A Survey on Submerged Arc Welding (SAW)-Review

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Abstract— Welding is a system of unchanging joining two materials (ordinarily metals) through kept blend coming about as a result of a suitable mix of temperature, weight and metallurgical conditions. Dependent upon the blend of temperature and weight from a high temperature with no weight to a high weight with low temperature, a wide extent of welding frames has been made. There are various sorts of welding including Metal Arc, Submerged Arc, Resistance Butt, Flash, Spot, Seam and Projection. While there are various systems for joining metals, welding is a champion among the most supportive and quick techniques 1available. SAW is in a general sense a round section welding process in which the bend is covered up by a front of granular and fusible motion. Thusly, physical properties of motion are basic examinations in SAW for upgrading welding properties.

Key words: Submerged Arc Welding (SAW), GMAW, FCAW

I. Introduction

SAW is in a general sense a round section welding process in which the bend is covered up by a front of granular and fusible transition. Thusly, physical properties of motion are basic considerations in SAW for upgrading welding properties. The wellspring of warmth for SAW is gotten from the round fragment delivered between an uncovered solid metal (or cored) as a consumable wire terminal and the workpiece. The roundabout section is kept up in a depression of fluid motion or slag that refines the weld metal and shields it from barometrical corrupting. Amalgam fixings in motion attempt to update the mechanical properties and break obstacle of the weld store. Submerged Arc Welding is a blend welding process in which warm is conveyed from a round fragment between the work and a steadily supported filler metal cathode. The fluid weld pool is protected from the incorporating atmosphere by thick front of fluid transition and slag molded from the granular fluxing material pre-put on the work. Welding isn't new. The most brief known sort of welding, called gathering welding, comes back to the year 2000 B.C. Configuration welding is a grungy procedure of joining metals by warming and beating until the point that the metals are united (blended) together. A victor among the most gigantic welding outlines imagined and completely utilized all through the world is Submerged Arc welding. Submerged Arc was not the essential altered welding process. Licenses dating in the mid 1920's portray tweaked welding shapes. It is a multifaceted devise for adjusted welding with a predictable revealed wire feed from a reel to the weld zone. The awesome part depicted in this patent is the utilization of vacillating of the wire in the joint to be welded. Regardless, correspondingly comparatively likewise with various other machine licenses of the time, it was utilized with an open twist in air. Assorted references watch the welds from this fundamental technique contained porosity and were not reasonable for a couple of uses.

II. Principle of SAW

The chart beneath demonstrates, in schematic structure, the primary standards of submerged curve welding. The filler material is an uncoated, persistent wire cathode, connected to the joint together with a stream of fine-grained transition, which is provided from a motion container by means of a cylinder. The electrical opposition of the anode ought to be as low as conceivable to encourage welding at a high flow, thus the welding flow is provided to the terminal through contacts extremely near the circular segment and promptly above it. The bend consumes in a hole which, aside from the circular segment itself, is loaded up with gas and metal vapor. The extent of the pit before the circular segment is depicted by unmelted essential material, and behind it by the liquid weld. The highest point of the depression is shaped by liquid transition. The graph likewise demonstrates the cemented weld and the hardened transition, which covers the weld in a slight layer and which should in this way be evacuated. Not the majority of the transition provided is spent: the overabundance motion can be sucked up and utilized once more.

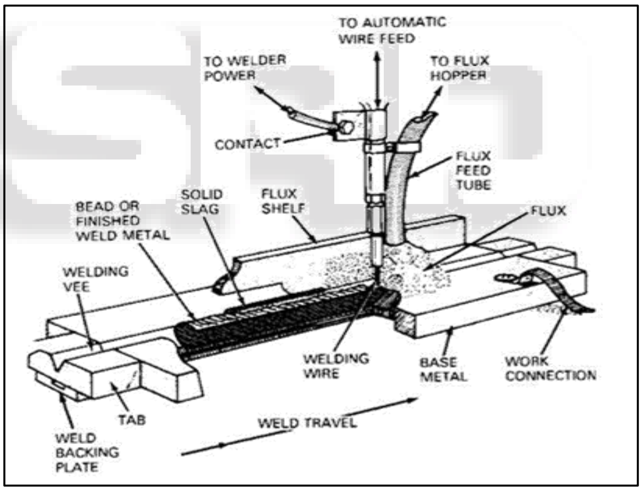

Fig. 1: Submerged Arc Welding

The filler metal is a continuously-fed wire electrode like GMAW and FCAW. Since the procedure is completely motorized, a few variations of the procedure can be used, for example, different lights and limited hole welding. The transition additionally has a warm protecting impact, and therefore lessens heat misfortunes from the circular segment. Thus, a greater amount of the information vitality is accessible for the genuine welding process itself than is the situation with procedures including an uncovered circular segment. The warm effectiveness is more noteworthy and the rate of welding is quicker. It has been discovered that submerged circular segment welding has a warm productivity of around 90 %, as against a rough estimation of around 75 % for MMA welding. Submerged curve welding can be performed utilizing either DC or AC.

