Optimization of Process Parameters and Its Responses in Arc Welding using Grey Based RSM

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Abstract

The arc welding is the highly promising joining process because of its wide industrial application involving joining of similar or dissimilar materials at high speed. Arc welding is a common joining method, which is usually characterized by high bead width and height and low tensile strength. With the recent focus on bead geometry and strength has become a priority for manufacturing industry. The arc welding process parameters like welding current, welding speed, electrode position and arc voltage play an important role in determining the quality of a weld joint. The GRSM approach has been found to improve the quality characteristics investigated in the work significantly.

Keywords: *Arc Welding, AISI040, Optimization, Grey Relational Analysis, RSM*

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1. Introduction

Welding is the most economical and efficient way to joint metals permanently. It plays an important role in steel fabrication and repair. It is also used in the fabrication of spacecraft, fighter planes, submarines, and atomic power plants. Welding ranks highly among industrial processes and involves more scientific principles and variables than those involved in any other industrial process. There are many different kinds of welds. Some processes cause sparks and others do not even require extra heat. Welding can be done anywhere, outdoors or indoors, underwater, and in outer space. Numerous welding methods or techniques are in common use for a wide range of applications. Weld quality plays an important role as it improves material strength, hardness and toughness of the product. Quality of a welded product is evaluated by different parameters like weld bead geometry, deposition rate, and hardness. These characteristics are controlled by a number of welding parameters like welding current, welding speed, arc voltage and electrode stick out and, therefore, to attain good quality, is important to set up the proper welding process parameters.

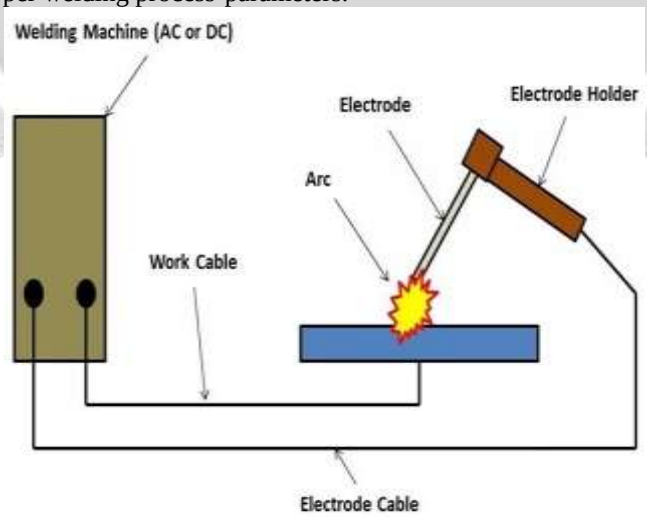

Figure 1.1 Basic circuit diagram of arc welding process

Arc welding is one of several fusion processes for joining metals. Arc welding is a process that is used to join metal to metal by using electricity to create enough heat to melt metal, and the melted metals when cool result in a binding of the metals. Since the joining is an inter-mixture of metals, the final weld joint potentially has the same strength properties as the metal of the parts. This is in sharp contrast to non-fusion processes of joining (i.e. soldering, brazing etc.) in which the mechanical and physical properties of the base materials cannot be

duplicated at the joint.

2. Problem Statement

Manufacturer face the problem of control the process input parameters to obtain a good welded joint with the required weld quality. Traditionally, it has been necessary to work out the weld input parameters for welded product to obtain a welded joint with the required quality. It requires a time-consuming trial and error development method. In the field of arc welding, the main problem facing for the manufacturer is how to choose the process input parameters that would produce an excellent weld joint, welding quality, and its strength. Conventionally, defining the weld input parameters (for newly welded products) to produce a welded joint with the required specifications is a time-consuming process involving error development effort and the skill of the welding engineer or welding machine operator in choosing the right weld input parameter and get optimum response.

