Experiment on Optimization of Robot Welding Process Parameters

G DilliBabu, D Siva Sankar, K. Sivaji Babu

ABSTRACT---Resistance spot welding plays an important role in the manufacturing industry especially in the automobile sector. There is a lot of research work in the area of manually spot welding process and optimization of spot welding parameters. Currently there is more demand on robot spot welding process in the manufacturing unit. But only few research works is going on in the area of robot spot welding process and optimization of robot welding parameters. The present study gives an experimental investigation on robot resistance spot welding. Optimum robot spot welding parameters were identified by using Taguchi design of experiments approach. Also the results are analyzed by using Analysis of Variance ANOVA.

Keywords: Robot, Spot Welding, optimization.

I. INTRODUCTION

Resistance spot welding (RSW) is the oldest process widely being used for joining sheet metals in various industries because of its simplicity, easy for automation and reliability for bulk production. RSW is an autogenously welding method, meaning that dissimilar other methods. It does not necessity filler metal. RSW uses the metal's usual electrical resistance and contraction in the path of current flow, to produce heat at the interface. The procedure begins with electrodes which hold two metal sheets .The current flows through the sheets from single electrode to the other and the resistance to this flowing current produces temperature. A high heat is generated where the weld sheets fuse at the faying surface areas and a molten region is generated in among two sheets. As the current closes the melt rapidly solidifies, forming a solid nugget. Ever since the single development by Thomson in 1877, the process has been applied actively for the assemblage of metal sheets in the automobile and aircraft productions.[1]

The levels of importance of resistance spots welding can be determined by the fact that 3000-6000 spots in a car there body are more than the weld. It has excellent technical benefits like low cost, high production rate &optimization for automation. These facilities create an attractive select for automobile assembly, truck cabin, rail vehicle and home appliances. Besides, the material-Two-materialassociates, like wire-to-wire connections on the electronic industry, are supplied by resistance spots welding. Application-specific measures, such as size of the welding nugget, control the quality of the joint. Determination of the quality of the resistance spots welding process uses heavy flows which are passed through the area of the interfaces of metals for a short time and Use pressure on sheets to join. Fluxes are not used in the RSW process, and use of filler metal is very rare [2].

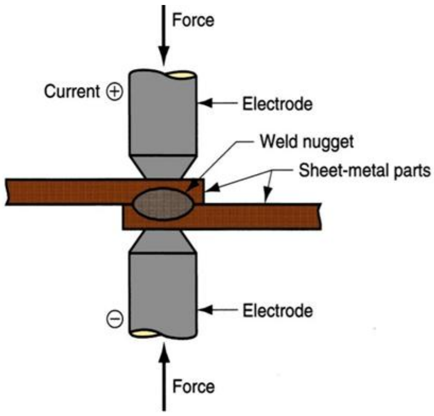

Fig. 1. Resistance spot welding principal

Kim[3] et al.based on this study, recently severalautomobile industries are trying to decrease the mass of the automobile interior and exterior parts in response to different environmental concerns. The solution is the development of Transformation Induced Plasticity (TRIP) steels with a more power and flexibility. RSW is a complex approach, for which specific spot welding optimal settings are required. However, in order to estimate the optimum spot welding conditions, more number of testsis required in the test-and-error method. The authors suggested that the Response Surface Methodology (RSM) is an alternative method for overcome this problem.

Shyamjith[4] et al. in this work two types of welding approaches have been employed. In the first approach, the resistance spot welding electrode is placed on the weld robot and the weld test specimen is stationary.Whereas in the second approach, the resistance spot welding electrode is stationary and the weld test specimen is placed on the weld robot. The advantages and disadvantages of above two approaches were studied and also applications of these approaches were discussed. A 4-axis robot resistance spot welding is also studied and concluded that this method is suitable for simple applications.

Peter[5] et al. studied about automatic resistance spot welding process. The spot welding process is studied by using virtual machine. The welding algorithms were developed and the process is studied by using analytical method. A hybrid circuit permits the virtual spot welding

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system to verify the requiredelectrical voltage between each 5o µs electrode's devices. The actual welding voltage and the current first sensing allow impedance, power and total electrical energy to move into the RSW process. By using calorimetric model the required energy input is calculated. The process is studied with the help of mild steel materials properties. Based on the studied the energy input and weld current decreases in both upslope and downslope phases.

Manoj[6] et al. this study is based on the impact of the spot welding process parameter on the tensile strength and the optimization of the RSW process.The spot welding parameters studied in the work are, weld current, weld time and electrode force. The experiments were planned by using Taguchi L18 orthogonal array approach. The effect of parameters on the output response tensile strength is studied by using signal to noise ration approach. Also the percentage of contribution of spot welding parameters is analyzed by using ANOVA analysis.

Park[7] et al. this work is based on the new methodology by using high current in RSW processes. In this approach the welding current is measured by using strain gauge. The strain gauge located on the external surface of the steel ring material. The strain gage stick on the 2ndloop on the weld equipment. In that case the electromagnetic force measured the high weld current in the welding equipment.

