© 2018 IJNRD | Volume 3, Issue 4 April 2018 | ISSN: 2456-4184

EXPERIMENTAL INVESTIGATION ON PARAMETER OPTIMISATION IN ORBITAL TIG WELDING

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ABSTRACT- This investigates the influence of welding parameters on the mechanical properties of Orbital TIG Welding.The various welding parameters like welding speed, shielding gas, wire feed rate, current, voltage, power supply, filler wire material and gas flow rate are affects the mechanical properties of welding. In this work also analyze the various types of testing methods used for determines the mechanical properties of weld materials and the material characterization can be obtained by the microstructure of different weld materials.

KEYWORDS: Orbital TIG Welding; Gas Metal Arc Welding (GMAW); Gas Tungsten Arc Welding (GTAW); Mechanical Properties; Welding Parameters, Welded Joints.

I.INTRODUCTION

1. *TUNGSTEN INERT GAS WELDING*

Tungsten Inert Gas (TIG) welding is an arc welding process that uses an arc between a tungsten electrode (non-consumable) and the work piece for welding. An inert gas sustains the arc and protects the molten metal from atmospheric contamination. The inert gas is normally argon, helium or a mixture of argon and helium. The process may be used with or without the addition of a filler metal. This process is also widely known as Gas Tungsten Arc Welding (GTAW). This process was developed in the late 1930s to provide a joining method for aluminum and magnesium components of the aircraft, replacing riveting. This process was then called Heli Arc process as helium was used as the inert shielding gas. TIG welding is widely used as a fabrication tool in many industries because of high quality welds produced by this process. Pipes and tubes welding are widely used in almost every engineering application, such as nuclear and thermal power plants, semiconductor fabrications, oil and gas industries, and petro chemical plants. Therefore, the welding quality of pipe lines has a direct effect on the public safety and quality of the products. Oil and gas industry will be one of the key industries demanding extensive pipe welding due to the prediction of a doubling of natural gas consumption over the next 20 yearsOn the other hand, the cost of pipe lines constructed should be considered to be as low as possible. Various automatic welding processes have been developed in pipe welding industries to speed up welding process, producing better weld quality, and reducing welding cost. Also, development in orbital pipe welding technology helps to maximize the productivity of available welders and make welding process easier by employing a variety of automated features, such as data collection, programming, and live weld progress. Different factors, such as gravity, arc force, surface tension, heat accumulation, joint preparation, and fit up precision effect welding pool during automatic orbital pipe welding. Therefore, need of feedback and controlling system is a vital part of orbital pipe system to ensure high welding quality Orbital welding is finding increasing value because it can present a cleaner, virtually crevice surface and deliver highly repeatable and consistent quality welds.

1.1 The Welding Process

TIG welding process is illustrated in Fig.1. The process uses non-consumable tungsten electrode held in a torch. During welding, shielding gas is fed through the torch to protect the electrode, molten weld pool, and solidifying weld metal from contamination by the atmosphere. The electric arc is produced by the passage of current through the conductive, ionized shielding gas. The arc is established between the tip of the electrode and the work. Heat generated by the arc melts the base metal.

1.2 TIG Welding Techniques

The TIG process is used for manual as well as machine and automatic welding. Each mode has its own advantages and limitations and the selection is made depending upon the quality and quality requirements and the available facility at the workshop and economy of production.

1.3 Manual Welding

In manual welding, the process functions like manipulation of the TIG torch, control of filler metal additions, welding current, travel speed and arc length are controlled by the welder, Fig-10. Manual TIG welding is extensively employed for positional welding.

1.4 Mechanised Welding

Machine welding is done with equipment that performs the welding operation under the constant observation and control of a welding operator. Machine TIG welding provides greater control over travel speed and heat input to the work piece. The higher cost of equipment to provide these benefits must be justified by production and quality requirements.

Machine TIG welding equipment ranges from simple weld program sequencer and mechanical manipulators to orbital tube and pipe welding systems. The sequencer automatically starts and completes the weld, stepping from one variable setting to other settings at predetermined times or locations along the weld joint. Part tolerances must be controlled closely and must be strong, since the sequencer cannot compensate for unwanted movement of the parts during welding. High precision parts and sturdy increase production costs, but welding sequences usually cost less than more sophisticated automatic controllers.

1.5 Automatic Welding

In automatic welding the equipment performs welding operation without adjustment of the controls by a welding operator. Some modern automatic welding systems (frequently called adaptive or feedback control) make corrections to welding variables based on information gathered during welding. The objective is to maintain weld quality even in the presence of variable weld conditions.

1.6 Pipe Welding

- Welding which is used in pipe lines, typically is divided in to mainline welding, tie-in welding, and repair welding.
- Speed in main line welding is critical factor and there is access for backing system, but in Tie-in and repair welding there is no access to the inside of pipe and speed is less important In this study, adaptive orbital pipe welding of main line will be explained with different processes.

