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Analysis of variation of hardness in TIG welded stainless steel alloy

Ankush Thakur
manshguide@gmail.com
Sirda Institute of Engineering and Technology, Sundernagar, Himachal Pradesh

Vikram Thakur
manshresearch@gmail.com
Sirda Institute of Engineering and Technology, Sundernagar, Himachal Pradesh

ABSTRACT

AISI 304 SS (stainless steel) has similar mechanical property as compare to AISI 304 SS grade, but its ability to resist corrosion is somewhat less as compare to AISI 304 SS grade in chloride environment. But it is very inexpensive so we can use it in indoor applications like indoor fabrication, automobile trim and application where atmosphere is not a considerable factor. But there is very less research reported on welding of AISI 304 SS grade. In order to find out the weakest locations of the joints and determine the optimum MIG welding parameters, this present work aims to demonstrate its MIG weldability and the emphasis is placed on the relations of the tensile properties and hardness to the welding parameters

Keywords: *TIG , Welding, ss-304, Aluminium*

1. INTRODUCTION

In 1930 the period of Second World War, for welding aluminum and magnesium in aircraft industry, the TIG welding was demonstrated first by Russell Meredith. To every branch of manufacturing welding technology has obtained access virtually; to name a few, pipeline, aircraft, automobiles, launch vehicles, nuclear power plants, ships, building construction, rail road equipment's, boilers. With the widespread applications of welding, the welding technology needs constant upgrading [2]. By causing coalescence the welding joins materials, generally metals, or a thermoplastic that is fabrication or sculptural process. For generating the weld, this operates a non-consumable tungsten electrode that is an arc welding process.

By an inert shielding gas, the weld area is confined from atmosphere, as well as filler metal is usually utilized. From the power source, the power is supplied, during a hand-piece or welding, the power source supply power as well as is brought to a tungsten electrode that is fixed into the hand piece. Then between the tungsten electrodes an electric arc is created and a constant-current welding power provide is utilized by work piece that produces the energy and during a column of highly ionized gas as well as metal vapors it conducted across the arc [1]. From the surrounding air by inert gas the tungsten electrode as well as the welding zone is protected. The electric arc will generate temperatures of up to 20,000 ° C, but this heat be able to combined to melt as well as connect two separate pieces of material. The weld pool may be utilized for connecting base metal with or with no filler material. The Schematic illustration of TIG welding as well as this procedure is seen in Figure 1 as well as Figure 2.

And the normal differences in the duration of the arc that arise in manual welding have no impact on the welding present. The capability to restrict the current to the fixed value is similarly important while the electrode is short circuited to the job component, or high current can flow unnecessarily damage the electrode. The size of the power source open circuit voltage is 60 to 80 V. The electrode is used as both the liquid metallic device as well as the red-hot filler wire tip with inert gases that protect a non-consumable tungsten pin. The Argon or Helium gas can be operated for shielding purposes. For a broad range of materials Argon is preferred and as no flux is used, inclusion cannot occur due to flux. Using TIG process almost all metals can be welded. By TIG choosing the appropriate combination, the dissimilar metal can also be welded. With zirconium or thorium these non-consumable tungsten electrodes are alloyed. In AC application Zr alloyed tungsten is used and has got good arc starting characteristics and to contamination it has high resistance. On the type of shielding gas, such as position of the weld type, the length of electrode, the cooling of the holder, the current carrying capacity of the electrode is depending.

