ANALYSIS AND OPTIMISATION OF PROCESS PARAMETERS IN RESISTANCE SPOT WELDING PROCESS OF LOW CARBON STEEL

[1]Prof.B.S.Gawai, [2] Prof.D.W. Ghatole, [3] Prof.R.R. Gadge , [4] Prof. C.R. Bundule
[1]Assisstant Professor, [2]Assisstant Professor, [3]Assisstant Professor , [4] Assisstant Professor
[1]Mechanical Department,
[1] Sanmati College of Engineering,Washim , India

Abstract : In the present investigation, Low carbon steel sheets are welded by resistance spot welding. The Electrode force,welding current and welding time are the principal variables that are controlled in order to provide the necessary combination of heat and pressure to form the weld. The effect of various parameters on weld strength of Hot Rolled E-34 material is determined by using Minitab 16 software and using design of experiment. Taguchi Method is chosen to design the experiments. The highly significant factor was determined by analysis of variance. In the analysis, it was observed that predicted and experimental results were in good agreement .The aim of the research is to find out improvement in welds strength and also reduces various welding defects

***Index Terms* – Tensile strength, Taguchi method, Low carbon steel.**

I. INTRODUCTION

Resistance welding is group of welding processes which produce coalescence of metals with the heat obtained from resistance offered by the workpiece to the flow of electrical current through the parts being joined. In this process, heavy electric current is passed through the metals to be joined. This causes local heating to increase temperature to plastic state over limited area of contact. Mechanical pressure is applied to join them completely. No additional filler metal is required. The current is passed through the electrodes which incorporate very low resistance in the circuit and the resistance at the joints of metals is very high. Spot welding plays an important role in manufacturing and it is the simplest and most widely used form of resistance spot welding.Spot welding is a resistance welding method used to join two to four overlapping metal sheets which are up to 3 mm thick each. In some applications with only two overlapping metal sheets, the sheet thickness can be up to 6 mm. Two copper electrodes are simultaneously used to clamp the metal sheets together and to pass current through the sheets.

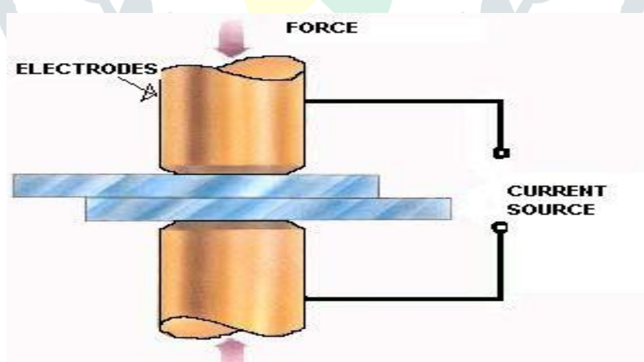


Fig. 1 Resistance spot welding

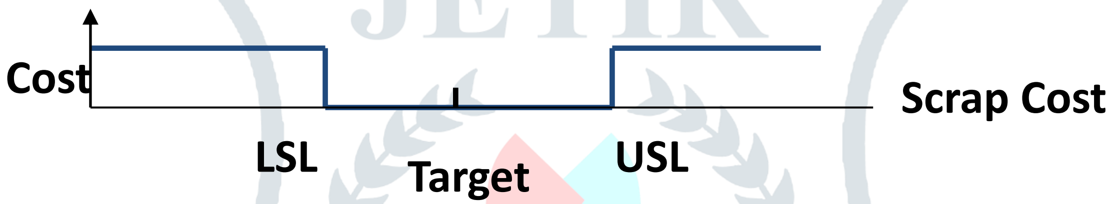
II. LITERATURE REVIEW

The review present in this section is related to mathematical modelling and optimization of process parameters of resistance spot welding machine. The present literature review investigates various techniques and methods for improvement in parameters like tensile

