Journal of Advances in Science and Technology
Vol. 13, Issue No. 1, (Special Issue) March-2017, ISSN 2230-9659

Effect of Process Parameters on Quality of Seam Welded AISI 304L

Gajanan Gaikwad[1]*, Kedar Inamdar[2]

[1]PG Student, Department of Mechanical engineering, Walchand College of Engineering, Sangli, India

[2]Professor Department of Mechanical Engineering, Walchand College of Engineering, Sangli, India

Abstract – Resistance Seam welding is one of the most commonly used methods for joining of two faying surfaces of metal sheets in automobile industries for producing leak proof joints. It is a process in which heat is produced at the joint by resistance to the flow of current. The aim of the work was to study the influence of process parameters on tensile strength of resistance seam welded joint for AISI 304L Stainless steel. The experimental studies were conducted under varying the electrode current, electrode force and heat time. Taguchi's experimental design method was used for setting of process parameters. Signal to noise ratio (S/N) was used to obtain combination of optimum welding parameters and analysis of variance (ANOVA) for determining the most dominating parameter which affects seam welded quality.

Keywords— Seam welding, Tensile strength, Taguchi method, Nugget width, Weld Quality.

---------------------------♦-----------------------------

INTRODUCTION

Resistance seam welding is a process in which faying surface areas of overlapped components are joined by resistance to flow of electric current under the pressure of circular electrode to produce series of overlapping spot welds. Resistance seam welding is very much similar in principle with the spot welding but produces continuous joints by wheels as electrode. Standard seam, mash seam and roll spot welding are the three forms of seam welding exist. As given in Fig. current applied to the material through the disc shaped rollers. Heat is generated at the interface of the material thus the rollers maintains continuous pressure to the material for producing row the weld nuggets along the interface. To produce satisfactory resistance seam weld, welding current, electrode pressure, heat and cool time are the most influential parameters used.

Resistance welding works on the joules heating principle,

$$Q = I^2 Rt \quad \text{..........................} \ (1)$$

Where, Q is heat generated (J), I is current (A), R is resistance of the interface (Ω) and t is time of application of current (Sec or cycle).

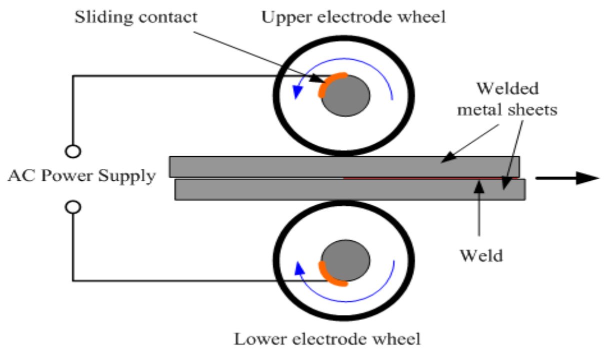

Fig. 1 Working of resistance seam welding

Steel sheets of thickness 0.5 – 1.5 mm can be seam welded in industries like domestic appliances, vehicle parts. For this application, welding speed upto 10 m/min can feasible.

Williams et al. [2] stated the factors which affects weld formation at high welding speeds for both uncoated and coated steels. They concluded that welding speed increases, current requirement for weld formation increases gradually. A factor which limits the welding speed are low electrode force levels, interrupted current programs and steels with high resistivity. It was experimentally showed that minimum indentation welds can be produced over a wide range of welding speeds and currents.

Tumuluru et al. [3] investigated procedure development and practice considerations for seam welding. Evaluation of mechanical strength of weld was carried out by Peel test and tensile tests. This paper presents the seam welding of ferrous materials like low carbon steel, stainless steel and nonferrous materials like Aluminium, Copper, Bronze etc. They concluded that welded joint will give tensile strength of 80 to 100% of the parent metal if the indentation is properly controlled.

Robert Matteson [4] studied the fundamentals of resistance seam welding. This Paper presents that there is an improvement in the welding range in speed if weld force increases under given electrode conditions. It also helps to control cracking.

Khosravi et al. [5] concluded that increasing current for low welding speeds results in the decrease nugget size. It also increases joining zone thickness in each galvanized and electro galvanized sheet when higher current used. Increase of welding speed while keeping welding current constant, increases the thickness of joining zone and nugget size decreases. It was found that Maximum hardness had always been in the center of the weld.

Habdel-Aleem et al. [6] found that increasing exhausting pressure, increases nugget penetration at an identical welding current. The results of tensile shear testing of joints stated that fracture always takes place near to the fusion boundary on the 1050 material. The hardness increases at the fusion boundary of 1050 Aluminium metal.

