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Abstract - There are many welding parameters In welding process, the major factors whose selection contributes to the welded product as they all affect the strength and quality to a larger extent are weld design (edge preparation), Root face, and Root gap. The purpose of this paper is to efficiently determine the optimum welding operation parameters for achieving the highest ultimate strength in range of parameters. In order to meet the purpose in terms of both efficiency and effectiveness, this study will utilize the Taguchi parameters design methodology. The study includes selection of parameters, utilizing an orthogonal array, conducting experimental runs, data analysis, determining the optimum combination, finally the experimental verification and comparison by regression modelling.

Keywords: Welding, Taguchi, Regression modelling

I. INTRODUCTION

Welding preferred over other joining process like riveting, casting and nut bolting because it is faster, quieter and many more advantageous over other joining techniques. Now a day, welding is extensively used in fabrications of automobiles, aircrafts, ships, electronic equipment, machinery, and home applications etc. as an alternative of casting or as a replacement of riveted or bolted joints. There are two main types of arc-welding processes. They are shielded metal arc welding and gas shielded arc welding.

The main advantages of shielded metal arc welding are that high-quality welds are made rapidly at a low cost. Shielded Metal Arc Welding, also known as manual metal arc welding, stick welding, or electric arc welding, is the most widely used of the various arc welding processes. Welding is performed with the heat of an electric arc that is maintained between the end of a coated metal electrode and the work piece (See Figure below).

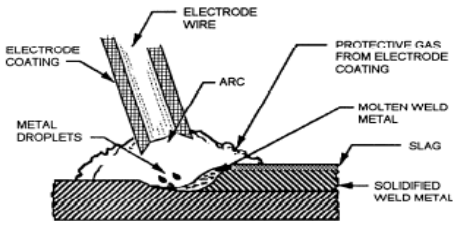

Figure 1. Electric arc welding process

II. TAGUCHI METHOD

Taguchi method is the process of engineering optimization in a three step approach namely system design, parameter design and tolerance design. In the system design, a basic functional prototype design will be produced by applying scientific and engineering knowledge. In parameter design, independent process parameter values will be optimized and where as in tolerance design, tolerances will be determined and analyzed for optimal values set by parameter design. Taguchi method is a powerful design of experiments (DOE) tool for optimization of engineering processes.

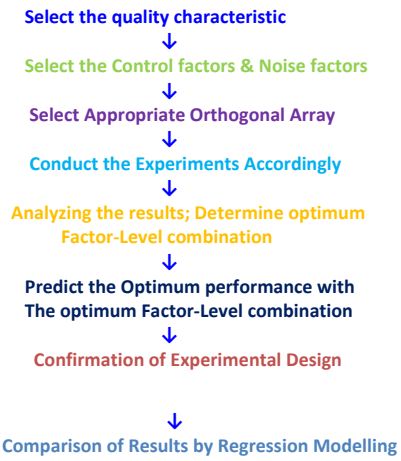

Figure 2. Steps of Taguchi Method

III. EXPERIMENTAL SETUP

A. *Work piece material*

Low carbon mild steel sheet having chemical compassion of following element.

TABLE I. Chemical composition of work piece.

Elements	C	Si	Mn	P	S
Weight %	0.06	0.09	0.37	0.063	0.065

The sheet sample in dimension of 100 mm in length, 50 mm in width, and 6 mm in thickness was used for electric arc welding in order to determine weld strength. The electrode used was 3.25mm of mild steel

B. *Method*

The following input and output parameters are:
Input parameters selected are V-butt angle, Root face, Root gap. The output parameter predicting strength of weld joint is Ultimate strength. The all sample is welded by keeping other parameters constant.

C. *Plan of Experiment*

The experiment was planned using Taguchi's orthogonal array in the design of experiments, which help in reducing the number of experiments. The L_9 orthogonal array. The welding parameters identified were v-butt angle, root face, root gap. Control parameters and their level indicated in table.

