Experimental Investigation of Resistance Spot Welding between SS202 & SS409

S.Sivaprabu[1], J.Balaji[2], G.Mullaiarasu[3], P.Nandhakumar[4], A.Ranjith[5], S.Umasankar[6]
[1,2]Assistant Professor, Department of Mechanical Engineering, Jayalakshmi Institute of Technology, Dharmapuri, Tamil Nadu – 636352, India.
[3,4,5,6]UG Student, Department of Mechanical Engineering, Jayalakshmi Institute of Technology, Dharmapuri, Tamil Nadu – 636352 , India

***Abstract*- Resistance spot welding is a process which is widely used in the automotive industry to join steel parts of various thicknesses and types. The current practice in the automotive industry in determining the welding schedule, which will be used in the welding process, is based on welding table or experiences. This however may not be the optimum welding schedule that will give the best spot weld quality. This work concentrates on the parameter optimization when spot welding steels with dissimilar thickness and type using Taguchi Method. The experimentation in this work used a L9 orthogonal array with three factors with each factor having three levels. The three factors used are welding current, weld time and electrode force. In this experimental investigation found good mechanical strength at Current-4KA, Electrode force-2.5kg/cm2 and weld cycle of 8. According to the Taguchi design the optimized parameter value of dissimilar steel was current-4KA, Electrode force-2.5 Kg/cm2 and Weld cycle 10.**

***Index Terms*- Optimization, RSW, Process Parameters, SS202, SS409.**

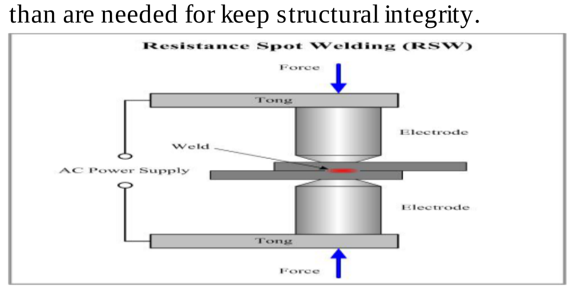
I. INTRODUCTION

Resistance spot welding is the resistance welding method more widely used by the industry. While in arc welding processes, electric current is used to maintain an arc between the torch and the surface of the work piece, in resistance welding methods, electric current produces heat in the piece by its flow through the work piece. The maximum amount of heat is produced where the electric resistance is maximum, which is at the surface between the sheets being joined, producing a molten nugget.

Force is applied before, during and after electric current. This force is necessary in order to maintain the electric current continuity and to assure the pressure necessary to avoid defects in the joint. In spot welding the joint is produced by local fusion caused by the flow of electric current between cylindrical electrodes. The size and shape of individual spot welds are determined by the area of contact between the electrodes and the work piece. These electrodes are normally made of cooper alloys.

This process deliver a big amount of energy to the spot in a very short time, thus the rest of the sheet does not have an excessive heated up. Compared with other welding process, such arc processes, resistance spot welding is easily automated, maintained and fast. Regarding the power density achieved and equipment is relatively inexpensive, the cost of each welding is one of the cheapest within all the welding processes.

Resistance spot welding is widely used in assembling automobile body parts, made of thinner-gauge metals, and for manufacturing pipe, tubing and smaller structural sections. Although resistance spot welding has been used widely by the industry, this process may be difficult to control. There are also strong interactions between the electrical, mechanical and thermal parts of the process. Because of that there are significant difficulties in modeling the spot welding process. These difficulties produce problems to know about the quality of resistance of spot welds Thus in the practice are carrying out more spot welds than are needed for keep structural integrity.



II. MATERIALS USED

2.1. SS202

Grade 202 stainless steel is a type of Cr-Ni-Mn stainless with similar properties to A240/SUS 302 stainless steel. The toughness of grade 202 at low temperatures is excellent. It is one of the most widely used precipitation hardening grades, and possesses good corrosion resistance, toughness, high harness, and strength.

