# Optimization of Resistance Spot Welding Process Parameter by Taguchi Method

Prof. A. A. Karad[1], Mr. V. S. Shete[2], Mr. N. V. Boraste[3]

[1] Professor, Department of ME, K. V. N. Naik Institute of Engineering, Education & Research, Nashik.

[2] B.E. Student, K. V. N. Naik Institute of Engineering, Education & Research, Nashik.

[3] B.E. Student, K. V. N. Naik Institute of Engineering, Education & Research, Nashik.

[1] avinash.karad1974@gmail.com, [2] vaibhavshete14@gmail.com, [3] borastenikhil@gmail.com

**Abstract**— Experimental investigation on resistance spot welding has been carried out using L9 Taguchi orthogonal array. Mild steel material has been considered for experimental work. The spot welding input parameters, which are considered for this work are electrode force on plate, welding time and welding current, however tensile strength of nugget has been taken as output parameter. L-9 orthogonal array Results show that Welding current has significant impact on the tensile strength of nugget. The best suitable value of input parameters were found as follows Electrode Force(KGF)536,Weldingtime(cycle)24,Welding current(KA)10.The output value maximum tensile strength is found to be 330.00( MPA).

**Keywords**— Spot Welding, Tensile Strength, Taguchi Method, S/N Ratio, ANOVA Optimization.

## INTRODUCTION

Resistance welding is a popular welding process due to its high speed and low cost combination. It also provides excellent reproducibility. Resistance spot welding (RSW) is one of the key metal joining techniques for high volume production in the automotive, biomedical and electronics industry. Large-Scale Resistance Spot Welding has become the predominant means of auto body assembly, with an average of two to six thousands spot welds. Increasing application of very thin metal sheets in manufacturing electronic components and devices, Small-Scale Resistance Spot Welding is attracting more and more researchers' attention. This work presents an approach to determine the effect of the process parameters (electrode force, weld time and welding current) on tensile strength of resistance weld joint for mild steel with the help of Taguchi method. The Taguchi method, which is effective to deal with responses, was influenced by multi-variables. This method drastically reduces the number of experiments that are required to model the response function compared with the full factorial design of experiments. The major advantage of this technique is to find out the possible interaction between the parameters. It is more resistant to general corrosion and pitting than conventional nickel chromium stainless steels such as 302-304. It has the following characteristics: Higher creep resistance, excellent formability, Rupture and tensile strength at high temperatures, Corrosion and pitting resistance.

### Identifying The Important Process Control Variables:

Some of the important process control variable which influences the tensile strength and other characteristics of the spot welding are current, welding time, holding time, squeezing time, pressure, electrode diameter. But in our study we consider only welding time, welding current and electrode force. So by general spot welding heat equation

$$H= I^2Rt$$

Where, H= heat generated, I= Current, R=resistance, t=time

In this study Cycle time, Current and the electrode force were considered as the parameters to study their effect on the tensile strength of mild steel.

## Experimentation

Preparation of the samples: - prepared the sample of dimension 100 x 25 mm for tensile strength and then join the two pieces by spot welding and set the range of parameter and calculate the tensile strength. This technique was used to prepare Mild steel. This method is most economical use in Mild steel. In this process the three different range electrode force, welding time, welding current.

The chemical composition of these steels was analyzed as listed in Table 1

Table1: Chemical Composition of Mild Steel

| C % | Mn % | P% | S % | Si% | Cu% | Ni% | Cr |
|---|---|---|---|---|---|---|---|
| 0.016 | 0.8443 | 0.02817 | 0.00586 | 0.4298 | 0.0661 | 10.07 | 17.22 |

Fig 1: Test specimens after tensile testing on UTM m/c

## Steps In Performing A Taguchi Experiment:

The process of performing a Taguchi experiment follows a number of distinct steps they are

Step1: Formulation of the problem–the success of any experiment is dependent on a full understanding of the nature of the problem.

Step2: Identification of the output performance characteristics most relevant to the problem.

Step3: Identification of control factors, noise factors and signal factors (if any). Control factors are those which can be controlled under normal production conditions. Noise factors are those which are either too difficult or too expensive to control under normal production conditions. Signal factors are those which affect the mean performance of the process.

Step4: Selection of factor levels, possible interactions and the degrees of freedom associated with each factor and the interaction effects.

Step5: Design of an appropriate Orthogonal Array (OA).

Step6: Preparation of the experiment.

Step7: Running of the experiment with appropriate data collection.

Step8: Statistical analysis and interpretation of experimental results.

Step9: Undertaking a confirmatory run of the experiment Copper alloy electrodes and the welding parameters according to the Taguchi L9 method as listed in Table 3 were used in the experiment.