1.7 Variation Of Mechanized Pipe Welding

Mainly, mechanized pipe welding is divided in to,

- Circular pipe welding (orbital)
- Stationary pipe welding

II.LITERATURE SURVEY

[1]**Ajit Khatter, Pawan Kumar, Manish Kumar et al** The purpose of this study is to propose a method to decide near optimal settings of the welding process parameters in TIG welding. The properties of the welded joints are affected by a large number of welding parameters. Properties include Tensile strength, Impact force, Hardness etc. Modeling of weld bead shape is important for predicting the quality of welds. In an attempt to model the welding process for predicting the bead shape parameters (also known as bead geometry parameters) of welded joints, modeling and optimization of bead shape parameters in tungsten inert gas (TIG) welding process has been tried in the present work. TIG welding process, considering the effects of main variables on weld strength.

[2]**Prakash Mohan et al** To improve welding quality of Aluminum (Al) plate an automated TIG welding system has been developed, by which welding speed can be control during welding process. Welding of Al plate has been performed in two phases. During 1st phase of welding, single side welding performed over Al plate and during 2nd phase both side welding performed for Al plate by changing different welding parameters. Effect of welding speed and welding current on the tensile strength of the weld joint has been investigated for both type of weld joint. Optical microscopic analysis has been done on the weld zone to evaluate the effect of welding parameters on welding quality. Micro-hardness value of the welded zone has been measured at the cross section to understand the change in mechanical property of the welded zone.

[3]**Anmoljeet Singh and Rutash Mittal** This paper presents an effect of welding process parameters on the mechanical and microstructural properties of dissimilar SS304-SS202 joints welded with TIG welding process with Inconel625 filler wire of diameter 3.2mm. The input parameter chosen were the welding current, welding speed and gas flow rate. The mechanical properties (output responses) chosen were- impact toughness and bending strength. A plan of experiments based on L9 orthogonal array (OA) of Taguchi method has been used to acquire the data. Statistical techniques- analysis of variance (ANOVA) and signal-to-noise (S/N) ratio have been employed to investigate the welding characteristics of dissimilar metal joint & optimize the welding parameters. The maximum values of impact strength and bending strength were found to be 7.3KJ/mm2 and 962.79N/mm2 respectively. The optimal combination of parameters was determined as A2B1C3 i.e. welding current at 115 Amp, welding speed at 1.5mm/sec and gas flow rate at the 12lit / min for impact strength and A2B3C3 i.e. welding current at 115 Amp, welding speed at 2.5mm/sec and gas flow rate at 12lit/min respectively for bending strength.

[4]**Sanjay Kumar, Pravin Kumar Singh, Dharmendra Patel,S. B. Prasad et al** AISI 304 Stainless Steel material has good inter-granular corrosion resistance which increase the life span pressure vessels and automobile components. Superior fracture toughness reduces the crack initiation and crack growth under high pressure. Gas Tungsten arc welding (GTAW), also known as Tungsten inert gas (TIG) welding is a popular choice of welding process when high level of weld quality or considerable precision welding operation is required. In present investigation a best set of process parameters for TIG welding is observed using Taguchi's L27 orthogonal. The selected input parameters are Current, Voltage, Root Gap and Gas flow rate. Further the mechanical testing was performed. Bending strength and micro-hardness values are chosen as the response values. The regression relation between input parameters and response values are designed with the help of Response surface methodology. Investigation shows the affect of each process parameters on the response values. Result shows that Hardness property is most affected by the Welding voltage, Strength of the weld joints is enhancing with reducing the welding voltage and same is maximum at 70 Amp of current.

[5]**Gurdev singh, Aman Bansal, Dr Amit kumar Gupta, Amandeep singh et al** Tungsten inert gas welding or in other word known as Gas tungsten arc welding is one of the welding process among the other welding technique. This type of welding is highly used to join the ferrous and non ferrous metal. The main motive of this paper study to knows about the optimal parameters for TIG welding. The material properties like Tensile strength, impact strength, hardness of weld joints largely affected by welding parameters. Therefore in last decade researcher have workout to find the optimal parameters for TIG welding. So this paper review the different scientific research in TIG welding to find the best parameter with help of Taguchi technique.

[6]**Prashant Kumar Singh, Pankaj Kumar, Baljeet Singh, Rahul Kumar Singh et al** Tungsten Inert Gas Welding (TIG) is relatively high strength welding technique. This technique are mostly used in fabrication and other industries to join the either similar or dissimilar materials. In particular, it can be used to join high-quality strength of metal and alloys. In this paper we discuss about the Tungsten Inert Gas welding of joining heat treatable of stainless steel and mild steel. These welded joints have higher tensile strength to weight ratio and finer micro

structure. Tungsten Inert Gas Welding of dissimilar material such as stainless steel and mild steel have the potential to hold good mechanical and metallurgical properties.

[7]**Shahin Ansari ,Quazi T.Z et al** The objective of any industry is production of high quality products at low cost and increase the production rate. Welding is most important operation in any industry. It is essential to optimize the various parameters viz; welding current, welding speed, voltage, gas flow rate, etc. of welding process so that we can achieve the reliability, productivity and quality of the products. TIG welding process is versatile and commonly used operation for joining of two materials with the application of heat and /or pressure or filler material to increase the production with less time and cost. The purpose of this study is to describe different methods to decide near optimal settings of the welding process parameters in TIG welding. The properties of the welded joints such as tensile strength, impact force, hardness etc. are affected by different welding parameters.