2.1.1 Chemical Composition

Element	Content (%)
Iron, Fe	68
Chromium, Cr	17- 19
Manganese, Mn	7.50-10
Nickel, Ni	4-6
Silicon, Si	≤ 1
Nitrogen, N	≤ 0.25
Carbon, C	≤ 0.15
Phosphorous, P	≤ 0.060
Sulfur, S	≤ 0.030

2.1.2 Mechanical Properties

Properties	Metric	Imperial
Tensile strength	515 MPa	74694 psi
Yield strength	275 MPa	39900 psi
Elastic modulus	207 GPa	30000 ksi
Poisson's ratio	0.27-0.30	0.27-0.30
Elongation abreak	40%	40%

2.2 SS409

Grade 409 stainless steel is a Ferritic steel that offers good mechanical properties and high-temperature corrosion resistance. It is commonly considered as a chromium stainless steel, with applications in exhaust systems of automobiles and applications that demand weldability. Grade 409 steels are also available in highly stabilized forms, such as grades S40930, S40920 and S40910. The stability of these grades is provided by the presence of niobium, titanium, or both, in the composition of steels.

2.2.1 Chemical Composition

	C	Mn	Si	P	S	Cr	Ni	Ti
min. max	- 0.08	- 1.00	- 1.00	- 0.045	- 0.045	10.5 11.75	- 0.5	6x C 0.75

2.2.2 Mechanical Properties

Tensile Strength (MPa) min	Yield Strength 0.2% Proof (MPa) min	Elongation (% in 50mm) min	Hardness	
			Rockwell (HB) max	Brinell (HB) max
450	240	25	75	131

III. DESIGN OF EXPERIMENT

3.1 Process Parameters & Levels

Levels	Process Parameters		
	Current KA	Electrode Force Kg/cm^2	Weld Cycle
1	4	2	6
2	4.5	2.5	8
3	5	3	10

3.2 Design of Orthogonal Array

Orthogonal array is designed by using minitab-16 software.

Current KA	Electrode Force Kg/cm^2	Weld Cycle
4	2	6
4	2.5	8
4	3	10
4.5	2	8
4.5	2.5	10
4.5	3	5
5	2	10
5	2.5	6
5	3	8

IV. DESTRUCTIVE TEST

4.1. ROCKWELL HARDNESS TEST

1. Rockwell Hardness systems use a direct readout machine determining the hardness number based upon the depth of penetration of either a diamond point or a steel ball. Deep penetration indicated a material having a low Rockwell Hardness number.
2. However, a low penetration indicates a material having a high Rockwell Hardness number. The Rockwell Hardness number is based upon the difference in the depth to which a penetrator is driven by a definite light or “minor” load and a definite heavy or “Major” load.
3. The ball penetrators are chucks that are made to hold 1/16” or 1/8” diameter hardened steel balls. Also available are ¼” and ½” ball penetrators for the testing of softer materials.
4. There are two types of anvils that are used on the Rockwell hardness testers. The flat faceplate models are used for flat specimens. The “V” type anvils hold round specimens firmly.
5. Test blocks or calibration blocks are flat steel or brass blocks, which have been tested and marked with the scale and Rockwell number. They

should be used to check the accuracy and calibration of the tester frequently.

Using the "B" Scale;

a. Use a 1/16 indenter

b. Major load: 100 Kg, Minor load: 10 Kg

c. Use for Case hardened steel titanium, tool steel.

d. Do not use on hardened steel

HARDNESS HRB VALUE

SAMPLE S	S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8	S 9
SS202	72	71	68	74	65	66	80	77	64
Ss 409	73	65	67	65	77	73	68	71	72

4.2. TENSILE TEST

Friction processed joints are evaluated for their mechanical characteristics through tensile testing. A tensile test helps determining tensile properties such as tensile strength, yield strength, percentage of elongation, and percentage of reduction in area and modulus of elasticity. The welding parameters were randomly chosen within the range available in the machine. The joints were made with random parameters and evaluate tensile strength and burn off. Then the joints were made and evaluate the mechanical and metallurgical characteristics. The friction welded specimens were prepared as per the ASTM standards. The test was carried out in a universal testing machine (UTM) 40 tones FIE make.