Inoue Tomohiro et al. [7] researched on an electric resistance welding (ERW) line pipe technique with a high performance weld seam developed by JFE Steel. The Finite element analysis method used to construct an analytical model of the ERW seam. Development of homogeneous heating technology helped to achieve improved seam mechanical properties.

Esme [8] studied to investigate the optimization process parameters for spot welded SAE 1010 steel sheets. This paper presents the influence of welding parameters like on the tensile shear strength. Level of contribution of the each welding process parameter to the overall improvement of the strength and quality is determined by using ANOVA. This paper concludes that welding current and electrode force were found as most significant parameters, whereas electrode diameter and welding time were less influential factors. The results showed that welding current was about two times more important than the less effective parameter electrode force for controlling the tensile shear strength.

Kamble [9] analyzed the optimization and effect of process parameters on shear strength of resistance spot welding using Taguchi method. For this study, they have taken welding current, welding time, electrode diameter and electrode force parameters. The result obtained from ANOVA method gives that process parameters that have highest statistical influence were current and electrode force.

2. EXPERIMENTAL PROCEDURE

2.1 Material

AISI 304L is the most versatile and widely used in the all the stainless steel. Their chemical composition, mechanical properties, weldability and corrosion and oxidation resistance provide the best all round performance at relatively low cost. AISI 304L has a carbon content max. 0.030. AISI 304L is used in a wide variety of home and commercial applications like food processing equipment, kitchen benches, heat exchangers, woven. AISI 304L of thickness 0.9 mm. Chemical composition (percent by weight) and properties of AISI 304L steel are given in table 1 and 2.

Table. 1 Material Composition

Percent Composition (%)	Iron Fe	Chromium Cr	Nickel Ni	Manganese Mn	Carbon C	Silicon Si
	67.84	20.02	8.212	1.196	0.240	0.135

Table. 2 Material Properties

Mechanical Properties	Tensile strength MPa	Modulus of elasticity GPa	% Elongation at break	% Reduction in area at break	Hardness (HB)
	420	193	40%	50%	150

2.2 Experimental Details

The specimen were prepared by cutting the workpiece material into suitable dimensions for tensile strength test as shown in Fig. 2 according to IS standards for seam welding [10]. The cut pieces were then cleaned to remove oil layer over the surface of material. Samples were welded using 100 KVA seam welding machine. Chromium copper electrode wheels were used as an electrode and kept constant for overall experiment.

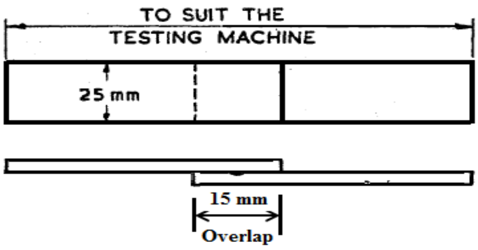

Fig. 2 Dimensions of specimen

Process parameters selected for this study are welding current, electrode pressure and welding time to find their effect on the tensile strength. Welding current considered as the major parameter amongst them which affects tensile strength. The values for process parameters and their levels is given in the Table 3.

Table. 3 Process Parameters and Their Levels

Process Parameter	Unit	Level 1	Level 2	Level 3
Welding current	KA	4.0	4.5	5.0
Electrode pressure	Kg/ cm^2	3	4	5
Welding Time	Millisecond	10	20	30

In complex manufacturing systems, interaction effects become very significant. Orthogonal array do not test all the possible combinations. As a result, effect of each process parameter on response variable like tensile strength was taken. Input parameters and their levels were selected based on trial experiments. In this study, L_9 orthogonal array which has 8 degrees of freedom was used. Three levels of each parameter were selected for experimentation. The experimental layout for input parameters an their levels using orthogonal array L_9 is shown in Table 4

Table. 4 Experimental Layout Using L_9 Orthogonal Array

Experiment No.	Welding Conditions		
	Welding Current(KA)	Electrode force (kg/cm^2)	Welding time (ms)
1	4.0	3.0	10
2	4.0	4.0	20
3	4.0	5.0	30
4	4.5	3.0	20
5	4.5	4.0	30
6	4.5	5.0	10
7	5.0	3.0	30
8	5.0	4.0	10
9	5.0	5.0	20

3. RESULTS AND DISCUSSIONS

The effect of these input parameters on seam welding process was investigated in form of response variables as tensile strength (MPa) and nugget width (mm). Tensile strength was performed on Universal Testing Machine while the specimens were held between two flat plate clamping jaws. Nugget width was measured using microzoom stereoscope. Results of tensile strength and nugget width are shown in Table 5. The analysis of responses was done by ANOVA and main effects plot.