3. Experimental Setup and Test Results

The present work, Electro arc machine has been used. The experiments are carried out with the help of this machine with 3mm diameter of welding electrode to weld 5mm wall thickness workpiece as per ASTM standard specimen. All the experiments were conducted on AISI1040 grade steel specimens having as per ASTM standard as a base metal. The chemical composition of base metal by weight % is given in Tables.

Table 3.1 Chemical composition of AISI 1040 steel

Material	C	Mn	P	S
AISI 1040	0.37 – 0.44	0.60 – 0.90	0.040	0.050

Table 3.2 Input variables and their levels

Factor	Symbol	Levels		
		Level 1	Level 2	Level 3
Welding Current (A)	A	80	90	100
Welding Speed (mm/s)	B	2.5	4.5	6.5
Electrode Position (deg)	C	30	60	90
Arc Voltage (V)	D	26	28	30

4. Results & Discussions

This work has presented the application of RSM technique to determine the optimal process parameters for arc welding process. Experimentation was done according to the orthogonal array design of experiments. Using the significance and the ANOVA technique the influence of each welding parameters is studied and the prediction of the is done. Then it is used to predict the arc welding process parameters for any given welding conditions. As mentioned in previous chapter methodology, the response surface methodology was executed with the help of computer program i.e. Minitab. In this work, firstly the input parameters and response has been considered.

Response Surface Regression Model

In this work, the multi responses of the welding process like bead width, bead height and tensile strength are converted into a single objective using grey relational analysis and further analyze with response surface methodology. This empirical relationship is expressed as:

$$GRG = 5.31 - 0.0477\ A - 0.436\ B + 0.00497\ C - 0.165\ D + 0.000202\ A * A + 0.00004\ B * B - 0.000025\ C * C + 0.00276\ D * D + 0.001812\ A * B - 0.000041\ A * C + 0.000130 A * D + 0.000300\ B * C + 0.00935\ B * D \quad (4.7)$$

Where, A= Welding current B= Welding speed C= Electrode position D= Arc voltage

5. Conclusions

Due to the limitation of employing RSM in multi criteria decision making system, in multi-output process is challenging task. In this work, AISI1040 steel has been weld using the arc welding and the Grey based hybrid RSM approach has been
implemented to predict the optimal combination of the process parameters under specified domain. RSM–CCD technique is used along with the traditional Taguchi orthogonal array for experimental design and the resulting conclusions are identified below:

- In this work, AISI1040 grade steel have been taken for experimental work because it is the most used material for manufacturing in the industries to manufacture crankshaft, fasteners, coupling and cold headed parts etc.
- The technique of GRSM is effective in predicting the optimal setting of arc welding parameters for AISI1040 steel as follows: Welding Current 100amp, Welding Speed 6.5 mm/s, Electrode Position 56.06deg and Arc Voltage 30volt.
- The experimental values match reasonably well with the predicted values of R-squared (0.951) for GRG, indicating adequate fitness of the developed model.
- The proposed optimization module is quite efficient in this sense that it can overcome the limitation or assumptions of existing optimization approaches.

References

[1] D. Kim and S. Rhee, "Optimization of Arc Welding Process Using a Genetic Algorithm Parameters Genetic algorithms can determine near-optimal settings of welding process parame- ters within a large search space with relatively few experiments," *Weld. Res. Suppl.*, pp. 184–189, 2001.

[2] N. Lenin, M. Sivakumar, and D. Vigneshkumar, "Process Parameter Optimization in ARC Welding of Dissimilar Metals," *Thammasat Int. J. Sc. Tech*, vol. 15, no. 3, pp. 1–7, 2010.

[3] J. E. R. Dhas and S. Kumanan, "Optimization of parameters of submerged arc weld using non-conventional techniques," *Appl. Soft Comput. J.*, vol. 11, pp. 5198–5204, 2011.

[4] R. D. J. Edwin and H. D. S. Jenkins, "A review on optimization of welding process," *Procedia Eng.*, vol. 38, pp. 544–554, 2012.