2.1 ORBITAL PIPEWELDING

- The term orbital pipe welding is an automated process performed on tubing and pipe in a fixed position where a weld head is track mounted for all position welding.
- Weld head of orbital welding systems rotates an electrode and electric arc around the weld joint to make the welding applications, such as pipeline welding, welding nuclear spent fuel canisters and soon, that high quality welds, reliable and high productivity are required, orbital pipe welding is one are constantly innovating to produce next generation system so fit.

Fig. 2.1 Orbital Pipe Welding

2.2 Closed Head Mechanism (Full Function in Place)

- For welds critical thin-wall tubing and pipes with small and medium sized fabricators select a closed head device].
- Standard closed orbital weld heads can be used for tube sizes from 1.6to 162mm (this number can be variese.g.upto200mm to203mm with wall thicknessesofupto3.9 mm(0.4to12.7mm)

2.3 5G Position

- This system performs auto genius welding and the tubes are maintained in a fixed position.
- The head cover the entire weld area while the tungsten electrode holder moves along the joint driven by a small dc gear motor inside of head.

2.4 Various Welding Groove Types In Orbital Pipe Welding

- Mechanized pipe welding compared to manual welding needs much accuracy of groove preparation and fit up typically, welding groove used in pressure vessels are traditional, butt, narrow or semi-narrow gap, and fillet profiles.

2.4.1 Defect In Tig Welding

- Not filling in the over where it is required.
- Filling of material where it's not required.
- Filling of area with other the material .
- Just filling of metal but not with Penetration.

2.4.2 Testing In Tig Welding

- UT-ultrasonic testing (except defect in confusion zone).
- RT-radio graphic testing (volumetric defect).
- PT- penetrant testing (open to surface ,surface track).
- MPI-magnetic practical instruction.

2.4.3 Welding Position

- G-groove welding.
- 1G-left to right or right to left welded is position in horizontal.
- 2D-welg line should be towards the line ward or way the line ward.
- 3G-vertical up and down.
- 4G-Overhead position.
- 5G-to weld a butt joint in a pipe.
- 6G-to weld a 45 degree filtered pipe.

The results depict that the number of required welding pass not ably was reduced in the welding of small groove with high heat in put In order to obtain a proper joint, it is important to look at the entire design of the facing too.

Tube ends must be square and flat all burrs should here moved on the outer as well as the inner side of the tube. There should not be any chamfers during tube edge preparation to produce the best joint fit-up possible and subsequently.

The best weld Immoderate gaps will have a significant effect on the weld bead profile, which is caused by differences in tube diameter or out-of-roundness so, pipe wall thickness should be repeatable at the weld joint because most of orbital tube welding performed without the use of filler material.

2.5 Orbital Welding Parameters And Equipment

- A welding quality is good when weld have enough penetration, desired micro structure, and right welding profile without any spatter.
- Typically, pipe welding equipment manufacturers suggest a series of pre- calculated weld program for different tube wall thick nesses, diameters and materials.

Machine Specification

Table.2.1 Machine Specification

Rated Input 1/3					
volts@ 50/60Hz	**208**	**230**	**400**	**460**	**575**
2-					
Amps	**60.8/40.4**	**54.6/36.1**	**29.7/20.6**	**25.4/17.8**	**19.9/14.1**
K.W		**11.2/ 13.6**			

Rated Output 1/3		
	DC volts 32/34	**DC amps 300/350**
Max volt 75	**Duty cycle 40% / 60%**	

2.6 WELDING SYSTEM

2.6.1 WELDING TORCHES

TIG welding torches hold the tungsten electrode, which conducts welding current to the arc, and provide a means for conveying shielding gas to the arc zone. Torches are rated in accordance with the maximum welding current that can be used without overheating. A range of electrode sizes and different types and sizes of nozzles, can normally be used in the same torch.The heat generally in the torch during welding is removed either by gas cooling or water cooling. Accordingly, the torches are called as Gas Cooled or Water Cooled Torch. Gas cooled torches provide cooling by the flow of the relatively cool shielding gas through the torch. Gas cooled torches are generally used for a maximum welding current of about 200 amperes. However, torches are available up to 300 A with gas cooling. The torches are heavy but are useful in site welding where there is no water availability.

Fig. 2.4 Selection of typical electrode holder (water cooled)

2.6.2 Torch Body

The torch body consists of brass body covered with molded rubber, which acts a thermal and electric barrier. The body has passages for shielding gas, welding current and water if it is a water cooled torch. Gas hose, water inlet and outlet hoses are connected to the body along with the electric supply.

2.6.3 Collect

Collets are used to grip tungsten electrodes and are made of copper or brass. They are in contact with the torch body to pass the current and heat. Good contact between the electrode and the inside diameter of the collet is essential for proper current transfer and electrode cooling. Contact between the torch body and the collet also must be good for current and heat conduction. Tungsten electrode of any particular diameter will require a collet of matching size.

2.6.4 Nozzles

Shielding gas is directed to the weld zone by gas nozzles or cups fitted onto the head of the torch. Gas nozzles are made of various heat resistant materials like ceramic, metal, metal jacketed ceramic fused quartz, or other materials. They are made in different shape, diameters and lengths.

2.6.5 Gas Lenses

Gas lens is an optional attachment to the torch, used to provide a laminar flow of shielding gas. These attachments contain a porous barrier diffuser and are fitted around the electrode or collet and remain inside the nozzles.

