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A review on TIG welding for optimizing process parameters on dissimilar joints

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ABSTRACT
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 abouttheTungsten Inert Gas welding of joining heat treatableof stainless steel and mild steel.These welded joints have higher tensile strength to weight ratio and finer micro structure. Tungsten Inert Gas Weldingofdissimilar material such as stainless steel and mild steel have the potential to hold good mechanical and metallurgical properties.

Keywords-TIG, stainless steel and mild steel, tensile properties, hardness, microstructure.

I. INTRODUCTION

Welding is a joining process usually metals or alloy by causing coalescence. In which process coalescence of materials is produced by heating them to recrystallization temperatures with or without use of pressure and with or without the use of filler material. Welding is used for permanent joints of metals. TIG welding is a part of welding process and it can be wildly used in modern industries for joining either similar or dissimilar materials. Tungsten inert gas (TIG) welding is also called the gas tungsten arc welding (GTAW). TIG welding advantages like joining of similar and dissimilar metals at very high quality weld, low heat affected zone, absence of slag etc. Gas tungsten arc welding wildly uses a non-consumable tungsten electrode to produce the weld because it created a very high temperature to weld the metals. Weld zone is protected by a shielding gas (usually inert gas such as argon) from atmospheric air or gases and a filler material is normally used for fill the gap of metal [1].

Tungsten Inert Gas (TIG) welding suffers from the following disadvantages: (a) low productivity; (b) relative Shallow penetration; and (c) the high sensitivity of the surface condition and chemical composition of the base metal [2]. Dissimilar metal welding is frequently used to join stainless steels to other metal of mild steel. This approach is most often used where a transition in mechanical properties and/or performance in service are required [3].

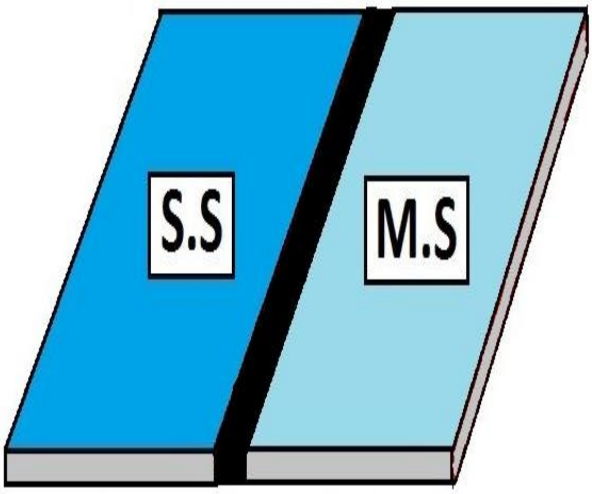

Fig. 1: Diagram of TIG welding plates

The materials used for dissimilar welding were SS-304 and MS-1018, nominally 3 mm in thickness. The chemical compositions of SS-304 and MS-1018 alloy are shown in Tables 1 and 2, respectively.

Table 1. Chemical compositions of SS-304

%	C	Mn	S	P	Si	Ni	Cr	Cu
304	.087	9.0	.009	.055	.23	1.050	15.45	1.64

Table 2. Chemical compositions of MS-1018

%	Fe	C	Mn	S	P
1018	98.97	0.17	0.68	0.051	0.040

Before welding, the samples were prepared and welding can be done. Transverse cross-sections were observed by optical microscopy (OM). The specimens for optical microscopy were cut perpendicular to the welding direction using an electrical discharge machine. The Vickers hardness profile of the weld was measured on the cross-section perpendicular to the welding direction [4].The tensile strength are performed on universal testing machine (UTM).

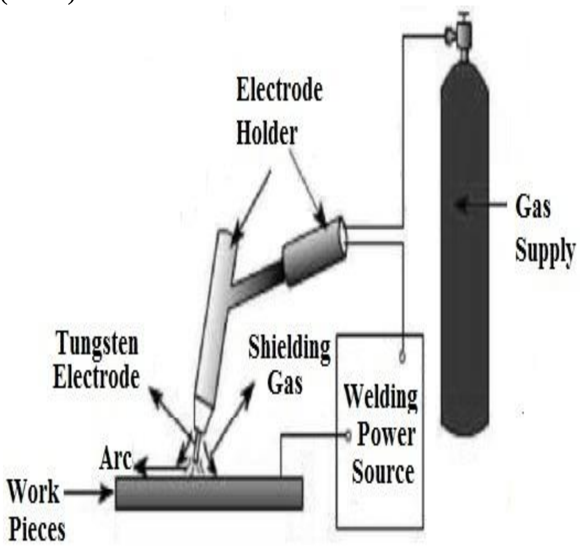

Fig. 2: Schematic diagram of TIG welding process [1]

II. PROCESS PARAMETERS

Although TIG welding gives high quality welds, proper execution of the process and control of a number of parameters is required for a successful outcome. Recent experimental works can be provided insight into how process parameters influence material flow in TIG welding process. Most of the material flow occurs through the retreating side and the transport of material beings forms the welded joint. Process parameters, such as Welding speed, Gas flow rate, Welding current acting on the working material during welding and the heat input during the process, are found to exert significant effects on the material and the temperature distribution by implication these factors inevitably influence the micro structural evolution and mechanical properties of the materials being joined [5].

