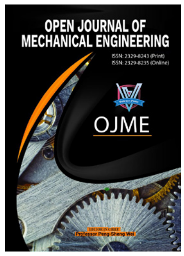

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ARTICLE

ENHANCEMENT OF PRODUCTIVITY BY ELIMINATING BACK CHIPPING

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ABSTRACT

In back chipping, the backside of the butt weld is cleaned mechanically for better penetration and weld quality. This is called as root weld. This consumes time, material, labor, and cost. Literature review demonstrates various attempts to eliminate back chipping. In this study, Zero Gap welding is introduced, to eliminate the back chipping. Here, Submerged Arc Welding (SAW) was performed with zero gap under the combination of various parameters like Current, Voltage, Weld head travel speed, Wire feed speed and Heat input. Welded joints were tested radiographically to investigate penetration, fusion and other defects. Tensile and bend test was also performed. Thus Grinding process for back chipping and manual welding for root run was eliminated to save time and cost.

KEYWORDS

Back-chipping, arc, SAW, DSAW.

1. INTRODUCTION

Back chipping is related to cleaning back side of a butt weld after welding from first side. It is necessary to clean the back side before welding the second side which is also called the root weld. Back chipping is a mechanical process in which the back side of the butt weld is cleaned by grinding or by pneumatic chipping. This process is noisy but gives clean back side. Care has to be taken to see that the chipping does not caulk the metal and cover root defects.

Double-sided arc welding (DSAW) method was proposed to eliminate back chipping[1]. Authors used two torches from opposite sides which are directly connected to the two terminals of the power supply. Many man-hours required for back chipping and the bead fairing work were reduced by using high efficiency twin-arc TIG welding method for storage tank[2]. For low-alloy high-strength steel thick plate welding, a new high efficiency technique DSAW, which does not need back chipping, was proposed[3]. Three-dimensional numerical models of DSAW with 50 mm thick plates were developed to predict the stress distribution by using finite-element analysis, computer parallel processing technology and multiple jobs design, and were compared with single arc welding. It was demonstrated that residual stresses of DSAW are lower than those of single arc welding[4].

DSAW method without back chipping, was used for welding thick plate of low-alloy high-strength steel. It was demonstrated that DSAW can perform welding of thick plate of low-alloy high-strength steel with lower preheating temperature or even without preheating[5]. DSAW, in which, gas metal arc welding (GMAW) was employed for root welding followed by filler passes was proposed[6]. It was done by two robots from both sides of the thick plate. Good comprehensive properties in bend, tensile strength, impact toughness, and hardness were obtained. Back chipping was eliminated.

It was demonstrated that double-sided GMAW is a high-efficiency welding method without back chipping. It has certain advantages and possibility of welding thick plates[7]. It was observed that residual stresses are developed due to conventional method, adopted with back chipping[8]. Author demonstrated that DSDAW method has better characteristics of lower residual peak tensile stress, smaller angular deformation, and well-proportioned stress distribution. DSAW has become an effective way of welding low-alloy thick section high-strength steel, as intermediate operations like back chipping; reheating and grinding can be eliminated[9]. DSAW gives reduced welding distortion and better mechanical properties of weld joint. Author presented effect of net–like microstructure on the mechanical properties of weld joint.

Thick plates of high-strength low-alloy steel are widely used in high pressure vessels, ship building, heavy machinery etc[10]. The conventional welding process is described as Gas Metal Arc Welding (GMAW) on one side, back chipping by means of carbon arc air gouging, then polishing, inspection with magnetic particle, preheating again, GMAW on other side and post-heating. Thus welding productivity is very low. Hence high efficiency methods are required. Author performed DSAW on the overhead position for thick plates of high strength successfully with high efficiency.

