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Optimization of Welding Process with Taguchi and ANOVA Technique

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ABSTRACT:
Mechanical properties of weld joint is strongly influenced by process parameters during welding process. The present experimental study highlighted the effect of various electric arc welding parameters on the weld bead hardness (BH) of weld metal and depth of weld bead penetration (BP). The purpose of this paper is to determine the optimum welding parameters for achieving the highest weld bead hardness and depth of penetration in range of parameters. Taguchi's L9 standard orthogonal array is selected for experimental planning. The experimental result analysis showed that the combination of higher levels of included angle, lower level of bevel height and lower level of groove opening is essential to achieve maximum weld bead hardness of weld joint.

Keywords: Welding parameters, shielded metal arc welding (SMAW), weld bead hardness, weld depth of penetration Taguchi L9 OA, Regression modelling

I. Introduction

Electric arc 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. 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. The main advantages of shielded metal arc welding are that high-quality welds are made rapidly at a low cost. In shielded Metal Arc Welding process a covered metal electrode is used and shielding is achieved from the gas that the result of decomposition of electrode covering. Globules of molten metal should not be allowed to come in contact with oxygen and nitrogen, other wise harmful oxide and nitride will form in the weld. Length of arc is the distance between the tip of the electrode and the work surface upon which the molten globules are deposited.

II. Material and method

Due to widely use in industrial and domestic Application, welding specimens were prepared from low carbon mild steel plates Containing 0.06% carbon, 0.09% silicon, 0.37 % manganese, 0.063 % phosphorus, 0.065 % sulphur. Having 100*50*6 mm size was used as base metal to provide a single butt joint configuration. The mild steel electrode also was selected as filler metal. In this study three welding parameters were taken at three ranges which is included angle (A): (40, 50, 60 deg.), bevel height (B): (1, 2, 3 mm) and groove opening(C): (1, 1.5, 2 mm).The some welding parameters such as current type input voltage, output voltage, supply phase, electrode diameter, electrode angle to work piece, electrode to work piece distance etc.were constant during experiments. The welding has been done according to Taguchi L9 orthogonal array. After the welding process the hardness of the weld bead and weld bead penetration were measured in order to find out the effect of welding parameters on weld bead hardness and penetration. All tests were performed on Rockwell Hardness Testing Machine for measured weld bead hardness. 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 larger the better

$$\textbf{S/N Ratio} = -10\ \textbf{Log}_{10}\ 1/n\ (\ \Sigma\ 1/\ Y_i^2 + \ldots 1/\ Y_n^2\ )$$

For smaller the better

$$\textbf{S/N Ratio} = -\ 10\ \textbf{Log}_{10}\ 1/n\ (\ \Sigma\ Y_i^2 + \ldots .\ Y_n^2\ )$$

All the three level of every factor are equally represented in the nine experiments.

III. Experiment & Data Analysis

Totally 9 experiments with different included butt angle, bevel height and groove opening combination were performed and weld bead hardness, weld reinforcement and weld depth penetration was measured for all cases. The result is shown in Table1.

TABLE.I. L9 Standard orthogonal Array

Exp./ Parameter	Para.1	Para.2	Para.3	Para.4
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

TABLE.II.Parameter combination & Response

Exp .No	A	B	C	BH	BP
1	1	1	1	40	5.5
2	1	2	2	36	5.5
3	1	3	3	33	5.4
4	2	1	2	30	5.6
5	2	2	3	32	5.7
6	2	3	1	29	5.3
7	3	1	3	27	5.9
8	3	2	1	25	5.7
9	3	3	2	22	5.6
Mean(M)	-	-	-	30.444	5.577

TABLE.III.S/N Ratio for BH, BP

Exp. No.	BH	BP
1	32.041	14.807
2	31.126	14.807
3	30.370	14.647
4	29.542	14.963
5	30.102	15.117
6	29.247	14.485
7	28.627	15.417
8	27.958	15.117
9	26.848	14.963
Mean(m)	29.540	14.924

TABLE.IV. Mean response for BH

Parameter/Level	Level1	Level 2	Level 3
A	**36.333**	30.333	24.666
B	**32.333**	31.000	28.000
C	**31.333**	29.333	30.666

TABLE V. Mean response for BP

Parameter/Level	Level1	Level 2	Level 3
A	5.466	5.533	**5.733**
B	**5.666**	5.633	5.433
C	5.500	5.566	**5.666**

TABLE.VI. S/N response for BH

Parameter/Level	Level1	Level 2	Level 3
A	**31.179**	29.630	27.811
B	**30.070**	29.728	28.821
C	**29.748**	29.172	29.699

TABLE.VII. S/N response for BP

Parameter/Level	Level1	Level 2	Level 3
A	14.753	14.855	**15.165**
B	**15.062**	15.013	14.698
C	14.803	14.911	**15.060**

IV. Result comparison & Discussion

Totally 9 experiments with different included, bevel height and groove opening combination was performed and optimization situation and their value were measured for weld hardness and weld depth penetration. 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.

Experimental result for BH:

Optimum situation for weld bead hardness is obtained on Level-A1B1C1.and maximum hardness is obtained on this level is 40 HRC. And experimental S/N Ratio for Hardness is 32.041 DB.

Taguchi Prediction Result for BH:

Optimum situation is obtained on A1B1C1 level and maximum hardness on this level is A1+B1+C1-2M = 39.111 HRC. And predicted S/N Ratio for hardness is 31.917 DB.

Regression Modeling Result for BH:

To generalize the results the modeling of input parameter and output parameters is done using RESSION MODELLING and MATLAB software R2011B.