For specified current if electrode is large, welding will be difficult and the arc will become erratic. However, the chances of electrode melting are increased by the selection of smaller diameter rod. The stainless steel TIG welding, with argon and 5% hydrogen, the nickel and its alloy may be carried out. To reduce the amount of oxides formed with stainless Steel and to increase the arc heating efficiency, the hydrogen helps. A mixture of argon as well as helium can be utilized in the case of aluminum alloy. In almost all positions, TIG welding can be done. In pressure component and other critical applications for root pass TIG is often used, a clean and accurate element is given by this. By TIG welding, the weld is made totally in aerospace works, owing to the high quality demanded there. By TIG welding, the Aluminum alloy is generally welded. With some amount of helium, Argon is the main shielding gas. By TIG with AC power source the high alloy steel, Mg, Zr, Ti, Ni alloys can be readily welded. As some of these alloys (Ti and Zr) are highly reactive must be ensuring by the pure inert gas atmosphere [3].

The highest quality welds most consistently is produced by the Gas tungsten arc welding. In any configuration it can weld all metal, but on heavy section it is not economically competitive. For welding STAINLESS STEEL, it is most popular and for nearly all process the stainless-steel pipes are used and especially in cryogenics where fusion is very necessary. On welding current due to high frequency voltage superimposed in TIG, the shielding gas gets ionized. To create a reservoir of molten material, this is sometimes achieved by melting the parts of work or applying a filler material which cools to make a solid joint, either used in combination with heat or pressure, or by itself, to generate the weld. In manual arc welding, the important procedure variables are: arc voltage, welding current as well as speed. Through their effects on weld bead penetration, the effect of these procedure variables is established. By weld bead geometry, the weld quality was strongly characterized because in formative mechanical properties of weld, the weld pool geometry performs an imperative role [4-6]. Due to increased welding current, the heat affected zone influenced with the enlarge of heat input. Because low heat input, the width of heat exaggerated zone enhances [7].

In appearance the weld bead geometry of weld repaired aluminum alloy was like as cast STAINLESS STEEL but different in the micro-structure [8]. In gas metal arc welding procedure, the relation between welding parameters and weld bead geometry was investigated which results on weld bead geometry as greatest effect of welding current. Beyond an optimum value if welding speed decreases on weld pool due to the pressure of electric arc, the depth of penetration is decreases [9]. The cooling rate is influenced by the heat input parameter, weld mechanical properties and weld bead size [10]. For low gun angle less depth of penetration was obtained due to less pre-heating of base metal [11]..

1.1 Principles of tig welding

With the electrode attached to the power source 's negative pole, DCEN conventionally utilizes direct current for welding most of the TIG process materials. An efficient oxide removal does not give by the welding on this polarity.

If in the DCEN (direct current electrode negative) or DCSP (Direct Current Straight Polarity) 2/3rd of the heat then it is concentrated on the weld joint. On the tungsten electrode, the DCEP (direct current electrode positive) or DCRP (Direct Current Reverse Polarity)2/3 rd of the heat is concentrated. For DCEN penetration is deepest, least for DCEP and less for AC.

1.2 DCSP - Direct Current Straight Polarity

This is used in this kind of TIG welding. The negative terminal of power supply is connected with the Tungsten electrode. DC welding process is most commonly and widely used by this type of connection. The negative terminal is being connected with the tungsten; it will just get thirty percentage of the welding energy. A good penetration as well as a narrow profile is shows by the resulting weld.

1.3 DCRP - Direct Current Reverse Polarity

The +ve terminal of power supply linked with the tungsten electrode in such kind of TIG welding setting. Because most heat is on the tungsten, such kind of connection is utilized hardly ever, so the tungsten can easily burn away and easily overheat. A shallow is produces by the DCRP, at low Amp broad profile as well as is mostly utilized on very light material.

2. RELATED WORK

Chen et al. 2019 In a butt joint methodology, Hybrid laser based TIG welding of (10 mm thick) SS400 low carbon steel to 304 austenitic stainless steel was conducted. Experimental and simulation methods examined the relation between the position of the heat sources, the mechanical properties, and the metallurgical transmutations of welds. Analysis indicate that improved weld performance was obtained whenever the heat source was put on a welding metal interface opposed to the stainless-steel aspect being offset. Weld efficiency in respect of tensile strength, microstructure, and hardness distribution was highly defined as the position of heating systems in hybrid laser-TIG welding due to the variations in thermodynamic properties of two welding components. Results of the Tensile test indicate that the samples welded failed with a ductile fracture mode mostly on SS400 base metal.