Metal active gas-Tungsten inert gas double-arc welding process was demonstrated to eliminate back chipping as well as backing plate[11]. It was demonstrated that Metal active gas-Tungsten inert gas (MAG-TIG) gives high quality and efficiency in root welding of thick plate than MAG. Contour method, Neutron diffraction measurement, and finite element method was used to study the residual stresses in a thick plate for the effect of back chipping[12].

It was demonstrated that back chipping has a great influence on the residual stress profile. Back chipping can change distribution shape of residual stress as well as position of the peak value. With the increase in back chipping thickness, the residual stresses increases.

Double-side arc welding method was adopted to eliminate back chipping for thick plate welding[13]. However, the welding condition is confined in vertical and horizontal positions. Finite element and Neutron diffraction method was used to understand the effect of back chipping[14]. Large residual stresses were generated. It was shown that, the larger back chipping width will be helpful to decrease stress corrosion crack. Finite element method was used to calculate residual stresses and was verified by neutron diffraction measurement.

Various welding parameters affecting weld bead are current, voltage, speed, electrode size, electrode work angle, electrode stick out and melting rate, depth of flux, polarity, and flux basicity index. The distance between the current pick-up tip and the arc root, called electrode stick out, has a considerable effect on the weld bead geometry. The melting rate of the electrode is increased with the increase in the stick out. Flux basicity index also influences the penetration. In general higher penetration is obtained with the use of low basicity index fluxes. High viscosity enhances the tendency of heat concentration in the narrow zone. The penetration is increased with the increase in slag, viscosity, arc stability and surface tension.

Back chipping is type of grinding process as shown in Figure 1, done in order to get sound root weld. It is used to remove the tack weld and root run of the weld and to enlarge groove size. Back chipping is mostly used for Single V and Double V groove welding joint. It almost takes 32 hours to grind 135 mm deep. Also, the cost of installation and cost of maintenance of back chip grinding machine is high.

Figure 1: Back chipping process.

2. METHODOLOGY

Whenever Groove welding (Single V) is performed there has to be some space between two plates while doing setup of that plate. In groove welding total bevel angle is around 70°-80° as shown in Figure 2. Full penetration in the joint is required to achieve a strong connection.

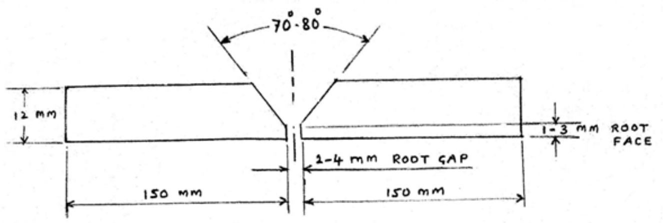

Figure 2: Simple V-groove welding.

Edges of the two plates are cut to form a groove angle. Due to this cutting action, Heat Affected Zone (HAZ) is formed on the parent material which has to be removed by grinding the affected area. If welding is performed in this HAZ, hardness of this area will increase which will lead to weld defects. Parent material is welded on a support to provide ease to the welder. There will be a provision for run-in and run- out plate which is used to start and end the welding and helps to minimize the defects like lack of fusion.

After this, Root pass is carried out by shielded metal arc welding (SMAW). After completing Root pass and two run of SMAW; SAW process is performed to fill the weld pool. Once the groove is filled completely, back chipping is done from opposite side of weld. Then weld deposited by SMAW process is removed completely by grinding from back side of the plate, e.g. If complete weld height is 20 mm (which included SMAW and SAW welding also) and if SMAW welding is till 7 mm, back chipping is done till 7 mm or approximately 10 mm. Once the back chipping process is done, SAW process is carried out in that back chipped area. This is how groove welding is done. In groove joining process, root run is done by using SMAW process because direct use of SAW process is not feasible. SAW process require very high current, so there should be some support below plate otherwise plate will puncture. Normally SAW is done after performing Root and two runs of SMAW process.

Figure 3: Zero Gap welding set up.

In this process there is material wastage. To save consumable, material, time, and manpower, Zero Gap welding is introduced. As shown in Figure3, zero root gap is kept between the plates. Bevel angle is 35°-40°. Using this method, SAW can be performed directly on the parent metal and back chipping is avoided.

