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Optimization of Resistance Spot welding Parameters Using Taguchi Method

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Abstract*: Resistance spot welding (RSW) is a major sheet metal joining process in many industries, such as the automobile, domestic appliances, and spacecraft fabrication. It is one of the oldest of the electric welding processes in use by industry today. Furthermore, other metal-to-metal connections, such as wire-to-wire joints in the electronics industry, are accomplished by resistance spot welding. Application-specific measures, such as the diameter of the welding spot, define the quality of the joint. The weld is made by a combination of heat, pressure, and time parameters. As the name implies, it uses the resistance of the materials to the flow of electric current that causes a localized heating in the parts to be joined. Understanding of physical mechanisms for easily manipulating and controlling weld qualities in advance is extremely important. This paper represents the optimization of various parameters of resistance spot welding. The experimental studies have been conducted under varying pressure, welding current, pressure, and welding time parameters. In this investigation, the quality characteristic (tensile strength and nugget diameter) parameters have been considered using Taguchi Method. The experimental studies have been carried out by varying welding currents, welding pressure and weld times for joining two sheets. The results of the investigation indicate the welding current to be the most significant parameter controlling the weld tensile strength as well as the nugget diameter. The contribution of welding current, holding time and pressure to tensile strength are 61%, 29%, 4% respectively and the contribution of these parameters to nugget diameter are 81%, 1.7%, 17% respectively. Relationship graphs have been plotted between tensile strength and nugget diameter with parametric variations according to the orthogonal array.

Keywords: RSW, Orthogonal Array, Taguchi, ANOVA, Nugget Diameter.

I. INTRODUCTION

RESISTANCE SPOT WELDING (RSW) is a process in which flying surfaces are joined at one or more spots due to the heat generated by the resistance to the flow of electric current through the workpieces that are held together under force by electrodes. The contacting surfaces in the region of current concentration are heated by a short-time pulse of low voltage, high-amperage current to form a fused nugget of weld metal. Even after the flow of current cases, the electrode force is maintained while the weld metal rapidly cools and solidifies. [1]

The electrodes are retracted after each weld, which usually is completed in a fraction of a second. Spot welding is the most widely used joining technique for the assembly of sheet metal products such as automotive assemblies, domestic appliances, home furniture's, building products, and enclosures and, to a limited extent, aircraft components. Many assemblies of two or more sheet metal stampings that do not require gas-tight or liquid-tight joints can be more economically joined by high-speed RSW than by mechanical methods. Containers frequently are spot welded. [2, 3]

The attachment of braces, brackets, pads, or clips to formed sheet metal parts such as cases, covers, bases, or trays is another common application of RSW. Major advantages of spot welding include high operating speeds and suitability for automation or robotization and inclusion in high-production assembly lines together with other fabricating operations. With automatic control of the current setting, timing, and electrode force, sound spot welds can be produced consistently at high production rates and low unit labour costs using semi-skilled operators. Most metals can be resistance spot welded if the appropriate equipment is used coupled with suitable welding conditions. This is particularly true for thin sheet or strip steel products, whether uncoated or coated. [5, 6]

