Optimization of the Process Parameters in Resistance Spot Welding Using Genetic Algorithm

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***Abstract*– This paper focused on Non-Linear method like Genetic Algorithm to optimize the machining parameters of Resistance Spot Welding that is cycle time (Weld, Hold, and Squeeze) and current which are responsible for Nugget Diameter & Strength of weld. Low carbon cold rolled EDD grade material has been consider for response. Corresponding mathematical model based on factorial regression &ANOVA developed which expresses generalized relation between responses and variable input process parameters.**

***Keyword*– Resistance Spot Welding, Nugget Diameter and Genetic Algorithm**

I. INTRODUCTION

Low carbon cold rolled EDD (Extra Deep Draw) steel is most consumable material in automobile industries,for making some parts like body frames, fuel tank, etc. Its cupping property almost high due to which there were possible to make parts whose depths are much higher than their thickness. Two strips of above material joined with variable process parameters like weld cycle time& current. The flow of current between joint possible due to resistance at localized area. The plastic shearing and deformation produce final joint. Genetic Algorithm is one of non linear computational method for optimization.

This method gives global result with high chances of probability. It generates fetus from parent genes which are fittest for survival. The main objective of this paper to find out or demonstrate the relation of responses like Nugget diameter & Strength with above mentioned process input parameters. It has been possible by using binary coded genetic algorithm.

II. LITERATURE REVIEW

Indian Standard [1] gives chemical composition of EDD (Extra Deep Draw) graded cold rolled low carbon steel with maximum value of allowable strength. M. Pournavari investigated [2] the effect of process variable like pressure, current, welding time on low carbon steel with their failure mode and peak load to describe spot weld performance. Marashi & Pournavari studied the failure mechanism of spot welded specimen with microstructure details of heat affected zones of welded section [3]. Yun J. Chaoo has studied [4] the ultimate strength and failure mechanism under combined Tensile/Shear loads. S.P.Tewari and Nitin Rathod investigated the impact of input process parameters like current, welding time of resistance spot welding with responses like nugget diameter and tensile strength on Low Carbon and HSLA Steel [5]. Narsiab Muhammad focused [6] on optimizing the weld zone developed by resistance spot welding and monitoring multiple quality characteristics by using orthogonal array method.

M.S. Kadam & S.K. Basu objective [7] to create relation of cutting speed & surface roughness on the various machining parameters of wire electrical discharge machining. S Elangovan create effective methodology [8] to increase strength of dissimilar metal joint with the help of genetic algorithm.

III. EXPERIMENTAL WORK

Pneumatic resistance spot welding machine is used for welding of specimens. Total thickness of material is 2.0mm. Cycle time (weld, squeeze &hold) and current used for responses like nugget diameter and strength of weld. Following tables shows specification of welding condition ranges &levels independent parameters.

Table 1: Specification of machine

Make of RSW machine	Nash Robotics& Automation Pvt Ltd, Nasik.
Material For specimen	Low carbon cold rolled steel, EDD grade.
Electrode	Dome cap electrode with diameter 11.5mm
Workpiece thickness	Total thickness-2.0mm
Supply	415 Volt
Frequency	50Hz
Cooling water flow	12-15 Lits/min
Maximum electrode force	400 Kgf

Table 2: Ranges & level of parameter

Factor	Notation		-2 Lowest	-1 Low	0 Mid	1 High	2 Highest
Weld Time	Cycle	X1	10	11	12	13	14
Hold Time	Cycle	X2	10	15	20	25	30
Squeeze time	Cycle	X3	15	20	25	30	35
Current	Ampere	X4	11	11.1	11.2	11.3	11.5

As per Response surface methodology based on centre composite design, 25 no of specimen were prepared and result obtained included in tabular form.

