Investigation on Effect of Heat Input In Saw Welding For Pressure Vessel

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Abstract—Submerged arc welding (SAW) is a high quality, high deposition rate welding process commonly used to join plates of higher thickness in load bearing components. This process provide a purer and cleaner high volume weldment that has a relatively a higher material deposition rate compared to the traditional welding methods. The effect of controllable process variables on the heat input and the hardness of weld metal and heat affected zone (HAZ) for bead on joint welding were calculated and analyzed using design of experiment software and Taguchi method technique developed for the SAW of boiler and pressure vessel plates. The main purpose of present work is to investigate and correlated the relationship between various parameters and hardness and tensile strength of single sqear butt joint and predicting weld bead qualities before applying to the actual joining of metal by welding. It is found that the hardness of weld metal and heat affected zone decreased when that is total heat input increased.

Keywords:– Design expert tool, hardness of weld metal and HAZ, x-ray, Submerged arc welding
Index Terms:- DOE,Taguchi Method and ANOVA Analysis

Nomenclature
DOE: Design of Experiments
ANOVA:Analysis of Variance
SAW: sub murg arc welding

I. INTRODUCTION

Swiss Glascoat Equipment Ltd is a leadingmanufacturerand supplier of exporters of vessel and its equipments to variousindustries like; chemical industry ,forging plant, Indian railway , etc. Swiss Glascoat Equipment Ltd is a produces pressure vessel mostly by submerges arc welding process because of higher thickness plates.

Pressure vessels such as cryogenic and gas storage tanks containing substances underpressure, pose a potential hazard to equipment and personnel from rupture or explosion/implosion. In next section the procedure followed in designing, fabricating, testing, and operating pressurized vessels in order to reduce hazards. The typical pressure vessel weld joint prepared either traditionalV grooves or have narrow or semi narrow gap profiles. Since the wall thickness up to 6mm or greater, welds made in many layers and each layer containing several passes. The normal process is SAW and the welding time for a single complete weld can be many hours. Although SAW is normally a mechanized process, pressure vessel welding up to now has usually been controlled by a full time operator. The operator has typically been responsible for positioning each individual weld run, for setting weld process parameters, for maintaining flux and wire levels, for removing slag and so on.

II. WORKING PRINCIPAL OF SUB MURGE ARC WELDING

A. Heat Input:

In arc welding, energy is transferred from the welding electrode to the base metal by an electric arc. When the welder starts the arc, both the base metal and the filler metal are melted to create the weld. This melting is possible because a sufficient amount of power (energy transferred per unit time) and energy density is supplied the electrode. Heat input is a relative measure of the energy transferred per unit length of weld. It is an important characteristic because, like preheat and interpass temperature, it influences the cooling rate, which may affect the mechanical properties and metallurgical structure of the weld and the HAZ. Heat input is typically calculated as the ratio of the power (i.e., voltage current) to the velocity of the resource (i.e., the arc) as follows:where, H = heat input (kJ/in or kJ/mm) E = arc voltage (volts)I = current (amps)S = travel speed (in/min or mm/min)This equation is useful for comparing different welding procedures for a given welding process. However, heat input is not necessarily applicable for comparing different processes (e.g., MAW and GMAW), unless additional data are available such as the heat transfer efficiency.

The heat input of submerged arc welding of steels is usually limited. High strength steels, austenitic steels, austenitic-ferrite steel require such selection of the welding limited heat, which is a compromise between welding efficiency and joint quality. Basic parameters of submerged arc welding are: arc current kind, intensity, voltage, speed of welding, wire diameter, length of wire extension, thickness and width of welding flux layer and inclination angle of an electrode or a welded joint. Welded joints of duplex austenitic ferritic steel grades as per the Dot Norske VERITAS [7] rules have to comply with such strength criteria as bend test, impact test, tensile test, hardness test, macroscopic and microscopic examination of the executed welded joint structure, specifying percentage index of ferrite content (ferrite share), as well as performing of the welded joint corrosion resistance test.

Fig.1: Principle of sub murg arc welding

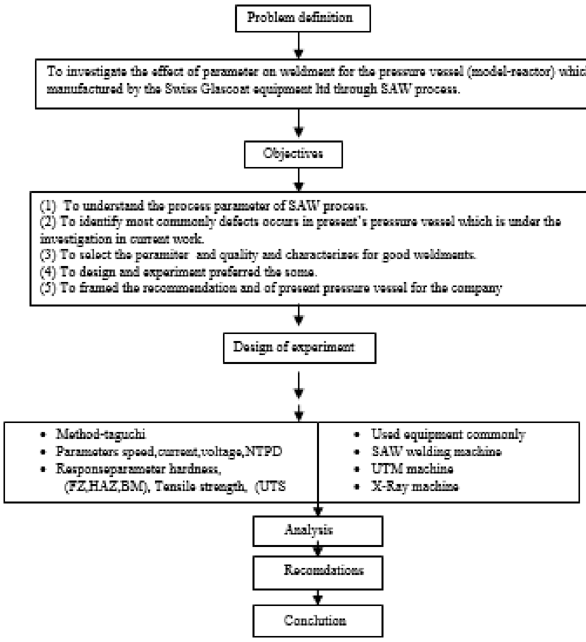
B. Problem Definition

To investigate the effect of parameters on weldment for the pressure vessel (model-reactor) which is manufactured by the SwissGlascoat equipment ltd through SAW process.

