International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169
Volume: 3 Issue: 12 6656 - 6659

Process Parameters Optimization of Resistance Spot Welding of Galvanized Steel Using Taguchi Method

B. D. Parmar
Mechanical Engineering Department
Government Polytechnic
Junagadh, Gujarat, India
e-mail:bdpar@yahoo.com

N. G. Parmar
Mechanical Engineering Department
Government Polytechnic
Kheda, Gujarat, India
e-mail:ng_parmar@yahoo.co.in

***Abstract*—** Spot welding is a resistance welding process for joining metal sheets by directly applying opposite forces with pointed tips. The current and the heat generation are localized by the form of electrode. The amount of heat produced is a function of current, time and resistance between the work pieces. The present work attempts experimental investigations to study influence of important process parameters of resistance spot welding on weld strength, current and cycle time are varied at three different levels for different thickness and manufactured specimens are tested for weld strength.. Experiment have been conducted as per Taguchi method and fixed the levels for the parameters Analysis of variance (ANOVA) and F-test has been used for determining most significant parameters affecting the spot weld parameters.

Keywords- *Spot welding, Weld strength, Cycle time,ANNOVA, DOE*

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I. INTRODUCTION

Resistance spot welding is a process that is being widely used in the industry for sheet metal fabrication purposes, as the name applies spot welding is a resistance welding process for joining metal sheets by directly applying opposing forces with electrodes with potential tips, the current and the heat generation are localized by electrodes. Resistance spot welding is a process in which faying surfaces are joined in one or more spots by resistance to the flow of electric current through work pieces 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. When the flow of current ceases, the electrode force is maintained while the weld metal rapidly cools and solidifies. The electrodes are retracted after each weld, which usually is completed in a fraction of a second.[1]

Figure 1 shows working principle of the resistance spot welding with the two electrodes. The process is used extensively for joining low and mild carbon steel sheet metal components for automobiles, cabinets, furniture and similar products. Stainless steel, aluminum and copper alloys are also spot welded commercially. Excessive heating in resistance welding results in metal expulsion during the welding operation. Since accurate method for selection of welding variables i.e. welding current, welding time and electrode force, thickness of sheet, electrode type, electrode tip diameter, gap in the electrodes, shape of electrode tip, electrode material etc. are lacking

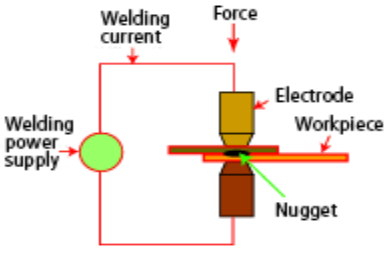

Figure1. Working principle of resistance spot welding

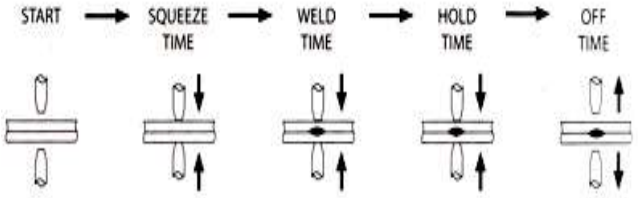

Figure 2 Welding cycle

. Generally, a weld cycle can be divided into a number of stages in figure 2:

- Pre-squeeze stage
- Squeeze stage
- Weld stage
- Hold stage
- Release stage

In the Pre-squeeze stage, the moving electrode closes towards the work pieces, resulting in contact between the electrodes and work pieces. The velocity of the electrodes at this point of impact is very important considering that too high impact energy will results in excessive electrode wear.In the squeeze stage, the electrodes are forced on the work piece surfaces by means of the force actuating system and this offers the possibility to deform the work piece to ensure sound contact between them. In the weld stage, while force remains on the work pieces, current will be flowing through the electrodes and the work piece, heating up every part in the secondary weld circuit proportional to the effective resistance present at each point. In the hold stage, the current is cut off and produced weld is allowed to solidify and cool down under maintain pressurizing force. After sufficient holding time, the electrodes release the work piece and the cycle is complete. The major advantages of the resistance welding processes over any other welding process is the feature that heat necessary for weld formation is generated at the exact location where the joints needs to appear. The possibility to highly reduce the time to complete a weld resulting in cycle times being competitive over other welding process. The another

advantage is the absence of a molten weld pool penetrating from one side through a work piece, resulting in less aesthetical damage to the work piece surfaces.

