Advances and Applications in Mathematical Sciences
Volume 20, Issue 2, December 2020, Pages 293-304

OPTIMIZATION OF PROCESS PARAMETERS USING MULTI-OBJECTIVE TAGUCHI ANALYSIS

HARI OM SHARMA, MOHIT AGARWAL, BODHISATWA SEAL and NADEEM ALI

IIMT Engineering College
Meerut, U.P., India
E-mail: hodce200607@gmail.com
mohitagar1987@gmail.com
seal.bodhisatwa@gmail.com
nadeem.thakur@gmail.com

Abstract

Welding process may be similar or dissimilar metals. Welding of dissimilar metals are different contain a variety of metals with different chemical composition. This research paper went gave a brief review of the work carried out on the hardness of the weld area and the welded joints. The laser light energy can be focused in creating that content can be converted into heat energy. By employing a light beam in the electromagnetic spectrum, the visible or near-infrared part, we have the energy to be processed using fixed or fiber optic beam delivery optics can transmit content from your source.

Need a customized technology in today's world which is rapidly growing day included easily in two propagation materials. These research two disparate materials in letters that had AISI 304 and was taken to the laser welding joint configurations adopt AISI 202. Three process parameters, the scan speed; four levels of optimization was pulse frequency and pulse diameter. Gray Taguchi method using the specified parameters with the L16 Orthogonal Array was to customize. It has been found that raises laser welding optimum quality characteristics with a pulse frequency of 45 mm / scanning speed of minutes, 0.3 mm Pulse diameter and 7 Hz. These levels length of weld hardness zone 304.77 HV and Heat Affected Zone in went were 0.0852 mm.

Introduction

Laser beam welding is used to having a welding procedure which includes two metals from use of the laser supply. Laser supply provides a focused and

2010 Mathematics Subject Classification: 74F15, 82D35.
Keywords: laser welding, material selection and grey taguchi analysis.
Received April 15, 2020; Accepted July 20, 2020

high concentration heat supply, which narrows, allows for weld bead deep enough with high welding speed scan. Using the procedure used in most manufacturing industry of high volume, such as in the automobile industry. But its influence due to its beneficial effects on other machining operations on other days in various functional areas of metal. Resulting laser is a high power density beam welding due to high heating and cooling rates are small heat affected zone.

Laser beam to add metals is an efficient technique. This may include metals at the surface level and depth to produce a sound welding. It must be connected to conventional welding processes for the welding quality. Weld quality is high and can be used for soldering used. High melting point such as high heat conductivity material and aluminum can be welded by a using a laser supply with power. Two to join the materials and welding are completely different. Can be added to small amounts of molten material and content for the duration of the controllable melting, but cannot be welded. Due to the elevated temperature and cooling rate of the welding zone must narrowly Crack.

Literature Review

"Laser" was as light amplification "by stimulated emission of Origin" Radiation words. The first laser by Theodore 1960. Is different from other sources of laser light, which he consistently emissions from light. Spatial cohesion also allows narrow living at great distances laser beam (collimation), which enables applications such as laser pointers. Temporal consistency of use could be to produce pulses of light, as a female one. Laser beam is an efficient technique for joining different metals. Laser beam welding is used for welding process including two metals using a laser supply. Laser supply is a fast and high-density heat source, which allows you to scan the narrow high welding speed, deep weld bead.

Need a customized technology in today's world which is rapidly growing day included easily in two propagation materials. Both economic and technical aspects dissimilar joints are important, because cost reduction by these joints and can provide a satisfactory service performance. The demand for such couples in the industry is very large. Therefore, study of uneven welding materials for many researchers is a major interest.

In industrial process applications due to the high level of automation in laser welding is a high profit; High power density as well as the production rate is very high. Produced by laser welding quality of weld joints is very good and parameters of laser welding to determine the quality of welds play an important role. Since the demand for a product depends on its quality, the parameters of the laser welding should be well optimized to get proper weld quality.