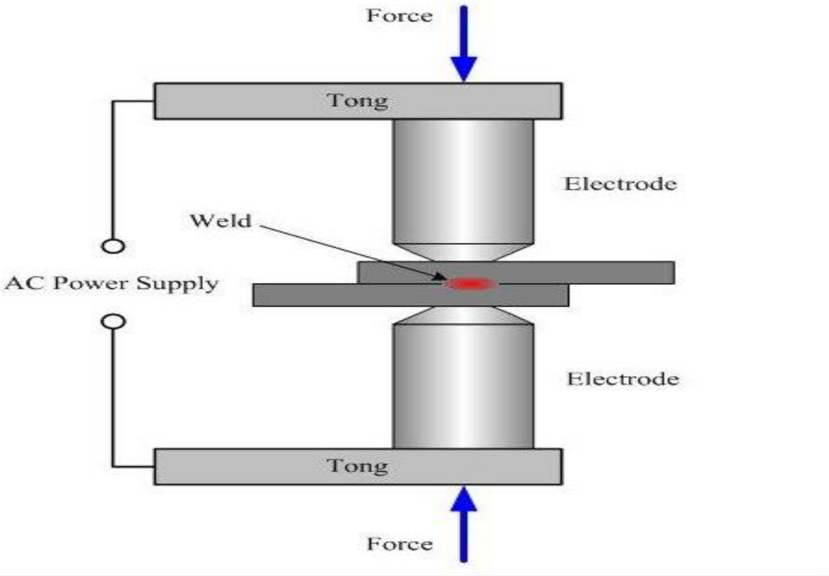


Fig.1 figure showing resistance spot welding

II. METHODOLOGY

A. SELECTION OF METAL

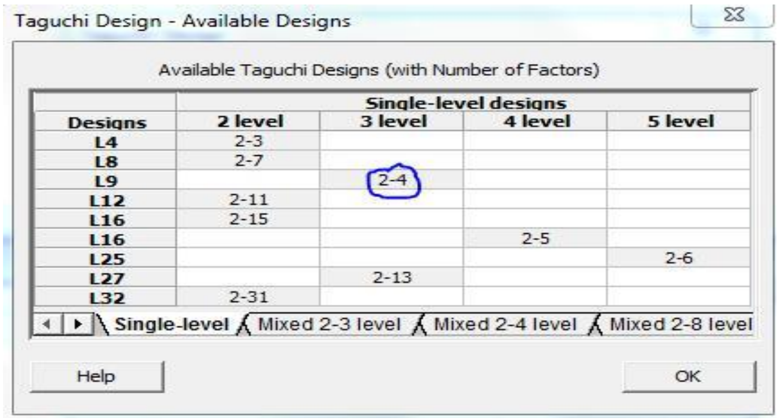
Firstly select the metal to be weld according to desire weldability which must rely on basic properties of the material, such as strength, corrosion or erosion resistance, ductility, and toughness. The properties of the various metallurgical structures associated with the thermal cycles encountered in the welding operation must also be included in the design process. [8, 9]

MATERIAL DETAIL:

Material used is low carbon cold rolled 0.9 mm mild steel sheets (AISI 1008/ASTM A366) with the following composition carbon 0.08%; manganese 0.6%;phosphorus 0.35%; copper 0.2% ;sulphur 0.04% remaining iron

B. SELECTION OF ORTHOGONAL ARRAY

Depending on a number of levels in a factor, a 2 or a 3 level OA can be selected. If some factors are two-level and some three-level, then whichever is predominant should indicate which kind of OA is selected. Once the decision is made about the right OA, then the number of trials for that array must provide an adequate total dof, When required dof fall between the two dof provided by two OAs, the next larger OA must be chosen. [10, 11]



Designs	Single-level designs 2 level	3 level	4 level	5 level
L4	2-3			
L8	2-7			
L9		2-4		
L12	2-11			
L16	2-15			
L16			2-5	
L25				2-6
L27		2-13		
L32	2-31			

Fig 2 Figure of orthogonal array selection

C. FIRST EXPERIMENT (for Tensile Strength)

The following figures show the method for achieving tensile strength.

Fig3 Picture of spot welding machine used for experiment

Fig4. Picture of welded specimen

D. *Analysis of S/N ratio based on Taguchi Method*

Table 1 Process parameters with their values at three **levels**

LEVELS	**CURRENT(KA)**	**ELECTRODE FORCE(KN)**	**TIME (SEC)**
1	**6**	**0.662**	**2**
2	**6.8**	**0.789**	**4**
3	**7.5**	**0.968**	**5**

Table 2 Experimental data for tensile shear (T-S) strength and S/N ratio

CURRENT	***ELRCTRODE FORCE***	***TIME***	***T-S(KN)***	***S/N RATIO***
1	***1***	***1***	***2.82***	***9.0050***
1	***2***	***2***	***3.10***	***9.8272***
1	***3***	***3***	***3.54***	***10.9801***
2	***1***	***2***	***4.23***	***12.5268***
2	***2***	***3***	***4.55***	***13.1602***
2	***3***	***1***	***3.54***	***10.9801***
3	***1***	***3***	***4.33***	***12.7298***
3	***2***	***1***	***3.94***	***11.9099***
3	***3***	***2***	***3.58***	***11.0777***