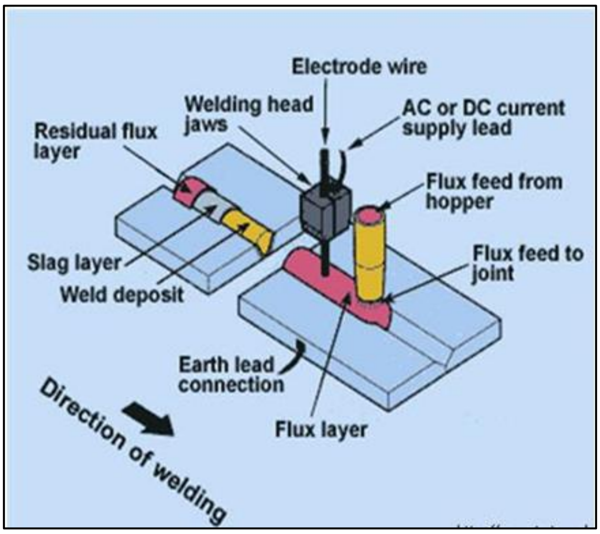

Fig. 2: Direction of Welding Process

III. Literature Survey

Submerged Arc Welding is a combination welding process in which warm is delivered from a circular segment between the work and a persistently encouraged filler metal cathode. Many analytical models have been developed using finite element analysis, and neural network. A summary of the work previously done on SAW is accessible in this section.

A. *Brief Literature Survey*

The work already done on the topic is presented below:

V Gunaraj et al.(2000), This paper features an examination and investigation of different process control factors and imperative weld globule quality parameters in observed of funnels made out of auxiliary steel (IS:2062) [1]. Numerical models were produced for the submerged circular segment welding of 6-mm thick auxiliary steel plates utilizing 3.15-mm-distance across steel cathodes. The models were created utilizing the five-level factorial method to relate the vital procedure control factors welding voltage, wire feed rate, welding velocity and spout to-plate separation to a couple of essential dab quality parameters infiltration, fortification, globule width, complete volume of the weld dot and weakening. The models created were checked for their ampleness with the f test. Utilizing the models, the fundamental and collaboration impacts of the procedure control factors on critical dab geometry parameters were resolved quantitatively and exhibited graphically

The created models and charts appearing direct and cooperation impact of process factors on the globule geometry are exceptionally helpful in choosing the procedure Parameters to accomplish the ideal weld dot quality. Additionally, the exactness of the outcomes acquired with the scientific models were tried by utilizing similarity trials. The trials were directed almost two years after the improvement of numerical models with the equivalent test setup, and it was discovered the exactness of the anticipated outcomes is about 98%. Further, these numerical models help to enhance SAW to make it a more savvy process.

Vera Lu et al. (2001), completed Post weld warm treatment (PWHT) is as often as possible connected to steel weight vessels, following the necessities of the ASME code, which sets up the parameters of the PWHT dependent on the thickness and compound sythesis of the welded segment [2]. This work demonstrates the consequences of an examination embraced on an example of ASTM A537 C1 steel exposed to qualifying welding technique tests including PWHT. The outcomes got demonstrated that this PWHT practice advanced a decrease in the mechanical properties of the base metal and the warmth influenced zone (HAZ).

Janez et al.(2003), an endeavor has been made to examine the impact of open circuit voltage, welding current, welding pace and basicity list on globule geometry and shape connections (dot width, weld entrance and stature of fortification ,weld infiltration shape factor and weld support frame factor), utilizing created fluxes, through tests dependent on structure framework [3]. The investigation of difference (ANOVA) system has been received to check the dimension and level of the immediate or intuitive impact of welding current, voltage, welding pace and flux basicity file on highlights of globule geometry and shape relationship. Reaction surface approach has been connected to infer numerical models that relate to the welding wonders utilizing created fluxes .Predictive condition have been utilized to speak to graphically the impact of process parameters on different reactions. No work so far has been performed which considers the four critical process parameter utilized in this investigation utilizing fluxes created from waste flux dust.