Experiment

Aim is to determine the welding parameters which can be used to eliminate the back chipping process. Base metal is 316L. Consumable material is electrode 316L, Ø 3.15 and Flux 15W. Plates of size 500 × 150 × 12 mm thick were taken.

Experiment 1

As shown in Figure 3, there is no root gap. Value of root face is 3 mm. Bevel angle was 35°-40°. SMAW process was not carried out. SAW process was directly done. After filling the weld pool, plate was turned and directly welding was done without removing the material from back side. Corresponding parameters are given in Table 1. Weld head Travel speed and wire feed speeds are in mm/min. Heat input is electrical energy supplied by welding arc to work piece. It is expressed in J/mm, kJ/mm, J/cm or kJ/cm. In the present set up it is expressed in kJ/mm.

Table 1: Parameters for experiment 1.

Run	Current amps	Voltage volts	Travel speed mm/min	Wire feed speed mm/min	Heat input (kJ/mm)
Root run	380 - 400	28	400	72	1.59
Root + 1 run	360 - 390	28	400	72	1.55
Root + 2 run	360 - 390	28	400	72	1.55
Root + 3 run	420	28	400	72	1.76

Figure 4 shows the result of using above parameters. Penetration throughout the thickness of plate was very poor. Lack of fusion was detected in radiography test. Macro-structural, Micro-structural and Micro-hardness analysis was not done.

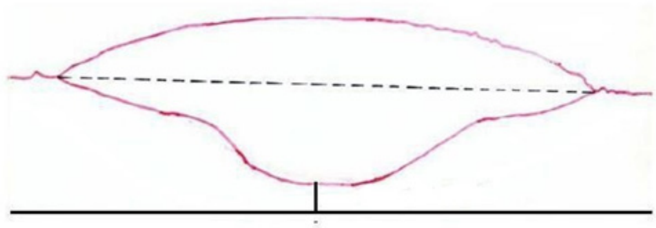

Figure 4: Radiography result of experiment 1.

Experiment 2

Set up was same as per Experiment 1. In order to improve penetration; current, Voltage, Travel speed and Heat input was increased in experiment 2. Corresponding parameters are given in Table 2.

Table 2: Parameters for experiment 2.

Run	Current amps	Voltage volts	Travel speed mm/min	Wire feed speed mm/min	Heat input (kJ/mm)
Root run	520-540	30	480	87	2.09
Root + 1 run	500-520	29	480	87	1.94
Root + 2 run	500-520	29	480	87	1.94
Root + 3 run	500-530	30	480	87	2.12

The Figure 5 shows the result of using above parameters. However, plate was punctured due to high current.

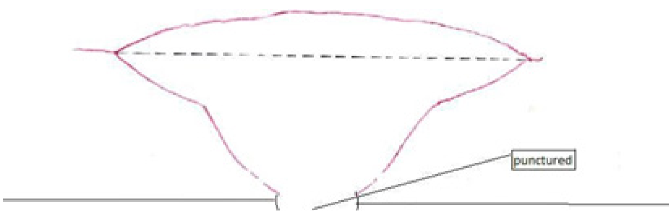

Figure 5: Radiography Result of experiment 2.

Experiment 3

Set up was same as per Experiment 1. Because of high current in 2nd experiment, plate was punctured, so ceramic backing strip was used, to absorb the heat. Corresponding parameters are given in Table 3.

Table 3: Parameters for experiment 3.

Run	Current amps	Voltage volts	Travel speed mm/min	Wire feed speed mm/min	Heat input (kJ/mm)
Root run	470-500	30	450	80	1.84
Root + 1 run	460-480	29	450	80	1.70
Root + 2 run	460-480	29	450	80	1.47
Root + 3 run	550	30	450	80	2.2

Figure 6 and 7 shows the fixing of ceramic tape from the bottom of the plate.