TABLE II. Control factor and their level

Level	V-butt angle(A) In (degree)	Root face(B) in mm	Root gap (C) in mm
1	40	1	1
2	50	2	1.5
3	60	3	2

TABLE III. 0rthogonal L9 array of taguchi

Experiment	P1	P2	P3
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

TABLE IV. Consulate design of parameters and their response.

Experiment No.	Combination of input parameters	Output response in N/ mm^2
1	111	18.966
2	122	19.047
3	133	19.620
4	212	22.890
5	223	23.707
6	231	24.688
7	313	25.506
8	321	25.587
9	332	22.890

Average of ultimate strength= 22.544 N/ mm^2

IV. ANALYSIS OF SIGNAL TO NOISE RATIO

In the Taguchi approach, the term signal represents the desired value (mean) for the output characteristics and term noise represent the undesirable value (standard deviation) for the output characteristics. Therefore S/N ratio is the ratio of mean to the standard deviation. Taguchi uses the S/N ratio to measure the quality characteristics deriving from desired value. The S/N ratio is defined as given equation.

For Higher the better

It is when the occurrences of some undesirable product characteristics is to be maximized. It is given by

$S/N = -10 \log ((\Sigma 1/ yi^2)/N$……. ---- "Eq.1

All the three level of every factor are equally represented in the nine experiments. S/N ratio and ultimate strength for each parameter at each level. Ultimate strength for each of the Parameters at each level is calculated. These also called as main effects.

TABLE V. S/N ratio for ultimate strength

Experiment No.	S/N ratio

1	25.559
2	25.596
3	25.853
4	27.192
5	27.497
6	27.849
7	28.132
8	28.160
9	27.192

Average of S/N Ratio = 27.003 db

V. Analysis of mean for ultimate Strength and S/N ratio

TABLE VI. Mean response of ultimate strength.

Parameter/Level	Level 1	Level 2	Level 3
V-butt angle	19.211	23.761	**24.661**
Root face	22.454	**22.780**	22.399
Root gap	**23.080**	21.609	22.944

TABLE VII. Mean response for S/N ratio

Parameter/Level	Level 1	Level 2	Level 3
V-butt angle	25.669	27.512	**27.828**
Root face	26.961	**27.084**	26.964
Root gap	**27.189**	26.660	27.160

The optimum level for a factor is the level that gives the highest value of parameter in each level in the experimental region denoted by bold letter. The estimated main effects can be used for this purpose.

VI. Main Effects

Main effects plots for the experiments have been given below.

A. *Response Graphs for Mean of ultimate strength*

1) Level 3 for V-butt angle, A3 = 24.661 N/ mm^2 indicated as the optimum situation in terms of ultimate strength values.

2) Level 2 for Root face, B2 = 22.780 N/ mm^2 indicated as the optimum situation in terms of ultimate strength values.

3) Level 1 for Root gap**,** C1 = 23.080 N/ mm^2 indicated as the optimum situation in terms of ultimate strength values.

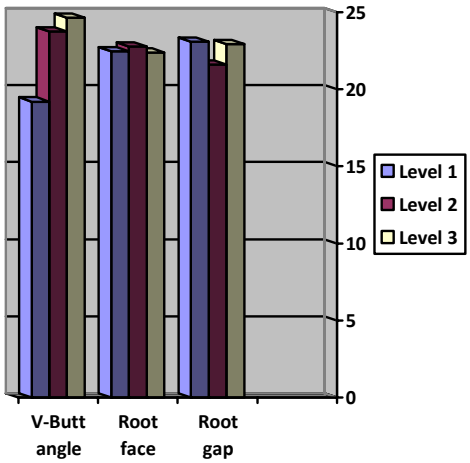

Figure 3. Response graph for mean of ultimate strength

B. *Graphs for S/N ratio of ultimate strength*

1) Level 3 for V-butt angle A3 =27.828 db indicated as the optimum situation in terms of S/N values.