C. Objectives Of Present Work

- To understand the process parameter of SAW process.
- To identify most commonly defects occurs in present's pressure vessel which is under the investigation in current work.
- To select the prevent and quality and characterizes for good weldments.
- To design and experiment preferred the some.
- To framed the recommendation and of present pressure vessel for the company.

D. Reserch Methodology Used



III. Scope Of Work

The ability toadjust the base metal current to control weld penetration without reducing depositionrate is introduced into SAW. To conveniently monitor weld The contribution is useful for the company to adept the control parameters of saw process during the fabrication of pressure vessel(model-)which give the good quality of weld joint.

A. Design Of Experiments And Results:

Taguchi methodTo conducting experiments the Taguchi method has been used L16 ORTHOGONAL ARRAY

Table. 1: L16 orthogonal array

TURN	SPEED (mm/min)	CURRENT (I)	VOLTAGE (V)	NTPD (mm)
1	-1	-1	-1	-1
2	-1	-1	-1	+1
3	-1	-1	+1	-1
4	-1	-1	+1	+1
5	-1	+1	-1	-1
6	-1	+1	-1	+1
7	-1	+1	+1	-1
8	-1	+1	+1	+1
9	+1	-1	-1	-1
10	+1	-1	-1	+1
11	+1	-1	+1	-1
12	+1	-1	+1	+1
13	+1	+1	-1	-1
14	+1	+1	-1	+1
15	+1	+1	+1	-1
16	+1	+1	+1	+1

IV. Specimen Pripretion

Butt Joint:In butt joint, the plates are kept in alignment and a butt strap or cover plate is placed over the joint Butt Joint: In butt joint, the plates are kept in alignment and a butt strap or cover plate is placed over the joint. Butt welded joints shall have complete penetration and full fusion. As-welded surfaces are permitted; how ever, the surface of welds shall be sufficiently free from coarse ripples, grooves, overlaps, and abrupt ridges and valleys to permit proper interpretation of radiographic and other required nondestructive examinations. If there is a question regarding the surface condition of the weld when interpreting a radiographic film, the film shall be compared to the actual weld surface for determination of acceptability.

Fig. 2: Experiments photo

- Square-groove welds are the most economical to use, but are limited by thickness of the members
- Welds for one side are normally limited to a 1/4 inch or less.

V. Geometry Of The Specimens For Tensile Test

Specimens were machined from materials according to the required dimensions.Specimen are made from: AISI 304 mild steel and their dimension are of length 250mm, width 150 mm and mild steel with total quantity 48 piece as per stander gage length 90 mm and both end 58mm arc, 24Radius,□Thickness 10mm, with width 15mm and area 150mm. Various places when the UTS and YS have been measured.

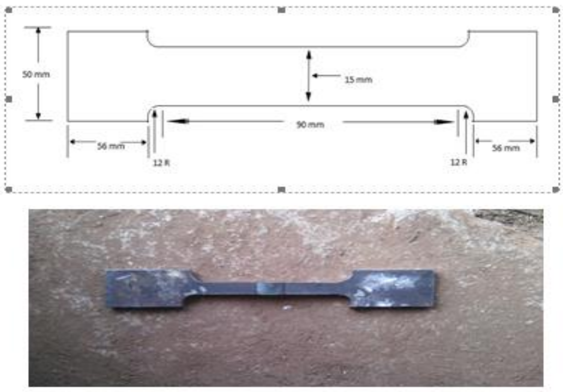


Fig. 3: sample specimen for tensile test

VI. Designe Of Expriment Leval Of Selected Perameters

There are four variable parameter are use of work in this experiment are tag chi method L16 matrix model are created with two limit (a)lower(2)higher as below table:

Table. 2: level of selected parameters

Parameters	Units	Notations	Lower limits	Higher limits
Welding current	Amp	I	450	550
Arc voltage	Volts	V	28	32
Welding speed	mm/min	S	280	340
Nozzle to plate distance	mm	N	20	30

VII. EQUIPMENT, MATERAIL AND CONSUMABALE USED

SAW machine: In present experiment the model reactor has been vessel SAW uses the arc struck between a continuously fed electrode and the work piece to melt the metal in the joint area and provide additional filler metal under a blanket of granular flux. This arc is completely submerged under the molten flux, which protects the molten metal from the atmosphere. There is no visible arc, spatter or fume during the welding operation. The continuous electrode may be a solid or cored wire. UTM machine.