Cárcel-Carrasco et al. 2019 The rolled stainless steel welds in AISI 304, pitting corrosion has been studied mostly in weld region as well as in the heat-affected zone (HAZ). When the above product is among the most widely used source of stainless Steel, it is crucial to remain aware of its processes contributing to its degradation, such as corrosion, as it can collapse mechanism or breakdown in a wide range of facilities and products. The 1.5 mm thick AISI 304 stainless steel plates were rolled and welded to various thicknesses for the experimental tests, and after that the specimens were exposed to corrosion and mechanical studies and a micrograph analysis. The physical-chemical transforms occurring, intrinsic metallurgical and deformation of the stresses across welding and cold rolling have been identified and studied, which have been important factors mostly in anti-corrosion AISI 304 behavior of rolling stainless Steel. A link among cold work locations in tests performed and quantity of pits was found following corrosion tests

Wang et al. 2019 Investigated the corrosion activity and microstructure of dissimilar welds between AISI 430 based ferritic stainless Steel and austenitic stainless Steel. The evolution of the phase inside each weld was studied with measurement of electron back-scattered diffraction (EBSD)and thermodynamics by electron. Analysis indicate the welding parameters were composed mainly of phases of ferrite and martensite. Thermodynamic measurements showed that high-temperature ferrite transitions into austenite to shape a blended state mostly during high-temperature phase transforming method. This austenite eventually converts into martensite mostly during subsequent step of high-rate cooling. It was also noticed that while increasing the portion of the melted-in-AISI 304 within dissimilar welds, contributed to rise in the portion of austenite at elevated temperatures. This meant that more parts of martensite were available at room temperature in the weld. The curves based on Potentiodynamic polarisation showed that with an increment of fusion ration of AISI 304, the corrosion-based resistance of welded joint declined and then improved or increased with further rise in the ratio of fusion.

Touileb et al. 2020 This study carried out on 430 stainless steel alloy ferrite alloys. Experiment design is used to provide finest flux framework. Nineteen compositions of the flux were primed using the method of mixing, utilizing Minitab17 software. Fluxes represents the three oxides combinations (TiO_2-SiO_2-MoO_3). The finest methodology to attain the optimum weld depth has been obtained in Minitab 17 software by using optimizer module. Thus, the depth obtained is two times that of traditional TIG welding. In addition, corrosion resistance and mechanical properties were evaluated forATIG and TIG welds in impact, hardness, and tensile tests as well as in the measurement of potentiodynamic polarization.

Kotari et al. 2020 TIG was evaluated for weld-brazing of dissimilar materials of magnesium alloy to stainless Steel, and the spreading and wettability ability of magnesium-based filler metal on the stainless-steel surface was analyzed. A scanning electron microscopy (SEM) and an optical microscope were used to examine the microstructures of welded specimen. Attributed to the prevalence of MgO and MgAl2 intermetallic compounds the microhardness at the welding interfaces reported to be greater than that of the substrates. The weld joints based ultimate tensile strength was approximately 69 MPa, and the tensile fracture took place at the heat-affected zone mostly on the interface of the stainless steel / weld seam and/or weak magnesium side material along intermetallic layer. Utilizing SEM analysis, the surface of the fracture was analyzed. Mostly with development of voids, the ductile phase of fracture has been observed.

3. THE PROPOSED METHOD

3.1 Proposed Methodology

This will discuss the experimental procedure in detail. The step by step Flow Chart of the procedure of experiment is given below. All the steps are explained in details in this chapter ahead.