3.1 effect of process parameter on tensile strength

According to given welding conditions, 9 samples of AISI 304L steel sheet were prepared. According to the IS standard (11), it is observed that shear limit for satisfactory weld joint tensile strength should not be less than 70% of the tensile strength of the material. The measured tensile strength of the parent material with standard procedure was 420MPa. Samples No. 1 to 9 failed in its welded joint while sample.

Table. 5 Tensile Strength Test Analyses

Experiment No.	Tensile Strength (MPa)	Area of Failure
1	158	Weld joint
2	178.5	Weld joint
3	197.5	Weld joint
4	229.8	Weld joint
5	234	Weld joint
6	231.2	Weld joint
7	236.1	Weld joint
8	251.7	Weld joint
9	275.6	Weld Joint

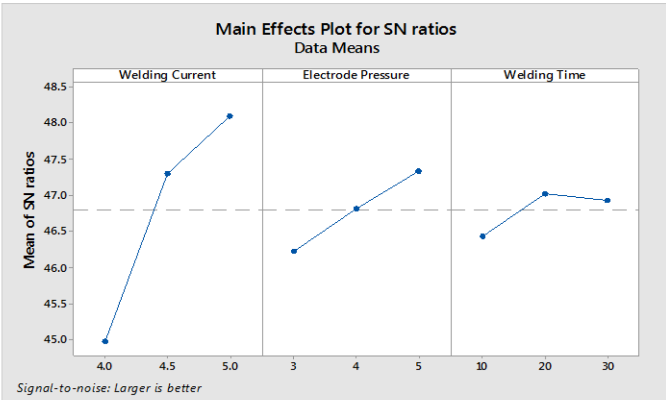

Fig. 3 S/N ratio plot for Tensile strength

Due to welding current used was very low for Samples 1, 2 and 3, it could give very less tensile strength. So they failed in its welding region. Satisfactory weld strength was obtained in the experimental No. 7, 8 and 9. It shows the effect of welding current on weld strength. S/N ratio plots (Fig No. 3) shows the effect of input parameters, welding current, electrode force and welding time on strength of seam welded specimen. As given in figure, for selected current values, weld strength and welding current are directly proportional to each other. As current values were increased, weld Strength increased.

3.2 effect of process parameter on Nugget width

Quality and strength of the seam welds are given by the shape and size of the weld nugget. Nugget width is the width of weld produced by disc shaped electrode wheel on workpiece. Measurement of nugget size was used to correlate welding process parameters and mechanical properties of weld produced. In general, it is observed that nugget size varies from 50% to 70% of actual tread width of the electrode wheel [1]. Nugget width is measured with the use of stereo-zoom microscope. Calculated nugget width with nugget penetration is given in table 6.

Table 6 also shows that when selected process parameters values increased from their lower to higher levels, weld penetration are also increasing. As the welding current value increases, Nugget width also increases significantly. For the same current, nugget width increased as heat time was also increased. The S/N ratio plot for nugget width is shown in Fig. 4. It clearly observes that current and electrode force are influential factors which control nugget width. More nugget width is obtained in case of lower cooling time.

Table. 6 Nugget Width Analyses

Experiment No.	Nugget width (mm)	Weld Penetration
1	3.49	Lowest
2	3.69	Low
3	3.76	Low
4	3.89	Medium
5	3.96	Medium
6	4.02	Medium
7	4.26	High
8	4.38	High
9	4.49	Highest

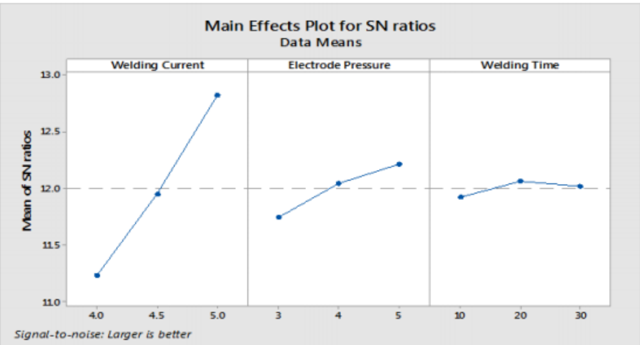

Fig. 4 S/N ratio plot for nugget width

4. ANALYSIS OF VARIANCE (ANOVA)

Analysis of Variance is a statistical analysis tool investigate the which welding process parameter significantly affects the response variables. ANOVA results are analyzed using MINITAB 16 Statistical analysis software. F-test value at 95% confidence level is used to find significant factors affecting the process and percentage contribution are calculated. If P-values in the table are less than 0.05 then corresponding variables in the table considered as statistically significant. The result of ANOVA for tensile strength and nugget width is given in the Table 7 and 8.