There is a lot of demand for spot welding process in the automotive industries because most of the automobile interior and exterior parts of joint by RSW process. At present they are approximately more than 4000 weld points on average steel vehicles. There is a need to reduce the weld errors, electrode wear, and electrode tip damage for improve the quality weld joints. Jader[8] et al. studied the various spot welding methods for optimizing the weld parameters. The authors mainly focus on automobile body spot welding application. Spot weld electrode tip life was estimated by using experimental investigation.

Ashwane[9] et al.in this work the authors studied the four parameters, they are weld materials, temperature, filler material landshield materials. Comparison of the automated welding and robotic welding also studied. They concluded that robot welding has raised the production much more than the manual welding.

Resistance spots welding parameters play akey role in vehicle's strength. Arjun[10] et al. conducted experiments to validate a series of spot welding parameters. Experiment 0.6 mm thick cold rolled off Analyst material grade was organized at JSC 270C.This study shows that many combinations are required to validate a series of parameters.

Anurag[11] et al. Resistance Spot Welding (RSW) is widely used for simple mechanism, high speed,low cost and suitable for automate the process. In this work focus on the understanding of behavior of spot welding and their failure characteristics. Based on the study the authors concluded that the RSW process mainly depends on the welding parameters such as weld time, weld current, electrode tip force.

Boriwal[12] et al.the work focused on the optimization on welding parameters in Resistance Spot Welding (RSW) Process by using fuzzy logic simulation. The parameters studied are weld electrode size, welding current, electrode force. The response output studied is tensile strength of spot welded materials.In this research RSW outputs have been successfully predicted by using design of experiment technique.Fuzzy logic simulation model was developed and tested for a number of test cases. The error in Fuzzy model predicted data was within acceptable limits.They concluded that Fuzzy logic simulation model can be used for complex processes like resistance spot welding.

Wen-Ren[13] et al. in this study aims to estimate resistance spot welding currents mathematically at high speed. ADSP21065 SHARC digital signal processor is used as the main device to monitor the welding current.The results are compared with the industrial welding current results for validate research data. The validated result shows that the proposed numerical method can accurately and speedilydetermines the welding current. Also the investigational results are compared with the latest welding current meter devices, and the error obtained in the measurement is less than 3%. This study will improve the automation of spot welding process in terms of weld quality in future.

In this paper, an experimental investigation is conducted to determine the optimization of robot spot welding parameters for minimizing the weld tensile strength by using Taguchi design of experiment approach.

II. EXPERIMENTAL SET-UP

2.1 specimens

A schematic diagram of the experimental specimen for the tensile test is shown in Fig.1 the material selected for the current experimentations is mild steel.

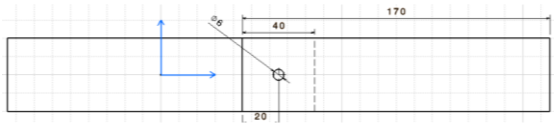

Fig.1. Spot welding test specimen (all dimensions are in mm).

2.2. Experimentation

Experiments are conducted by using spot welding robot IRB 6700. The electrodes used are Cu-Cr Alloy with tip of Φ6mm diameter. The experimental set up is shown in the fig.2.

Fig.2. Experimental Setup for Robot Spot Welding.

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2.3. Robot spot welding parameters and their levels

Robot spot welding parameters and their levels were determined by using trial and error method. The parameter and levels are shown in table 1. The output response studied was weld tensile strength. Tensile strength is measured by using Universal Testing Machine (UTM).

Table 1.Levels of the variables used in the experiment.

Variables	Low (1)	Canter (2)	High (3)
Weld time (A) in (cycles)	15	30	45
Weld current (B) in(KA)	3	6	9
Electrode force (C) in(N)	1500	2500	3500

2.4. Design of Taguchi orthogonal array layout

The experiments are conducted based on Taguchi L9 orthogonal array design. Taguchi Design and experimental results are shown in the table 2. The results are analyzed by using signal to noise ratios (S/N) concept. Larger is better S/N ration characteristic is chosen for the current investigation.

Main effect plot for S/N ratio for tensile strength of robot spot welding is shown in the figure 3. From this figure it is very clear that the weld strength is increasing by increasing weld time and by decreasing the weld force. Weld current should be at medium level to achieve the maximum tensile strength of the robot spot welding.

Table 2. Design and experimental results of the L9 orthogonal array experiment

S. No.	Factors			Tensile Strength (MPa)				
	A	B	C	Trail 1	Trial 2	Trail 3	Trial 4	S/N
1	1	1	1	3.2	3.3	3.2	3.2	10.16
2	1	2	2	3.2	3.3	3.3	3.4	10.36
3	1	3	3	2.9	2.8	2.8	3	9.16
4	2	1	2	3	3.2	3.2	3.1	9.88
5	2	2	3	3.2	3.1	3.2	3	9.88
6	2	3	1	3.2	3.3	3.3	3.2	10.23
7	3	1	3	2.9	3	2.8	2.9	9.24
8	3	2	1	3.2	3.5	3.4	3.5	10.61
9	3	3	2	3.2	3.4	3.1	3.4	10.28

