

# Parametric Study in Spot Welding for Dissimilar Weld Joints

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**ABSTRACT:** In this work investigate the mechanical properties in different regions of the spot welded Stainless steel sheet and Mild steel sheet subjected to different Welding Parameters. The 2.0 (100 \* 32) mm thick AISI 202 Stainless steel and 2.0 (100 \* 32) mm thick AISI 1018 sheet are was successfully welded using spot welding method with variable welding parameters. The Experimental procedure are developed by Design of Experiment and the optimum value of Welded parameters are identified through Response surface Methodology. The variable parameters are taken as Electrode force, Weld Current and the Weld time. The measurable parameters are taken as Tensile strength and hardness. The optimum parameters are defined the quality of the mechanical properties of the Dissimilar steel joints. The predicted Optimum parameters are displayed good mechanical properties.

## I. INTRODUCTION

Resistance spot welding (RSW) is a most important sheet metal assembly process in several industries, such as the automobile, home appliances, air craft and space craft assemblies. It is an effective joining process broadly used for the production of sheet metal assemblies. There are 4000-5000 spot welds in any automobile vehicle, which shows importance of the resistance spot welding. RSW have outstanding technology and economical profits such as less cost, great production ratio and flexibility for computerization which is attractive choice for auto body assembly, joining of vehicle cabins, rail coaches and domestic usage applications. Although resistance spot welding is now over 120 years old, which industries are, used even today joining of metals by the application of pressure, current and time. As the name denotes, it uses the resistance to flow of current concerning the materials that causes confined heating the parts to be merged. Nachimani Charde et al, [1] investigated Material characterizations of similar and dis-similar such as mild steels, stainless steels, and both steel mixed joints under resistance spot welding with the thickness of 2 mm in real experimental welding and compare to simulation result with help of SORPAS tool. They determine stainless steel have greater tensile shear forces as compared with mild steel weld joints. Hardness tests also done the above specimens and found hardness was twice time increase in the welded zone compared in base metal area. D.W. Zhao et al, [2] in their work electrode force effects on the mechanical properties, size of weld nugget, mode of failure microstructure and hardness of spot welded dual phase steel all are examined with help of experiment setup. Weld nugget size is accompanying with mechanical properties such as tensile shear load and failure mode and micro hardness of heat affected zone (HAZ) is higher than that of the weld nugget and the base metal. Hessamoddin Moshayedi et al, [3] in this work a two dimensional axisymmetric combination of electro-thermo-mechanical finite element method (FEM) model created to study the effect of welding time and current concentration on nugget size in resistance spot welding of AISI 304L ASS sheet with help of commercial software package ANSYS. The experimental parameters are used for improving the result in simulation and comparison study. When the welding current exceeds a critical value for nugget formation, it causes a rapid growth of nugget. Danial Kianersi et al, [4] investigate of phase transformation, mechanical properties and characterization of microstructure of AISI 316L austenitic stainless steel sheets of resistance spot welding. Metallographic studies are carried out the welded specimen with various weld current rates that will be showed relationship between the current intensity and nugget size. Microhardness investigation also done that showed that weld nugget area has lower than the area of heat affected zone and base metal with respective low and high level of current density. Tensile – shear load capacity of welded materials are also studied with different current flow rates.

R.S Florea et al, [5] analyzed the fatigue behavior of resistance spot welding (RSW) in aluminum 6061-T6 alloy. There are three conditions are nominal, low and high rates of welding parameters are used to study of

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nugget microstructure. In addition to that different fatigue failure modes are observed different load ranges. Optical microscope images are captured for three different conditions and different places such as base metal (BM), fusion zone (FZ) and heat affected zone (HAZ). Mohsen Eshraghi et al, [6] carried out their work different weld parameters effect on weld pool properties of DP600 dual phase steel using thermo mechanical coupled field finite element analysis with help of SYSWELD software package. Parameters optimization was done using ANOVA technique and found the optimized values, compared with simulation result and experimental setup. Óscar Martín et al, [7] predicting the tensile shear load bearing capacity (TSLBC) of AISI 304 austenitic stainless steel (ASS) sheet by resistance spot welding with three different weld parameters such as welding time, welding current and electrode force. Parameters was optimized with help of Artificial neural network (ANN) is offered for optimize the above mentioned parameters and obtained the non-linear curves. From their work the weld nugget and tensile shear load bearing capacity (TSLBC) also rises with increment of weld time and weld current. In addition to that excess value of weld time and weld current root expulsion of fusion metal and accordingly TSLBC going to downwards. Micro hardness is found with usage of vickers hardness testing machine at three different regions such as weld nugget, heat affected zone and base metal. Ding Min et al, [8] states that mechanical behavior properties of ferrite steel after spot weld. Tensile properties of welded specimens at various weld current and electrode forces are investigated. The studies of microstructures are welded specimens also carried out at various areas like fusion zone and base metal. Thermo graphic studies also carried out to find the temperature distribution of weld specimen during the welding. M. Vural et al, [9] did dis-similar sheets like galvanized and AISI 304 austenitic stainless steel (ASS) sheet are used for resistance spot welding. Totally three combinations of sheets such as AISI304-AISI304, galvanized sheet-AISI304 and galvanized sheet-galvanized was welded after their fatigue test also carried out even S-N curve plotted for each specimen. ShaikShafee et al, [10] statistically study the strength of the cold rolled low carbon steel (CR3) by resistance spot welding by experimentally. Parameters optimization done by analysis of variance (ANOVA) technique to find out most optimal parameter for improving the weld strength. BayramKocabekir et al, [11] carried their work in resistance spot welding of similar metal sheet of AISI316L with different cooling medium. Atmosphere air, nitrogen and 10% of borax solution are used as a cooling medium during the welding. From the three cooling medium nitrogen has tensile shear load bearing capacity (TSLBC) is higher than other two cooling mediums.