Sample	Tensile Strength N/mm^2
1	213.00
2	229.20
3	221.00
4	226.80
5	199.80
6	211.20
7	215.20
8	212.40
9	201.00

V. PROCESS PARAMETER OPTIMIZATION FOR TENSILE STRENGTH

5.1 S/N Ratio Value of Tensile Strength

Samples	Designation	Tensile Strength N/mm^2	S/N Ratio Value
1	$A_1B_1C_1$	213.00	46.5676
2	$A_1B_2C_2$	229.20	47.2043
3	$A_1B_3C_3$	221.00	46.8878
4	$A_2B_1C_2$	226.80	47.1129
5	$A_2B_2C_3$	199.80	46.0119
6	$A_2B_3C_1$	211.20	46.4939
7	$A_3B_1C_3$	215.20	46.6568
8	$A_3B_2C_1$	212.40	46.5431
9	$A_3B_3C_2$	201.00	46.0639

5.2 Response Table for Signal to Noise Ratios Larger is better

Level	Current	Electrode Force	Weld Cycle
1	46.89	46.78	46.53
2	46.54	46.59	46.79
3	46.42	46.48	46.52
Delta	0.47	0.30	0.27
Rank	1	2	3

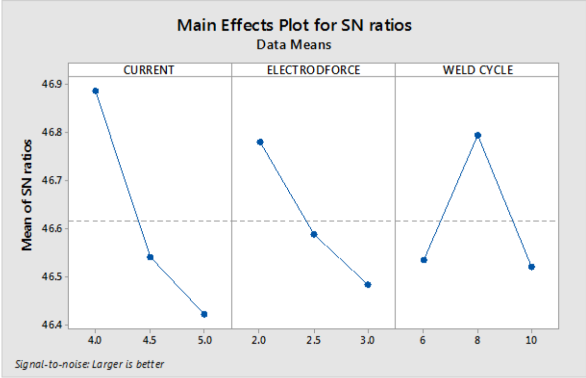
5.3 Response Table for Means

Level	Current	Electrode force	Weld cycle
1	221.1	218.3	212.2
2	212.6	213.8	219.0
3	209.5	211.1	212.0
Delta	11.5	7.3	7.0
Rank	1	2	3

5.4 Analysis of Variance

Source	DF	Seq SS	Adj SS	F	P	% Of Contribution
Current	2	214.11	107.05	0.49	0.671	26
Electrode force	2	80.83	40.41	0.19	0.844	10
Weld cycle	2	95.28	47.67	0.22	0.821	11
Error	2	435.71	217.85			53
Total	8	825.92				100

5.5 Main Effects Plot for S/N Ratio



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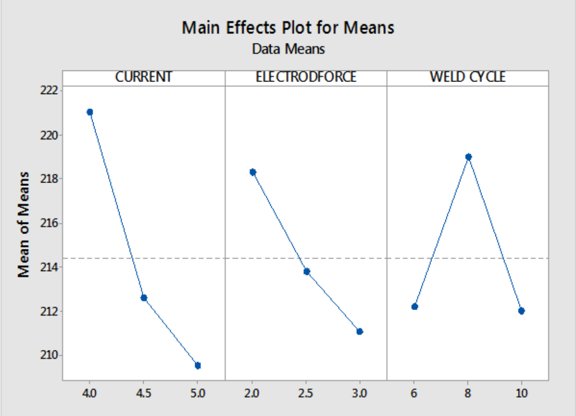

VI. RESULT & CONCLUSION

The following conclusions can be inferred from the experimental study carried out:

1) The two dissimilar metals, i.e., SS 202 and SS409 steel can be spot welded together, producing a good weld joint with reasonably good strength.
2) In the Spot weld joint between SS 202 and SS 409 carbon steel, the weld Strength increases with Increasing welding Current.
3) In the Spot weld joint between SS 202 and SS 409 the weld Strength increases with Increasing Electrode force.
4) In this experimental investigation we found good mechanical strength at Current-4KA, Electrode force-2.5kg/cm^2 and weld cycle of 8.

6.1 Optimal Control Factor

A_1 (Current-4KA), B_2 (Electrode Force-2.5Kg/cm^2) & C_3 (Weld cycle-10) .

6.2 Percentage of Contribution of Process Parameter

Current - 26%, Electrode force – 10% & Weld cycle – 10%

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