Table 2: L9 Table Formulation

| Expt. | Electrode force | Welding current | Welding time |
|---|---|---|---|
| 1 | 1 | 1 | 1 |
| 2 | 1 | 2 | 2 |
| 3 | 1 | 3 | 3 |
| 4 | 2 | 1 | 2 |
| 5 | 2 | 2 | 3 |
| 6 | 2 | 3 | 1 |
| 7 | 3 | 1 | 3 |
| 8 | 3 | 2 | 1 |
| 9 | 3 | 3 | 2 |

Table 3 Process Parameters With Their Values At Three Levels

| LEVEL | 1 | 2 | 3 |
|---|---|---|---|
| ELECTRODE FORCE | 460 | 498 | 536 |
| WELDING CURRENT | 10 | 13 | 16 |
| WELDING TIME | 18 | 21 | 24 |

## **Result and Discussion**:

The signal-to-noise concept is closely related to the robustness of a product or process design. Robustness has to do with a product's ability to cope with variation and is based on the idea

Table no. 4 Tensile Strength Response According To L9 Array

| EXPT | ELECTRODE FORCE (KGF) | WELDING CURRENT (KA) | WELDING TIME (CYCLE) | TENSILE STRENGTH (MPA) |
|---|---|---|---|---|
| 1 | 460 | 10 | 18 | 298.18 |
| 2 | 460 | 13 | 21 | 269.96 |
| 3 | 460 | 16 | 24 | 269.00 |
| 4 | 498 | 10 | 21 | 281.57 |
| 5 | 498 | 13 | 24 | 307.00 |
| 6 | 498 | 16 | 18 | 278.29 |
| 7 | 536 | 10 | 24 | 330.00 |

ISSN 2091-2730

| | | | | |
|---|---|---|---|---|
| 8 | 536 | 13 | 18 | 279.93 |
| 9 | 536 | 16 | 21 | 269.78 |

| Electrode force(KGF) | Welding Current(KA) | Welding Time(cycle) | TS (MPA) | SNRA |
|---|---|---|---|---|

that quality is a function of good design. A robust design or product delivers strong "signal". It performs its expected function and can cope up with variations ("noise"), both internal and external. Since a good manufacturing process will be faithful to a product design, robustness must be designed into a product before manufacturing commences. According to Taguchi, if a product is designed to avoid failure in the field, then factory defects will be simultaneously reduced. There is no attempt to reduce variation, which is assumed to be inevitable, but there is a definite focus on reducing the effects of variation. "Noise" in processes will exist, but designing a strong “signals” into a product can minimize their effect. The dimensionless signal-to-noise ratio is used to measure controllable factors that can have such a negative effect on the performance of a design. It allows for the convenient adjustment of these factors. Provided that a process is consistent, adjustments can be conveniently made using the signal-to-noise ratio to achieve the desired target.

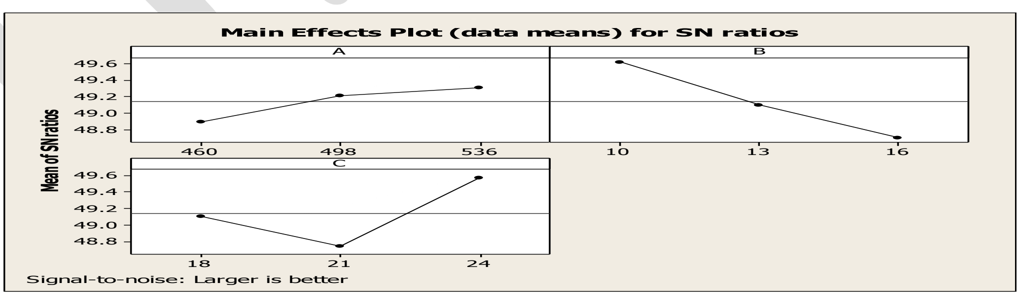
The signal to noise ratio (S/N ratio) was used to measure the sensitivity of the quality characteristic being investigated in a controlled manner. In Taguchi method, the term ‘signal' represents the desirable effect (mean) for the output characteristic and the term ‘noise' represents the undesirable effect (signal disturbance, S.D) for the output characteristic which influence the outcome due to external factors namely noise factors. The S/N ratio can be defined as:

S/N ratio, $\eta = -10 \log (MSD)$

where, MSD :mean-square deviation for the output characteristic.

Sample of dimension 100 x 25 mm were cut from a complete Mild steel sheet of 1.2 mm thickness. Then the pieces were joined by spot welding.

Graph 1: Effect of various parameters



| | | | | |
|---|---|---|---|---|
| 460 | 10 | 18 | 298.18 | 49.4896 |
| 460 | 13 | 21 | 269.96 | 48.6067 |
| 460 | 16 | 24 | 269.00 | 48.5950 |
| 498 | 10 | 21 | 281.57 | 48.9917 |
| 498 | 13 | 24 | 307.00 | 49.7428 |
| 498 | 16 | 18 | 278.29 | 48.890 |
| 536 | 10 | 24 | 330.00 | 50.3703 |
| 536 | 13 | 18 | 279.93 | 48.9410 |
| 536 | 16 | 21 | 269.78 | 48.620 |

Table 6: Response Table

| Level | Electrode force (kgf) | Welding Current(ka) | Welding Time(cycle) |
|---|---|---|---|
| 1 | 48.90 | 49.62 | 49.11 |
| 2 | 49.21 | 49.10 | 48.74 |
| 3 | 49.31 | 48.70 | 49.57 |
| Delta | 0.41 | 0.92 | 0.83 |
| Rank | 3 | 1 | 2 |

## **Analysis Of Variance**:

The main aim of ANOVA is to investigate the design parameters and to indicate which parameters are significantly affecting the output parameters. In the analysis, the sum of squares and variance are calculated. F-test value at 95% confidence level is used to decide the significant factors affecting the process and percentage contribution is calculated. Larger F – value indicates that the variation of the process parameter makes a big change on the performance. The analysis of variance (ANOVA) is applied in order to test the equality of several means, resulting in what process parameters (factors) are statistically significant.