M. Alizadeh-Sh et al, [12] inspected various phase transformation and mechanical properties of AISI430 ferritic stainless steel during resistance spot welding. Mechanical properties are calculated in terms of peak load. In addition to this procedures Metallurgical characterization studied in different zones like base metal (BM), heat affected zone (HAZ) and fusion zone (FZ). Dursum O zyurek [13] effect on welding strength in presence of nitrogen during welding condition of AISI 304L austenitic stainless steel (ASS) sheet was studied. Microstructure and micro hardness of AISI304L stainless steel also studied in different weld parameters with accompany of nitrogen and atmosphere air. Getting result of micro hardness in presence of nitrogen is higher than with atmosphere air condition. NizamettinKahraman [14] commercial pure (CP) titanium sheet ASTM Grade2 was taken for investigation purpose with cooling medium of argon gas during spot welding. Usually the welding parameters current, force and time also incorporated in this processes. In microstructure examination the effect of argon gas as a cooling medium also studied. In hardness test nugget area have highest hardness rate compare to heat affected zone and base metal. Vishvesh J Badheka et al, [15] martensite steel SS420 used to study the effect of welding current and post heating temperature. Post heating is essential for SS 420 to control the hardness and ductility ratio of weld nugget. When post heat is increase that will cause nugget size also increases accordingly. Post heat and hardness have inversely proportional and it shows in graphical manner.

## II. METHODOLOGY

### 2.1 MATERIAL SELECTION

In this work AISI 202 stainless steel and AISI 1018 mild steel with 2.0 mm thickness sheet selected for experimental work and its chemical compositions and mechanical properties are tabulated in table1 and table 2.

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Table 1 Chemical composition of AISI 202 & AISI 1018

Element	Content (%) in AISI 202	Content (%) in AISI 1018
Iron, Fe	68	98.81 - 99.26 %
Chromium, Cr	17-19	-
Manganese, Mn	7.50-10	0.60 - 0.90 %
Nickel, Ni	46	-
Silicon, Si	≤ 1	-
Nitrogen, N	≤ 0.25	-
Carbon, C	≤ 0.15	0.14 - 0.20 %
Phosphorous, P	≤ 0.060	≤ 0.040 %
Sulfur, S	≤ 0.060	≤ 0.050 %

Table 2 Mechanical properties of AISI 202& AIS 1018

Property	Content @ 25 <sup>0</sup> C in AISI 202	Content @ 25 <sup>0</sup> C in AISI 1018
Poisson's Ratio	0.27 - 0.30	0.290
Elastic Modulus (GPa)	190 - 210	205
Tensile Strength (Mpa)	515	440
Yield Strength (Mpa)	275	370

### III. EXPERIMENTAL PROCEDURE

In this study, similar grades of austenitic stainless steel sheet and Mild steel (AISI 202 and AISI 1018) of 2.0 mm thickness were spot welded by KPW – 250 (SPM) spot welding machine. The dimension of sheet is 100 mm length (L), 32 mm width (w) and 2.0 mm thick (t). Sheet surfaces were chemically washed by astron before resistance spot welding to eliminate surface impurities. The tests were carried out using a current and time controlled electric resistance spot welding machine. The electrodes material was Copper alloy with end diameter 8 mm. This machine was equipped with a pneumatic pressure system. Welding, squeezing and holding cycles were manually selected. Three process parameters are. Current, Electrode Force and Weld cycles were selected as given in table 3. The parameters which kept constant are electrode material and electrode diameter. Experiments were done respect to the test conditions indicated by the Taguchi L27 Orthogonal Array (OA). The parameters used in the resistance spot welding of the sheets are tabulated.