Table 3: Design and experiments of resistance spot welding

Sr. No	Weld Cycle X1	Hold Cycle X2	Squeeze Cycle X3	Current X4	Nugget Dia in mm Y1	Breaking Load in N	Tensile Strength N/mm2
1	11	15	20	11.1	5.5	9516	275.5
2	13	15	20	11.1	5.1	9887	312.4
3	11	25	20	11.1	5.4	9693	276.3
4	13	25	20	11.1	5.2	9957.15	304.9
5	11	15	30	11.1	5.5	9614	278.3
6	13	15	30	11.1	5.1	10006.2	318.5
7	11	25	30	11.1	5.4	9731	281
8	13	25	30	11.1	5.2	10006.2	306.3
9	11	15	20	11.3	5.6	9609	273.35
10	13	15	20	11.3	5.4	9825.1	289.9
11	11	25	20	11.3	5.7	9712	271.28
12	13	25	20	11.3	5.3	9957	299.2
13	11	15	30	11.3	5.5	9516	275.5
14	13	15	30	11.3	5.2	9810	300.4
15	11	25	30	11.3	5.7	9712	271.3
16	13	25	30	11.2	5.2	9957	304.8
17	10	20	25	11.2	5.6	9597.5	273.3
18	14	20	25	11.2	5.1	9947	310.5
19	12	10	25	11.2	5.2	9723	301.9
20	12	30	25	11.2	5.3	9957	299.2
21	12	20	15	11.2	5.4	9764	282
22	12	20	35	11.2	5.3	9908	297.7
23	12	20	25	11	5.1	9880	314
24	12	20	25	11.5	5.7	9761	272.65
25	12	20	25	11.2	5.2	9859	301.9

The range of Nugget diameter is 5.1 to5.7 mm and strength is 270 to 350 N/mm^2.These values are decided from Indian standard of cold rolled low carbon steel –IS 513.There is shearing action takeplace at welded area if any tensile nature of load applied during destructive testing.

Formula for strength= Breaking Load/ Shearing Area=P/2πDt

Where D is Nugget diameter & t= Thickness of specimen, P=Breaking Load

IV. SUMMARY OUTPUT

Following statistical data generated by using MINITAB-15 computer software.

For Nugget Diameter

- Regression statistics

R Square	0.865
R Square adjusted	0.837
Standard error	0.080707

Source	Standard Error
X1	0.5400
X2	0.00677
X3	0.01500
X4	0.26966

- ANOVA

Source	DF	SS	MS	F	P
Regrssion	4	0.83133	0.20783	31.91	0.00
Residual error	20	0.13027	0.00651		
Total	24	0.96160			

For Breaking Load

-Regression statistics

R Square	0.872
R Square adjusted	0.847
Standard error	0.05917

-ANOVA

Source	DF	SS	MS	F	P
Regression	4	0.0478579	0.1196	34.17	0.00
Residual Error	20	0.00700033	0.00352		

Total	24	0.054899		
Predictor	Coefficient	Secondary Coefficient	T-Statistic	P-Value
Constant	10156	1276	7.96	0.00
X1	124.26	12.09	10.28	0.00
X2	11.588	2.418	4.79	0.00
X3	3.872	2.418	1.60	0.125
X4	-194.6	112.1	-1.74	0.098

For Strength of Weld

-Regression statistics

R Square	0.856
R Square adjusted	0.827
Standard error	6.58139

–ANOVA

Source	DF	SS	MS	F	P
Regression	4	5147.2	1286.3	29.71	0.00
Residual Error	20	866.3	43.3		
Total	24	6013.5			

Predictor	Coefficient	Secondary Coefficient	T	P
Constant	804.2	141.9	5.87	0.00
X1	12.594	1.344	9.37	0.00
X2	-0.1681	0.2699	-0.63	0.539
X3	0.4839	0.2689	1.82	0.084
X4	-60.04	12.47	-4.82	0.00

V. MATHEMATICAL FORMULATION

Nugget Diameter(Y1)=f(X1, X2, X3, X4)
Following equation are generated

$$\text{Nugget Diameter(Y1)} = -3.89 - 0.146\, X1 + 0.00415\, X2 - 0.00418\, X3 + 0.984\, X4$$

$$\text{Strength of weld(Y2)} = 804 + 12.6\, X1 - 0.168\, X2 + 0.489\, X3 - 60.0\, X4$$

Where, $270 \leq \text{Strength} \leq 350$

$$10 \leq X1 \leq 14$$
$$10 \leq X2 \leq 30$$
$$15 \leq X3 \leq 35$$
$$11.1 \leq X4 \leq 11.5$$

VI. METHODOLOGY

The first step in a GA is to initialize the population that means to create an initial population .An initial population of desired size is generated randomly. A Simple Genetic Algorithm largely uses three basic operators which are-1) Reproduction 2) Cross over 3) Mutation. There are two basic parameters of genetic algorithm, cross over probability (Pc) &mutation probability (Pm) &hence they are taken.0.7&0.01 respectively. GA Optimization for Excel is used for execution of the problem. Following data in tabular form shows the results at different levels of generation.