[5] D. Katherasan, J. V. Elias, P. Sathiya, and A. N. Haq, "Flux cored arc welding parameter optimization using particle swarm optimization algorithm," *Procedia Eng.*, vol. 38, pp. 3913–3926, 2012.

[6] K. Srinivasulu Reddy, "Optimization and Prediction of Welding Parameters and Bead Geometry in Submerged Arc Welding," *Int. J. Appl. Eng. Res. Dev.*, vol. 3, no. 3, pp. 1–6, 2013.

[7] M. S. C., B. R. Narendra Babu, B. S. Praveen Kumar, and Y. Vijayakumar, "Optimization Of Shielded Metal Arc Welding Parameters For Welding Of Pipes By Using Taguchi Approach," *Int. J. Eng. Res. Appl.*, vol. 3, no. 3, pp. 1460–1465, 2013.

[8] N. Kiaee and M. Aghaie-Khafri, "Optimization of gas tungsten arc welding process by response surface methodology," *Materials and Design*, vol. 54. pp. 25–31, 2014.

[9] O. Osayi, E. A. P. Egbe, and S. A. Lawal, "Optimization of Process Parameters of Manual Arc Welding of Mild Steel Using Taguchi Method," *Am. J. Mech. Eng.*, vol. 3, no. 3, pp. 93–97, 2015.

[10] M. A. Moradpour, S. H. Hashemi, and K. Khalili, "Multi-objective Optimization of Welding Parameters in Submerged Arc Welding of API X65 Steel Plates," *J. Iron Steel Res. Int.*, vol. 22, no. 9, pp. 870–878, 2015.

[11] D. S. Jadoun, R. P. Kori, and D. K. Kasdekar, "Optimization of Welding Parameter for Arc Welding of Mild Steel Plate (Grade-40)," no. 1, pp. 13–16, 2016.

[12] G. Singh and S. K. Sharma, "Optimization of Submerged Arc Welding Process: A Review," Int. J. Adv. Res. Sci. Eng., vol. 5, no. 5, pp. 459–464, 2016.

[13] A. Kumar, M. K. Khurana, and P. K. Yadav, "Optimization of Gas Metal Arc Welding Process Parameters," IOP Conf. Ser. Mater. Sci. Eng., vol. 149, no. 1, pp. 1–11, 2016.

[14] M. V. Patil, "Multi response simulation and optimization of gas tungsten arc welding," Appl. Math. Model., vol. 42, pp. 540–553, 2017.

[15] W. Yan, H. Zhang, Z. gang Jiang, and K. K. B. Hon, "Multi-objective optimization of arc welding parameters: the trade-offs between energy and thermal efficiency," J. Clean. Prod., vol. 140, pp. 1842–1849, 2017.

[16] A. A. Shukla, V. S. Joshi, A. Chel, and B. A. Shukla, "Analysis of Shielded metal arc welding parameter on Depth of Penetration on AISI 1020 plates using Response surface methodology," Procedia Manuf., vol. 20, pp. 239–246, 2018.

[17] A. A. Sheikh and P. D. Kamble, "Optimization of welding process parameter to minimize defect in welding of sheet," Int. Res. J. Eng. Technol., vol. 5, no. 5, pp. 4310–4314, 2018.

[18] N. Ghosh, P. Kumar Pal, G. Nandi, and R. Rudrapati, "Parametric Optimization of Gas metal arc welding process by PCA based Taguchi method on Austenitic Stainless Steel AISI 316L," Mater. Today Proc., vol. 5, no. 1, pp. 1620–1625, 2018.

[19] A. Choudhary, M. Kumar, and D. R. Unune, "Experimental investigation and optimization of weld bead characteristics during submerged arc welding of AISI 1023 steel," Def. Technol., vol. 15, no. 1, pp. 72–82, 2019.

[20] A. Kumar, T. Soota, and J. Kumar, "Optimisation of wire-cut EDM process parameter by Grey-based response surface methodology," J. Ind. Eng. Int., vol. 14, no. 4, pp. 821–829, 2018.