R Quintana et al. (2003), created metal coatings with complex compound sytheses and stages, just as varying mechanical properties, the Submerged Arc Welding (SAW) process is frequently utilized, utilizing an incredible assortment of kinds of agglomerate fluxes1 [4]. All agglomerate fluxes comprise of two key parts: the network and the alloyed load. The two constituents of the flux total, by different procedures, with the assistance of agglomerating operators. Agglomeration by granulation (pelletising) utilizing fluid sodium or potassium glass is the most well-known and broadly utilized for these kinds of fluxes.

Ana Ma. et al. (2003), talked about synthetic and auxiliary portrayal of fluxes for submerged-circular segment welding was led [5]. Three flux details were readied utilizing mineral oxides for agglomerating and sintering forms. A business agglomerated and sintered flux was utilized for correlation. The four fluxes were broke down artificially by nuclear ingestion and X-beam diffraction to determinate the amount and sort of oxides shaped, just as the adjustment in oxidation number after the sintering procedure at 950 ºC of the underlying mixes. Differential thermal examination was done from 1000 to 1350 ºC so as to decide the temperatures for stage changes and dissolving of the diverse mixes framed in the sintering procedure.

This sort of flux portrayal empowers us to evaluate the particles that may be available in the plasma circular segment amid the submerged welding process due to the fluxes. This investigation additionally makes conceivable the forecast of responses in the weld pool.

A standout amongst the most huge productivity qualities of an agglomerate flux is the effectiveness of the exchange of the substance component of the alloyed heap of the flux to the kept metal by specific wire-flux frameworks and welding regimens. The components of the alloyed load can comprise up to 85% of the creation cost of the flux. A standout amongst the most broadly utilized and financial compound frameworks for fluxes used to restore pieces subject to wear because of scraped area and light effect, and for metal to metal wear, is the framework comprised by FeCr, FeMn and graphite. The substance movement and auxiliary qualities of the network of the agglomerate flux impact the viability of the exchange of the concoction components alloyed to the metal kept amid SAW. In concoction terms, the SAW procedure can be viewed as an extremely heterogeneous response, which creates in various states and scopes of temperature and focus, the responding segments of which are wire-terminal, flux and base material. The last result of this response is a combination (welding line), with a particular concoction creation, microstructure and mechanical properties, which can be changed by innovative parameters, with slag and gases.

P. Kanjilal et al. (2005), had demonstrated rotatable plans dependent on factual investigations for blends have been produced to anticipate the joined impact of flux blend and welding parameters on submerged circular segment weld metal concoction creation and mechanical properties [5]. Globule on-plate weld stores on low carbon steel plates were made at various flux sythesis and welding parameter mixes. The outcomes demonstrate that flux blend related factors dependent on individual flux fixings and welding parameters have individual just as association impacts on reactions, viz. weld metal substance sythesis and mechanical properties. When all is said in done, two factor cooperation impact are higher than the individual impact of blend related factors. Among welding parameters, extremity is observed to be essential for all reactions under examination.

Saurav Datta et al. (2006), examined that quality has now turned into a vital issue in the present assembling world [6]. At whatever point an item is fit for adjusting to attractive attributes that suit its zone of utilization, it is named as high caliber. Accordingly, every assembling procedure must be structured so that the result would result in an amazing item. The determination of the assembling conditions to yield the most noteworthy allure can be resolved through process streamlining. Accordingly, there exists an expanding need to scan for the ideal conditions. In the present work, we expect to assess an ideal parameter mix to get adequate quality attributes of dab geometry in submerged circular segment dab on-plate weldment on mellow steel plates.

Keshav Prasad et al. (2006), examined the impact of the submerged circular segment welding (SAW) process parameters (welding current and welding speed) on the microstructure, hardness, and sturdiness of HSLA steel weld joints. Endeavors have likewise been made to break down the outcomes based on the warmth input [7]. The SAW procedure was utilized for the welding of 16 mm thick HSLA steel plates. The weld joints were readied utilizing nearly high warmth input (3.0 to 6.3 KJ/mm) by fluctuating welding current (500-700 An) and welding speed (200-300 mm/min). Results demonstrated that the expansion in warmth input coarsens the grain structure both in the weld metal and warmth influenced zone (HAZ). The hardness has been found to differ from the weld focus line to base metal and pinnacle hardness was found in the HAZ. The hardness of the weld metal was to a great extent uniform. The hardness decreased with the expansion in welding current and decrease in welding speed (expanding heat input) while the strength demonstrated blended pattern. The expansion in welding current from 500 A to 600 An at a given welding speed (200 mm/min or 300 mm/min) expanded strength and further increment in welding current up to 700 A brought down the sturdiness.

