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Review on Optimization of Submerged Arc Welding Process

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Abstract – The present review is on optimization of submerged arc welding process. The physical and mechanical properties of the weld metal vary with different welding parameters such as arc voltage, welding current and welding speed. Hence it is essential to study and optimize these factors to achieve high quality welding procedures. Engineers in the manufacturing industries and researchers always face the problem of selecting appropriate or optimum combinations of input welding parameters for achieving the required weld quality. Optimal control of the welding parameters will give the best properties of the weld and reduce weld defects. Weld strength is directly proportional to the penetration depth. Hence it is essential to study the effect of voltage, welding current and welding speed on depth of penetration, weld bead width and reinforcement height of weld.

Keywords- Submerged arc welding, Current, Voltage, arc travel speed, Width, Penetration, Flux, Taguchi, Full factorial, ANNOVA.

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1. INTRODUCTION

The SAW process is different from other arc welding processes such as shield metal arc welding, gas tungsten arc welding and gas metal arc welding. SMAW is a manual arc welding process that uses a consumable electrode with coated flux. GTAW is also a manual arc welding that uses a nonconsumable tungsten electrode with filler wire. GMAW is a semi-automatic or automatic arc welding process that uses a continuous consumable filler wire with a shielding gas such as argon or carbon dioxide. The greatest advantage of SAW is its high welding productivity due to its high deposition rate, ease of automation and low operator skill requirements. Its productivity level is about 4 to 10 times that of the SMAW welding process.

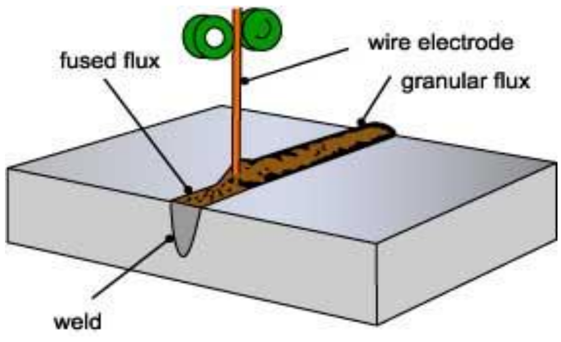

Fig. 1 Submerged Arc Welding

The arc is covered by the flux or molten slag, minimal welding fume or arc light is emitted. Therefore, the working environment is very comfortable to worker or operators who may not need to wear goggles and thick clothes to protect themselves.

Effect of welding parameters on weld geometry

i) Current

It controls the melting rate of the electrode wire and thereby the weld deposition rate. It also controls the depth of penetration and thereby the extent of dilution of the weld metal by the base metal. Too high a current causes excessive weld reinforcement which is not useful, and burn through in the case of thinner plates.

ii) Voltage

The arc voltage is key factor in determining the shape and width of the arc and to some degree also in determining its penetration.

iii) Speed of arc travel

The welding speed affects the penetration. If the speed is increased relative to the original value, penetration will be decreased and the weld will be narrower. Reducing the speed increases penetration and results in a wider weld.

iv) Wire diameter

Change in wire size will result in a change in current density. Larger wire diameter results in a reduction in penetration and to some extent also the risk of burning through at the bottom of the weld. The arc will become more difficult to strike and arc stability will be adversely affected.

2. LITERATURE SURVEY

Following are the researchers who have worked in area of optimization of submerged arc welding process.

Shahnawaz alam and Mohd.Ibrahim Khan [1] has studied effect of arc voltage, current, welding speed, wire feed rate and nozzle-to-plate distance on weld bead width. They used two level full factorial techniques for experiment design. Multiple regressions analysis has been used to develop a mathematical model to predict weld width using a single wire Submerged arc welding. Adequacy and significance of the model has been checked by using ANNOVA, F-test and t-test respectively. They suggested that, the two levels full factorial designs are an effective tool for quantifying the main and interaction effect of variables on weld width and developed model can be effectively used to predict the weld width in the submerged arc welding within the range of parameters used.

Sourav datta et al. [2] has worked to evaluate an optimal parameter combination to obtain acceptable quality characteristics of bead geometry in submerged arc welding. They designed SAW process to consume fused flux/slag, in the mixture of fresh flux. Thus, their work tries to utilize the concept of 'waste to wealth'. They conduct the Experiments using welding current, slag-mix percentage and flux basicity index as process parameters and varied at four different levels. They used Taguchi optimization technique followed by grey relational analysis to determine the optimal amount of slag-mix to be used without affecting any quality parameters of satisfactory weld bead.