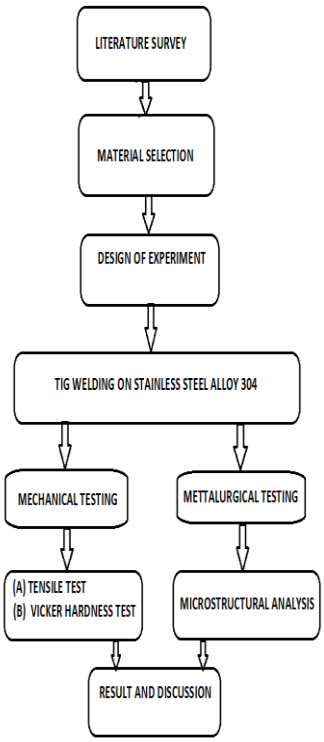

Fig. 1: Flow Chart for Planning of Work

Table 1: Welding parameters of experiment

Parameters	Range
Welding current	90-180 Amperes
Voltage	250 Volts
Gas flow rate	10-14 litres/minute
Distance of tip from weld centre	3 mm
Current type	AC

3.2 Development Of A Tig Welding System

For suitable welding as well as control on welding parameters welding system was established. The welding system constitutes mainly subsequent parts:

Fig. 2: TIGWelding Setup– Ever Last TIG 250 AC/DC TIG Welding System

3.2.1 Tig Welding Equipments

1) **Tig Torch:** Torch with movabe tractor unit is permanent. In the torch a tungsten electrode is set, and Argon gas flows during this torch.
2) **Tig Machine:** This is the major component of the TIG welding system that supplies the controlled quantity of voltages as well as currents through the welding procedure. A rectifier with current range of 10-250 amperes as well as a voltage of up to 250 V was used, depending on the current setting.
3) **Gas Cylinder:** For TIG welding Argon gas is supplied with a specific flow rate to the welding torch in order to inert atmosphere is created as well as a stable arc for welding is created. Gas flow is controlled by valve as well as regulator.
4) **Work Holding Table:** a surface plate is utilized to hold the work piece in order to gap among the tungsten electrode as well as the work piece is retained during welding. Appropriate clamping was applied to hold the piece of work.
5) The torch was held at an angle nearly 90 ° to the piece of work.

4. RESULT ANALYSIS

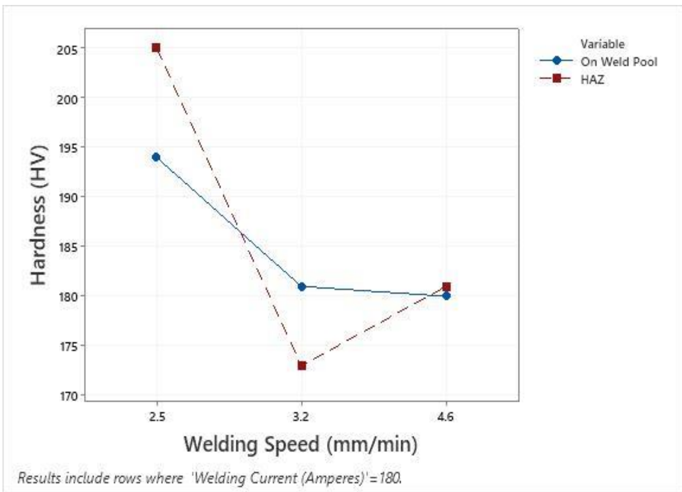

Fig. 3: Variation of Hardness of Specimens with Welding Speed at 180 Amperes on (a) Weld Pool (b) HAZ

