. 4Issue 6, June-2015, pp: (484-494).

[18] Mallikarjun Kallimatha, G Rajendrab, S. Sathishc, "TIG Welding Al6061 using Taguchi and Regression analysis methods" International Journal of Engineering Research, Volume No.3 Issue No: Special 1, pp: 151-154.

[19] Mr. L. Suresh Kumar, Dr. S. M. Verma, P. Radhakrishna Prasad, P.Kirankumar, Dr.T.Siva Shanker, "Experimental Investigation for Welding Aspects of AISI 304 & 316 by Taguchi Technique for the Process of TIG & MIG Welding" International Journal of Engineering Trends and Technology-Volume2Issue2- 2011.

[20] A. Vinoth Jebaraj& L. Ajaykumar "Microstructure analysis and the influence ofshortening on stress corrosion cracking resistance of duplex stainless steel welded joints" Indian Journal of Engineering & Material Sciences Vol. 21, April 2014, pp. 155-167.

[21] Tong WEN, Shi-yao LIU, Shi CHEN, Lan-tao LIU, Chen YANG, "Influence of high frequency vibration on microstructure and mechanical properties of TIG welding joints of AZ31 magnesium alloy" Transaction of Nonferrous Metals society of China, Vol. 25 No.2 February 2015.