ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE) Volume 1, Issue 2 , June 2016

An Experimental Analysis of Spot Welding Parameters

[1]Ramkrishna Parihar
[1] M-Tech scholar
[1]ramkrishnaparihar54@gmail.com

Abstract: **— in this experimental work, an attempt is made through ANOVA & using grey based Taguchi method is that weld time is found to be most significant factor. There were four input parameter which are weld time, hold time, weld current and electrode force are considered. There were three outputs attributed which is Tensile Shear Strength (TSS), Heat Affected Zone (HAZ) & Weld Nugget Diameter (WND) is taken. Analysis of variance (ANOVA) has been carried out with the help of Minitab 17 software.**

***Index Terms*—ANOVA, Grey based Taguchi method, Minitab17, Optimization**

I. INTRODUCTION

Resistance spot welding has its importance in automotive industry due to its flexibility, robustness and speedy weld to metal. Resistance spot welding works on electrical resistance concept. In resistance spot welding, a spot weld joint is made by, a workpiece to be held between two electrodes and then pressure and current are applied. A schematic diagram of resistance spot welding is as shown in Fig 1. Resistance spot welding simply works on four basic cycles which are squeeze, weld, and hold and off cycle.

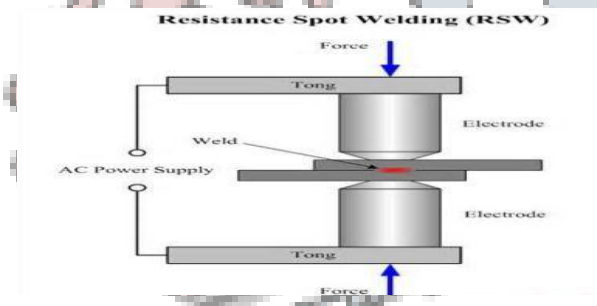

Fig. 1. Process of spot welding

II. PROBLEM FORMULATION

Due to quality needs in production engineering, it is necessary to design of experiments. The proper setting of parameters level may not lead bed quality of products.

III. EXPERIMENTAL SET UP

a. Selection of materials

For this experimental work, two dissimilar metals which are AISI304 stainless steel & mild steel were selected. The dimensions of specimen are taken as 160mm×30×1mm which is shown in Fig. 2.

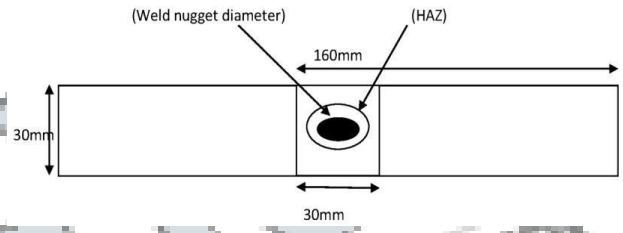

Fig. 2. Specimen

b. Set up of machine

For this experimental work, a manually operated Resistance Spot Welding (RSW) with the attachment of timer circuit for controlling squeezing time, hold time & weld current in cycles have been used. A spring balance system with dial gauge has been fixed between foot pedal and bottom electrode for measuring the electrode force. A set up of machine is shown in Fig.3.

Fig. 3. RSW set up

c. Welding of work pieces

Work samples have been cut in the dimensions of 160mm×30×1mm. A total of 27 experimentation runs were

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering
(IJERMCE) Volume 1, Issue 2 , June 2016

done & each of repeated thrice. A few samples are as shown in Fig. 4.

Fig. 4. Welded samples

d. Tensile test

All of the welded samples have been underwent Universal Testing Machine (UTM). The processes of tensile test are as shown in Fig. 5.

Fig. 5. Tensile test

IV. METHODOLOGY

a. Selection of levels

In this paper, there are four parameter under their three levels have been selected, which are described in Table I.

Table I. Levels

L	(A)	(B)	(C)	(D)
1	10	10	2044	19.81
2	30	30	2628	39.65
3	50	50	3650	59.48

Where,

L= levels, A= weld time in cycle, B= hold time in cycle= weld time in cycle, C= weld current in ampere D= electrode force in Newton.

b. Methods

Grey based Taguchi method has been applied for optimization of factors. The main objective of Taguchi method is to minimization of variations with in improvement of product quality with the reduction of time, cost & materials. Grey based Taguchi method is a combination of relational analysis to Taguchi method.