Experimental Procedure

Material Selection

Laser welding of AISI 304 stainless steel and AISI selected 202 stainless steel. AISI 304 stainless steel was sliced to dimensions of (50 x 30 x 1.6) mm and AISI 202 stainless steel (50 x 30 x 1.6) mm. Sixteen samples of each material were sliced in the aforesaid dimensions. Both materials to learn the chemical composition underwent XRF testing. Both materials chemical compositions table went in the first.

Table 1. Composition of AISI 304 and AISI 202 (Weight %).

Composition	C	Si	Mn	Ni	Cr	S	P	Cu	Fe
AISI 304	0.030	0.75	2.0	11.30	18.026	0.030	0.045	0.22	66.772
AISI 202	0.5	0.169	0.583	0.08	0.064	0.012	0.02	0.17	95.892

Nd: Yag Laser Beam Welding

400 W ND in this paper: YAG laser using AISI 304 was stainless steel and AISI 202 stainless steel welding lap joint configuration.

A sample before welding was ground properly by the grinder so as to eliminate the present Bur and oxide therein. After grinding the samples were adjusted to their proper dimensions and surface went to get over.

Then the souls to remove any existing growing material on the surface of the samples were cleaned by decreasing elements. The occurrence of samples on the sample surface, it is very important that there also reduces the absorption of fat ingredients laser.

The experiment was done with a focus on NID: AISI 304 stainless steel and YAG laser on AISI 202 stainless steel interface. Specification of used laser beams is presented below:

Average laser power: 400 W

Highest pulse energy: 15 kW

Highest scan speed: 1.5 m/min

Highest pulse diameter: 2 mm

To find effective hardness of the weld zone and HAZ use some laser parameters was stable and there were varied in a range. Constant parameters set in the machine are as follows:

Pulse energy: 25 J

Pulse power: 5 kW

Pulse duration: 5 ms

Process parameters that are optimized they were set at levels in the machine range. 4^{th} level in each parameter. For evaluation of effective response was to consider the impact of these process parameters.

Hardness Measurement

All 16 samples were prepared for measuring the macro-hardness. Image as shown in 1 (A) piece of work was put on the bottom of the indicator.

Welding position to view through the microscope available in the machine has been properly controlled. 3 kg of force, such as the time and was determined to force the Vickers machine that is shown in the data acquisition system in 1 (b). Was indentation on the welded parts. Each indentation diagonal was measured by the machine and equations based on the formula provided in Figure 1, was measured hardness values.

$$H_v = \frac{1.8544F}{d^2(1)}$$

F = Force in kgf

d = Diameter

Figure One. (i) Vickers hardness machine (ii) Data acquisition system.

Welding pair were indentation at three different points of welding and average hardness values was taken as the final hardness value of the sample.

Table 2 shows the hardness values of 3 samples

Table 2. Welding hardness value.

No.	HV-1	HV-2	HV-3	HV-
1	265.00	262.80	263.90	263.902
2	288.90	284.00	285.40	286.10
3	281.80	283.20	283.40	282.80
4	289.00	289.10	285.90	288.00
5	281.20	284.70	284.30	283.40
6	265.60	265.80	266.00	265.80
7	296.40	296.80	294.50	295.90
8	280.80	286.10	286.00	284.30
9	288.20	287.20	288.90	288.10
10	290.00	293.00	287.60	290.20
11	258.10	250.10	253.80	254.00
12	258.20	254.90	260.30	257.80
13	286.10	288.20	283.70	286.00
14	278.40	275.80	274.70	276.30
15	263.00	264.40	264.30	263.90
16	248.00	248.90	247.40	248.10

Heat Affected Zone Measurement

Heat affected area to optimize the process parameters affect (HAZ) was taken as another response parameters. Welded samples in the first leg were cut by wire Electro Discharge Machining. It was cut in such a way that the weld zone in small pieces of samples. Using Electro Discharge Machining brass electrode wire sample size of 1 mm x 0.5 mm was prepared. All 16 samples were taken for further been cut to the desired size and polishing. The process of wire Electro Discharge Machining cutting with a data acquisition system went shown in Fig. Two. Was designed for the cut to the desired size, sample polishing. Side region of the welding had been polished.