2.7 Electrodes

Tungsten electrodes are non-consumable because they do not melt and get transferred to the weld. The function of a tungsten electrode is to serve as one of the electrical terminals of the arc, which supplies the heat required for welding. Its melting point is 3410^{0}C. Close to this high temperature, tungsten becomes thermionic, when electrons are emitted from tungsten due to heat.

The electrodes are available in different diameters, 0.25, 0.5, 1.0, 1.2, 2.4, 3.2, 4, 4.8, 6.3 mm and lengths usually 150 mm. Color codes are given at the tip of the electrodes. The color coding depends on the national standard to which it is manufactured.

2.7.1 Classification Of Electrode

Tungsten electrodes are classified on the basis of their chemical composition, as per IS 2811 as below.

- Pure tungsten – 99.5 % + impurities 0.5 %
- 1% Thoriated tungsten > 98.5 + thoria 0.8-1.2 % , Impurities < 0.5%
- 2% Thoriated tungsten > 97.5 % + thoria 1.7- 2.2 % Impurities – <0.5%
- Zirconated electrode > 99.2% + zirconia 0.15-0.4 % and impurities < 0.5 %

2.7.2 Thoraited Tungsten (EWTH)

The thermionic emission of tungsten can be improved by alloying it with metal oxides that have very low work functions. As a result, the electrodes are able to handle higher welding currents without failing. Thorium oxide is one such additive. Two types of thoriated tungsten electrodes are available. The EWTh-1 and EWTh-2 electrode contain 1 % and 2 % thorium oxide (ThO_2) called thoria, respectively, evenly dispersed though their entire lengths.

2.7.3 Ceriated Tungsten (EWCE)

The EWCe-2 electrodes are tungsten electrodes containing 2 percent cerium oxide (CeO_2) referred to as ceria. Compared with pure tungsten, the ceriated electrodes exhibit a reduced rate of vaporization or burn-off. EWCe-w electrodes will operate successfully with AC or DC.

2.7.4 Lantahnated Tungsten (EWLA)

These electrode contains 1 percent lanthanum oxide (LaO_2), referred to as lanthana. The advantages and operating characteristics of these electrodes are very similar to the ceriated tungsten electrodes.

2.7.5 Zirconated Tungsten (EWZR)

Zirconated tungsten electrodes (EWZR) contain a small amount of zirconium oxide (ZrO_2),. They are used for AC welding because they combine the desirable arc stability characteristics and balled end typical of pure tungsten with the current capacity and starting characteristics of thoriated tungsten. They have higher resistance to contamination than pure tungsten, and are preferred for radiographic quality welding applications where tungsten contaminations of the weld are not permitted.

2.7.6 Electrode Tip Configuration

The shape of the tungsten electrode tip is an important process variable in TIG welding. Tungsten electrodes may be used with a variety of tip preparations. With AC welding, pure or zirconiated tungsten electrodes from a hemispherical balled end. The size of the hemisphere should not exceed 1-1/2 times the electrode diameter, otherwise it may fall off while it is molten, Fig.4. For DC welding with thoriated, ceriated, or lanthanated tungsten electrodes, the end is typically ground to a specific included angle, often with a truncated end. In general, as the included angle increases, the weld penetration increases and the width of the weld bead decreases.

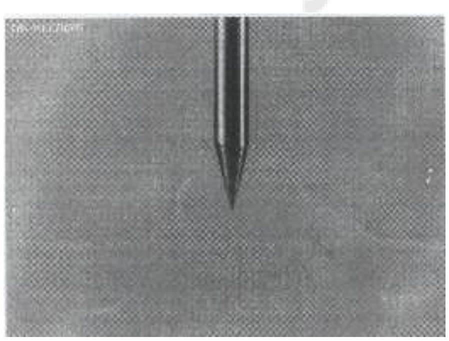

Fig. 2.6 Electrode tip for DC TIG

2.7.7 Electrode Contamination

Contamination of the tungsten electrode is most likely to occur when a welder accidentally dips the tungsten into the molten weld pool or touches the tungsten with the filler metal. In such cases, the weld metal/ filler metal sticks on to the electrode and arc gets disturbed. The contaminated electrode will have to be ground off or. The tungsten electrode may also become oxidized by an improper shielding gas or insufficient gas flow, during welding or after the arc has been extinguished. The contaminated end of the tungsten electrode will adversely affect the arc characteristics and may cause tungsten inclusions in the weld metal. If this occurs, the contaminated portion of the electrode is removed.

2.8 Power Sources

TIG power sources typically have either drooping or nearly true constant current static output characteristics, such as those shown in Fig-5. The static output characteristic is a function of the type of welding current control used in the power source design.

2.8.1 Direct Current

Using direct current, the tungsten electrode may be connected to either the negative or the positive terminal of the power supply. In almost all cases, electrode negative (cathode) is chosen. With that polarity, electrons flow from the electrode to the work and positive ions are transferred from the work to the electrode and the connection is known as DCEN or straight polarity connection

2.8.2 Pulsed Dc Welding

Pulsed DC involves the repetitive variation in arc current from a background (low) value to the peak (high) value. Adjustments of the pulse current time, background current time, peak current level, and background current level can be made to provide a current output wave form suited to a particular application, Fig-7. Generally, pulse frequencies are adjustable from 0.5 to 20 pulses per second. Pulses DC is usually applied with the electrode negative (DCEN).