Table. 7 Anova for Tensile Strength

Source	DF	SS	MSS	F-Value	P-Value	% Cont.
Welding Current	2	9247.1	4623.55	48.74	0.02	79.49
Electrode Pressure	2	1077.4	538.68	5.68	0.042	15.95
Welding Time	2	314.2	157.09	1.66	0.377	1.75
Error	2	189.7	94.86			
Total	8	10828.4				100

Table. 8 Anova for Nugget Width

Source	DF	SS	MSS	F-Value	P-Value	% Cont.
Welding Current	2	0.8054	0.4027	575.29	0.002	91.56
Electrode Pressure	2	0.0674	0.0337	48.14	0.02	7.66
Welding Time	2	0.0054	0.0027	3.86	0.206	0.61
Error	2	0.0014	0.0007			
Total	8	0.8796				100

5. CONCLUSION

Taguchi's experimental design method has been used for the optimization of process parameters in RSEW process. An L_9 Orthogonal array is used to study the relationships between tensile strength and three controllable process parameters such as welding current, Electrode force and welding time. The experimental result of this work concludes that,

I. Welding current were found as a highly effective parameter among all process parameters. As welding current was increased, tensile strength and nugget width increased.

II. Tensile strength is highly affected by welding current (79.49%) and electrode pressure (15.95%); while nugget width is dependent on welding current having percentage contribution of 91.56%.

III. It is proved that welding current two times important than the other two factors for controlling tensile strength.

IV. Higher levels of experimental combination given more weld penetration.

ACKNOWLEDGEMENT

The authors acknowledge Merasha Shapers Private Limited to support for performing the experiments required for this work

REFERENCES

[1] Resistance Seam Welding by The ASM Committee on Resistance Welding of Steel, ASM handbook, Vol. 6,Welding, Brazing and Soldering, pp. 425-436.

[2] N.T. Williams, W. Waddell, "High speed resistance seam welding of uncoated and coated steels", British Steel Corporation, ECSC Agreement No. 7210.KA/809, Final Technical Report, pp.1-5.

[3] Murali D. Tumuluru, United States Steel Corporation, Hongyang Zhang, University of Toledo, R. (Bob) Matteson, Taylor Winfield Technologies, "Procedure Development and Practice Considerations for Resistance Welding", ASM Handbook, Vol. 6A, Welding Fundamentals and Processes, pp. 463-485.

[4] Robert Matteson, Taylor-Winfield Technologies, "Resistance Seam Welding",ASM Handbook, Vol. 6A, Welding Fundamentals and Processes, pp 438-447.

[5] Alireza Khosravi, Ayyub Halvaee, Mohammad Hossein Hasannia, "Weldability of electro galvanized versus galvanized interstitial free steel sheets by resistance seam welding", Technical report, Materials and Design, Vol. 44, pp. 90–98, 2013.

[6] H Abdel- Aleem, M Kato , K Nishio , T Yamaguchi & K Furukawa, "Joining of 1050/5052 by resistance seam welding and materials evaluation of joints", Welding International 2005 19 (3), Selected from Journal of Light Metal Welding and Construction 2004 42 (8) 199–204; Reference JL/04/8/379; Translation, pp. 199–204.

[7] Inoue Tomohiro, Suzuki Masahito, Okabe Takatoshi, Matsui Yutaka, "Development of Advanced Electric Resistance Welding (ERW) Line pipe "Mighty Seam TM" with High Quality Weld Seam Suitable for Extra-Low Temperature Services", JFE Technical Report No. 18, pp. 18-22, 2013

[8] Ugur Esme, "Application of Taguchi method for the optimization of resistance spot welding Process", The Arabian Journal for Science and Engineering, Vol. 34, pp. 519-528, 2009.

[9] Kamble Vijay Ananda, "Analysis of effect of process parameters on resistance spot welding shear strength", International Journal of Scientific Research, pp. 224-227, 2013

[10] "Resistance Welding: Theory and Use", Prepared by Resistance Welding Committee, American Welding Society, Reinhold Publishing Corporation, New York, 1956, pp. 102.

[11] Bureau of Indian Standard, "Code of practice for seam welding in mild steel", Sixth Reprint November 1995, pp. 1-12.

Corresponding Author

Gajanan Gaikwad*

PG Student, Department of Mechanical Engineering, Walchand College of Engineering, Sangli, India

E-Mail – gaikwad.gajanan893@gmail.com