A Review on Parametric Optimization of Submerged Arc Welding Process

Harsh H. Patel[1] Yagnang R. Pandya[2] Rakesh B. Prajapati[3]
[1,2]Department of Mechanical Engineering
[1,2]AIT [3]Sal College of Engineering

Abstract— Submerged arc welding is preferable more its inherent qualities such as Higher deposition rate, deeper penetration, control of variables, high quality, smooth finish. The bead geometry shows the quality of weld which is depends on input process parameters. The present work gives review of the effect of these Input parameters on weld bead geometry. Selection of process parameters has great influence on the quality of a welded connection. To automate a welding process, which is the present trend in any fabrication industry. It is also important that mathematical models have to be developed to relate the process variables to the weld bead parameters. All the welding processes are used with the aim of getting a welded joint with the desires weld bead geometry and excellent mechanical properties with a efficient quality welded joint at a relatively low cost with high productivity. Optimization designs concentrate on only one or two parameters, but in very more depth to gain a precise understanding of relationships between parameters.

Key words: Submerged arc welding (SAW), process parameters, Weld bead geometry, Design of experiments, parametric optimization

I. INTRODUCTION

Submerged arc welding is basically an arc welding process. Submerged arc welding is the best efficient welding process for fabrication industries. In submerged arc welding process Coalescence is produced by heating application with an electric arc and arc set up model between a bare metal electrode and the work piece. The basic components of submerged arc welding are power source, flux hopper, electrode wire, granular flux, control panel, welding gun. As per the name given arc is merged beneath a layer of granular flux in this type of welding. The power source can be a transformer for AC welding or a rectifier (motor generator) for DC welding. The consumables are a bare, possibly coppered, continuous electrode and a granular welding flux fed to the joint by a hose from a flux hopper. The arc burns in a cavity filled gases like CO2, CO and etc. formed by breakdown on the total flux and metal fumes. Use of these technology and social implications in the national prospective. The effective process parameters include Arc current, Arc voltage, Welding speed, nozzle to plate distance, Wire feed rate and flux basicity index. The present work gives review of the effect of these parameters on weld bead geometry and flux consumption. Submerged arc welding is one of the oldest automatic welding process during 1930 s and it contributes to approximately 10% of the total welding needs the world. It is generally used for welding of low carbon steels, high strength low alloy steels, nickel base alloys and stainless steels. Apart from coalescence this process can be used for cladding applications to increase corrosion resistance and wear resistance on the surfaces. Weld produced are uniform, ductile, sound and good impact resistance.

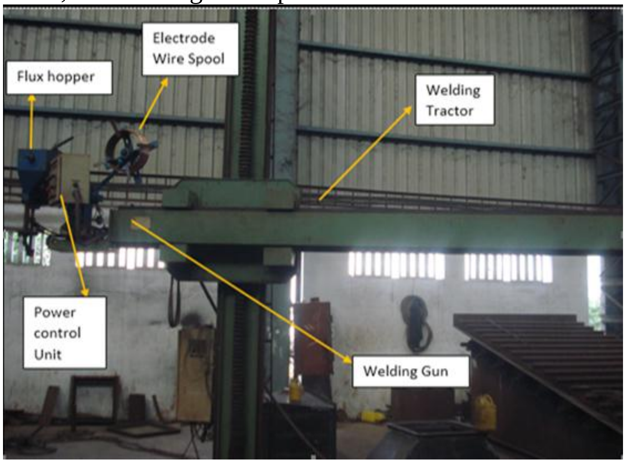

Fig. 1: Submerged Arc Welding Machine

II. LITERATURE REVIEW

Serdar Karaoglua et al. [1] has investigated that the sensitivity analysis of Input parameters and fine tuning requirements of the Input parameters for optimum weld bead geometry. Changeable process Input parameters such as welding current, welding voltage and welding speed are used as Input parameters in this study. The output parameters are width, height and penetration of the weld bead. In this Experimental part of the study is based on three level factorial design of three process parameters. In order to investigate the effects of input (process) parameters on output parameters, which determine the weld bead geometry, a mathematical model is constructed by using multiple curvilinear regression analysis. After carrying out a sensitivity analysis using developed empirical equations, relative effects of input parameters on output parameters are obtained. Effects of all three design parameters on the bead width and bead height show that even small changes in these Input parameters plays an important role in the quality of welding operation. The result also shows that the penetration is almost non-sensitive to the variations in voltage and speed. It was conclude that Bead width is more sensitive to voltage and speed variations than that of bead height and penetration. All three Input process parameters have effects in determining the bead height. In order to decrease the bead height, higher values of voltage and speed can be considered. Current is the most important parameter in determining the penetration. Voltage and speed cannot be effectively used to control penetration.