2.8.3 Alternating Current

Alternating current undergoes periodic reversal in welding current polarity from electrode positive to electrode negative. Thus, AC can combine the work cleaning action of electrode positive (reverse polarity) with the deep penetration characteristic of electrode negative (straight polarity).

2.9 Shieding Gases

Shielding gas is directed by the torch to the arc and weld pool to protect the electrode, the molten weld metal and the hot tip of the filler metal from atmospheric contamination.

2.9.1 Types of Shielding Gas

Argon and Helium or Mixtures of the two are the most common types of inert gas used for shielding. Argon hydrogen mixtures are also used for special applications.

2.9.2 Argon

Argon is 35% heavier than air and ten times heavier than helium. Welding grade Argon is refined to a minimum purity of 99.95 percent. This is acceptable for TIG welding of most metals except the reactive and refractory metals, for which a minimum purity of 99.997 percent is required.

2.9.3 Advantages of Argon Compared To Helium

- Smoother, quieter arc action
- Reduced penetration
- Cleaning action when welding materials such as aluminum and magnesium
- Lower cost and greater availability
- Lower flow rates for good shielding
- Better cross-draft resistance
- Easier arc starting due to low ionization potential

The reduced penetration of an argon shielded arc is particularly helpful in vertical or overhead welding since the tendency for the base metal to sag or run is decreased.

2.9.4 Helium

Helium (He) is an inert, very light monatomic gas, having an atomic weight of four. It is obtained by separation from natural gas. Welding grade helium is refined to a purity of at least 99.99 percent. As Helium is lighter, it tends to rise around the nozzle and hence to produce equivalent shielding effectiveness, the flow of helium must be two or three times that of argon. The same general relationship is true for mixtures of argon and helium, particularly those high in helium content.

III. ARGON HYDROGEN MIXTURES

Argon-hydrogen mixtures are employed in special cases, such as mechanized welding of light gage stainless steel tubing, where the hydrogen does not cause adverse metallurgical effects such as porosity and hydrogen-induced cracking. Increased welding speeds can be achieved in almost direct proportion to the amount of hydrogen added to argon because of the increased arc voltage. However, the amount of hydrogen that can be added varies with the metal thickness and type of joint for each particular application. Excessive hydrogen will cause porosity. Argon-hydrogen mixtures are limited to use on stainless steel, nickel-copper, and nickel-base alloys.

3.1 Gas Flow Rates

Shielding gal flow requirements are based on cup or nozzle size, weld pool size, and air movement. In general, the flow rate increases in proportion to the cross sectional area at the nozzle. It is usually in the range of 6 - 10 litres per minute of argon at 1 to 2 atmosphere gage pressure. And 20- 30 litres per minute for helium.

3.2 Backup Purge

Backup purge gas can also be used to protect the underside of the weld and its adjacent base metal surfaces from oxidation during welding. Uniformity of root bead contour, freedom from undercutting, and the desired amount of root bead reinforcement are more likely to be achieved when using gas backup under controlled conditions. In some materials, gas backup reduces rot cracking and porosity in the weld.

IV. ARC INITIATION

With the power supply energized, and the shielding gas flowing from the cup, the torch is lowered toward the work piece until the tungsten electrode makes contact with the work piece. The current starts flowing due to the shorting of the electrode with the base metal and when the torch is quickly withdrawn a short distance, arc is established.

The advantage of this method of arc initiation is its simplicity of operation. The disadvantage of touch starting is the tendency for the electrode to stick to the work piece, causing electrode contamination and transfer of tungsten toe the work piece.

4.1 High-Frequency Start

High-frequency starting can be used with DC or AC power sources for both manual and automatic applications. High frequency generators usually have a spark-gap oscillator that superimposes a high-voltage AC output at radio frequencies on the main circuit.

4.2 Arc Current

In general, arc current controls the weld penetration, the effect being directly proportional. The range of current used depends on the material, thickness, and speed, level of penetration desired.

The process can be used with either direct or alternating current, the choice depending largely on the metal to be welded. Direct current with the electrode negative offers the advantages of deep penetration and fast welding speeds. Alternating current provides a cathodic cleaning (sputtering) which removes refractory oxides from the joint surfaces of aluminum and magnesium, allowing superior welds to be made.

4.3 Arc Voltage

- In pipe welding, arc voltage which is directly related to the arc length depends on weld current, stability of arc, and concentricity of pipe
  .Arc length influences weld penetration and longer arc length leads to less penetration and arc length produces poor penetration in very low arc power.
- The distance between electrode and tube should be kept constant to avoid stubbing-out. In a constant arc length, by increasing feed rate, penetration and HAZ increased.

4.4 Welding Speed

- Using of automatic orbital welding is the most effective way to control welding speed the main goal of welding machine is to weld as fast as possible while the quality of weld stays constant.
- Weld speed depends on the tube wall thickness and flow rate of material in the study welding speed is suggested to beset at1.7 to 4.2mm/s, running faster on thinner-wall materials and slower on heavy-wall tube.