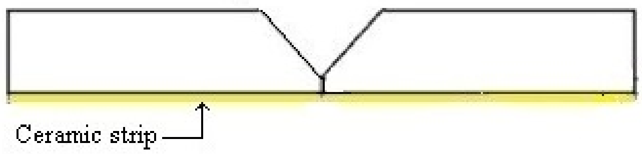

Figure 6: Component with ceramic strip.

Figure 7: Ceramic tape set up.

It gives good penetration as shown in Figure 8, but ceramic strip is expensive hence one more trial was taken as per experiment 4.

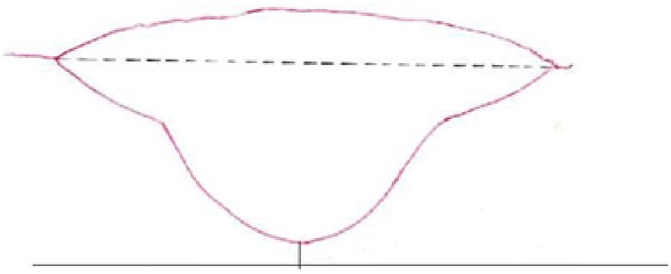

Figure 8: Radiography result of experiment 3.

Experiment 4

Set up was same as per Experiment 1. In 3rd experiment, fixing of ceramic tape consumes time. Also there are chances that ceramic tape may fall down, if it gets loose, so again puncture can happen. In this experiment, parameters are adjusted in such a manner that it gives good penetration without puncture in the plate. Figure 9 shows root run by SAW process with zero gap and 3 mm root face.

Figure 9: Root run in zero root gap.

Figure10 shows welding done without back chipping from back side on the plate, which has zero root gap and 3 mm root face.

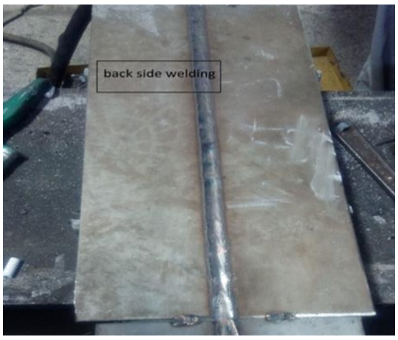

Figure 10: Welding from back side in zero root gap.

Corresponding parameters are given in Table 4.

Table 4: Parameters for experiment 4.

Run	Current amps	Voltage volts	Travel speed mm/min	Wire feed speed mm/min	Heat input (kJ/mm)
Root run	500	30	500	87	1.98
Root + 1 run	520-550	30	500	87	1.87
Root + 2 run	520-550	30	500	87	1.87
Root + 3 run	550	30	500	87	1.98

Figure 11 Shows the result of using above parameters. Good penetration was observed.

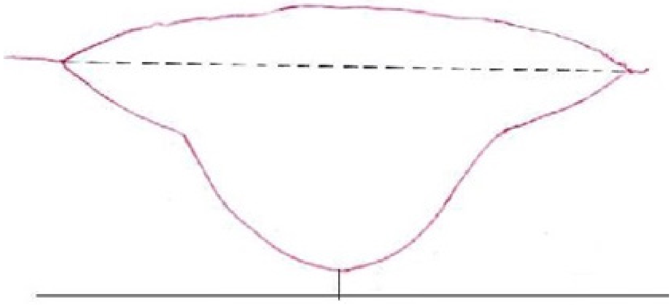

Figure 11: Radiography Result of experiment 4.

3. RESULTS AND DISCUSSION

Back chipping needs to be done to avoid the welding defects that often occur in the root weld. SMAW welding is one method which is widely used. Literature review shows various attempts to eliminate back chipping but they are costly. In this work, simple and novel, Zero Gap method is suggested which is very economical. Various trials were conducted and experiment no. 4 was found to be satisfactory. Radiographic result shows good penetration. It also show satisfactory results for Tensile and Bend test. These parameters were validated in real-world Process equipment manufacturing Industry. Comparisons of various parameters with and without Zero Gap are given in Table 5.