2) Level 2 for Root face B2 = 27.084 db indicated as the optimum situation in terms of S/N values.

3) Level 1for Root gap C1 = 27.189 db indicated as the optimum situation in terms of S/N values.

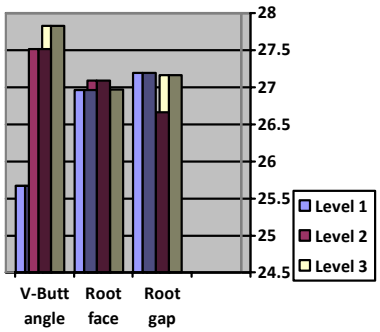

Figure 4. Response graph for mean of S/N ratio

VII. Results

The maximum ultimate strength for:
V-butt angle is in the Level 3=A3=Higher (60 degree).
Root face is in Level 2 =B2=Medium (2 mm)
Root gap is in Level1= C1= Lower (1 mm)

A. *Conformation of Experiment*

While considering three factor the experiments were conducted and result is that the combination of Higher V-butt angle (level 3), Medium Root face (level 2) and Root gap (leve l) then the ultimate strength is maximum**.**

TABLE VIII. conformation of experiment

Ultimate strength (Y) in N/ mm^2	S/N ratio in (db)
25.587	28.160

B. *Mathematical regression Modelling*

For the combination of parameters, ultimate strength value is tabulated. Empirical formula has find out by using regression modeling.

Modelling of parameters

To generalize the results the modelling of input parameter and output parameter is done using REGRESSION MODELLING andMATLAB software R2011b**.**

C_0= 0.6751
C_1=0.6252
C_2= 0.0028
C_3=-0.0148

C_0 = Antilog (0.6751), C_1 = 0.6252, C_2 = 0.0028**,**
C_3 = -0.0148

$Y = 1.964 (\text{V-butt angle})^{0.6252} * (\text{Root face})^{0.0028} * (\text{Root gap})^{-0.0148}$

$Y = 1.964(60)^{0.0203} * (2)^{0.0845} * (1)^{0.1500}$
$Y = 25.425$ N/ mm^2

C. Predicted Result (By Taguchi Method)Predicted ultimate strength =
A3+B2+C1-2*Y
=24.661+22.780+23.080-2*22.544
= 25.433 N/ mm^2

Predicted S/N Ratio = sA3+sB2+sC1-2*m
= 27.828+27.084+27.189-2*27.003
= 28.095 db

VIII. Comparison of Results

There is comparison between Actual experimental result and Predicted result of Taguchi Design experiment and Regression modelling.

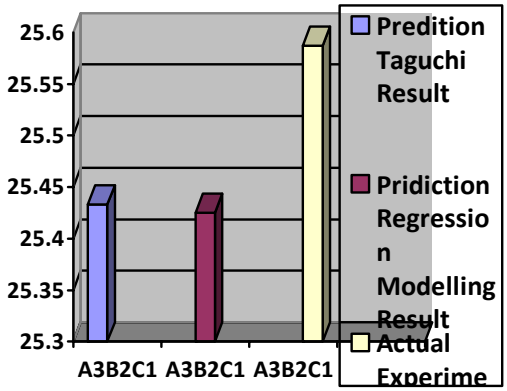

Figure 5. Comparison of results for Strength

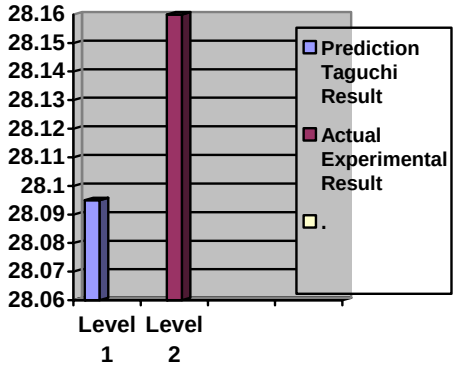

Figure 6. Comparison of results for S/N Ratio

IX. SUMMARY

In the present work the relation between ultimate strength and various process parameters namely V-butt angle, Root face, Root gap has been developed**.**