II. EXPERIMENTAL PLAN

In Resistance spot welding machine, the magnitude of current and the welding time are two important process parameters which affect the strength of welds.[2]. The change of current will be made through the change of percentage of preset maximum current and length of time through number of cycles. Other process parameters in welding schedule, such as electrode force, hold time and off time, etc are kept constant during the test. [3,4]. A design of experiment (DOE) is used to study the effect of process parameters on responses.[5]

Table 1, Process parameters to be controlled

Factors	Unit	Levels		
		1	2	3
Current(I)	KAmp	1	2	3
Cycle Time(T)	Second	2	4	6

Twenty seven Specimen of Galvanized steel sheet having chemical composition of (w_t %) 0.065 C, 0.095 Si, 0.017 Cr 0.032 Ni, 0.053 Cu, 0.404 M_n, 0.017 S, 0.018 P, (balance) Fe was used for manufacturing on resistance spot welding Machine at manufacturing laboratory, Government Polytechnic, Junagadh with different combinations of current(1000amp to 3000amp) and welding time(2 to 6 Seconds) and for different thickness (0.35mm to 1.5mm)

Figure 3. Manufactured test specimen (sample)

Figure 4 .Resistance spot welding Machine

Weld strength is tested on Universal Testing Machine (Enkay) at applied mechanics department,Government Polytechnic, Junagadh.

Figure 5 weld strength Test set-up

ISSN: 2321-8169
6656 - 6659

Table 2 Weld strength test results

Sr. No	Factors symbol		Weld strength (N/mm2)		
	I	T	t=0.35mm	t=1.0mm	t=1.5mm
1	1	2	170	156	148
2	1	4	228	224	218
3	1	6	310	294	200
4	2	2	215	207	215
5	2	4	270	255	221
6	2	6	305	300	248
7	3	2	220	228	257
8	3	4	290	305	265
9	3	6	335	342	278

III. METHODOLOGY

A. *Taguchi Method*

The Taguchi design method is a simple and robust technique for optimizing the process parameters. In this method, main parameters which are assumed to have influence on process results are located at different rows in a designed orthogonal array (OA). With such an arrangement, completely randomized experiments can be conducted [6]. An advantage of the Taguchi method is that it emphasizes a mean performance characteristic value close to the target value rather than a value within certain specification limits, thus improving the, product quality. It can be used to quickly narrow the scope of a research project or to identify problems in a manufacturing process from data already in existence [7]. In this method, main process parameters or control factors which influence process results are taken as input parameters and the experiment is performed as per specifically designed OA. The selection of appropriate OA is based on total degree of freedom (dof) which is computed as [8]:

dof = {(number of levels – 1) for each factor}
+{(number of levels – 1) x(number of levels – 1) for each inter action + 1}. (1)

B. *S/N Ratio*

It is used to determine the influence and variation caused by each factor and interaction relative to the total variation observed in the result. S/N ratio uses a single measure, mean square deviation (MSD), which incorporates the effect of changes in mean as well as the variation (standard deviation)[5].Results behave linearly when expressed in terms of S/N ratios. Aim of experimental plan is to increase weld strength. Hence, higher is the better quality characteristic is considered. S/N ratio (η) is determined [9]

$\eta = -10\log10\ (MSD)$ (2)

$MSD = \sum[(Yavg - Yo)^2/n\ ]$ (3)

Where, Yavg is average value of n data points and Yo is target value (Zero in our case)

IV. RESULT ANALYSIS

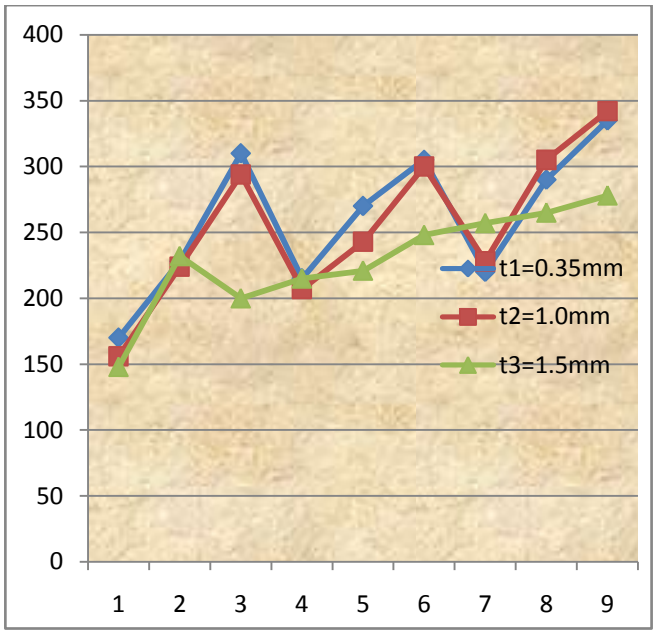

Figure 6 Weld strength Vs Experiment no

From the experimental results, it can be observed that for 1mm thickness, the maximum weld strength 342 N/mm^{2,}was obtained at current value 3 Kamp and cycle time 6 seconds,

But at the same value of current and cycle time weld strength was obtained 278 N/mm^2 for 1.5 mm thickness, which means there is decrease in weld strength as thickness increases for same value of processing Parameters. Minimum experimental weld strength 148 N/mm^{2,} was obtained at current value 1 Kamp and cycle time 2 seconds for 1.5 mm thickness sheet.