III. LITERATURE REVIEW

Kohyama et.al [6]studied he Microstructural changes in welded joints of 316 SS by dual-ion irradiation was analyzed in this study. They welded the specimens at three different parameters Current, Voltage, Flow Rate. They used the welding specimen have dimensions 500Lx 300w x 15t and finally conclusion of Microstructure evolution in welded joints is emphasized to be very sensitive to He/dpa ratio, especially in HAZ. Thus, mechanical and corrosion property changes m welded joints under fusion environment, should be very carefully evaluated. And the I-butt welding of 15 mm thickness plate, may produce the least swelling resistant zone m the HAZ.

Ahmet Durgutlu [7] studied the experimental investigation of the effect of hydrogen in argon as a shielding gas on TIG welding of ss material by changing the parameters Shielding gas 1.5%H2–Ar and 5%H2–Ar and pure Argon. Tensile strength and Penetration on plate specimen have dimensions 200L x 80w x 4 mm. They find the shielding gas of 1.5%H2–Ar the sample welded highest tensile strength was obtained. And it can be observed that increasing hydrogen content in the shielding gas reduces the mechanical properties.

P. Liu et.al [8] worked on microstructure characteristics in TIG welded joint of Mg/Al dissimilar materials using the welding plate specification of 100Lx40Wx3thk mm on parameters of welding velocity, wire feed velocity. And they find out the Microstructure, Hardness and Fracture and conclusion of there is an obvious fusion zone between the Mg substrate and weld metal. The structure close to the weld metal is columnar crystals, which grow into the weld metal. The Mg substrate close to the fusion zone was largely affected by the welding thermal cycle, and the crystals were small. The weld metal was mainly composed of dendrite crystal.

M. Ahmad et.al.[9] Analyzed the microstructure and characterization of phases in TIG welded joints of Zircaloy-4 and ss 304L on the plate specimen on 2 x 1 x 0.3 cm.Input process parameter range of voltage 30–60 V, current 12–15 and Gas flow rate 15 l/min using the X-ray diffraction (XRD) technique. They finally find Zr(Cr, Fe)2 intermetallic compound and Zr2Fe–Zr2Ni eutectic phases have been observed in the molten zone of the TIG welded joints of the Zircaloy-4 and stainless steel 304L. The density of Zr(Cr, Fe) is about twice as compared to Zr2Fe–Zr2Ni eutectic phase. Hardness of the Zr (Cr, Fe)2 intermetallic compound is about three times higher eutectic phase. Density of Zr (Cr, Fe)2 intermetallic compound is low on the side of Zircaloy-4 as compared to SS 304L.compared to Zr2Fe–Zr2Ni.

B.Y. Kang et.al[10] study the effect of alternate supply of shielding gases in austenite stainless steel GTA Welding on the material of Stainless Steel 304 by used the specimen of 200L x 100w x 12 thk weld and apply the both Conventional and Alternate method. The input parameter of Shielding gas, welding ampere (A) and welding voltage (V). The result of under similar welding conditions, the alternate method with Ar and He compared with the conventional methods of Ar and Ar + 67% He produced the lowest degree of welding distortion. Compared with the conventional method of Ar +

67% He, the alternate method with Ar and He under similar welding conditions showed similar welding speed without largely deteriorating the weld shape. The alternate method with Ar and He presented the possibility of solving the problem of the increase in gas cost and welding distortion with the use of He in stainless steel welding.

S. P. Gadewar et.al **[11]** analyzed of the experimental investigations of weld characteristics for a single pass tig welding with SS304 using the specimen of 100L x 25w x (1or 2 or 3) thickness of welding plate. They used the input parameters of Welding current (15-180 Amp), Shielding Gas Flow (1-18 LPM), Work Piece thickness (1-3mm) and apply the Regression analysis technique. And the final result of it is observed that as thickness of the work piece increases the Front width and Back width value across the weld also increases.