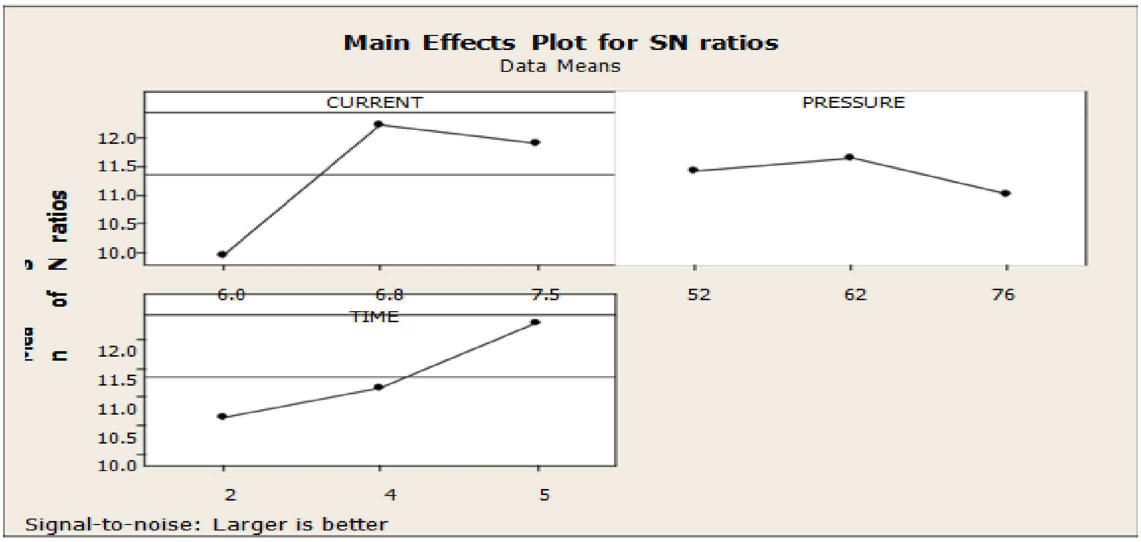


Fig 5 Main effects plot for S/N ratio (tensile strength)

Table 3 Response table for S/N ratio for T-S strength

LEVEL	***CURRENT***	***PRESSURE***	***WELD TIME***
1	***9.937***	***11.421***	***10.632***
2	***12.222***	***11.632***	***11.144***
3	***11.906***	***11.013***	***12.290***
DELTA	***2.285***	***0.620***	***1.658***
RANK	***1***	***3***	***2***

E. ANALYSIS OF VARIANCE (ANOVA)

ANOVA is a statistically based, objective decision-making tool for detecting any differences in the average performance of groups of items tested. ANOVA helps informally testing the significance of all main factors and their interactions by comparing the mean square against an estimate of the experimental errors at specific confidence levels.

Table-4 ANOVA for SN ratios (tensile strength)

CF	**DOF**	**SS**	**MS**	**F RATIO**	**P**	**%C**
CURRENT	2	9.1956	4.5978	9.92	0.092	61.11
PRESSURE	2	0.5956	0.2978	0.64	0.609	3.96
TIME	2	4.3261	2.1631	4.67	0.177	28.76
ERROR	2	0.9273	0.4637			
TOTAL	8	15.0446				

R-Sq = 95.3% R-Sq(adj) = 81.1%;Significant at 95% confidence

F. SECOND EXPERIMENT (for Nugget Diameter)

The results have been recorded as shown in (Tab.1) and analysis the nugget diameter of the welded specimen. The following figures show the method for achieving nugget diameter length.