Ankita Singh et al. [3] applied Taguchi's robust design coupled with fuzzy based desirability function approach for optimizing multiple bead geometry parameters of submerged arc weldment.

Anirudha Ghosh et al. [4] developed mathematical model based on multi-regression method and side by side predicted through artificial neural networks. They concluded that, the neural network model is capable of making bead geometry prediction of the real-time quality control based on observations of bead geometry and for online welding process control. They described graphically prediction technique, which is able to give maximum, minimum range of possible output and input variables, side by side just clicking on the graphs idea of variables can be available quickly and accurately. It is the main advantage, different from others of this method.

Saurav Datta et al. [5] treated the percentage of fused flux in the mixture as a process parameter. Various bead geometry parameters viz. bead width, reinforcement; depth of penetration and depth of HAZ have been measured for each of weld prepared in the study. They adopted and applied Taguchi optimization technique coupled with grey relational analysis for evaluating optimal parametric combination to achieve acceptable depth of penetration that is deeper penetration and minimum bead height, bead width and depth of HAZ. They suggested that Taguchi method is very efficient for process optimization technique that can be performed in a limited number of experimental runs.

Keshav Prasad and D. K. Dwivedi [6] investigates the influence of the submerged arc welding process parameters that is welding current and welding speed on the microstructure, hardness, and toughness of HSLA steel weld joints. They concluded that, the increase in heat input coarsens the grain structure both in the weld metal and heat affected zone (HAZ). The hardness has been found to vary from the weld centre line to base metal and peak hardness was found in the HAZ.

S. Kumanan et al. [7] applied Taguchi technique and regression analysis to determine the optimal process parameters for submerged arc welding. They conducted planned experiment in semiautomatic SAW machine and signal-to-noise ratios are computed to determine the optimum parameters.

Syarul Asraf Mohamat et al. [8] studied the effect of SAW process parameters on different response parameters by using robotic welding with the variables in welding current, speed and arc voltage. The effects are on welding penetration, micro-structural and hardness measurement. They concluded that, Welding current is a factor that influences the penetration. Arc voltage and welding speed are also a factor that can influence the penetration.

N.B. Mostafa et al. [9] studied prediction of weld penetration influenced by process parameters of welding current, arc voltage, nozzle to plate distance, electrode to work angle and welding speed and optimize these parameters to maximize weld penetration. The optimization result also shows that weld penetration attains its maximum value when welding current, arc voltage, nozzle to plate distance and electrode to work angle are at maximum value and welding speed is having minimum value.

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Saurav Datta et al. [11] solved the correlated multiple criteria optimization problem of submerged arc welding. Their target was to search an optimal process environment, capable of producing desired bead geometry parameters of the weldment. Four correlated features of bead geometry, depth of penetration, reinforcement, bead width and percentage dilution had selected in the study. The process environment has been assumed consisting of four variables like voltage, wire feed rate, traverse speed, and electrode stick-out. Taguchi's robust optimization technique has been applied to determine the optimal setting.

Y. S. Tarng et al. [12] studied the use of fuzzy logic in the Taguchi method to optimize the submerged arc welding process with multiple performance characteristics. They employed an orthogonal array, the signal-to-noise ratio, multi response performance index, and analysis of variance to study the performance characteristics in the submerged arc welding process. They optimized process parameters, namely arc current, arc voltage, welding speed, and preheat temperature with considerations of the performance characteristics, including deposition rate and dilution. They presented an application of fuzzy logic using the Taguchi method for the optimization of the submerged arc welding process with multiple performance characteristics. They used Fuzzy logic to perform a fuzzy reasoning of the multiple performance characteristics.

Saurav Datta et al. [13] have applied Taguchi philosophy for obtaining optimal parametric combinations to achieve desired weld bead geometry and dimensions related to the heat affected zone, such as HAZ width in submerged arc welding. They adopted Taguchi's L9 orthogonal array design and experiments have been conducted accordingly with three different levels of conventional process parameters. The slag, generated during welding, has been consumed in further runs by mixing it with fresh unmelted flux. The percentage of slag in the mixture of fused flux (slag) and fresh flux has been defined as slag mix percentage. Welding has been performed by using varying slag mix percentage, treated as another process variable, in order to obtain the optimum amount of slag-mix that can be used without any alarming adverse effect on features of bead geometry and HAZ.