Saurav Datta et al. (2006), completed use of the Taguchi strategy in blend with dark social examination has been connected for illuminating numerous criteria (objective) advancement issue in submerged circular segment welding (SAW) [8]. A dark social review assessed with dim social examination has been received to uncover an ideal parameter blend so as to acquire adequate highlights of weld quality attributes in submerged circular segment globule on-plate welding. Slag use, in ensuing runs, in the wake of blending it with crisp unmelted flux, has been presented. The parentage of slag in the blend of crisp flux and melded flux (slag) has been signified as slag-blend rate.

Aside from two regular process parameters: welding current and flux basicity record, the investigation went for utilizing fluctuating rates of slag-blend, treated as another procedure variable, to demonstrate the degree of agreeableness of utilizing slagmix in ordinary SAW forms, without yielding any trademark highlights of weld dot geometry and HAZ, inside the trial space. The quality attributes related with dab geometry and HAZ were dot width, fortification, profundity of entrance and HAZ width. Anticipated outcomes have been checked with corroborative trials, indicating great assention. This demonstrates the utility of the proposed strategy for quality enhancement in SAW process and gives the greatest (ideal) measure of slag-blend that can be expended in the SAW procedure with no negative impact on trademark highlights of the nature of the weldment as far as globule geometry.

Saurav Datta et al. (2007), examined Taguchi reasoning has been connected for getting ideal parametric mixes to accomplish wanted weld globule geometry and measurements identified with the warmth influenced zone (HAZ, for example, HAZ width in the present case, in submerged bend welding [9]. The theory and system proposed by Dr. Genichi Taguchi can be utilized for consistent enhancement in items that are created by submerged circular segment welding. This methodology features the reasons for low quality, which can be disposed of without anyone else's input alteration among the estimations of the procedure factors on the off chance that they will in general change amid the procedure. Contingent upon utilitarian prerequisites of the welded joint, a worthy weldment ought to affirm most extreme infiltration, least fortification, least dab width, least HAZ width, least dab volume, and so forth to suit its zone of utilization. Thus, there exists an expanding request to assess an ideal parameter setting that would bring the ideal yield. This could be accomplished by streamlining of welding factors. In light of Taguchi's methodology, the present examination has been gone for incorporating measurable procedures into the designing procedure.

Kook-soo Bang et al. (2008), reasoned that submerged circular segment welding was performed utilizing metal-cored wires and fluxes with various pieces [10]. The impacts of wire/flux mix on the compound arrangement, elasticity, and effect strength of the weld metal were examined and translated as far as component exchange between the slag and the weld metal, i.e., amount. Both carbon and manganese demonstrate negative amount in many blends, showing the exchange of the components from the weld metal to the slag amid welding. The measure of exchange, nonetheless, is distinctive relying upon the flux organization. Progressively fundamental fluxes yield more positive C and Mn through the decrease of oxygen content in the weld metal and apparently higher Mn action in the slag, separately. The exchange of silicon, be that as it may, is affected by Al_2O_3, TiO2 and ZrO_2 substance in the flux. Si turns out to be more positive and achieves a positive estimation of 0.044 as the oxides substance increment. This is on the grounds that Al, Ti, and Zr could supplant Si in the SiO_2 arrange, leaving more Si allowed to exchange from the slag to the weld metal.

The SAW procedure has been intended to expend intertwined flux, in the blend of crisp flux. Hence, the work attempts to use the idea of 'waste to riches'. Aside from process improvement, the work has been started to create scientific models to indicate diverse globule geometry parameters, as a component of process factors. Consequently, improvement has been performed to decide the most extreme measure of slag-flux blend that can be utilized without relinquishing any negative impact on dot geometry, contrasted with the traditional SAW process, which devours crisp flux as it were. Investigations have been directed utilizing welding current, slag-blend rate and flux basicity list as process parameters, fluctuated at four unique dimensions. Utilizing four 3 full factorial structures, without replication, we have done welding on mellow steel plates to acquire dab on plate welds. In the wake of estimating dot width, profundity of infiltration and support; in light of basic suppositions on the state of dot geometry, we determined other significant globule geometry parameters: rate weakening, weld entrance shape factor, weld fortification frame factor, territory of entrance, zone of support and absolute dab cross sectional zone.

Serdar Karaoglua et al. (2008), watched process parameters has incredible impact on the nature of a welded association. Scientific displaying can be used in the advancement and control system of parameters [11]. Instead of the outstanding impacts of principle process parameters, this investigation centers around the affectability examination of parameters and adjusting prerequisites of the parameters for ideal weld dot geometry. Alterable process parameters, for example, welding current, welding voltage and welding speed are utilized as structure factors. The target work is framed utilizing width, stature and entrance of the weld dab. Trial part of the investigation depends on three dimension factorial plans of three process parameters.