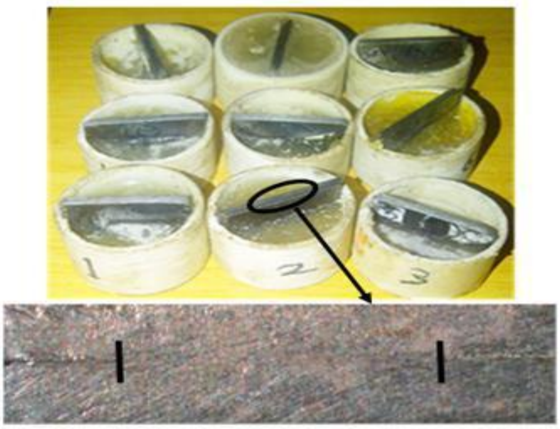


Fig 6 Picture of nugget diameter

Table 5 Experimental data for nugget diameter strength and S/N ratio

CURRENT	PRESSURE	TIME	NUGGET DIA(mm)	S/N RATIO
1	1	1	6800	76.6502
1	2	2	7200	77.0252
1	3	3	7210	77.2783
2	1	2	7500	77.5012
2	2	3	7700	77.7298
2	3	1	7800	77.9525
3	1	3	7900	78.0618
3	2	1	8200	78.1697
3	3	2	8620	78.8103

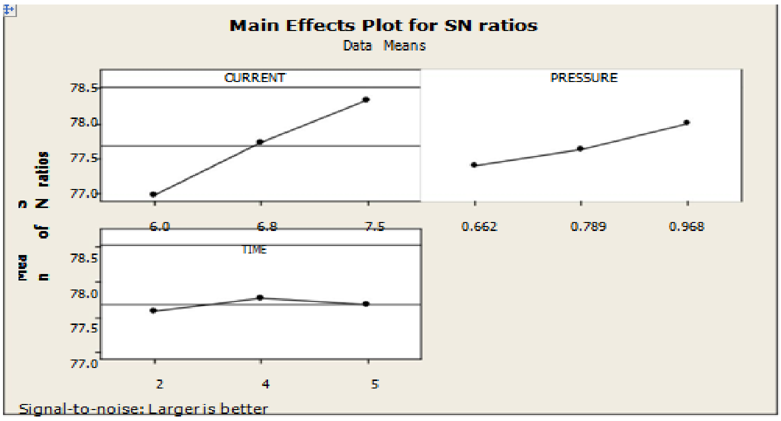


Fig 7 Main effects plot for S/N ratio.(nugget diameter)

Table 6 Response table for S/N ratio for nugget diameter

LEVEL	CURRENT	PRESSURE	WELD TIME
1	76.98	77.40	77.59
2	77.73	77.64	77.78
3	78.35	77.01	77.69
DELTA	1.36	0.61	0.19
RANK	1	2	3

Table7 Analysis of Variance for SN ratios (nugget diameter)

CF	DOF	SS	MS	F RATIO	P	%C
CURRENT	2	2173622	1153144	128.22	0.008	80.82
PRESSURE	2	453089	147878	26.72	0.097	16.85
TIME	2	45622	19144	2.69	0.452	1.70
ERROR	2	16956	8478			
TOTAL	8	2689289				

R-Sq = 95.3% R-Sq(adj) = 81.1%;Significant at 95% confidence

III. RESULTS AND DISCUSSION

The following conclusions could be drawn from the above investigation:

1. The response of S/N ratio with respect to tensile strength indicates the welding current to be the most significant parameter that controls the weld tensile strength where's the holding time and pressure are comparatively less significant in this regard.

2. The contribution of welding current holding time and pressure towards tensile strength is 61%, 28.7%and 4% respectively as determined by the ANOVA method for tensile strength

3. Optimum results have been obtaining by Taguchi method using a medium current of 6.8 KA, the medium pressure of 0.79KPa and high holding time of 5 seconds.

4. The response of S/N ratio with respect to nugget diameter also indicates the welding current to be the most significant parameter that controls the nugget diameter where's the pressure and welding time are comparatively less significant in this regard.