4.5 Welding Current

- Welding current affects the depth of penetration by influencing heat concentration in the weld pool
- The main goal in welding current controlling is to obtain defect free welds with full penetration.

4.6 Arc Pulsing

- In welding with arc pulsing, in a fixed duration of time the power source pulses rapidly between a peak and back ground current to reduce heat input and as a result, producing better and repeatable weld quality.
- This method may be used in welding of joints with poor fit up which are difficult to weld.

4.7. Power Source

- More recently, variable polarity welding power supplies have been introduced in to the pipe welding world.
- In the pipe construction world, portability is the key. Developed power supplies used to day in orbital pipe welding, tend to be at the top of the range.

V. ANALOG POWER SOURCE

- Analog power sources are programmed by entering the desired speed, amperage, and other parameters on dials and putting the machine into motion with mechanical switches.

- The units allow one pass (one orbit around the pipe) to be programmed When multiple passes are required, welder's musts top the machine, reset the dials for the next pass, and restart the weld.
- Analog power sources are easy to understand operation, good tolerance of environmental extremes, and simple maintenance requirements. However, analog power sources cannot lock out unauthorized changes in critical parameters, and they do not store programs.

5.1. Micro Processor Based Power Sources

- Microprocessor based units require a longer learning curve than do analog power sources.
- Most weld programming is done by the welder using the equipment and can store up to 100weld programs, so most programs use simple prompts that require little computer literacy.
- These power sources have the features of, using many levels of programming for all parameters, possibility of multi passes without stopping, usability in automatic weld procedure, storage of weld program, simplifying the weld development process.
- Also, use of solid stated at a cards that allow program transfer between systems or off-line programming on personal computers.

5.2. Filler Wire

- Filler wire manufacturers has been involved with different challenges since improving of pipe and welding manufacturing require new filler wire technology as well.
- Flux cored wires were invented in1957which consists of a metal sheath containing a core of flux.
- The core is mixture of powdered ingredients, including fluxing elements, de oxidizers, de nitriding compounds, and alloying materials to improve hardness, strength and as a result corrosion resistance.

5.3. Shielding Gas

- Both, solid and flux cored wires required proper shielding gas to have higher productivity.
- In orbital pipe welding system, equipment is mounted close to the torch and lower amount of spatter is a factor that should be considered.
- Selecting of shielding gas composition is highly depended on the wire manufacturer's recommendation.
- Arc stability, general weld ability, spatter, and metallurgy of the deposited metal are affected by shielding gas. Shielding gas prevents the molten material from combining with oxygen in the ambient atmosphere.

VI. GAS TUNGSTEN ARC WELDING (GTAW)

- GTAW process is an extremely important arc welding process. During the 1960s, to increase penetration of automated GTAW process, current extended to higher level.
- At currents above about 250A, the arc tends to displace the weld pool, this effect increased as the current increases more. Recent development in GTAW introduce new methods of welding, such as active fluxes(A- GTAW), dual shield GTAW, narrow gap GTAW, key hole GTAW and laser- GTAW hybrid processes.

6.1 Shielding Gas Inorbital Gtaw Process

- Shielding gas is required on the tube and pipe during welding to prevent combining of molten weld pool with the oxygen in the ambient atmosphere.
- Chemical metallurgical processes between the gases and the molten pool that occur during welding should be considered during process of selecting shielding gas Composition of a shielding mixture in arc welding depends mostly on the kind of material to be welded.
- Additional hydrogen in to shielding gas allows higher welding speed. Also, it increases the volume of molten material in the weld pool due to the higher thermal conductivity of argon–hydrogen mixtures at temperatures at which molecules of hydrogen dissociate.

6.2 Welding Torch Degree Of Freedom

- In adaptive orbital pipe welding the great challenge is the position of welding torch during welding process.
- As shown in Figure 45 the welding of pipe is divided in to four positions.
- The positions are the flat position, the overhead position, the ascending vertical position and the vertical descendant position.

6.3 Weld Quality test And Control

- Higher weld quality is obtained with modern orbital welding system compared to the manual welding.
- The reason is that, the equipment of orbital system is designed for real-time monitoring of the affecting weld parameters.
- To have an ideal welding result with orbital welding system, all the equipment and operators should be certified. Also, each weld should be tested and certified to the desired standard level.
- In pipe welding, the following factors affect the welding joints result and should be considered:
  - Tube material, dimensions, and welding consumables
  - Machines, equipment, appliances, tools
  - Work preparation, welding parameter
  - Pipe welder, working conditions, supervision
  - Climate and environmental conditions
  - Knowledge, experience

QUALITY TEST

- Inspection, examination of the surface
- Test welds (destructive testing)
- Ultrasonic examination and radiation tests
- Pressure tests with water or air.

VII. DEFECTS INORBITAL WELDING

- Lack of fusion
- In complete penetration
- Excess penetration
- Burn through
- Icicle
- Inclusion
- Porosity
- Crack

7. 1 Lack of Fusion

- Depending on the joint, you may have to weld all the way down to the bottom or your plates to achieve what's known as Complete Joint Penetration (CJP).
- Most fillet welds, on the other hand, require only Partial Joint Penetration (PJP).Either way, you'll have to set your welding machines other's sufficient voltage and current to get the job done.