Material is sectioned and edges rounded off to prevent cracking. Punch marks are made to see elongation, Acceptance criteria minimum value fore procedure qualification are provide in order to pass the tensile test the specimen shall have a tensile strength that is not lees than the minimum specific tensile strength of the base metal.

A. *X-RAY Machine:*

X-ray machine are used in NDT it is find out the defects in welding in various zone the machine are make in specification.

Source size	:	2.77 mm
Source Ir-192	:	7.50 CI
Film Type	:	Agfa D-7
S.F.D	:	200 mm
Exposure Time	:	4.15 Min
Material	:	: SA516 MGR 380
Processing	:	5 Min. 20'C
Techniques	:	S.W.S.I.-D.W.S.I.
I.Q.I. Hole Type	:	ASTM
I.Q.I. Wire Type	:	ASTM 1-B
Film Densities	:	Min2.0 to 4.0
Intensify Screen	:	Lead

B. *Materials:*

The Material SA516 mgr 380 are standard used in pressure vessel and boiler sell as economically, because of their high strength and toughness and relatively low cost and gas pipelines. Boiler and pressure vessel plate are the most important structural Plates.

C. *Specimens:*

Specimens were machined from materials according to the required dimensions[2].Specimen dimensions are as follows: AISI 304 mild steel and of length 250mm, width 150 mm and mild steel with total quantity 48 piece as per stander gage length 90 mm and both end 58mm arc 24R .Thickness 10mm with width 15mm and area 150mm.

D. *Wire:*

SFA 5.16 A7.4 ERTi-2. Grade 2 is the "workhorse" of the industrial corrosion market and most common unalloyed (or Commercially Pure—CP) grade. Grade 2 is generally the most readily available in all product forms and has the lowest cost.

VIII. OBSERVATIONS OF EXPERIMENTS

The observations and measurements obtain from the experiments are tabulated as show in Table-5.1. Under the predicted control parameter as explained in section-4 the quality characteristics hardness at various places in weld zone. Strength and heat input has been evaluated. In next section the attempt is made to identify the reasons behinds the obtain results and based on that recomdations have been prepaid for the best quality of weldment.

Table. 3: Observationof experiments

Sr. no	Speed(M in/mm)	Curren t(I)	Voltage (V)	NTPD (mm)	Hardness BHN (HFZ)	Hardness BHN (HHAZ)	Hardnes bhn (HBM)	UTS n/mm	YS n/mm	HI(KJ /mm)
1	280	450	28	20	178	163	143	42.00	26.00	2.70
2	280	450	28	30	178	162	143	45.66	29.66	2.70
3	280	450	32	20	170	149	143	42.60	26.80	3.08
4	280	450	32	30	171	163	143	44.60	28.60	3.08
5	280	550	28	20	170	143	143	36.93	21.93	3.30
6	280	550	28	30	178	156	144	47.81	32.81	3.30
7	280	550	32	20	173	154	144	46.66	27.66	3.77
8	280	550	32	30	163	143	146	51.18	28.16	3.77
9	340	450	28	20	170	149	143	47.57	31.57	2.22
10	340	450	28	30	171	163	143	44.66	28.66	2.22
11	340	450	32	20	178	171	144	50.70	30.70	2.54
12	340	450	32	30	178	166	146	45.58	29.58	2.54
13	340	550	28	20	163	143	146	45.56	30.56	2.71
14	340	550	28	30	170	153	143	49.09	34.09	2.71
15	340	550	32	20	156	149	143	47.13	32.13	3.10
16	340	550	32	30	153	147	143	51.53	35.53	3.10

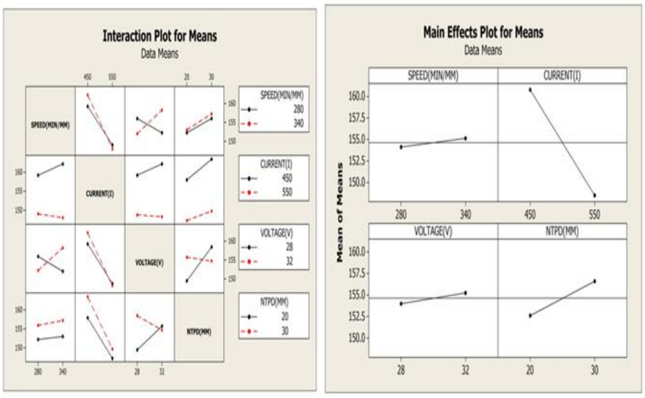


Fig. 4: Indivisdual and Combine effect of perameters

The control parameter like speed, current, voltage and NTPD have a individual aswell as combine effect on hardness in heat affected zone (HAZ) . It is found individualeffect of control parameter speed, voltage and NTPD is increasing moderately onhardness in heat affected zone (HAZ) and current is decreasing higher on hardness in heataffected zone (HAZ) and It is found combining effect of control parameter like speed and current, speed and voltage, current and voltage, current and NTPD, voltage and NTPDare found but speed and NTPD and current and NTPD have no combine effect onhardness in heat affected zone (HAZ).