So as to explore the impacts of information (process) parameters on yield parameters, which decide the weld dot geometry, a scientific model is built by utilizing different curvilinear relapse investigation. In the wake of completing an affectability investigation utilizing created experimental conditions, relative impacts of info parameters on yield parameters are gotten. Impacts of each of the three structure parameters on the globule width and dab stature demonstrate that even little changes in these parameters assume an essential job in the nature of welding activity. The outcomes likewise uncover that the infiltration is nearly non-delicate to the varieties in voltage and speed.

Saurav Datta et al. (2009), talked about advancement issue of submerged curve welding. The objective was to look through an ideal procedure condition, fit for creating wanted dot geometry parameters of the weldment [12]. Four corresponded highlights of globule geometry: profundity of infiltration, support, dot width, and rate weakening has been chosen in the examination. The procedure condition has been accepted comprising of factors like voltage, wire feed rate, navigate speed.

Various related reactions have been changed over into free quality records called important segments. Important segment examination (PCA) has been adjusted to secret various goals of the improvement issue into a solitary target work. This single target work has been meant as composite important segment. Taguchi's powerful streamlining method has been connected to decide the ideal setting, which can expand the composite vital segment. Consequence of this previously mentioned advancement system has been contrasted with that of dark Taguchi strategy; another methodology which is broadly utilized for taking care of multicriteria streamlining issues. A corroborative test indicated agreeable outcome.

Vinod Kumar et al. (2009), submerged circular segment welding adds to roughly 10% of the all out welding. Around 10% - 15% of the flux gets changed over into fine particles named as flux dust when welding, because of transportation and taking care off [13]. On the off chance that welding is performed without expelling these fine particles from the flux, the gases produced amid welding are not ready to get away, in this way it might result into surface porosity. Then again, if these fine particles are expelled by sieving, the expense of welding will be expanded altogether. What's more, if this flux dust is dumped/tossed, will make the contamination. Along these lines to diminish the expense of welding and contamination, in the present work endeavors have been made to build up the acidic and essential agglomerated fluxes by using squandered flux dust. The examination of the present investigation indicated compound sythesis and mechanical properties of the all weld metal arranged from the created fluxes and the parent fluxes to be in a similar range. In this manner the created fluxes arranged from the waste flux residue can be utilized with no trade off in mechanical properties and nature of the welded joint.

Shahnwaz Alam et al. [2011] Design of investigation utilizing 2-level full factorial method has been utilized to direct trials and to create connections numerical models for foreseeing the weld dot infiltration in single wire submerged bend welding of 12 mm thick gentle steel plates [14]. The reaction factor, specifically dot entrance, as influenced by circular segment voltage, current, welding speed, wire feed rate and spout to-plate remove have been explored and broke down. The models created have been checked for their sufficiency and hugeness by utilizing the examination of change, F-test and the t-test, separately. Primary and collaboration impacts of the procedure factors on weld dab infiltration have likewise been exhibited in graphical shape. The created models could be utilized for the expectation of vital weld dot entrance and control of the weld globule quality by choosing fitting procedure parameter esteems. Furthermore, the model-anticipated infiltration esteems have been contrasted and their individual test esteems.

Sudhakaran R et al. (2011), The weld quality can be accomplished by meeting quality prerequisites, for example, dot geometry which is very affected by different process parameters engaged with the process [15]. Inadequate weld globule measurements will add to disappointment of the welded structure. This paper presents an investigation on advancement of process parameter utilizing genetic algorithm (GA) to advance profundity to width proportion in 202 review hardened steel gas tungsten bend welded (GTAW) plates. Investigations were directed dependent on focal composite rota Table plan and scientific models were produced relating the imperative controllable GTAWprocess parameters like welding current, welding speed, protecting gas stream rate and welding firearm point with weld dab parameters like profundity of entrance, dot width and profundity to width proportion. Utilizing these models the direct and connection impacts of the procedure parameters on weld dot geometry were considered. Improvement of process parameters was finished utilizing GA A source code was created utilizing Turbo C to do the advancement for profundity to width proportion with infiltration and dot width as imperatives. The ideal procedure parameters gave an estimation of 0.9 for profundity to width proportion which exhibits the precision and viability of the model introduced and program created. The got outcomes help in choosing rapidly the procedure parameters to accomplish the ideal quality.