Causes

- Low welding current
- Excess welding speed

Prevention

- Maintain proper current & welding speed
- Proper cleaning of each bead

Repair

- Chipping back & re-welding

7.2 Incomplete Penetration

- Improper penetration of weld metal through the thickness of joint or weld metal not extending to the required depth into the joint root
- Acts as stress riser from which a crack may propagate.

Cause

- Root gap too small & high welding speed
- Low heat input & Too large electrode dia
- Improper grooving and fixturing

Prevention

- Proper joint preparation
- Proper heat input & welding speed
- Use suitable size of electrode

Repair

- Back gouge and back weld or remove and re weld.

7.3. Excessive Penetration

- Weld metal lying outside the plane joining the toes
- Makes notches that create stress concentration.
- An economic waste.

Cause

- Too wide a root gap
- Too high welding current
- Slow travel speeds
- Large size electrodes

Prevention

- Correct the root opening and root face
- Reduce the wire-feed speed

Repair

- Remove and re-weld

7.4 Burn-Through

- The holes burned through the parent metal in a single pass weld or the root run in multi run weld
- Seldom occurs.

Causes

- Excessive welding current with low welding speed
- Insufficient root face
- Excessive root gap

Repair

- Remove and re-weld

7.5 Inclusion

- Metallic or nonmetallic solid material entrapped within the WM, between weld passes or between WM &BM".
- May be in the form of slag or any other foreign material, which does not get a chance to float on the surface of the solidifying WMH2: the most undesirable inclusion(causing: cold crack)lowers the strength of joint & make it weaker
- Non- metallic inclusion
- Most dangerous May be sulphide, oxide, silicate or aluminate type Acts as stress raiser Slag inclusions are elongated or globular pockets of metallic oxides and other solid compounds.

Cause

- Inadequate cleaning of weld metal between passes
- Rapid rate of welding
- Too large electrode
- improper current
- Long arcs

Prevention

- Maintain proper current & heat input
- Proper cleaning of weld

Repair

- chip back & re-weld

7.6 Porosity

- Porosity is the technical term for gas bubbles. These develop inside or on the face of welds because metal in a molten state is highly vulnerable to impurities entering the mix.
- For this reason, some form of shielding gas (or dry flux ingredients in rods) is used in most welding processes.

Porosity is usually caused by one of the following

- The flow meter setting on the shielding gas tank is too high.
- You're using the wrong gas mixture or rod/wire.

Cause

- Work piece or electrode contains/contaminated with:-
- High sulphur & carbon
- Excessive moisture, rustorscale, oil, grease, etc.
- Atmospheric gases [N2,excessive O2(Al-welding)]
- Anodizing coating on Al(contains moisture)
- Long arc
- Fast solidification rate

7.7 Cracks

- A hair line separation in the BM/BM-WM-body/ WM/HAZ may appear:
- At the root or middle or In the crate surface or subsurface

Cause

- Poor ductility of base metal
- High C& S- content of BM/WM
- High contraction stresses
- Electrode with high hydrogen content

Remedies

- Pre- heating
- Mn/S ratio:18 min.
- Use low H_2 electrode
- Avoid rapid cooling

VIII. ORBITAL WELDING FINAL PARAMETERS

Table. 8.1 SS+SS Parameters

MATERIAL: SS+SS							FM : 347-SI						
PASS :1							LEVELS &PARAMETERS						
AMPS(V)	112.0	112.0	112.0	112.0	112.0	112.0	AGC(IPM)	6.8	6.8	6.8	6.8	6.8	6.8
WIRE(IPM)	032	032	032	032	032	032	TRAVEL (IPM)	2.5	2.5	2.5	2.5	2.5	2.5
AMPL(IN)							O SPD (S)						
I DWL(S)							O DWL(S)						
PASS :2							LEVELS &PARAMETERS						
AMPS(V)	105.0	105.0	105.0	105.0	105.0	105.0	AGC(IPM)	5.6	5.6	5.6	5.6	5.6	5.6
WIRE (IPM)	070	070	070	070	070	070	TRAVEL (IPM)	1.5	1.5	1.5	1.5	1.5	1.5
AMPL(IN)	0.120	0.120	0.120	0.120	0.120	0.120	O SPD (S)	0.30	0.30	0.30	0.30	0.30	0.30
I DWL(S)	0.30	0.30	0.30	0.30	0.30	0.30	O DWL(S)	0.30	0.30	0.30	0.30	0.30	0.30
PASS :3							LEVELS &PARAMETERS						
AMPS(V)	098	098	098	098	098	098	AGC(IPM)	6.3	6.3	6.3	6.3	6.3	6.3
WIRE(IPM)	075	075	075	075	075	075	TRAVEL (IPM)	2.0	2.0	2.0	2.0	2.0	2.0
AMPL(IN)	0.34	0.34	0.34	0.34	0.34	0.34	O SPD (S)	0.35	0.35	0.35	0.35	0.35	0.35
I DWL(S)	0.30	0.30	0.30	0.30	0.30	0.30	O DWL(S)	0.30	0.30	0.30	0.30	0.30	0.30