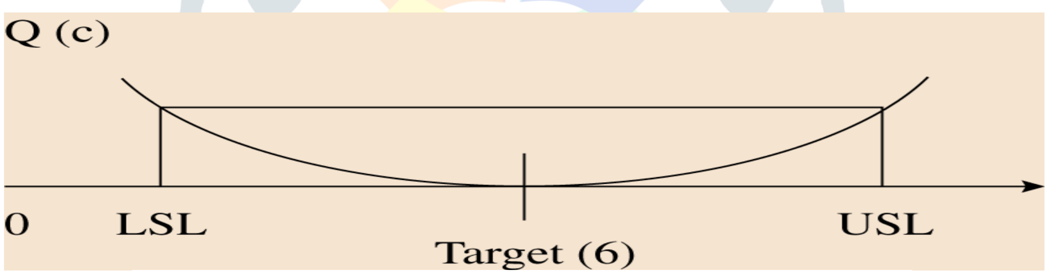
Strength and nugget diameter. The survey is given as:
Ugur Esme has studied optimization of RSW process parameters for SAE 1010 steel using Taguchi method. He investigated that increasing welding current and electrode force are prime factors controlling the weld strength. He concluded that Taguchi method can be effectively used for optimization of spot welding parameters. A. G. Thakur, T. E. Rao, M. S. Mukhedkar and V. M. Nandedkar has studied optimization of RSW process parameters for Galvanized steel using Taguchi method. They investigated that increasing welding current and welding time are prime factors controlling the weld strength. The results showed that welding current was about two times more important than the second factor welding time for controlling tensile shear strength. M. Zhou et al. have done a computer simulation by using Design of Experiments (DOE) concept and quantitative relationships were established to link a weld's geometric and mechanical attributes to its strength under tensile-shear loading. A.G. Thakur and V. M. Nandedkar presented a systematic approach to determine effects of process parameters on tensile shear strength of resistance weld joint of austenitic stainless steel AISI 304 using Taguchi method. Resit Unal and Edwin B Dean presented an overview of the Taguchi methods for improving quality and reducing cost, describe the current state of applications and its role in identifying cost sensitive design parameters. Min Jou presented the phenomena of how the changes in controllable parameter of % heat input affects a measurable output signal indicative of strength and weld quality for various steel sheets used in automotive industry.

III. METHODOLOGY

Introduced by Dr. Genichi Taguchi (1980).Taguchi method is one of the most important statistical tools for TQM.It involves reducing the variation through robust design of Experiments. The overall objective of Taguchi method is to produce high quality product at low cost to the manufacturer unique aspects of the Taguchi method.The Taguchi definition of quality. The traditional definition is conformance to specifications. The traditional model for quality losses and No losses within the specification limits.



The Taguchi loss function, the quality loss is zero only if we are on target.



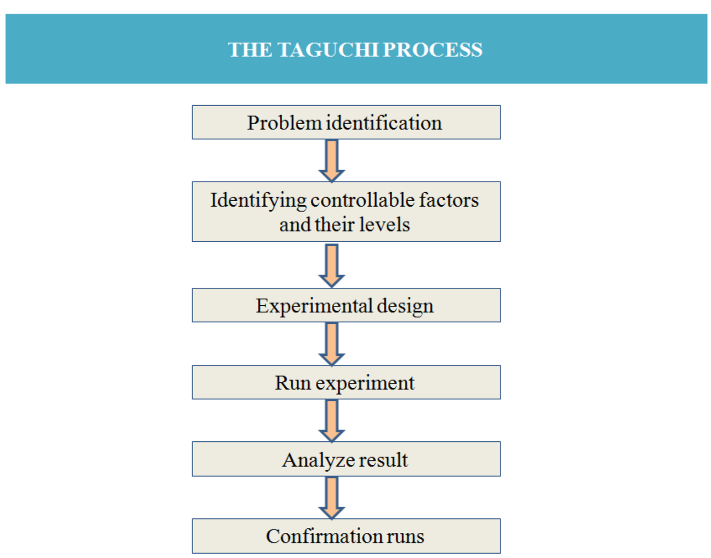


Fig.2 Flow chart of Process

IV. EXPERIMENTATION

Experimentation is the important step in the total analysis. Total 9 runs of experiments based on Orthogonal array were done. Electrode force, Current and weld time are varied as per values for each level mentioned in Table-1. Three responses are taken for each setting. The mean of the three responses was considered. The experimental data is given in Table 1.