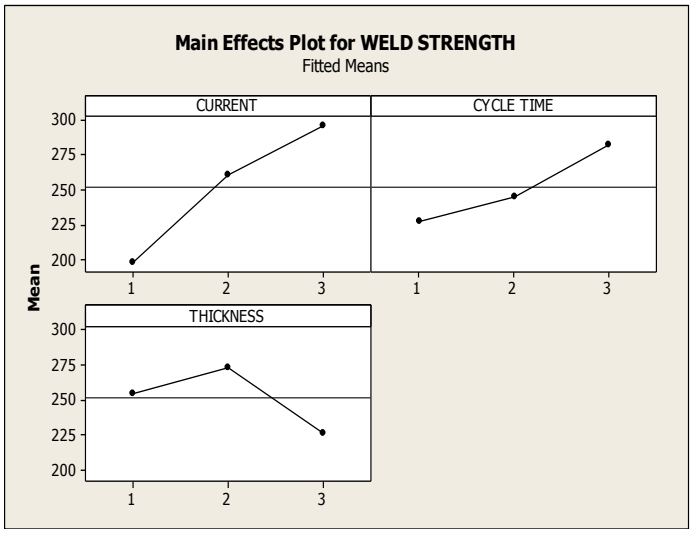

Figure 7 Main effect plot for Weld Strength

Table 3 ANNOVA

Source	DF	Seq SS	Adj SS	Seq MS	F	P
Current	2	14850.9	14850.9	7425.4	28.84	0.034
Cycle time	2	4730.9	4730.9	2365.4	9.19	0.098
Thickness	2	3461.6	3461.6	1730.8	6.72	0.129
Error	2	514.9	514.9	257.4		
Total	8	23558.2				

S = 16.0451 R-Sq = 97.81% R-Sq(adj) = 91.26%

Analysis of variance (ANOVA) of Weld Strength is carried out at 95% of confidence level to check the significance of model and various terms in it as shown in Table 2. [10]Probability of F value greater than calculated F value due to noise is indicated by P value. If P value is less , significance of corresponding term is established. The coefficient of determination (R^2) which indicates the percentage of total variation in the response explained by the terms in the model is 97.81%.From the ANOVA analysis the percentage contribution of individual parameters on weld strength was found, Highly effective parameters on weld strength were found as welding current and thickness of material, where as cycle time were less effective factors

V. CONCLUSION

This paper has presented an investigation the effect of welding parameters on the weld strength. Results shows that Weld strength increases as welding current increases. In addition to cycle time the thickness of material has a significant impact on welding strength, as thickness increases weld strength decreases for the same processing parameters of spot welding machine,

VI. ACKNOWLEDGEMENT

The authors are thankful to the Principal and all staff of Mechanical engineering and Applied mechanics department of Government polytechnic Junagadh for permission and co-operation to conduct experiments on Resistance spot welding machine and UTM.

VII. REFERENCES

[1] O.P.Khanna "A text book of Production Technology " Dhanpat Rai publications,pp.11.73-11.90
[2] A. Aravinthan, K sivayoganathan,D AL-Dabass, V Balendran"A neural network system for spot weld strength prediction"System Engineering Research Group
[3] B.Bouyousfi & T.Sahraooui "Effect of Process Parameters on the Physical characteristics of spot weld joints "Material and design,(2007)
[4] S.Aslanlar,A Ogur,U Ozsarac,E.IIhan,ZDemir "Effect of welding current on Mechanical Properties Of Galvanized Chromided steel sheets in electrical resistance spot welding"
[5] Montgomery, D.C. (2001), Design and Analysis of Experiments, 5th edition, John Wiley & Sons, Inc, New York.
[6] B. D. Parmar, N.G. Parmar B.C.Khatri "Experimental Analysis of Processing Parameters for Improving Mechanical Properties of Fused Deposition Modeling built Parts "Proc. of the 5th International Conference on Advances in Mechanical Engineering (ICAME-2011), June 06-08, 2011S.V. National Institute of Technology, Surat – 395 007, Gujarat, India
[7] S. Fraley, M. Oom, B. Terrien and J. Z. Date, Design of experiments via Taguchi methods: orthogonal arrays, The michigan chemical process dynamic and controls open text book, USA (2006).
[8] A. K. Dubey and V. Yadava, Multi-objective optimisation of Nd:YAG laser cutting of nickel-based superalloy sheet using orthogonal array with principal component analysis, Optics& Laser Technology, 46 (2008) 124-132.
[9] J. S. Kwak, Application of Taguchi and response surface methodologies for geometric error in surface grinding process, Int. Journal of Machine Tools & Manufacture, 45 (2005) 327-334.
[10] N.G.Parmar, B.D.Parmar, B.C.Khatri "An Experimental Study on Reusable type Wire EDM of HcHcr steel based on Taguchi Methodology" Proc. of the 4th National Conference on Emerging Trends in Mechanical Engineering, 2011.