Table. 8.2 Grade C+Grade C Parameters

MATERIAL: GRADEC+GRADEC							FM : ER80S-G						
PASS :1							LEVELS &PARAMETERS						
AMPS(V)	140	140	140	140	140	140	AGC(IPM)	6.0	6.0	6.0	6.0	6.0	6.0
WIRE(IPM)	030	030	030	030	030	030	TRAVEL (IPM)	2.6	2.6	2.6	2.6	2.6	2.6
AMPL(IN)							O SPD (S)						
I DWL(S)							O DWL(S)						
ASS :2							LEVELS &PARAMETERS						
AMPS(V)	140	140	140	140	140	140	AGC(IPM)	6.4	6.4	6.4	6.4	6.4	6.4
WIRE(IPM)	075	075	075	075	075	075	TRAVEL (IPM)	1.41	1.41	1.41	1.41	1.41	1.41

AMPL(IN)	0.120	0.120	0.120	0.120	0.120	0.120	**O SPD (S)**	0.30	0.30	0.30	0.30	0.30	0.30
I DWL(S)	0.44	0.44	0.44	0.44	0.44	0.44	**O DWL(S)**	0.44	0.44	0.44	0.44	0.44	0.44

PASS :3							**LEVELS &PARAMETERS**						
AMPS(V)	140	140	140	140	140	140	**AGC(IPM)**	6.6	6.6	6.6	6.6	6.6	6.6
WIRE (IPM)	090	090	090	090	090	090	**TRAVEL (IPM)**	1.41	1.41	1.41	1.41	1.41	1.41
AMPL(IN)	0.21	0.21	0.21	0.21	0.21	0.21	**O SPD (S)**	0.30	0.30	0.30	0.30	0.30	0.30
I DWL(S)	0.40	0.40	0.40	0.40	0.40	0.40	**O DWL(S)**	0.40	0.40	0.40	0.40	0.40	0.40

Table. 8.3. T91+T22parameters

MATERIAL: T91+T22							**FM : ER90S-G**						
PASS :1							**LEVELS &PARAMETERS**						
AMPS(V)	135	135	135	135	135	135	**AGC(IPM)**	7.0	7.0	7.0	7.0	7.0	7.0
WIRE(IPM)	32	32	32	32	32	32	**TRAVEL (IPM)**	2.6	2.6	2.6	2.6	2.6	2.6
AMPL(IN)							**O SPD (S)**						
I DWL(S)							**O DWL(S)**						

PASS :2							**LEVELS &PARAMETERS**						
AMPS(V)	96	96	96	96	96	96	**AGC(IPM)**	7.6	7.6	7.6	7.6	7.6	7.6
WIRE(IPM)	99	99	99	99	99	99	**TRAVEL (IPM)**	1.6	1.6	1.6	1.6	1.6	1.6
AMPL(IN)	0.38	0.38	0.38	0.38	0.38	0.38	**O SPD (S)**	0.40	0.40	0.40	0.40	0.40	0.40
I DWL(S)	0.30	0.30	0.30	0.30	0.30	0.30	**O DWL(S)**	0.30	0.30	0.30	0.30	0.30	0.30

8.1 Result

Before the corrections number of defects and finished joints quantity:

Date of weld	**Total weld joints**	**Number of defects**	**Number of finished joints**
6.2.2018	10	6	4
7.2.2018	12	4	8
8.2.2018	17	5	12

After the corrections number of defects and finished joints quantity:

Date of weld	**Total joints**	**Number of defects**	**Number of finished joints**
09.2.2018	17	2	15

10.2.2018	18	2	16
11.2.2018	10	2	8
16.2.2018	25	Nil	Nil

IX. CONCLUSION

Welding is a special process since the correlation between its process variables and the result expected is not the constant one. In welding many variables are responsible for a particular desired result. If one of the those variables are changed, the outcome may 1.change abruptly, 2.no change in the result, 3.outcome change very minimally. So devising the optimal parameters for a welding is critical one. The welder/operator has to follow the procedures and precautions effectively. Even the welder/operator follows the procedures and variables strictly, sometimes it went wrong (failure in NDT, HYDRO, failure in service). In This project we have followed the distinct procedure to solve this issue of optimization.

In this project we have grouped the process variables in 3 categories.

- Essential variables(which has direct impact on the result)
- Non-essential variable (which has minimum impact on the result)
- Supplementary variables(which don't have direct impact but act as a enable for the desire result/defect)

These classification are taken from the universally accepted welding codes like ASME sec. IX AWS D1.1 etc.We have done these experiment/analysis on a orbital TIG welding machine which is 5G operation in nature. Values for individual positions(0-30'/30'-60' etc) also studied and optimized wherever necessary for the fitness of the joint.Due to shortage of time and provision given by conducting the studies we have taken values for non-essential and supplementary variables from the WPSs. We have done analysis only on few essential variables. As the desired results are like, Passing the RT, visual, hydro, Spectro.

These results are outcome of

- Individual variables
- Derivative of two or more variables implication (derivative means combined effect)
- Derivatives of derivatives etc.

The results are taken (i.e. certain variables are fixed for optimized output) based on the decision that the joint made by this inputs are passing required tests, With this condition of variables and test requirements, the project is done and optimized variable values are found out with enough no. of repetition. The result of this project will serve as a ready reckoner for any welder for welding these materials with some small variations.

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