Table 5: Comparison of various parameters.

Parameters	Without Zero Gap	With Zero Gap
SMAW process	Required	Not required
SAW process	Required	Required
Back chipping	Required	Not required
Manpower	More	Less
Consumable wastage	More	Less
Grinding	Required	Not required

Comparison of time is given in Table 6. Plate size is 500 × 150 × 12 thick. It can be seen that there is reduction of time up to 39% in Zero Gap welding.

Table 6: Comparison of time.

Parameters	Without Zero Gap (min/meter)	With Zero Gap (min/meter)
Plate cutting	30	30
V angle preparation by Plasma	10	10
cutting machine	20	20
Grinding on work piece	30	30
Plate setup time	20	0
SMAW preparation	25	0
SMAW process	30	30
SAW preparation	20	20
SAW Process	60	0
Back chipping process	30	30
SAW preparation	20	10
Back side welding	295	180
Total time		

Comparison of material required and cost is given in Table 7. One Euro is taken as Rs 83.85 for cost values.

It can be seen that in Zero Gap welding, material required is reduced by 27.5 % whereas cost is reduced by 30.9 %.

Table 7: Material and cost estimation.

Parameters	Without Zero Gap		With Zero Gap	
	Quantity	Cost	Quantity	Cost
	Kg/ meter	Euro	Kg/ meter	Euro
Material for SMAW process (Root run + 2 run = 4 mm)	1.8	9.66	0	0
Material for SAW process	2.10	10.02	2.86	13.64
Grinding wheel	2 nos.	6.56	1 no.	3.28
Material required for SAW process (From back side)	1.98	9.44	0.895	4.27
15W Flux (for SAW)	4.896	35.03	4.056	29.02
SMAW welder		5.96		Nil
SAW welder		5.96		5.96
Helper		2.98		2.98
Total	10.776	85.61	7.811	59.15

Thus, proposed welding method can reduce material requirement, manpower, cost, set up time and total time. However parameters like voltage, current, Travel speed of the Weld head, Wire feed speed has to be followed properly. Skilled workers are required to operate the SAW machine. Machining / Grinding have to be done properly on the plate. Zero gap should be maintained properly. Also machine working condition should be proper.

4. CONCLUSION AND FUTURE SCOPE

In today's competitive world, Project managers are reducing the project costs as well as project time. This imposes lot of challenges for manufacturers to deliver the products with desired quality and within expected time at desired cost. This leads to lot of new developments and innovations in the area of manufacturing technology.

Very few papers are available in this domain. All the work done so far focuses on Double side welding. In this study, Zero Gap SAW process was introduced to eliminate back chipping. Optimal parameters were decided by conducting different experiments. Experiment 1 was carried out with Low current frequency, which resulted in poor penetration and lack of fusion. Experiment 2 which was performed with high current frequency, resulted in good penetration but because of high current, plate was punctured. Experiment 3 which was carried out with ceramic tape as a back support, resulted in good penetration. As ceramic tape was expensive for large job, experiment 4 was carried out with suitable parameters. These parameter yielded good penetration and also passed Tensile and Bend test satisfactorily. Finally these parameters were validated in real world Process equipment manufacturing industry.

Thus, by using Zero Gap welding method it was possible to reduce material requirement by 27.5%, decrease time by 39% and save cost by 31%. To the best of knowledge, this method has not been demonstrated yet.

Future scope includes use of Taguchi techniques to achieve optimum parameters. Also more sophisticated machines can be used for preparing good weld edges in order to get perfect zero gap as even small gap may puncture the weld and plate. Macro-structural, Micro-structural and Micro-hardness analysis can be done to study the structure and hardness changes. Impact test can also be conducted to determine amount of energy absorbed during fracture.

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