The main steps of grey relational analysis are given as below:

- Normalize the value of output characteristics.
- Find out the Grey Relational Coefficient (GRC).
- Determine the Grey Relational Grade (GRG).
- Determine ANOVA table.
- Conduct confirmation test.

c. Selection of Orthogonal Array (OA)

Orthogonal array selected according to number of parameters & their parameters. There are L9, L12, L18, L27 etc orthogonal available but in this study L27 OA were selected.

d. Normalized value

Here in this research there are three quality attributes which are TSS, HAZ & WND were selected for optimization. For the weld quality purpose TSS & WND is required to be as Higher the Better (HB) & HAZ is required to be Lower the Better (LB).

- Higher the Better (HB)

$$(\quad) \quad \frac{(\quad) \quad (\quad)(\quad)}{(\quad) \quad (\quad)(\quad)} \qquad (1)$$

- Lower the Better (LB)

$$\frac{(\quad) \quad (\quad)}{} \qquad (2)$$

$$(\quad) \qquad (\quad)$$

$$(\quad)(\quad) \qquad (\quad)(\quad)$$

Where,

Where (no. of runs) & (no. of responses)

Normalized values are described in Table IV.

e. Deviation sequence

The values of deviation sequence are illustrated in Table reference sequence ( ) ( ) and the comparability sequence ( ) i.e.

Where, ( ) is the deviation sequence of the

$$(\quad) \qquad (\quad) \qquad (\quad) \qquad (3)$$

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering
(IJERMCE) Volume 1, Issue 2 , June 2016

Determination of Grey Relational coefficient (GRC) & Grey Relational Grade (GRG)

The formulas for determination of GRC are given as below:

( ) ——————(4)
( )

Where, is distinguishing coefficient & it is taken as 0.5. After determination of GRC for all three attributes, it is need to average value for determine the GRG. The values of GRC & GRG are mentioned in Table VI.

Table II. L27 orthogonal array

R	A	B	C	D
1	1	1	1	1
2	1	1	2	2
3	1	1	3	3
4	1	2	1	2
5	1	2	2	3
6	1	2	3	1
7	1	3	1	3
8	1	3	2	1
9	1	3	3	2
10	2	1	1	1
11	2	1	2	2
12	2	1	3	3
13	2	2	1	2
14	2	2	2	3
15	2	2	3	1
16	2	3	1	3
17	2	3	2	1
18	2	3	3	2
19	3	1	1	1
20	3	1	2	2
21	3	1	3	3
22	3	2	1	2
23	3	2	2	3
24	3	2	3	1
25	3	3	1	3
26	3	3	2	1
27	3	3	3	2

Where,
R= no. of runs
The values of TSS, HAZ, & WND are given in Table III.

Table III. The values of TSS, HAZ, & WND

R	TSS (KN)	HAZ (mm)	WND (mm)
1	2.1	2.43	2.03
2	2.0	2.56	2.10
3	2.4	3.36	2.90
4	2.4	3.03	2.56
5	2.3	3.46	2.96
6	2.9	3.7	3.23
7	2.5	3.26	2.86
8	2.0	2.83	2.46
9	3.4	3.86	3.60
10	3.4	5.76	5.06
11	3.9	5.76	5.06
12	4.1	5.73	4.96
13	3.5	5.43	4.83
14	3.5	5.3	4.73
15	4.2	5.73	5.20
16	3.3	5.3	4.83
17	3.4	5.56	5.00
18	3.9	5.83	5.20

19	3.6	6.53	6.06
20	3.4	6.73	6.33
21	4.0	7.7	7.13
22	4.4	6.8	6.23
23	4.2	6.83	6.16
24	4.5	7.76	7.10
25	4.2	7.2	6.70
26	4.3	7.1	6.43
27	4.4	7.9	7.20

Table IV. Normalized values

R	N1	N2	N3
1	2.43	0.04	0
2	2.56	0	0.01
3	3.36	0.16	0.16
4	3.03	0.16	0.10
5	3.46	0.12	0.17
6	3.7	0.36	0.23
7	3.26	0.2	0.16
8	2.83	0	0.08
9	3.86	0.56	0.30
10	5.76	0.56	0.58
11	5.76	0.76	0.58
12	5.73	0.84	0.56
13	5.43	0.6	0.54
14	5.3	0.6	0.54
15	5.73	0.88	0.61
16	5.3	0.52	0.54
17	5.56	0.56	0.57
18	5.83	0.76	0.61
19	6.53	0.64	0.77
20	6.73	0.56	0.83
21	7.7	0.8	0.98
22	6.8	0.96	0.81
23	6.83	0.88	0.79
24	7.76	1	0.98
25	7.2	0.88	0.90
26	7.1	0.92	0.85
27	7.9	0.96	1

Where,
N1,N2& N3 are the normalized values of TSS, HAZ & WND.