Vinod kumar (2011), To robotize a welding procedure, which is the present pattern in creation industry, it is basic that scientific models must be produced to relate the procedure factors to the weld globule parameters [16]. Submerged circular segment welding (SAW) is described by its high dependability, profound entrance, smooth completion and high profitability particularly to weld of funnels and Boiler joints. In the present work numerical models have been produced for SAW utilizing created fluxes. Reaction surface philosophy has been utilized to anticipate basic elements of the weld dot geometry and shape connections. The models created have been checked for their ampleness and noteworthiness by utilizing the F-test and the t-test, individually. Fundamental and cooperation impacts of the procedure factors on dab geometry and shape factors are displayed in graphical frame and utilizing which not just the expectation of critical weld dot measurements and shape connections yet additionally controlling the weld globule quality by choosing fitting procedure parameter esteems are conceivable.

Rati Saluja et al. (2012), Automatic and mechanical welding frameworks could utilize viably, when ideal process parameters for accomplishing the ideal quality and relative impacts of information parameters on yield parameters can be gotten [17]. Reaction surface strategy (RSM) procedure is Applied to decide and describe the circumstances and logical results connection between obvious mean reactions and Input control factors impacting the reactions. This Paper manages the use of Factorial plan approach for streamlining four submerged curve welding parameters viz. Welding current, bend voltage, welding pace and cathode stand out by creating numerical model for sound quality globule width, dot entrance and weld fortification on butt joint.

Pranesh B. Bamankar (2013) Experiments are conducted using submerged arc 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 [18]. The experiments are designed using Taguchi method (with Taguchi L9 orthogonal array) considering three factors and three levels. The experiment was conducted on semiautomatic AUTO WELD MAJOR (LW) with CPRA 800 (S) Power source manufactured by Esab India. Mild steel plates of dimensions 50 mm (length) x 50 mm (width) x 12 mm (height) were used as base metal. Automelt EH 14 copper coated electrode of 2.4 mm diameter was used as filler wire. Agglomerated flux, OK Flux 10.71 (L) Manufactured by ESAB INDIA Coding - AWS / SFA 5.17 was used. A square butt joint with a 1.6 mm root opening was selected to join the plates in flat position, keeping electrode perpendicular to plates. Specimens of 10 mm width were cut transverse to the welding direction from each welded plates. These specimens were cleaned, ground, polished and etched with 10% nital (90% alcohol + 10% of nitric acid).Weld bead profiles were traced by using an optical microscope at 20X magnification. Measurements were made for depth of penetration and bead width

Increase in welding current increases the depth of penetration. It is known that molten metal droplets transferring from the electrode to the plate are strongly overheated. It can be reasonably assumed that this extra heat contributes to more melting of the work piece. As current increases the temperature of the droplets and hence the heat content of the droplets increases which results in more heat being transferred to the base plate. Increase in current reduces the size but increases the momentum of the droplets which on striking the weld pool causes a deeper penetration or indentation. The increase in penetration as current increased could also be attributed to the fact that enhanced arc force and heat input per unit length of the weld bead resulted in higher current density that caused melting a larger volume of the base metal and hence deeper penetration.

Degala Venkata Kiran (2014), The influence of the leading and trailing arc welding current on two-wire tandem submerged (SAW-T) arc weld quality was studied at a iso-heat input of 2.5 kJ/mm. The weld quality includes weld bead dimensions, cooling time from 800 to 500 °C in the weld pool, weld bead ferrite phase fraction, and micro-hardness. The cooling time was calculated from the temperature distribution predicted using the numerical model. For a constant heat input, the weld penetration significantly reduced with decreasing leading arc current at a low level of trailing arc current while the final weld penetration was less sensitive to the leading arc current at higher trailing arc current. Significant variation of the average weld pool cooling time from 800 to 500 °C was not observed with increasing leading arc current from 700 to 1000 A at a constant trailing arc current and heat input of 1000 A and 2.5 kJ/mm. However, minimum weld pool cooling time was observed at higher currents. An increase of the leading or trailing arc current at a constant heat input yielded a minor rise of the weld pool acicular ferrite phase volume fraction and decreased the amount of allotriomorphic ferrite phase, leading to a small improvement in the weld bead micro-hardness. In the present study, the welds produced at a leading and trailing arc current of 1000 A and welding speed of 26.80 mm/s displayed better quality weld beads with high productivity.