5. The contribution of welding current holding time and pressure towards nugget diameter is 80.82, 1.70 and 16.85 respectively as determined by the ANOVA method

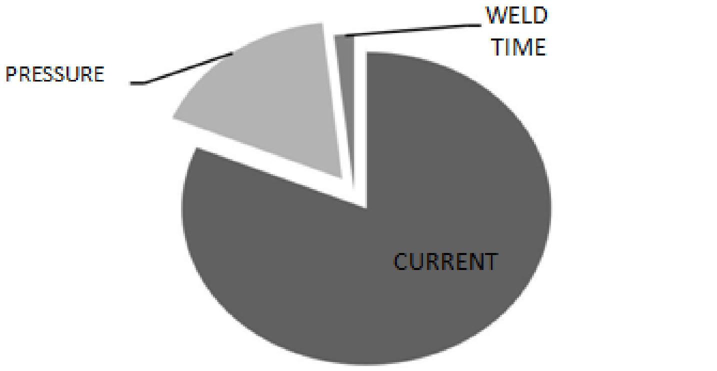


Fig 8 Contribution Pi Diagram (for nugget diameter)

6. It follows the **80-20 rule** of Pareto principle. The current contributes 80% the formation of nugget diameter although it is one of the important contributing factors.

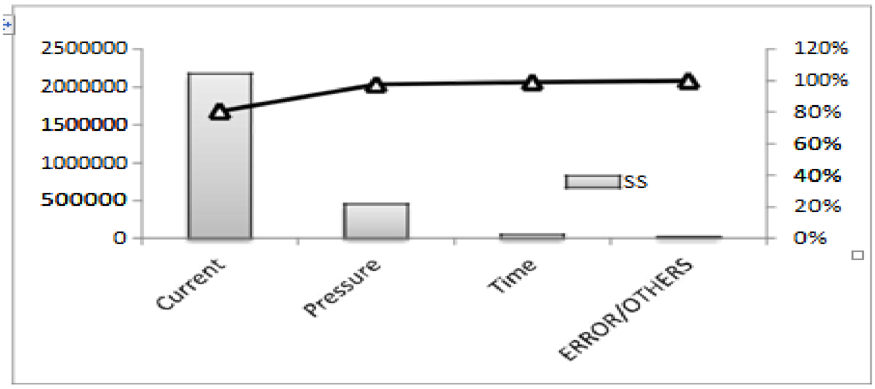


Fig 9 Pareto chart of contributing factors

7. Relationship graph could be plotted between the tensile strength and nugget diameter with parametric variations according to orthogonal array(fig)

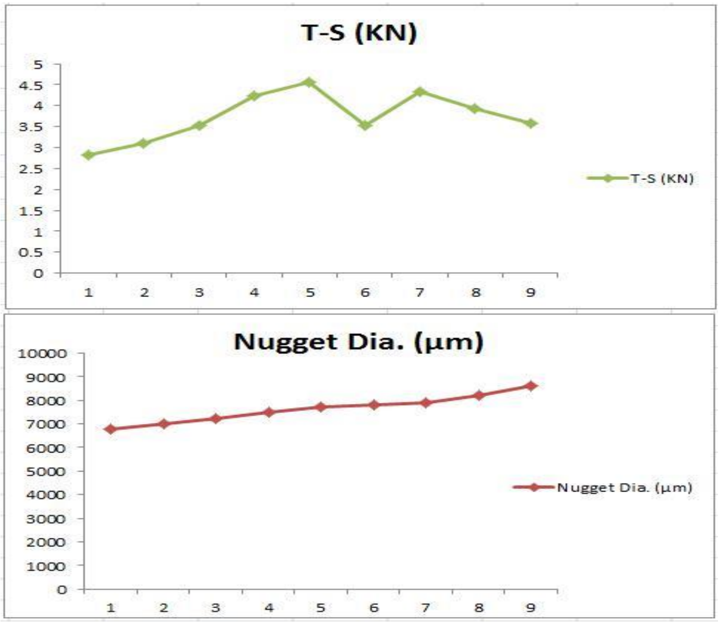


Fig 10 Comparison graph between tensile strength and nugget diameter

CONCLUSION

A. LIMITATIONS & SCOPE FOR FUTURE WORK

The following limitations and problems have been experienced during the course of the present investigation:

1. There is high variation in current in the welding duration hence it‘s very difficult to measure current.
2. The steel sheet is very thin (0.9mm) hence while measuring the tensile strength holding grip problem occurs in UTM machine.
3. If the nugget did not cut exactly from the center the error occurs due to variation.
4. Due to the air cold electrodes. The duty cycle of the welding machine is high which consume a large amount of time.
5. The above study is applicable only for that particular material (AISI-1008 steel sheets) there will be significant variation in parameters for other materials
6. Both the experiments have been analysed by ANOVA with 95 % level of confidence, and an error of ±5%.