Figure 2. (i) Cutting samples by WEDM (ii) Data acquisition system

Taguchi Analysis

Taguchi method of experimental design to optimize designs for performance and cost is a effective, logical and simplified approach. It can optimize the parameters of the process to reduce the fluctuations of the performance observed in the system for the source of diversity. Compared to others, Taguchi method aiming point is the use of the concept and puts the results on the designated point.

Table 4. Experimental parameter and outcome.

Run order	scan speed	pulse diameter	Pulse frequency	Hardne	HA
1	30	0.3	1	263.9	0.05
2	30	0.6	3	286.1	0.09
3	30	0.9	5	282.8	0.14

4	30	1.2	7	288.0	0.20
5	45	0.3	3	283.4	0.06
6	45	0.6	1	265.8	0.04
7	45	0.9	7	295.9	0.13
8	45	1.2	5	284.3	0.11
9	60	0.3	5	288.1	0.06
10	60	0.6	7	290.2	0.08
11	60	0.9	1	254.0	0.04
12	60	1.2	3	257.8	0.07
13	75	0.3	7	286.0	0.06
14	75	0.6	5	276.3	0.07
15	75	0.9	3	263.9	0.09
16	75	1.2	1	248.1	0.08

Results and Discussion

Table 5. S N ratio with matching aspect combination.

Run no.	Scan speed	Pulse diameter	Pulse frequency	Hardness	HAZ	S N Ratio hardness	S N Ratio HAZ
1	30	0.3	1	263.9	0.05	48.4288	26.0206
2	30	0.6	3	286.1	0.09	49.1304	20.9151
3	30	0.9	5	282.8	0.14	49.0296	17.0774
4	30	1.2	7	288.0	0.20	49.1878	13.9794
5	45	0.3	3	283.4	0.06	49.0480	24.4370
6	45	0.6	1	265.8	0.04	48.4911	27.9588
7	45	0.9	7	295.9	0.13	49.4229	17.7211
8	45	1.2	5	284.3	0.11	49.0755	19.1721
9	60	0.3	5	288.1	0.06	49.1909	24.4370

10	60	0.6	7	290.2	0.08	49.2539	21.9382
11	60	0.9	1	254.0	0.04	48.0967	27.9588
12	60	1.2	3	257.8	0.07	48.2257	23.0980
13	75	0.3	7	286.0	0.06	49.1273	24.4370
14	75	0.6	5	276.3	0.07	48.8276	23.0980
15	75	0.9	3	263.9	0.09	48.4288	20.9151
16	75	1.2	1	248.1	0.08	47.8925	21.9382

Single Objective Optimization Technique

Taguchi methodology for Hardness

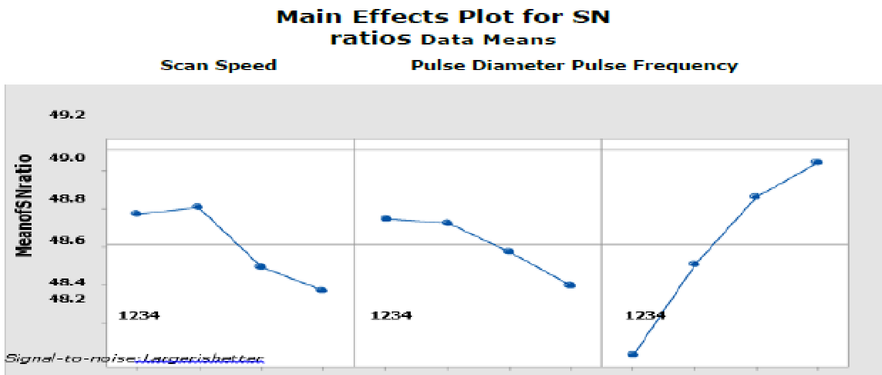

Figure 5. Main effect Hardness graph for SN ratios.