Experiment	Electrode force (kN)	Welding current (kA)	Weld time (cycles)
1	1.37	8.3	15
2	1.37	9.6	17
3	1.37	10.5	19
4	1.76	8.3	17
5	1.76	9.6	19
6	1.76	10.5	15
7	2.15	8.3	19
8	2.15	9.6	15
9	2.15	10.5	17

Table 1: L9 orthogonal array

Details of experimental procedure

1. Preparing rectangular low carbon steel plates of size 252 mm X 30 mm X 1mm in shaping machine for performing the spot welding operation.
2. Cleaning the work pieces for any oil or dust
3. Checking and preparing the spot gun ready for performing the spot welding operation
4. Carrying out spot welding operation as per orthogonal array combination for each experiment
5. Checking and preparing the tensile testing machine ready for performing the tensile testing operation.
6. Placing the specimens in the jaws correctly
7. Applying the load.
8. Measuring the tensile shear strength of each specimen.

Fig.3.Universal Testing Machine

Fig.4Photograph before test

Fig.5 Photograph after test

V. RESULTS AND DISCUSSIONS

The confirmation experiment is the final step in the design of the experiment process. The purpose of the confirmation experiment is to validate the conclusions drawn during the analysis phase. The confirmation experiment is performed by conducting a test with a specific combination of the factors and levels previously evaluated. In this study, after determining the optimum conditions and predicting the response under these conditions, a new experiment was designed and conducted with the optimum levels of the welding parameters.

SL NO	Electrode force kN	Welding current kA	Weld time Cycles	T.S strength Mpa (mean)	S/N ratio for T-S strength dB
	A	B	C		
1	1.37	8.3	15	91.73	39.25
2	1.37	9.6	17	112.00	40.98
3	1.37	10.5	19	122.14	41.73
4	1.76	8.3	17	109.40	40.78
5	1.76	9.6	19	106.80	40.57
6	1.76	10.5	15	140.07	42.92
7	2.15	8.3	19	150.20	43.53
8	2.15	9.6	15	104.21	40.36
9	2.15	10.5	17	191.00	45.62

Table 2: S/N Ratios for the Tensile Shear Strength Measurements

The final step is to verify the improvement of the performance characteristic. The predicted tensile strength using the optimal levels of welding parameters can be calculated as

Yopt = T/N + (Electrode force (opt) – T/N) + (Welding current(opt) – T/N) + (Welding time(opt) -T/N)

Yopt =186.8 Mpa

Where Yopt is the predicted optimum performance, T is the number of observed values of all the experiments, Nis the number of observed values.Based on the Signal to Noise ratio, the optimum level for each parameter is that with the highest S/N ratio, the optimum level for electrode force was found to be level 3, the optimum level for welding current was found to be level 3 and for welding time the Optimum level was found to be level 2 and is marked with *.

	S/N Ratio		
Level	Electrode force	Welding current	Welding time
1	40.65	41.18	40.84
2	41.42	40.63	42.46*
3	43.17*	43.42*	41.94

ANALYSIS OF VARIANCE (ANOVA)

A better feel for the relative effect of the different welding parameters on the tensile shear strength (TS) was obtained by decomposition of variance, which is called analysis of variance (ANOVA). The total variance in the result, is credited among the parameters with the help of statistical methods which also helps in calculating the percentage significance of each factor. Obviously a factor scoring more percentage should be taken care of on priority basis (sometimes some unavoidable constraints of time, money, etc) do not permit optimization of each and every parameters and some of the parameters should be left as they are.

Control Factor	Degree of freedom	Factor sum of squares	Pure sum of squares	Contribution %
Electrode force	2	2608.9	1863.72	24.81
Welding current	2	3151.0	2405.82	32.04
Welding time	2	1003.24	258.06	3.43
Error	2	745.00	2980.72	39.69
Total	8	7508.32		

Table-3 ANOVA and % contribution (%C) for T-S strength

VI. CONCLUSION

This project has presented an analysis on the optimization and the effect of welding parameters on the tensile shear strength of spot welded low carbon steel sheets.

- The least number of experiments required to obtain maximum important information was determined by using the orthogonal array.
- An optimum parameter combination for the maximum tensile shear strength was obtained by using the analysis of signal-to-noise (S/N) ratio. The confirmation tests indicated that it is possible to increase tensile shear strength significantly by using the proposed statistical technique. The experimental tests conducted showed that the tensile shear strength was increased significantly.
- The level of importance of the welding parameters on the tensile shear strength is determined by using ANOVA. Based on the ANOVA method, the highly effective parameters on tensile shear strength were found as welding current and electrode force, whereas welding time was less effective factor.

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