There is a scope for further work in the following directions

1. Heat affected zone could further be investigated for spot welds in regard to its microstructure.
2. Effect of variation in the electrode diameter on the characteristics of spot welds could be studied.
3. Effect of variation in the thickness of sheets and strength of spot welds obtained could be compared
4. We can also study the effect on water cooled and air cooled electrodes in resistance spot welding.
5. AC current and DC current welding could also be compared to their advantages and limitation.

REFERENCES

[1] AWS/SAE D8.9M, Recommended Practices for Test Methods for Evaluating the ResistanceSpot Welding Behaviour of Automotive Sheet Steel Materials, The American Welding Society, Miami, FL., 2002.
[2] A field guide to experimental design‖ Washington State University, Tree Fruit.Research and Extension Centerhttp://www.tfrec.wsu.edu/anova/basic.htmlp
[3] Aslanlar S, Ogur A, Ozsarac U, Ilhan E. Welding time effect on mechanical properties of automotive sheets in electrical resistance spot welding. J MaterDes 2008; 29:1427–31.
[4] ASM Metals HandBook Volume 06 - Welding, Brazing, and Soldering
[5] AWS D8.7: Recommended Practices for Automotive Weld Quality—Resistance Spot Welding, American Welding Society, Miami, FL, 2004.
[6] Barkey, M. E., and Kang, H., 1999, __Testing of Spot Welded Coupons in Combined Tension and Shear,‘‘ Exp. Tech., 23~5!, pp. 20–22.
[7] C.F. Larson, Bibliography on resistance welding 1950–1971, Welding Journal 51 (1972).
[8] Copeland, Lee. "Object-Oriented Testing." Software Quality Engineering. STAR East 2001. The Rosen Centre Hotel, Orlando, Florida. 14 May 2001
[9] D.C. Montgometry, Design and analysis of experiments, 4th edition, New York: Wiley; 1997.
[10] Dickinson D.W., Franklin J.E., and Stanya A., Characterization of spot welding behaviour by dynamic electrical parameter monitoring, Welding Journal, 59, 170-s, 1980.
[11] Dilthey U. and Hicken S., Metallographic investigations into wear processes on electrodes during the resistance spot welding of aluminum, Welding and Cutting, Vol. 50, No. 1, 34, 1998.

[12] Easterling K.E., *Introduction to the physical metallurgy of welding*, 2nd Ed., Butterworth Ewing, K. W., Cheresh, M., Thompson, R., and Kukuchek, P., 1982, ‗Static and Impact Strengths of Spot-Welded HSLA and Low Carbon Steel Joints,''SAE Paper 820281.

[13] Gedeon S.A., Sorensen C.D., Ulrich K.T., and Eagar T.W., Measurement of dynamic electrical and mechanical properties of resistance spot welds, Welding Journal, 66, 378-s, 1987.

[14] Granjon H., *Fundamentals of welding metallurgy,* Woodhead Publishing, Abington (GB), 1991.

[15] Handbook for resistance spot welding, Miller Electric Mfg. Co. Appleton, 2010

[16] Heinemann, Cambridge (GB), 1992.

[17]J.f. Young and R.S. Shane, Ed., Materials, And Processes, Part B: Processes, 3rd Ed., Marceldekker, 1985, p 11257-1126

[18] J.g. Bralla, ed., Handbook Of Product Design For Manufacturing, McGraw-Hill, 1986, p 7-35

[19] K. S. Yeung, and P.H. Thornton, ―Transient Thermal Analysis of Spot Welding Electrodes‖, Welding Research, January, (1999), pp. 1–6.