Table V. Deviation sequence

R	TSS ( )	HAZ ( )	WND ( )
Reference sequence	1	1	1
1	0.96	0	1
2	1	0.03	0.99
3	0.84	0.18	0.84
4	0.84	0.11	0.9
5	0.88	0.19	0.83
6	0.64	0.24	0.77
7	0.8	0.16	0.84
8	1	0.08	0.92
9	0.44	0.27	0.7
10	0.44	0.61	0.42
11	0.24	0.61	0.42
12	0.16	0.61	0.44
13	0.4	0.55	0.46
14	0.4	0.53	0.46
15	0.12	0.61	0.39
16	0.48	0.53	0.46
17	0.44	0.58	0.43

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering
(IJERMCE) Volume 1, Issue 2 , June 2016

18	0.24	0.63	0.39
19	0.36	0.75	0.23
20	0.44	0.79	0.17
21	0.2	0.97	0.02
22	0.04	0.8	0.19
23	0.12	0.81	0.21
24	0	0.98	0.02
25	0.12	0.88	0.1
26	0.08	0.86	0.15
27	0.04	1	0

Table VI. The values of GRC & GRG

R	GRC1	GRC2	GRC3	GRG
1	0.3424	1	0.3333	0.5585
2	0.3333	0.9433	0.3355	0.5373
3	0.3731	0.7352	0.3731	0.4938
4	0.3731	0.8196	0.3571	0.5166
5	0.3623	0.7246	0.3759	0.4876
6	0.4385	0.6756	0.3937	0.5026
7	0.3846	0.7575	0.3731	0.5050
8	0.3333	0.8620	0.3521	0.5158
9	0.5319	0.6493	0.4166	0.5326
10	0.5319	0.4504	0.5434	0.5085
11	0.6756	0.4504	0.5434	0.5564
12	0.7575	0.4504	0.5319	0.5799
13	0.5555	0.4761	0.5208	0.5174
14	0.5555	0.4854	0.5208	0.5205
15	0.8064	0.4504	0.5617	0.6061
16	0.5555	0.4854	0.5208	0.5205
17	0.5319	0.4629	0.5376	0.5108
18	0.6756	0.4424	0.5617	0.5599
19	0.5813	0.4	0.6849	0.5554
20	0.5319	0.3875	0.7462	0.5552
21	0.7142	0.3401	0.9615	0.6719
22	0.9259	0.3846	0.7246	0.6783
23	0.8064	0.316	0.7042	0.6088
24	1	0.3378	0.9615	0.7664
25	0.8064	0.3623	0.8333	0.6673
26	0.8620	0.3676	0.7692	0.6662
27	0.9259	0.3333	1	0.7530

Where,

GRC1, GRC2, GRC3= Grey Relational grade of TSS, HAZ & WND

GRG= Grey Relational Grade

V. RESULTS & DISCUSSIONS

a. Analysis of variance (ANO VA)

ANOVA is a statistical which is used for data analysis. ANOVA tool comprises of Degree of Freedom (DOF), Sum of Square, Mean Square (MS), F-test. ANOVA analysis are describes in Table VI. Response table for GRG are given in Table VIII

Table VII. ANOVA for GRG

Source	DOF	SS	MS	F-value	% C
A	2	0.102206	0.051103	24.55	63.45
B	2	0.003027	0.001513	0.73	1.88
C	2	0.016847	0.008423	4.05	10.46
D	2	0.001534	0.000767	0.37	0.95
Error	18	0.037473	0.002082		23.26
Total	26	0.161086			100

Table VIII. Response table of GRG

Level	A	B	C	D
1	0.5166	0.5574	0.5586	0.5767
2	0.5422	0.5782	0.5509	0.5785
3	0.6580	0.5812	0.6073	0.5617
Delta	0.1414	0.0238	0.0564	0.0168
Rank	1	3	2	4

It is confirm from ANOVA table is that according to contribution, weld time got to be at first place, weld current at second place, hold time at third place & electrode force at fourth place. Fig. 6. Shows mean effect plot.