Rui-Hua Zhang et.al **[12]** study of the mechanism of penetration increase in A-TIG welding used the stainless steel materials plate which specimen are 150Lx 40w x 10 t and 300L x 40w x 20 t mm. They used the input parameters which are flux- Al2O3, Fe2 O3, SiO2, Cr2O3, TiO2, MnO, and B2O3 to find the result of penetration simulation by the PHOENICS software. The final result of that experiments are Arc construction and increase in voltage can cause the width of the weld to become narrower but have little effect on penetration. Stronger inward fluid flow patterns leading to weld beads with narrower width and deeper penetration could be apparently identified in the case of A-TIG welding.

C. Balaji et.al **[13]**have studied on evaluation of mechanical properties of SS 316 L weldments using tungsten inert gas welding. They consider the stainless steel 316 L rod specimen which have dimensions of 25 mm diameter and 75 mm length. They changed the input parameters range which are current (90,100,110 amp) bevel angle (60, 70, 80^0) gas volume (1.1, 0.9, 0.7 lpm) uses the Taguchi L-9 orthogonal array technique and they find the result are The tensile test has showed that the Current of 110A, Bevel Angle of 600 and a gas flow of 0.7 lpm offers the maximum tensile strength. The tensile test has also showed that the Current of 100A, Bevel Angle of 600 and a gas flow of 0.9 LPM offers the minimum tensile strength. The micro hardness has showed that the sample with the minimal tensile strength has the maximum micro hardness, which concludes that, the increase in micro hardness results in the decrease of the tensile strength. Dheeraj Singh et. al**[14]** studied on parametric optimization of TIG process parameters using Taguchi and Grey Taguchi analysis. They used the Stainless Steel 304 grade plate which dimensions are 1.2 t x 250 l x 30 w and changed the process parameters which are Current (40-85A), Gas flow rate (5-20 lit./ min), Welding speed (8-14m/min) and Gun angle (50^0-80^0). And they applied the Taguchi method L16 orthogonal array for optimization the result. Finally they find results which are If the optimal setting for steel with a current 40 A, gas flow rate 5 ltr/min, welding speed 12 m/min and gun angle 800, for stainless steel, the final work piece give the Tensile load (294.1Mpa), Area of penetration (13.05 mm2), penetration (2.215 mm) maximum Bead width (5.22 mm) and Bead height (0.055 mm) are minimum.

Cheng-HsienKuo et.al **[15]** studied on the effect of activated TIG flux on performance of dissimilar welds between mild steel and stainless steel and they used the dissimilar plate which have the dimensions of 100l x 50w x 6 t and they use the Austenitic stainless steel (SUS 316L) and hot-roll mild steel (JIS G3131) for weld. They changed the process parameters which are different flux CaO, Fe2O3, Cr2O3, and SiO2. Finally they find the conclusion of the surface appearance of TIG welds produced with oxide flux tended to form residual slag. The SiO2 powder can give the greatest improvement in joint penetration and also a satisfactory surface appearance of G3131 mild steel to 316L stainless steel dissimilar welds. TIG welding with SiO2 powder can increase weld depth-to-width ratio, which indicates a high degree of energy concentration during welding process, and tends to reduce angular distortion of the weldment. Furthermore, the defects susceptibility of the welds can also be reduced.

IV. CONCLUDING REMARKS

From above literature review it is indicated that

1. Gas Tungsten Arc Welding process parameters Welding Speed, Welding Voltage, Welding Current, Gas flow rate, Electrode diameter, Distance between tig torch and work-piece etc. are important control on welding materials.
2. TIG welding parameters are affect the weld strength in terms of weld bead geometry and mechanical strength.
3. Microstructure characteristic will be studied at different zones and investigated how the material will be affected by the temperature distribution during TIG welding compare to the Base material.
4. Hardness will be calculated at various different zone.

V. SUMMARY AND FUTURE WORK

In this above review article, microstructure and material properties are specific issues. TIG weld strength is optimized by weld bead geometry. A width to penetration ratio means a narrow or thin plate weld. This can also provide a high quality of the weld.

The stainless steel and mild steel are challenging to weld due to their high thermal conductivity in weld pool. Hence it is proposed to go for TIG welding of dissimilar weld. It is proposed to perform the process parameter optimization work for Gas Tungsten Arc welding. The Design of Experiment (DOE) shall be done by Taguchi Method.

Taguchi Method can be used to conduct the experiments because its implementation are simple. TIG welding parameters welding current, welding speed, current and gas flow rate are selected for controlling the process. Welded joints specimen shall be tested by a Universal Testing Machine and elongation shall also be calculated. From the basis of experiments result to develop the mathematical models and evaluate the various process parameters effect on tensile strength of material.

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