Prachya Peasura (2017) This research studied the effects of submerged arc welding (SAW) process parameters on the mechanical properties of this steel. The weld sample originated from ASTM A283 grade A sheet of 6.00-millimeter thickness. The welding sample was treated using SAW with the variation of three process factors. For the first factor, welding currents of 260, 270, and 280 amperes were investigated. The second factor assessed the travel speed, which was tested at both 10 and 11 millimeters/second. The third factor examined the voltage parameter, which was varied between 28 and 33 volts. Each welding condition was conducted randomly, and each condition was tested a total of three times, using full factorial design. The resulting materials were examined using tensile strength and hardness tests and were observed with optical microscopy (OM) and scanning electron microscopy (SEM). The results showed that the welding current, voltage, and travel speed significantly affected the tensile strength and hardness (value < 0.05). The optimum SAW parameters were 270 amperes, 33 volts, and 10 millimeters/second travel speed. High density and fine pearlite were discovered and resulted in increased material tensile strength and hardness.

In this research, the influence of the SAW factors on the mechanical properties of ASTM A283 grade A steel was studied. The specimens were welded with welding currents of 260, 270, and 280 amperes, voltages of 28 and 33 volts, and travel speeds maintained at 10 or 11 mm/sec. The mechanical properties and microstructure were analyzed. The results from this study are summarized as follows:(1)The factorial design of welding current with voltage and travel speed resulted in interactions on tensile strength and hardness at the 95% the confidence level (value < 0.05).(2)The optimal SAW factors were a current of 270 amperes, voltage of 33 volts, and travel speed of 10 mm/sec, which resulted in tensile strength of 541 MPa and hardness of 254 HV.(3)The microstructure of ASTM A516 grade A steel had pearlite and ferrite when the SAW factors were optimized, which affects the pearlite density in the parent phase.(4)The tensile strength and hardness obtained for the weld samples were found to correspond to the formation of pearlite density and fine pearlite in the weld metal and heat-affected zone.

Ajitanshu Vedrtnam (2018) A constant voltage fully automatic SAW machine (TORNADO SAW M − 800) of 800 A, 3-phase, 50 Hz rectifier type power source, and 3.2 mm stainless steel electrode was used for the welding. Fig. 1(a) and Fig. 1 (b) show the experimental set-up and a welded sample respectively. Weld beads were deposited using wire reel of 3.2 mm as per the design matrix on the stainless steel samples of 101.6 × 76.2 × 10 mm3. The samples were cleaned manually using the brush to make them dust and rust free before clamping them to the welding bed having the required earth connection. The welded samples were cleaned to make them free from slag. A vernier caliper is used to measure bead height and bead width. Every experimental run (for same inputs) was performed three times and the average bead width and height were considered as final reading to minimize the error. Hardness was measured with the Rockwell hardness tester.

The process parameters were determined for the optimum weld bead width, bead height and bead hardness in the SAW process using RSW, regression analysis, and GA. It was found that weld parameters significantly affect the response variables selected for the study. The results reflect that an increment in voltage increases the bead width but decreases the bead height, whereas the current increment result-in increment in bead height and no change in bead width. The increment in welding speed result-in decreased bead width and height. With an increment in the nozzle-to-plate distance, the bead width decrease, but bead height increases. The bead hardness increases with current but voltage and travel speed do not have a significant persuade on the hardness. The predictions from the mathematical model developed by RSM and the corresponding experimental results are having a fair agreement. The regression analysis, ANOVA and residues plots indicate that error is with-in considerable limits, but the verification experiments confirmed that polynomial relations of response parameters from RSW is having the better fit to data and thus the closer results to experimentation when compared to the relations obtained from the regression analysis.

References

[1] S. V. Nadkarni, Modern arc welding technology, Advani-Oerlikon limited.1988.
[2] R. S Parmar, Welding Processes & Technology, Khanna Publications, New Delhi, 1997.
[3] Vincent Van Der Mee, Fred Neessen, Development of High Strength Steel Consumables from Project to Product, Lincoln Smitweld by, The Netherlands, 2007.
[4] Box G.E.P., Hunter W.G. and Hunter J.S. "Statistics for Experimenters-An Introduction of Design, Data Analysis and Model Building", John Wiley and Sons, New York, 1978.
[5] Box G.E.P and Draper N.R. "Evolutionary Operations: A Statistical Method for Process Improvement", John Wiley and Sons, New York, 1969.
[6] Taguchi G. and Wu Y. "Off-line quality control", Central Japan Quality Control Association , Nagaya, Japan, 1979.
[7] Roy R.K. "A primer on Taguchi method ", Van Nostrand Reinhold, New York, 1990.
[8] Ross P.J. "Taguchi Techniques for quality engineering ", McGraw Hill, New York, 1996.
[9] Peterson R.G. "Design and Analysis of experiments ", Marcel Dekker, New York, 1985.
[10] Phadke M.S. "Quality Engineering using Robust Design ", Pearson Education, Inc., South Asia,2008.
[11] Indian Standard acceptance tests for wire-flux Combinations for submerged-arc welding of structural steels (First Revision)
[12] Kook-soo Bang1, Chan Park, Hong-chul Jung, and Jong-bong Lee, Effects of Flux Composition on the Element Transfer and Mechanical Properties of Weld Metal in Submerged Arc Welding, Pg 471-477, 2009.