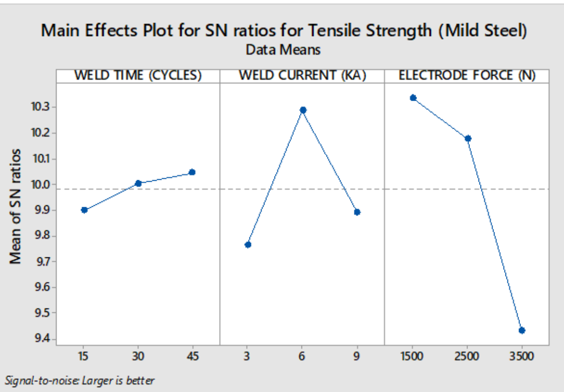

Fig. 3. Main effect plot for S/N ration

The results are also analyzed by using ANOVA Analysis. The ANOVA table is shown in the table 3. ANOVA data shows that all the selected parameters significantly affect the output reponse (Tensile strength). The percentage contribution of the weld time is 2.02%, weld current is 23.35% and electrode force is 70.95%.

Table 7.ANOVA table for MS tensile strength

Source	DF	Adj SS	Adj MS	F-Value	P-Value	% Contribution
Weld Time (Cycles)	2	0.005139	0.002569	0.55	0.644	2.02
weld current (ka)	2	0.059306	0.029653	6.37	0.136	23.35
Electrode Force (N)	2	0.180139	0.090069	19.36	0.049	70.95
Error	2	0.009306	0.004653			3.6
Total	8	0.253889				100

III. CONCLUSIONS:

In this study, the experimentation of robotic spot welding is done using ABB robot for better weld strength.

Based on the signal-to-noise (S/N) ratio analysis, the optimum robot weld strength value for Mild Steel material can be obtainable at 45 cycle welding time,6 kA weld current and 1500 N Electrode force.

Based on the ANOVA analysis, the percentage contribution of different robot spot welding parameter is Electrode force (70.95%), weld current (23.35%) and weld time (2.02%).

Confirmation tests were carried out to verify the predicted optimal conditions.

REFERENCES:

1. AravinthanArumugam, MohdAmiziNor "Spot Welding Parameter optimization To Improve Weld Characteristics For Dissimilar Metals" Intern. J. Sci. & Technol. Research Vol. 4, no 01, pp. 2015
2. ZohaNasir, Dr.M.I.Khan, "Resistance spot welding and optimization techniques used to optimize its process parameters" Intern. Research J. of Engg. & Technol. (IRJET) Vol.03 no. 05 pp.2016
3. T. Kim, H. Park and S. Rhee "optimization of welding parameters for resistance spot welding of TRIP steel with response surface methodology" Intern. J. of Prod. Research, Vol. 43, no. 21, 1 November 2005, 4643–4657
4. ShyamjithUralath, Hemant Raj Singh, "Selection and Applications of Automatic Spot Welding Methods" IOSR J. of Mech. & Civil Engg. Vol. 11, no. 4. pp. 50-54, 2014
5. Peter Puschner, Marcus Klein, Gerhard Kolzer "Fully Automatic Spot Welding System for Application in Automotive Industry" Vol. 20(4), pp. 383-390, 2015.

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6. ManojRaut and VishalAchwal "optimization of Spot Welding Process Parameters For Maximum Tensile Strength" intern. J. of Mech. Engg. & robotic Res. Vol. 3, no. 4, Oct. 2014
7. SooWoong Park and Suck Joona "A New Current Measurement Method in Resistance Spot Welding" IEEE Transactions on Instrumentation & Measurement. Vol. 39, Number. 5, pp. 1990
8. M A Al-Jader, J D Cullen, N athi and A I Al-Shamma "Spot Welding Theoretical and Practical investigations of the Expulsion occurrence in Joining Metal for the Automotive Industry" 2nd Intern. Conference on Dvlpmt. in Systems Engg. pp.2009.
9. Ashwane Kumar Srivastava, Er. Sanjeev Kumar and Er. D.P Singh "Robotic &Automated Welding" Intern. J. of Engg. Research & Management Technol. Vol.2, no.3, pp. 2015. ISSN: 2348-4039
10. Arjun Kumar, Dr. Sanjeev Sharma, "Parameter Range Validation For Resistance Spot Welding" IJARIIE-ISSN(0)-Vol-3 no.3, pp. 2395-4396, 2017.
11. Anurag Tewari, EktaRawat, "A Review Paper on optimization of Process Parameter of Resistance Spot Welding" Intern. Journal for Research in Applied Sci. &Engg. Technol. (IJRASET) Vol. 5, no.4, pp.2017.
12. L. Boriwal, R. M. Sarviya and M. M. Mahapatra "Modelling the resistance spot welding of galvanized steel sheets using Fuzzy logic" Intern. J. of Latest Trends in Engg. & Technol. (IJLTET) Vol. 5 no. 3, pp. 2015
13. Wen-Ren Yang and Chau-Shing Wang "Current Measurement of Resistance Spot Welding Using DSP" Tamkang Journal of Sci. &Engg. Vol. 14, Number. 1, pp. 3338 (2011)