Table 6: Results Of ANNOVA For T-S Strength

| **Source** | **DF** | **Seq SS** | **Adj SS** | **Adj MS** | **F Ratio** | **P Value** | **% C** |
|---|---|---|---|---|---|---|---|
| A | 2 | 327.6 | 327.6 | 163.8 | 0.70 | 0.588 | 9.46 |
| B | 2 | 1442.9 | 1442.9 | 721.4 | 3.09 | 0.245 | 41.69 |
| C | 2 | 1223.1 | 1223.1 | 611.6 | 2.62 | 0.277 | 35.33 |
| Error | 2 | 467.5 | 467.5 | 233.7 | | | 13.50 |
| Total | 8 | 3461.0 | | | | | 100 |

**S = 15.2881 R-Sq = 86.49% R-Sq(adj) = 45.98%**

## **Conclusion**:

Experiments have been carried out using L-9 Taguchi orthogonal array. Nine standard combinations of input parameters have been tried to get the betterment of response. It is revealed by experiments the input variable Electrode force (KGF)) 536, Welding current (KA) 10, Welding time (CYCLE) 24 however the best output value observed to be 330.00(MPA). This gives an edge to weld maker to get the optimal/near optimal input process parameters.

**REFERENCES:**

[1] Aravinthan Arumugam, MohdAmizi Nor, "Sopt Welding Parameter Optimization To Improve Weld Characteristic For Dissimilar Metals", International Joural Of Scientific & Technology Research Volume 4, 01, January 2015.

[2] Manoj Raut And Vishal Achwal, "Optimization of Spot Welding Process Parameters For Maximum Tensile strength." International Joural of Mechanical Engineering and Robotics Research Vol. 3, No. 4, October 2014.

[3] Makwana Brijesh V, Mr. Ruchir Desai, Mr. Pradhyuman Parmar, "Optimization Of Process Parameter For RSW Process Of Austenitic SS304 using Response Surface Method" International Journal For Technological Research In Engineering Volume 1, 9,April-2014.

[4] Shaikshafee, Dr. B. BaluNaik, Dr. K. Sammaiah, Dr.Mohd.Mohinoddin, "RSW Process Parameters Optimization by Taguchi Method", IOSR Joural Of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1648, p-ISSN: 2320-334X, Volume 11, 5 Ver.II (Sept.-Oct. 2014), PP 46-54.

[5] Saurabh Kumar Gupta, K.N. Pandey, "Application Of Taguchi Method For Optimization Of Friction Stir Welding Process Parameter to Joining of Al Alloy", Advanced Material Manufacuturing & Characterization Volume 3, 1(2013).

[6] Dr. D. R. Prajapati , Daman Vir Singh Cheema , "Optimization Of Weld Crack Expansion Defect Of Wheel Rim By Using Taguchi Approach: A Case Study". International Journal Of Innovative Research In Science, Engineering Technology, Vol. 2, Issue 8, August 13.

[7] Norasiah Muhammad, Yupiter HP Manurung, Mohammad Hafidzi,SunhajiKiyaiAbas, GhalibTham,M.RidzwanAbd.Rahim "A Quality Improvement Approach for Resistance Spot Welding using Multi-objective Taguchi Method and Response Surface Methodology, International Journal on Science and Engineering, Vol.02, 2012, No.3 P17-22.

[8] Hamid Eisazadeh,MohsenHamedi, AyobHalvaee"New Parametric study of nugget size in resistance spot welding process using FEM".Advanced Welding & Joining Department, Korea Institute of Industry technology, 2011, P 925 – 930.

[9] A.G Thakur, T.E Rao, M.S Mukhedkar and V.M. Nandekar, 2010 "Application Of Taguchi Method for RSW of Galvanized Steel", ARPN Joural Of Engineering and Applied Sciences Vol.5, No. 11, November 2010.

[10] K. Kishore, P.V. Gopal Krishna, K. Veladri and Ali Syed Qasim"Analysis of Defects in Gas Shielded Arc Welding of AISI 1040 Steel Using Taguchi Method". ARPN Journal of Engineering and Applied Sciences, vol. 5, no. 1, 2010, p1p. 37 - 41.

[11] A.G.Thakur, V.M.Nandedkar, Application of Taguchi Method to Determine Resistance spot welding conditions of Austenitic Stainless Steel AISI 304, Journal of Scientific& Industrial Research ,vol 69,Sept 2010, P 680-683.

[12] UgurEsme,"Application of Taguchi method for Optimization of resistance spot Welding process" The Arabian journal of science and Engineering, Volume34, Number 2B, 2009, P521-52.