Ravinder Pal Singh et al. [14] have studied a comprehensive review of parameters of submerged arc welding and their effect on weld quality. They suggested that, Very less work has been reported on metal transfer in submerged arc welding. An efficient metal transfer behavior enables uniform stream of small droplets transferred from the electrode at given current. The material transfers across the arc gap influences the chemical composition and metallurgy of weld metal, arc stability, and weld bead geometry as well as strength of the weld. The study of effect of polarity change on metal transfer behavior in submerged arc welding is scarce. Polarity change affects the amount of heat generated at welding electrode and work piece and hence influences the metal deposition rate, weld bead geometry and mechanical properties of the weld metal.

Pranesh B.Bamankar et al. [15] have done work on Study of the effect of process parameters on depth of penetration and bead width in SAW process. Experiments are conducted using SAW process parameters viz. welding current, arc voltage and welding speed (Trolley speed) on mild steel of 12 mm thickness to study the effect of these parameters on penetration depth. The experiments are designed using Taguchi method (with Taguchi L9 orthogonal array) considering three factors and three levels. The results shows penetration will be at maximum value when welding current and arc voltage are at their maximum possible value and welding speed is at its minimum value.

K. Kishore et al. [16] worked on analysis of defects in gas shielded arc welding of AISI1040 steel using Taguchi method. Design of experiments based on orthogonal array is employed to develop the weldments. The weldments are subjected to testing to find the qualitative properties. The data obtained is checked for adequacy based on ANOVA. The result is computed in the form of contribution from each parameter through which optimal parameters are identified for minimum defects. The data in this work is collected using ultrasound testing in which angle beam technique is adopted for the testing of weldments and results are quantified accordingly. The testing of specimens indicated the presence of defects like LOP, LOF, Blowhole, and Cracks.

Gowthaman.K et al. [17] experimented on determination of SAW parameters using Taguchi method and Regression analysis. They used Taguchi technique and regression analysis to determine the optimal process parameters for SAW. The planned experiments are conducted in the semiautomatic submerged arc welding machine and the signal-to-noise ratios are computed to determine the optimum parameters. The percentage contribution of each factor is validated by ANOVA technique. Multiple regression analysis is conducted using statistical package for social science software and the mathematical model is built to predict the bead geometry for any given welding conditions.

J. Edwin et al. [18] were collected data as per Taguchi's Design of Experiments and regression analysis was carried to establish input–output relationships of the process. By this relationship, an attempt was made to minimize weld bead width, a good indicator of bead geometry using optimization procedures based on the genetic algorithm (GA) and particle swarm optimization (PSO) algorithm to determine optimal weld parameters. The optimized values obtained from these techniques were compared with experimental results and presented.

Dhas et al. [19] have elaborated the study of welding procedures generation for the submerged arc welding process.

Biswas et al. [20] studied the effect of process parameters on output features of submerged arc weld by using Taguchi method

3. CONCLUSION

The literature review gives insight into the SAW assisted welding of different materials. Various input parameters of the process are welding current, welding voltage, arc travel speed, stick out distance, wire feed rate and output parameters are weld bead width, depth of penetration, height of reinforcement, hardness, tensile strength, impact strength and weld deposition rate.

Researchers have investigated the effects of various input parameters of the process on output parameters which are mentioned above.

Design of experiment methods such as Full Factorial Design, Taguchi Method and Response Surface Methodology were used with different optimization techniques. Traditional along with newly developed optimization methods were used to evaluate the optimum value of process parameter.

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REFERENCES

[1] Shahnwaz Alam and Mohd.Ibrahim Khan, “Prediction of the Effect of Submerged Arc Welding Process Parameters on Weld Bead Width for MS 1018 Steel”, International Journal of Engineering and Innovative Technology (IJEIT) Volume 1, Issue 5, may 2012, 2277-3754.

[2] Saurav Datta, Asish Bandyopadhyay and Pradip Kumar Pal, “Modeling and optimization of features of bead geometry including percentage dilution in submerged arc weldingusing mixture of fresh flux and fused slag”, International Journal of Advanced Manufacturing Technology, 2008 DOI 10.1007/s00170-006-0917-4, 36:1080–1090.

[3] Ankita Singh, Saurav Datta, Siba Sankar Mahapatra,Tapan Singha and Gautam Majumdar, “Optimization of bead geometry of submerged arc weld using fuzzy based desirability function approach”, Journal of Intelligence Manufacturing, Publish online, April 2011, DOI 10.1007/s10845-011-0535-3.

[4] Aniruddha Ghosh, Somnath, Chattopadhyaya, R.K.Das and P.K.Sarkar, “Prediction of Submerged Arc Welding Yield Parameters through Graphical Technique”, Procedia Engineering, October 2011, 2797–2802.