Table 4: Optimum result at levels of generation

Generation	X1	X2	X3	X4	Y1
250	13.62	26.48	20.24	11.49	5.45
500	10.77	22.82	28.96	11.16	5.49
1000	10.30	23.53	23.53	11.08	5.52

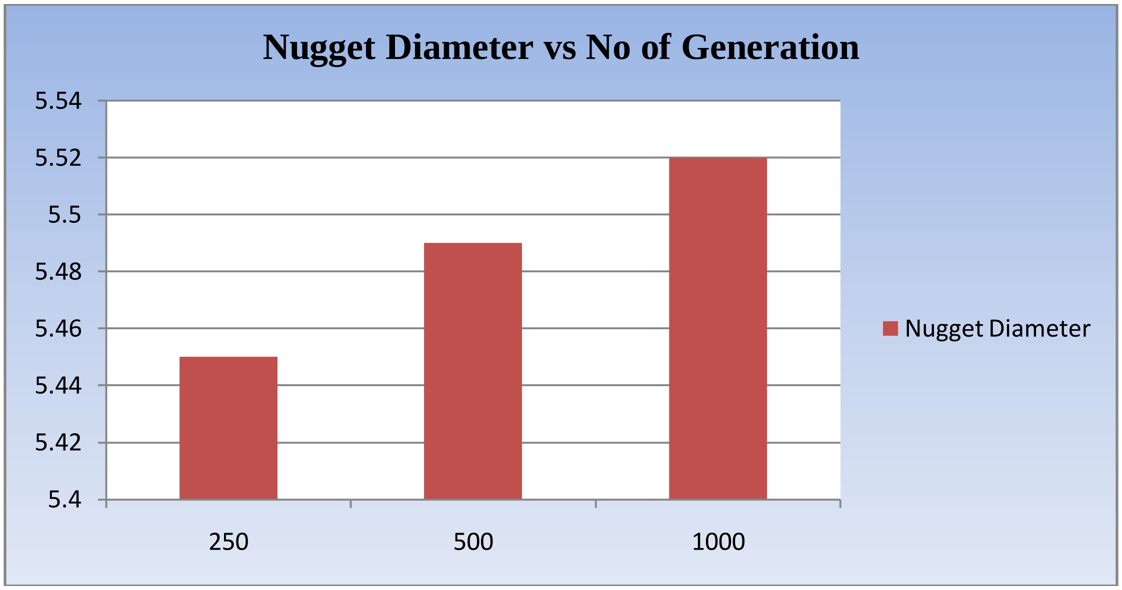

Figure 1: Graph showing performance of nugget diameter with no of generation

VI. CONCLUSION

- The result of this study indicates that the input parameters significantly influenced their Nugget size and strength of weld.
- As the number of generation increases gives profound result.
- GA Methodology provides an alternative method for obtaining maximum value of nugget diameter.

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REFERENCES

[1] Indian Standard IS513-*Lowcarbon cold rolled steel for automobile purpose.* Revision No-4 Published in 1994 by Bureau Of Indian Standards. Pp1-8.

[2] M .Pournavari-*Effect of welding parameters on the park load and energy Absorption of Low carbon steel resistance spot welds, published* in ISR Network Mechanical Engineering,Vol-2011,pp1-7.

[3] M.Pournavari, Pirooz Marashi-*Failure behavior of resistance spot welded low carbon steel in Tensile-Shear and coach peel Taste,* published in Journal of Association of Metallurgical Engineers of Serbia, in August 2009. pp149-157.

[4] Yuh J.Chao-*Ultimate strength and failure mechanism of Resistance Spot Weld subjected to tensile, Shear or combined loads,* published in Journal of Engineering Materials and Technology, in April-2003,Vol-125.pp-125-131.

[5] S.P.Tewari. Nitin Rathod-*Resistance spot weldability of low carbon and HSLA steels,* published in Thammasat International Journal of Science& Technology,Vol-15,in 2010. Pp1-11.

[6] Narasiab Muhammad,Yupiter HP Manurung-*AQuality Improvement Approach for resistance spot welding using multi-objective Taguji Method and response surface methodology* ,published in International Journal on advance science engineering information technology in 2012,Vol-2.pp-1-6.

[7] M.S.Kadam , S.K.Basu- *Optimization of the machining parameters in wire electricaldischarge machining process using genetic algorithm,* published in journal of manufacturing and technology in june 2007.pp10-15.

[8] S Elangovan, S Venkateshwaran-*Experimental investigations on optimization of ultrasonic welding parameters for copper to brass joints using response surface method and genetic algorithm,* published in international journal of advanced engineering research and studies, Vol. 1,in june-2012.pp55-64.