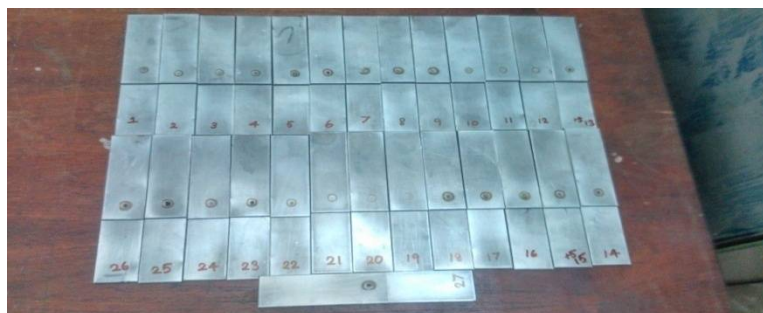


Figure 3.1. Welded Specimens

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A modification of Ohm's Law may be made when watts and heat are considered synonymous. When current is passed through a conductor the electrical resistance of the conductor to current flow will cause heat to be generated that can be conveyed as follows,

$V = IR$ , Where, R = Resistance offered by the work piece to the flow of current.

$H = IVt$

$H = I (IR) t$

$H = I^2Rt$

Where, H = Heat generated (Joules),  $I^2$  = Welding Current Squared (Amperes), R = Resistance (Ohms), t = Time of current flow (seconds)

## IV. RESULTS

According to L27 orthogonal array totally 27 trails are done in spot welding and 27 specimens are tested that results tabulated below table 3. During welding electrode material and tip diameter of electrode around 8mm kept constant throughout the process. The Tensile test values of the samples are as follows as per ASTM E384-2011

Table 3. Tensile strength test results

Trail No	Electrode Force (KN)	Weld Current (KA)	Weld Time (Cycle)	Tensile Load (KN)
1.	3	8	12	9.01
2.	3	8	14	11.36
3.	3	8	16	11.55
4.	3	10	12	14.61
5.	3	10	14	15.26
6.	3	10	16	13.72
7.	3	12	12	15.45
8.	3	12	14	15.47
9.	3	12	16	16.56
10.	3.5	8	12	8.37
11.	3.5	8	14	10.10
12.	3.5	8	16	10.77
13.	3.5	10	12	14.69
14.	3.5	10	14	14.91
15.	3.5	10	16	16.37
16.	3.5	12	12	15.30
17.	3.5	12	14	17.00
18.	3.5	12	16	17.21
19.	4	8	12	8.54
20.	4	8	14	10.15
21.	4	8	16	12.30
22.	4	10	12	14.92
23.	4	10	14	15.82
24.	4	10	16	16.91
25.	4	12	12	15.81
26.	4	12	14	17.32
27.	4	12	16	14.88

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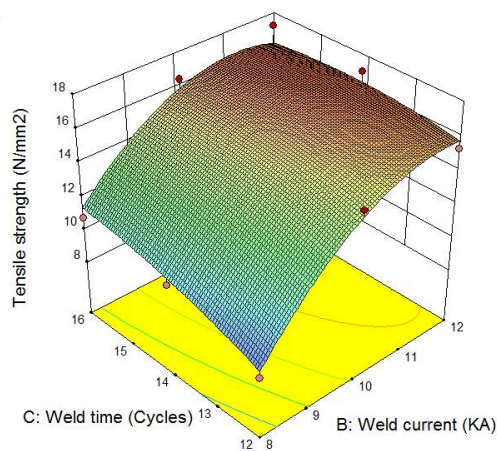
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## 4.2 RSM RESULTS

From the test results the optimized values are tabulated and shown below in table 4.3. The selected values are electrode force, weld current and weld time of 3 KN, 12 KA and 16 Cycles respectively. The both dissimilar members as Stainless steel and Alloy steel are joined by spot welding. The welded results are used to predict the optimum welded parameters through Response surface methodology.