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REFERENCES

[1]. *Ahmed Khalid Hussain, Abdul Lateef, Mohd Javed, Pramesh.T(2010), 'Influence of Welding Speed on Tensile Strength of Welded Joint in TIG welding process' international journal of applied engineering research, DINDIGUL, Volume 1, No 3, 2010.*

[2]. *Lenin N., Sivakumar M. and Vigneshkumar D.(2010) 'Process Parameter Optimization in ARC Welding of Dissimilar Metal S'Thammasat Int. J. Sc. Tech., Vol. 15, No. 3.*

[3]. *A. G. Thakur[1], T. E. Rao, (2010), 'Application of Taguchi OF method for resistance spot welding of galvanized steel' ARPN Journal of Engineering and Applied Sciences.*

[4]. *Edwin J., Das Raja and Kumanan S. (2011), "Optimization of Process Parameters of Submerged Arc Welding Using Non-Conventional Techniques" Applied Soft Computing, Vol. 11 Issue 8, PP. 5198-5204.*

[5]. *Serdar Karaoglu and Secgin Abdullah (2008), "Sensitivity Analysis of Submerged Arc Welding Parameters" Journal of material processing technology", Vol. 202 Issue 1-3, PP.500-507.*

[6]. *Kumanan S., Edwin J., Das Raja and Gowthaman K (2007), "Determination of Submerged Arc Welding Process Parameters Using Taguchi Method and Regression Analysis" , Indian Journal of Engineering and Material. Sciences, Vol. 14 Issue 3.*

[7]. *Anawa E .M. and Olabi A. G. (2008), "Optimization of Tensile Strength of Ferrite / Austenitic Laser Welded Components", Optics and laser in engineering, Vol. 46, PP 571-577.*

[8]. *Sahin Y. (2006), "Optimal Testing Parameters on the Wear Behavior of Various Steel", Materials and Design, Vol. 27 Issue 6, PP. 455-460.*

[9]. *Tarang Y. S., Yang W. H. and Jung S. C. (2000), "The Use of Fuzzy Logic in the Taguchi Method for the Optimization of the Submerged Arc Welding Process", The International Journal of Advanced Manufacturing Technology, Vol. 16 Issue 9, PP.688-694.*

[10]. *Gunaraj and Murugan (1999)," Prediction and Comparison of the Area of the Heat- Affected Zone for the Bead-on- Plate and Bead-on-Joints in Submerged Arc Welding of Pipes" , Journal of Materials Processing Technology, Vol. 95 Issue1-3, PP 246-261.*

[11]. *Yang W. H. and Tarang Y. S. (1998), "Optimization of the Weld Bead Geometry in Gas Tungsten Arc Welding by Taguchi Method", International of Journal Advance Manufacturing Technology. Vol. 37, PP 601-611.*

[12]. *Kackar N. Raghu, (1985), "Off-line Quality Control Parameter Design & Taguchi Method" Journal of Quality Technology, Vol. 17, No. 4, pp. 176-188.*

[13]. *Sijo M.T and Biju N, 2010, "Taguchi method for optimization of cutting parameters in Turning Operations" AMAE.2010.01.536 pp-103-105.*

[14]. *M.Janardhan and Dr. A. Gopala Krishna (2011) "Determination and optimization of cylindrical grinding process parameters using Taguchi method and Regression Analysis" International Journal of Engineering Science and Technology.ISSN: 0975-5462.*

[15]. *Resit Unal Edwin B. Dean (1991) "Taguchi approach to design optimization for quality and cost". Annual Conference of the International Society of Parametric Analysts. Pp -1-10.*

[16]. *Yang W.H. and Y.S. Tarang 1998. "Design optimization of cutting parameters for turning operations based on Taguchi method." Journal of material processing technology. Volume 84, pp 122-129.*

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