In Figure 5, the main effect plot indicates that the pulse frequency scan on the second level of speed, pulse diameter at level 1 and 4 Wavell weld hardness customized level to maximum. Optimized process parameters for hardness:

Scan speed: 45 mm/min

Pulse diameter: 0.3 mm

Pulse frequency: 7Hz

ANOVA for the SN ratio in the 6 have a significant impact on the rigidity of all process parameters that have been related to stiffness and found. Pulse frequency to determine the weld hardness is the most important factor.

Confirms 91.6% of the R 2 value using the reliability.

Hardness = 280 - 0.298 (scan speed) - 12.6 (pulse diameter) + 5.32 (pulse frequency) (5)

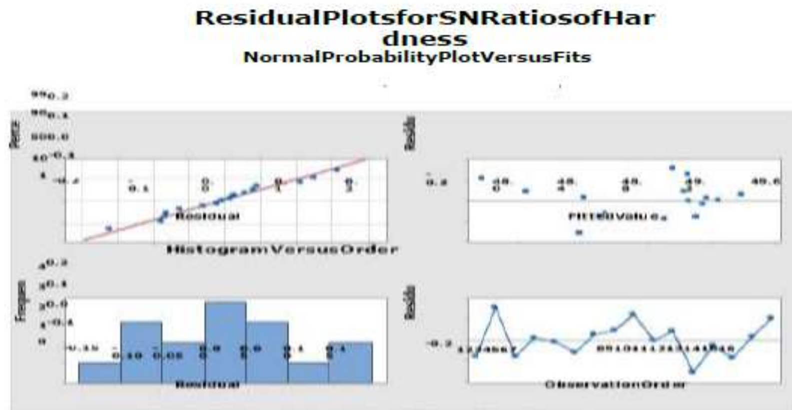

Figure 6. Residual plots for SN ratios of hardness.

Taguchi methodology for HAZ

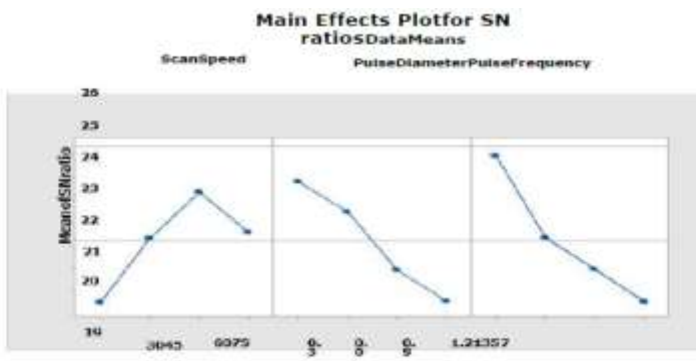

Figure 7. Main effect HAZ graph for SN ratios.

The main impact in the table plot indicates that the scan speed 3rd level is pulse diameter 1 level and pulse frequency at level 1 Weld hardness customized level to maximum. Optimized process parameters for hardness:

Scan speed: 60 mm/min

Pulse diameter: 0.3 mm

Pulse frequency: 1Hz

Related HAZ was performed ANOVA for the SN ratio in the 7 and found that all processes have a significant impact on the rigidity of the parameters. Pulse frequency to determine the weld hardness is the most important factor. Confirms 83.7% of the R2 value using the reliability. Later was normal regression analysis equation was established a relationship between the input parameters and hardness 6.