N. Murugana et.al. [2] has investigated that it is very essential that mathematical models have to be enveloped to relate the process variables to the weld bead parameters or output parameters. Because of its high productivity, smooth finish, high reliability and deep penetration submerged arc welding (SAW) has become a natural choice in industries for fabrication, especially for welding of pipes. In this study they selected welding speed, Arc voltage, Wire feed rate, and nozzle to plate distance as input parameters and responses are bead width, reinforcement and penetration. Mathematical models have been developed for submerged arc welding (SAW) of pipes using five level factorial techniques to predict three critical dimensions of the weld bead geometry and shape relationships. The models developed have been checked for their adequacy and significance by using the F-test and the t-test, respectively. Main and interaction effects of the input process parameters on bead geometry and shape factors are presented in graphical form and using which not only the prediction of important weld bead dimensions and shape relationships but also the controlling of the weld bead quality by selecting appropriate process parameter values are possible. On experimentation and investigation it was concluded that out of the four process variables considered, wire feed rate had a significant positive effect but welding speed had an appreciable negative effect on most of the important bead parameters, Reinforcement form factor, penetration size factor, penetration and bead width all increased with the increase in wire feed rate for all values of welding speed but this increasing rate of the bead parameters with the increase in wire feed rate(F), gradually decreased with the increase in welding speed(S).

Y.S. Tarng et al. [3] has studied and investigated that the use of the grey-based Taguchi method to obtain the submerged arc welding (SAW) process parameters with consideration of multiple performance characteristics has been studied in this paper. A grey relational analysis of the S/N ratios can convert the optimization of the multiple performance characteristics into the optimization of a single performance characteristic known as the grey relational grade. A grey relational grade obtained from the grey relational analysis is used as the performance characteristic in the Taguchi design of experiment method. In this paper arc current, welding speed, arc voltage, preheat temperature and electrode stick out are use as input parameters and responses are deposition rate, dilution and hardness. Then, optimal process parameters are determined by using the parameter design proposed by the Taguchi method. Experimental results have shown that optimal submerged arc welding (SAW) process parameters in hardfacing can be determined effectively so as to improving multiple weld qualities through this new approach. On experimentation and investigation it was concluded that arc current, welding speed, and electrode stick-out are the significant welding process parameters for affecting the multiple performance Characteristics. It is also shown that the performance characteristics of the submerged arc welding (SAW) process such as Deposition rate, dilution, and hardness are improved together by using the method proposed by this study.

J. Edwin Raja Dhas et al. [4] has investigated that the effect of weld input parameters such as welding current, welding speed, electrode stick out and welding current on geometry of weld bead. A relationship between them is thought to be complicated because of the non-linear characteristics. In this paper trial-and-error methods to obtain optimal conditions incur considerable time and cost. In order to overcome these problems, non-traditional methods have been suggested. Bead-on-plate Welds were carried out on mild steel plates using semi-automatic submerged arc welding (SAW) machine. Data were collected as per taguchi's design of experiments and regression analysis was carried out to establish input–output relationships of the process. By this relationship, an attempt was made to minimize weld bead width which is a good indicator of bead geometry, using optimization procedures based on the genetic algorithm (GA) and particle swarm optimization (PSO) algorithm to obtain optimal weld parameters. On Experimentation and investigation it was concluded that the developed PSO algorithm is a powerful tool in experimental welding optimization, even when experimenter does not have to model the process. These tools find a good scope in the welding shop floor environment to set the initial process parameter for the weld.

V. Gunaraj et al. [5] has studied and investigated that the use of response surface methodology(RSM) by designing a four-factor five-level central composite rotatable design matrix with full replication for planning, conduction, execution and development of mathematical models. These are important not only for predicting the weld bead quality but also for selecting optimum process parameters for achieving the desired quality and process optimization. This paper use input parameter as the open-circuit voltage (V), the wire feed rate (F), the welding speed (S) and the nozzle-to-plate distance (N), as input parameter and the penetration (P), the reinforcement (R), the width (W) and the percentage dilution (D) are as output parameters. This study used IS 2062 as base material. Response surface methodology (RSM) is a important technique to determine and represent the cause and effect relationship between true mean responses and input control variables influencing the responses as a two or three dimensional hyper surface. Submerged arc welding (SAW) is used mostly in industry to join metals in the manufacture of pipes of different length and diameters. The main problem faced in the manufacture of pipes by the submerged arc welding (SAW) process is the selection of the optimum combination of input parameters for achievement of the required qualities of weld. This problem can be solved by the development of mathematical models through effective and strategic planning and the execution of experiments by response surface methodology (RSM). On Experimentation and investigation it was concluded that all of the responses viz. penetration (P), reinforcement (R), bead width (W), and dilution (D) decrease with increase in welding speed. As the nozzle-to-plate distance increases, penetration (P), width (W), and dilution (D) decrease, but Reinforcement(R) increases. An increase in the wire feed rate results in an increase in penetration (P), reinforcement (R), and dilution (D), but width (W) remains unaltered.