[5] Saurav Datta, Asish Bandyopadhyay and Pradip Kumar Pal, “Slag recycling in submerged arc welding and its influence on weld quality leading to parametric optimization”, International Journal of Advanced Manufacturing Technology 2008, DOI 10.1007/s00170-007-1224-4, 39:229–238.

[6] Keshav Prasadand and D. K. Dwivedi, “Some investigations on microstructure and mechanical properties of submerged arc welded HSLA steel joints”, International Journal of Advanced Manufacturing Technology 2008 DOI 10.1007/s00170-006-0855-1, 36:475–483.

[7] S. Kumanan, J. Edwin Raja Dhas and K. Gowthaman, “Determination of submerged arc welding process parameters using Taguchi method and regression analysis”, Indian Journal of engineering and material sciences, vol. 14, June 2007, 177-183.

[8] Syarul Asraf Mohamata, Izatul Aini Ibrahima, Amalina Amira and Abdul Ghaliba, “The Effect of Flux Core Arc Welding (FCAW) processes on different Parameters”,74 International Symposium on Robotics and Intelligent Sensors 2012 (IRIS 2012), 1497 – 1501.

[9] N.B. Mostafa and M.N. Khajavi, “ Optimization of welding parameters for weld penetration in FCAW”, Journal of achievements in materials and manufacturing engineering, vol.16, issue 1-2, may- June 2006, 132-136.

[10] Abhay Sharma, Navneet Arora and Bhanu K. Mishra, “A practical approach towards mathematical modeling of deposition rate during twin-wire submerged arc welding”, International Journal of Advanced

Manufacturing Technology 2008 DOI 10.1007/s00170-006-0847-1, 36:463–474.

[11] Saurav Datta, Goutam Nandi, Asish Bandyopadhyay and Pradip Kumar Pal, "Application of PCA-based hybrid Taguchi method for correlated multicriteria optimization of submerged arc weld: a case study", International Journal of Advanced Manufacturing Technology 2009, DOI 10.1007/s00170-009-1976-0, 45:276–286.

[12] Y. S. Tarng, W. H. Yang and S. C. Juang, "The Use of Fuzzy Logic in the Taguchi Method for the Optimizations of the Submerged Arc Welding Process", International Journal of Advanced Manufacturing Technology 2000, 16:688–694.

[13] Saurav Datta, Ashish Bandyopadhyay and Pradip Kumar Pal, "Grey-based Taguchi method for optimization of bead geometry in submerged arc bead-on-plate welding", International Journal of Advanced Manufacturing Technology 2008 DOI 10.1007/s00170-007-1283-6, 39:1136–1143.

[14] Ravinder Pal Singh, R.K. Garg and D.K. Shukla, "Parametric Effect on Mechanical Properties in Submerged arc welding process - A review", International Journal of Engineering Science and Technology (IJEST) Feb.2012, Vol. 4 No.02 0975-5462.

[15] Pranesh Bamankar, Dr. S.M. Sawant, "Study of the effect of process parameters on depth of penetration and bead width in SAW" International Journal of Advanced Engineering Research and Studies ,Vol. 4, 2013, pp. 08-10.

[16] K. Kishore, P.V. Gopal Krishnan, K. Veladri, Qasim Ali, "Analysis of defects in gas shielded arc welding of AISI1040 steel using Taguchi method" ARPN Journal of Engineering and Applied Sciences, Vol. 5,2010, pp. 37-41

[17] Gowthaman.K, Saiganesh.J, Rajnikam.CS, "Determination of SAW process parameters using Taguchi method and Regression analysis "Indian Journal of engineering and materials sciences, Vol.14 , 2007, pp. 177-183.

[18] J. Edwin Raja Dhas, S. Kumanan, "Optimization of parameters of SAW using non-conventional techniques" Applied Soft Computing, Vol. 11, 2011, pp.5198-5204

[19] Dhas, R., Edwin, J., Gothman, K. and Kumanan, "Determination of submerged arc welding process parameters using Taguchi method and regression analysis", Indian Journal of Engineering & Materials Sciences, pp.177-183.

[20] Biswas, S., Mahapatra, S.S. and Patnaik, "An Evolutionary Approach to Parameter Optimization of Submerged Arc Welding inthe Hardfacing Process", International Journal of Manufacturing Research, vol.2, no. 4, 2007, pp. 462-483.

[21] A Manual of Submerged arc welding by ESAB India Ltd.

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