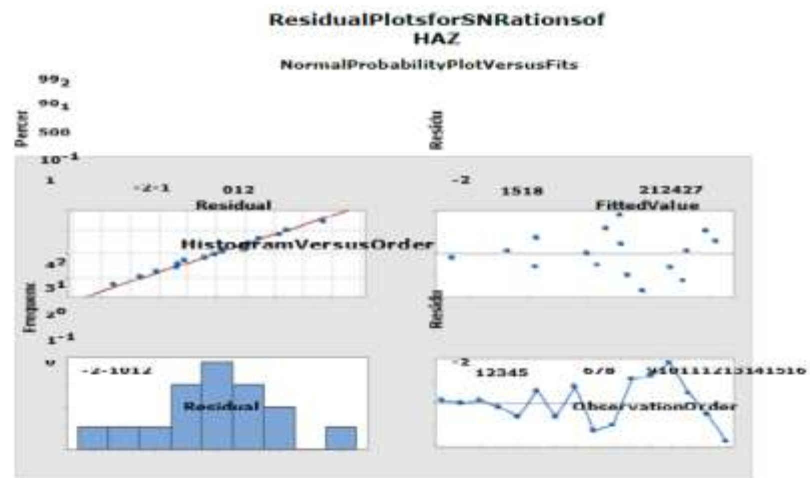

Figure 8. Residual plots for SN ratios of HAZ.

Conclusions

- AISI 304 stainless steel and AISI two Disimr material called 202 stainless steel was welded combined pattern adopted by laser welding. Taguchi method had been used to optimize the controllable variables. The characteristics of laser welding are:-

- Laser welding with a pulse frequency of 45 mm / scanning speed of minutes, 0.3 mm Pulse diameter and 7 Hz also produce optimum quality characteristics.

- The length of the hardness of the weld zone on optimal settings weld model 300.05 HV and Heat Affected Zone went was 0.0948 mm.

- The length of the hardness of the weld zone 304.77 HV and Heat Affected Zone went pie as 0.0852 mm experimental optimal settings.

• The stainless steel and it was found to carbon steel laser welding decreases hardness with scan speeds and an increase in vascular diameter, while the hardness increases with increasing pulse frequency.

• The reduced Heat Affected Zone increases the speed of the scan, for the same samples while increasing the pulse diameter and pulse frequency.

• Welding process has the highest impact on determining the length of weld hardness and Heat Affected Zone pulse frequency when personally analyze the responses. But when the lowest impact on were considered together, found that the length of the weld hardness and Heat Affected Zone pulse frequency on both reactions.

• That the highest SN ratio indicates the estimated results optimization model is sufficient.

• Less than the hardness and the expected outcome of Heat Affected Zone it is clear that the hardness actually up and about at the Heat Affected Zone.

References

[1] https://en.wikipedia.org

[2] M. Barone and F. Selleri, Frontiers of Fundamental Physics, New York, Plenum Press. (1994)

[3] C. D. Patel, An Experimental Investigation and Optimization of Laser Welding Process Parameters for Mild Steel.

[4] A. E. Kannatey, Principles of Laser Materials Processing, New Jersey, John Wiley and Sons inc. (2008)

[5] D. Herzog, P. Jaeschke, O. Meier and H. Haferkamp, Investigations on the thermal effect caused by laser cutting with respect to static strength of CFRP, International Journal of Machine Tools and Manufacture 48(12-13) (2008), 1464-1473.

[6] Weld Pool Control in Nd: YAG Laser Welding paper number MC8.98058A in the framework of the Strategic Research Program of the Netherlands Institute for Metals Research in the Netherlands.

[7] P. Muthu, Optimization of the Process Parameters of Resistance Spot Welding of AISI316l Sheets Using Taguchi Method, Journal of Mechanics and Mechanical Engineering, (2019), 64-69.

[8] D. Kianersi, A. Mostafaei and A. A. Amadeh, Resistance spot welding joints of AISI316L austenitic stainless steel sheets: Phase transformations, mechanical properties and microstructure characterizations, Journal of Materials and Design (2014), 251-263.

[9] B, D. Naika, N. Ramanaiaha, M. Srinivasa Raoa, T. Rajasekhara and G. Rambabua, Multi objective optimization of friction stir welding process, International Journal of Engineering Research and Technology (IJERT) Special Issue (2019), 1-6.

[10] P. Sreeraj, Optimization of resistance spot welding process parameters using Moora approach, Journal of Mechanical Engineering and Technology 8(2) (2016), 81-93.