D.V. Kiran.et al. [6] has investigated that detailed experimental study on the influence of leading wire current, welding speed, trailing wire current pulses on the weld bead dimensions and mechanical properties in singlepass tandem submerged welding of a typical high strength low alloy (HSLA) steel. This study use current, voltage and welding speed as input parameter and weld beds width, reinforcement and cooling rate as responses. Two-wire tandem submerged arc welding process include simultaneous depositions from two electrode wires with the leading wire generally connected to a DC power source and the trailing wire connected to a pulsed AC power source. The weld bead profile and mechanical properties in the tandem submerged welding are significantly affected by the leading and trailing wire current transients and the welding Speed. The experimental results show that the final weld bead width and reinforcement height are primarily influenced by the trailing wire current while the penetration is influenced by the leading wire current with the other conditions remaining constant. Increase in trailing wire current pulses enhance the weld pool size that tends to reduce the cooling rate, inhibit acicular ferrite phases in weld microstructure and result in poor mechanical properties.

Shahnwaz Alamet al. [7] has investigate that two level full factorial a technique has been used for experiment design. Multiple regression analysis has been used to develop a mathematical model to predict weld width using a single wire Submerged arc welding depositing bead-on-plate welds on 12mm plate. This investigation uses arc voltages, current, welding speed, wires feed rate and nozzle-to-plate distance as process parameters and AISI 1018 as base material. Adequacy and significance of the model has been checked by using analysis of variance, F-test and t-test respectively. Main and interaction effects of process variables on weld-width have been graphically presented. Experiments have been performed to compare the results obtained with the corresponding predicted values. The models developed have been found to be adequate with a confidence level 95%.Weld width has been found to increase with increase in voltage, current and wire feed rate and decreases with increase in welding speed and nozzle-to-plate distance. Cross validation test fulfills the validity of the model developed. On Experimentation and investigation it was concluded that Weld width rapidly increases with voltage, slowly increases with current and wire feed rate and decreases with welding speed and nozzle to plate distance.

Pranesh B. Bamankar et al. [8] has investigate that controlling metal transfer modes in submerged arc welding (SAW) process is necessary to high quality welding procedures. Quality has now become an important issue in today's manufacturing world. Experiments are conducted using submerged arc process parameters viz. welding current, welding speed (trolley speed) and arc voltage 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. On Experimentation and investigation it was concluded that Current is predominant factor affect the bead width. Bead width almost linearly increases with arc voltage and current and decreases, with welding speed.

III. CONCLUDING REMARKS

On the basis of literature survey conclude that many researchers have worked on different type of material by using different type of parameters like arc current, arc voltage, welding speed, nozzle to plate distance, basicity index, pre heat temperature and etc. And effect of these parameters was studied on various materials like IS 2062 steel plate, HSLA steel, AISI 1018 low/mild carbon steel and etc. and its effect on output parameters like weld bead width, bead height, penetration and etc. by using different types of design of experiment techniques such as taguchi, response surface methodology and full factorial design. In most of the works welding current, arc voltage, welding speed, nozzle to plate distance and wire feed rate are considering for predicting and optimizing the weld bead geometry. However certain the other parameters such as wire diameter, welding gun Angle, flux feed rate, preheat Temperature are not concentrated much especially.

- Some researchers conclude that the arc Current is the most important parameter in determining the penetration. Penetration is almost non-sensitive to variations in voltage and speed.
- Bead width is more sensitive to voltage and speed variations than that of all three process parameters have effects in determining the bead height.
- Penetration, width, penetration size factor and reinforcement form factor all increased with the increase in wire feed rate for all values of welding speed but this increasing rate of the bead parameters with the increase in wire feed rate (F) gradually decreased with the increase in welding speed(S).

REFERENCES

[1] Serdar Karaoglu, Abdullah Secgin," Sensitivity analysis of submerged arc welding process parameters" journal of materials processing technology 202 (2008) 500–507, October 2007.

[2] N. Murugan, V. Gunaraj," Prediction and control of weld bead geometry and shape relationships in submerged arc welding of pipes" Journal of Materials Processing Technology 168 (2005) 478–487, 2005.

[3] Y.S. Tarng, S.C. Juang, C.H. Chang , "The use of grey-based Taguchi methods to determine submerged arc welding process parameters in hardfacing", Journal of Materials Processing Technology 128 (2002) 1–6,2002.

[4] J. Edwin Raja Dhas, S. Kumanan, "Optimization of parameters of submerged arc weld using non-conventional Techniques" Applied Soft Computing 11 (2011) 5198–5204, May 2011.

[5] V. Gunaraj, N. Murugan," Application of response surface methodology for predicting weld Bead quality in submerged arc welding of pipes", Journal of Materials Processing Technology 88 (1999) 266–275, 1999.

[6] D.V. Kiran, B. Basu , A. De , "Influence of process variables on weld bead quality in two wire tandem submerged arc welding of HSLA steel", Journal of Materials Processing Technology 212 (2012) 2041–2050, May 2012.

[7] Shahnwaz Alam, Mohd.Ibrahim Khan, "Prediction of the Effect of Submerged Arc Welding Process Parameters on Weld Bead Width for MS", International Journal of Engineering and Innovative Technology (IJEIT) Volume 1, Issue 5, May 2012.

[8] Pranesh B. Bamankar, Dr. S.M. Sawant, "Study of the effect of process parameters on depth of penetration and bead width in saw (submerged arc welding) process", International Journal of Advanced Engineering Research and Studies E-ISSN2249–8974, IJAERS/Vol. II/ Issue III/April-June, 2013.