**Table 4. Optimized Results by RSM**

Trail No	Electrode Force (KN)	Weld Current (KA)	Weld Time (Cycle)	Tensile Load (KN)	Desirability
1.	3.668	11.256	14.960	16.773	0.969
2.	3.668	11.257	14.942	16.773	0.969
3.	3.667	11.255	14.974	16.773	0.969
4.	3.667	11.249	14.996	16.773	0.969
5.	3.669	11.261	14.913	16.773	0.969
6.	3.669	11.234	14.977	16.773	0.969
7.	3.672	11.254	14.853	16.772	0.969
8.	3.674	11.215	14.864	16.771	0.969
9.	3.674	11.178	14.962	16.770	0.969
10.	3.662	11.252	15.137	16.770	0.969
11.	3.664	11.178	15.235	16.765	0.968
12.	3.657	11.244	15.302	16.760	0.968
13.	3.655	11.269	15.311	16.758	0.968
14.	3.652	11.334	15.244	16.757	0.968
15.	3.654	11.432	14.960	16.757	0.968



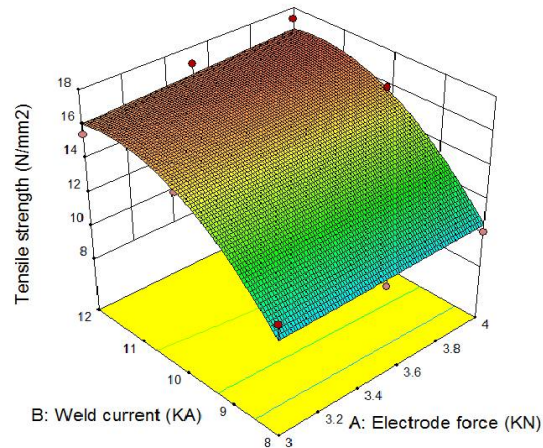
**Figure 4.1 Weld time Vs Weld current on Tensile strength**



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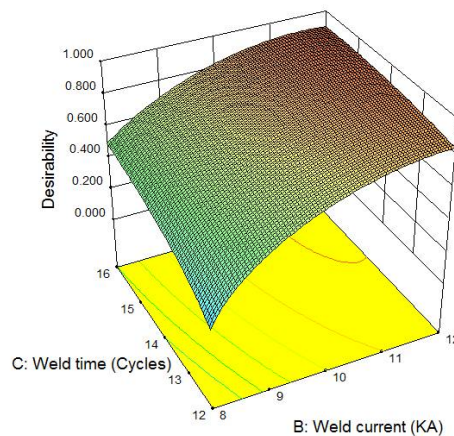
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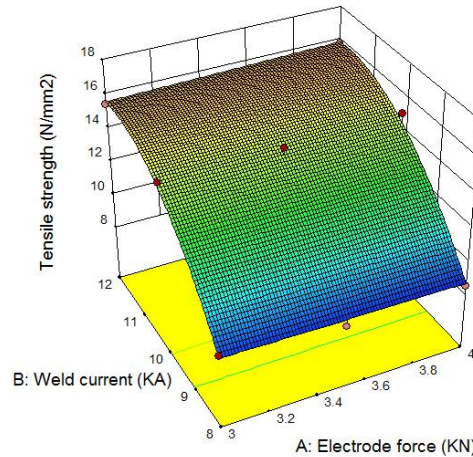


**Figure 4.2 Weld current Vs Electrode force on Tensile Strength**

The relationship between weld current and weld current are shown with respect to the tensile strength in figure 4.3 and the three dimensional plot in figure 4.1. The relationship between weld current and Electrode force are shown with respect to the Tensile strength in figure 4.2. The Three Dimensional Plot shows, the Tensile Strength about the variable parameters in Figure 4.3, and 4.4.



**Figure 4.3 Weld current Vs Weld Time on Desirability**



**Figure 4.4 Weld current Vs Electrode force on Tensile strength**

**Table 4.4 Predicted Optimized result by RSM**

Number	Electrode force (KN)	Weld current (KA)	Weld time (Cycles)	Tensile (N/mm <sup>2</sup> )	Desirability
1	3.668	11.256	14.960	16.773	0.969

The above table shows the optimized results of the tested values of tensile strength for Dissimilar welded joints and predicted the value of tensile strength (16.77 N/mm<sup>2</sup>) for optimum three weld parameters such as electrode force, weld current and weld time of 3.668 KN, 11.256 KA and 14.96 Cycles respectively.

## V. CONCLUSION

In this study the Resistance Spot Welding (RSW) process parameters were optimized for Dissimilar AISI 1018 Mild steel and AISI 202 Stainless steel sheet joints to obtain desirable mechanical properties and the results were validated using Response surface methodology optimization technique. The Experimental design designed by using Design of Experiment as Taguchi's L27.

It has been observed that welding current and welding time are has more significant effect, electrode force has less effect compare to above mentioned two parameters are response of tensile strength and hardness.

The maximum tensile strength of 16.773 KN could be obtained under the welding conditions of electrode resistant force 3.668 KN, weld current 11.256 KA and weld time 14.96 cycle. Under these welding conditions, the heat generation owing to get resistant might be optimum to cause sufficient plastic deformation between the materials in spot welding. The better welding parameter identified from the total no of twenty seven no of experimental results.

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