C0 = 7.1786, C1 = - 0.9488, C2 = - 0.1226, C3 = - 0.0183

BH = Antilog (C0) * (Included angle) ^{C1}* (Bevel height) ^{C2}* (Groove opening) ^{C3}

BH = Antilog (7.1786) *(Included angle) $^{-0.9488}$ * (Bevel height) $^{-0.1226}$ * (Groove opening) $^{-0.0183}$
BH = 39.59 HRC.

Experimental Result for BP:

Optimum situation for weld bead penetration is obtained on Level A3B1C3.and maximum penetration is obtained on this level is 5.9 mm and experimental S/N Ratio for BP is 15.417 DB.

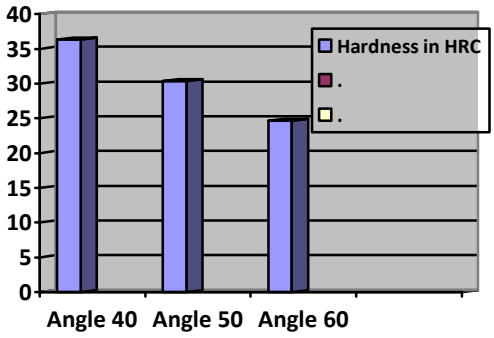
Taguchi Prediction Result for BP:

Optimum situation is obtained on Level A3B1C3 and maximum weld penetration on this level is A3+B1+C3-2M = 5.9 mm. And predicted S/N Ratio for BP is 15.437 DB.

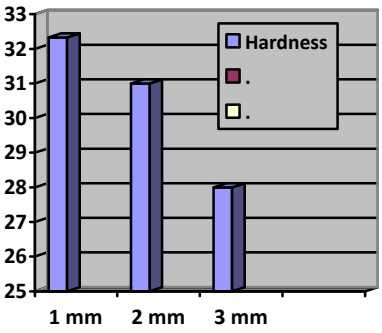
Regression Modeling Result for BP:

C0 = 1.2780, C1 = 0.1142, C2 = - 0.0347, C3 = 0.0420
BP= Antilog (C0) * (Included angle) ^{C1}* (Bevel height) ^{C2}* (Groove opening) ^{C3}
BP = Antilog (1.2780) *(Included angle) $^{0.1142}$ * (Bevel height) $^{-0.0347}$ * (Groove opening) $^{0.0420}$
BP = 5.89 mm.

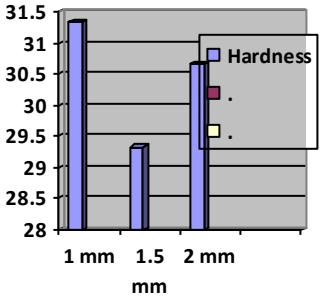
Effect of included angle on the weld bead hardness shown by graph below



Effect of bevel height on weld bead hardness shown by graph below

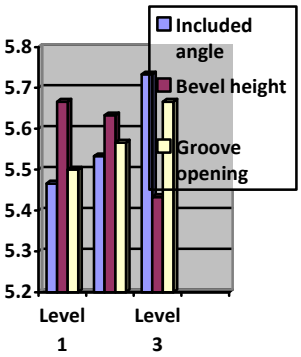


Effect of groove opening on weld bead hardness shown by graph below



E

ffect of included angle, bevel height and groove opening on the weld bead penetration at varies level is equal to the mean of weld bead penetration of all the experiment such as show by graph



V. Analysis of variance

The main effect of analysis of variance (ANOVA) is to investigate the design parameters and to indicate which parameters are significantly affecting the output parameters. In the analysis the sum of square and variance are calculated. F-test value at 95 % confidence level is used to decide the significant factors affecting the process and percentage contribution is calculated.

TABLE.VIII. ANOVA for BP

Symbol	Parameter	DOF	SS	MS	F-value	% C.
A	Included angle	2	0.273	0.136	21.0	44.535
B	Bevel height	2	0.231	0.115	17.769	37.683
C	Groove opening	2	0.096	0.048	7.384	15.660
Error		2	0.013	0.006		2.120
Total		8	0.613	0.305		100

TABLE.IX. ANOVA for BH

Symbol	Parameter	DOF	SS	MS	F-value	% C.
A	Included angle	2	17.049	8.524	59.197	83.414
B	Bevel height	2	2.493	1.246	8.656	12.197
C	Groove opening	2	0.609	0.304	2.114	2.979
Error		2	0.288	0.144		1.409
Total		8	20.439	10.218		100

VI. Conclusion

This paper has presented an investigation on the optimization and the effect of welding parameters on the weld bead hardness and depth of weld bead penetration of electric arc welding mild steel sheet. The level of importance of welding parameters on the depth of weld bead penetration and weld bead hardness is determined by using the ANOVA. Based on ANOVA method, the highly effective parameters to depth of penetration in decreasing order is included angle, Bevel height and groove opening. And highly effecting parameters to weld bead hardness in decreasing order is included angle, Bevel height and groove opening. An optimum parameters combination for the maximum depth of penetration and hardness was obtained by using analysis of S/N ratio.

VII. Summary

In the present work the relation between weld bead hardness and weld bead penetration and various process parameters namely included angle, bevel height, groove
opening 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]. H.R.Ghazvinloo(2010), "Effect of electrode to work angle, filler diameter and shielding gas type on weld geometry of HQ130 steel joint produced by robotic GMAW", Indian journal of science and technology.

[14]. Bipin kumar srivastava (2010), " A review on effect of arc welding parameter on mechanical behaviour of ferrous metals/alloys " ,International journal of engg.science and technology.

[15]. M.Aghakhani (2011), "Parametric optimization of gas metal arc welding process by Taguchi method on weld dilution" International journal of modelling and optimization.

[16]. Farhad kolahan(2010), "Modeling and optimization of MAG welding for gas pipeline using regression analysis and simulated annealing algorithm" ,Journal of science and industrial research.