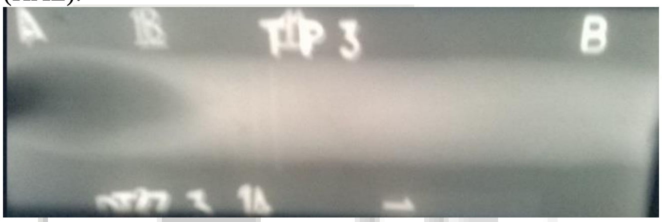


Fig. 5: x ray result of TP

IX. X-RAY RESULT AND DESCUTION

Table. 4: X-ray reports

TP 1	OK	Accept
TP 2	IP	Reject
TP 3	LF	Reject
TP 4	IP &POROSITY	Reject
TP 5	LF	Reject
TP 6	OK	Accept
TP 7	OK	Accept
TP 8	OK	Accept
TP 9	OK	Accept
TP 10	IP	Reject
TP 11	OK	Accept
TP 12	OK	Accept
TP 13	OK	Accept
TP 14	OK	Accept
TP 15	OK	Accept
TP 16	LF	Reject

IP-incomplete penetration, LF-luck of fusion

A. Result For X-Ray Testing:

There are total 16 TEST PAICE in x-ray in variation of result in testing there are test piece 1,6 to 9, and 11 to 15 are a complete penetration and whiteout defect welding result it is observe to this TP are effected in hardness and tensile strength as per good weld definition, it is useful to analysis in good quality weld.

X. RECOMDATION

Good weld definition- As per standard and advance literate review at define a good quality weld definition There are required good weld in deference mechanical property in for example hardness value in deference zones and tensile strength of weld and x-ray result consider,

Table. 5: Required qualities

Sr.no	Hardness Values			UTS	YS	X-Ray
	BM	HAZ	FZ			
1	Moderate	lower	higher	higher	higher	accepted

Table. 6: Result good weld definition

Perameter	Hardness(HFZ)	Hardness(HHAZ)	UTS(N/mm)	YS(N/mm)	HI(kj/mm)	X-Ray
Speed	L	M	H	H	H	Ok
Current	L	L	M	M	L	Ok
Voltage	L	M	H	L	L	Ok
NTPD	M	M	H	H	N	Ok

XI. CONCLUSION

From the literature survey it is infers that as such there is no complete design and manufacturing methodology found for current types of SAW welding process in pressure vessel. The company follows the different types of welding defect solved methods fore the manufacturing of pressure vessel. There fore there is scope to suggest the research methodology for the specific capacity of defects solved weld and good quality weld.

There are observed in the after analysis of as result in the SAW welding process parameters are directly affect the total heat input. The individual effect of current, voltage, speed on hardness of FZ and HAZ is higher. It is observed that the hardness is higher in the FZ than the HAZ. , hardness increases by in the weld metal and in the HAZ at and hardness increases in weld metal and in the HAZ. The reduction in hardness is higher at the arc voltage 32 volt and reduction in hardness is lower at arc voltage 28 volt when the current vary from 450amp to 550amp.

Hardness reduces by in FZ and in HAZ when welding current increase from 450 Amp to 550 Amp and arc voltage at 28 V. In the same way hardness reduces in weld and in HAZ when current increase from 450 Amp to 550 Amp and arc voltage is at 32 V The reduction in hardness is lower at the 340 mm/min welding speed and increment in hardness is higher at 280 mm/min welding speed for the current vary from 450 to 550 ampere.

Hardness increase by in FZ and reduce in HAZ, when welding current increase from 450 Amp to 550 Amp and welding speed at 280 mm/min. In the same way hardness increases by in FZ and decreases in HAZ when current increase from 450 Amp to 550 Amp and welding speed is at 550 mm/min. The recommendations are good weld definitions in the required quality are all the point x-ray results must be accepted or ok and hardness in FZ are higher and HAZ are lower and also UTS value in affected parameter speed voltage and NTPD are higher but YS value is only affected speed higher.

There are total 16 TEST PAICE in x-ray in variation of result in testing there are test piece 6 to 10 and 14 to 16 are a complete penetration and whiteout defect welding result it is observe to this TP are effected in hardness and tensile strength as per good weld definition, it is useful to analysis in good quality weld. Both results are below the critical point so we can say it will be safe welding for specific capacity.

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