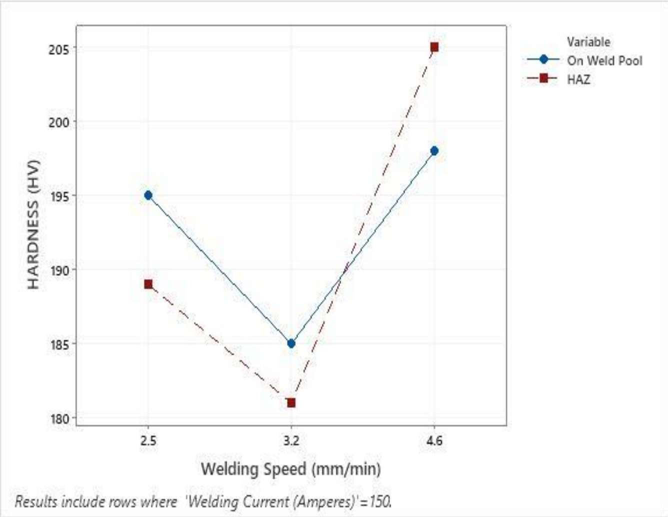

Fig. 4: Variation of Hardness of Specimens with Welding Speed at 150 Amperes on (a) Weld Pool (b) HAZ

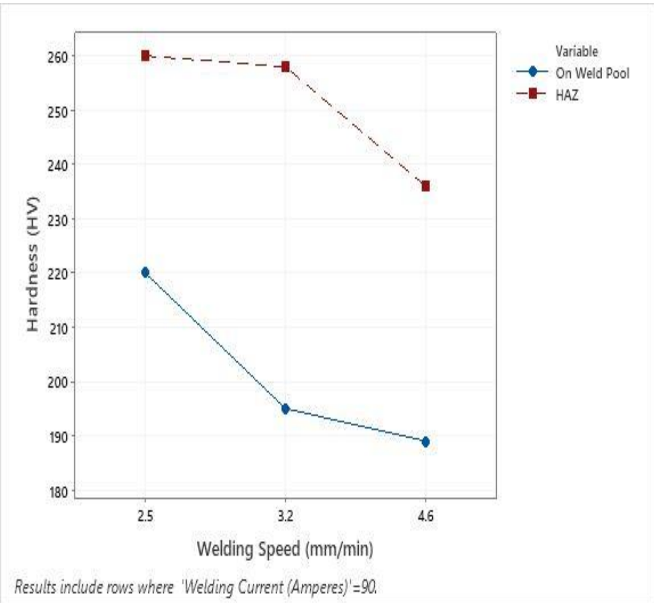

Fig. 5: Variation of Hardness of Specimens with Welding Speed at 90 Amperes on (a) Weld Pool (b) HAZ

This more direct effect mostly on base material results in a higher penetration of the weld as it reduces the weld pool's cushioning impact. The hardness variation on the welding samples at 180 amperes on the weld pool and HAZ is shown in Figure 4.4. At 100 amperes, the hardness in the weld pool changes not so much at welding speed, but at HAZ, the hardness varies greatly at 3.2 mm / min welding speed, that is due to variation in the cooling rate produced at different welding speeds. The variations in the reliability of samples with welding speed at 150 amperes and 90 amperes of welding current with respect to the welding pool and HAZ are shown in Figure 4.5 and Figure 4.6. In cases of 150-ampere welding current, the average hardness is lower than that of other instances of samples welded at 90 amperes and 180 amperes of the welding current. And in the case of a 150 ampere, the lowest hardness is accomplished with 3.2 mm/min welding speed. Conversely, optimum durability is obtained at a welding speed of 2.5 mm/min with 90 amperes welded capacity.

5. CONCLUSION

Welding strength or tensile strength of the weld joints of SS-304 based on the welding parameters like welding current, welding speed as well as filler material.At low gas flow rate welded specimens of SS-304 show high tensile strength as well as low ductility.Welding defects like Porosity can drastically affect the properties of welded specimens of SS-304 alloy. At high welding speed, there is a high tendency of welding faults as well as inappropriate weld metal penetration occursResults in a change in microstructure particularly grain size, the hardness value of the weld zone changes with the distance from the weld centre. Hardness can increase because of two reasons; one is due to formation of metal oxides at low gas flow rates and another is due to proper fusion of filler metal with base metal.

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