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering
(IJERMCE) Volume 1, Issue 2 , June 2016

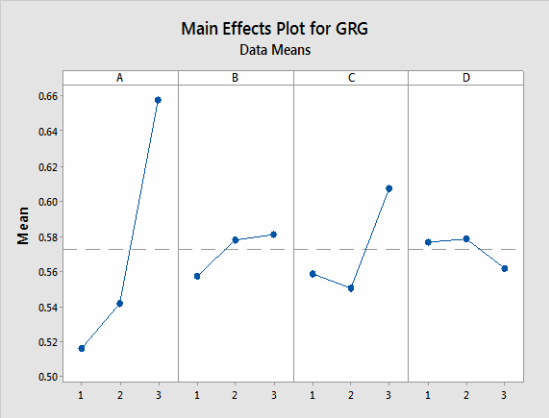

Fig. 6. Main effect plot

VI. CONCLUSIONS

Grey based Taguchi method is a very useful technique for optimization of parameters. In this experimental work, it is concluded that weld time, hold time, weld current & electrode force contributed 63.45%, 1.88%, 10.46%, 0.95% respectively.

REFERENCES

[1] Ahilan C., Kumanan S., Shivkumaran N. "Application of Grey Based Taguchi Method in Multi-Response Optimization of Turnining Process." *Advanced in Production Engineering & Management* 5, No. 3 (210).

[2] Alenius M., Pohjanne P., Somervuori M., Hänninen H. "Exploring the Mechanical Properties of Spot Welded Dissimilar Joints for Stainless and Galvanized Steels." *Welding Journal*, 2006: 305-313.

[3] Aravinthan A., Nachimani C. "Analysis of Spot Weld Growth on Mild and Stainless Steel." *American Welding Society and the Welding Research Council* 90 (2011): 143-147.

[4] Arumugam A., Nor M. "Spot Welding Parameter Optimization to Improve Weld Characteristics for Dissimilar Metals." *International Journal of Scientific & Technology Research* 4, No. 1 (2015): 75-80.

[5] Arya D.M., Chaturvedi V., Vimal J. "Application of Signal to Noise Ratio Methodology for Optimization of Mig Welding Process Parameters." *International Journal of Engineering Research And Applications* 3, No. 4 (2013): 1904-1910.

[6] Balasubramanian M., Balasubramanian V. "E®Ect of Process Parameters on Sprc35 Spot Welded Automotive Panels." *Acta Metall. Sin.(Engl. Lett.)* 23, No. 3 (2010): 185-190.

[7] Balasubramanian S., Ganapathy S. "Grey Relational Analysis to Determine Optimum Process Parameters for Wire Electro Discharge Machining (Wedm)." *International Journal of Engineering Science And Technology* 3, No. 1 (2011): 95-101.

[8] Biradar A. K., Akarate M. M. Ram Reddy S. "Study and Analysis of Resistance Spot Welding of Dissimilar Metal having Medium Range Thickness." *International J. of Math. Sci. & Engg. Appls.* 3, No. 4 (2009): 33-51.

[9] Researcher, Welding & Joining Research Center, Steel Research Laboratories, 2013, 91-98.

[10] Sreeraj P., Kannan T. , Maji S. "Grey-Based Taguchi Method for Optimization of Heat Affected Zone in Flux Cored Arc Bead on Plate Welding." *International Journal of Advanced Engineering Research And Studies* 4, No. 1 (Oct.-Dec 2014): 46-53.

[11] Sreeraj P., Kannan T. , Maji S. "Optimization of Heat Affected Zone in Submerged Arc Welding Process Using Greybased Taguchi Approach." *International Journal of Engineering*, 2014: 100-108.

[12] Thakur A. G., Rao T. E, Mukhedkar M. S. , Nandedkar V. M. "Application of Taguchi Method for Resistance Spot Welding of Galvanized Steel." *Arpn Journal of Engineering and Applied Sciences* 5, No. 11 (2010): 22-26.