[13] Saurav Datta & Asish Bandyopadhyay & Pradip Kumar Pal, Modeling and optimization of features of bead geometry including percentage dilution in submerged arc welding using mixture of fresh flux and fused slag, Journal of Advanced Manufacturing Technology, Pg 1080-1090, 2006.
[14] Serdar Karaoglu, Abdullah Sec4gin, Sensitivity analysis of submerged arc welding process parameters, journal of materials processing technology, Pg 500-507, 2008.
[15] Keshav Prasad & D. K. Dwivedi, Some investigations on microstructure and mechanical properties of submerged arc welded HSLA steel joints, Journal of Advanced Manufacturing Technology, Pg 475-483, 2006.
[16] R Quintana, Acruz, Lperdomo, Gcastellanos, Llgarcia, Afarmoso and Acores, Study of the transfer efficiency of alloyed elements in fluxes during the submerged arc welding process, Welding international, Pg 958-965, 2003.
[17] P. Kanjilal, T.K. Pal, S.K. Majumdar, Combined effect of flux and welding parameters on chemical composition and mechanical properties of submerged arc weld metal, Journal of Materials Processing Technology, Pg 223-231, 2005.
[18] Ana Ma. Paniagua-Mercadoa, Paulino Estrada-Diazc, Victor M. Lopez-Hirata, Chemical and structural characterization of the crystalline phases in agglomerated fluxes for submerged-arc welding, Journal of Materials Processing Technology, Pg 93-100, 2003.
[19] Vera Lucia Othero de Brito, Herman Jacobus Cornelis Voorwald, Nasareno das Neves, and Ivani de S. Bott, Effects of a Postweld Heat Treatment on a Submerged Arc Welded ASTM A537 Pressure Vessel Steel, Journal of Materials Engineering and Performance, Pg 249-257, 2001.
[20] Saurav Datta & Asish Bandyopadhyay & Pradip Kumar Pal, Application of Taguchi philosophy for parametric optimization of bead geometry and HAZ width in submerged arc welding using a mixture of fresh flux and fused flux, Journal of Advanced Manufacturing Technology, Pg 289-298, 2007.
[21] Saurav Datta & Goutam Nandi & Asish Bandyopadhyay & Pradip Kumar Pal, Application of PCA-based hybrid Taguchi method for correlated multicriteria optimization of submerged arc weld, Journal of Advanced Manufacturing Technology, Pg 276-286, 2009.
[22] Saurav Datta & Asish Bandyopadhyay & Pradip Kumar Pal, Solving multi-criteria optimization problem in submerged arc welding consuming a mixture of fresh flux and fused slag, Journal of Advanced Manufacturing Technology, Pg 935-945, 2006.
[23] Vinod Kumar Dr. Narendra Mohan Dr. J.S.Khamba, Development Of Cost Effective Agglomerated Fluxes From Waste Flux Dust For Submerged Arc Welding, Proceding the world congress of engineering, 2009.
[24] V. Gunaraj& N. Murugan, Prediction and Optimization of Weld Bead Volume for the Submerged Arc Process, 2000.
[25] Janez, Effect of Welding Parameters on Bead Geometry and Flux Consumption, 1998.
[26] Rati Saluja &K M Moeed, Modeling and Parametric Optimization using Factorial Design Approach of Submerged Arc Bead Geometry for Butt Joint, 2012.
[27] Sudhakaran R. & Senthil Kumar K. M. & Vel Murugan V., Effect of Welding Process Parameters on Weld Bead Geometry and Optimization of Process Parameters to Maximize Depth to Width Ratio for Stainless Steel Gas Tungsten Arc Welded Plates Using Genetic Algorithm,2011.
[28] Vinod Kumar,Modeling of Weld Bead Geometry and Shape Relationships in Submerged Arc Welding using Developed Fluxes, 2011.
[29] Mitra A. "Fundamentals of quality control and improvement", Addison Wesley Longman Pvt. Ltd., Delhi, 2001.
[30] Byrne D.M. and Taguchi G. "The Taguchi approach to parameter design", Quality Progress, Vol. 20(12), pp. 19-26, 1987.
[31] Barker T.B. "Quality engineering by design: Taguchi philosophy", Quality Progress, pp. 33-42, 1986.
[32] Ross P.J. "Taguchi Techniques for quality engineering", McGraw Hill, New York, 1996.