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Review of Selection of Tungsten Inert Gas Welding Parameters for Stainless Steel

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Abstract – Tungsten Inert Gas (TIG) is also called as gas tungsten arc welding (GTAW). It is most commonly used welding process in many industrial applications. It uses non consumable electrode made of tungsten and shielding gas to prevent weld pool contaminations from atmospheric gases especially when joining high strength reactive metals such as stainless steel, aluminium and magnesium alloys. Stainless steel are the corrosion resistance steels which contains minimum of 10.5% of chromium. Although the nickel and molybdenum is added to improve corrosion resistance chromium is always the deciding factor. They have wide applications in chemical processing equipments, food equipments.

Keywords— TIG, DCSP, DCEN, Electrode, Shield gas

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INTRODUCTION

Welding is a manufacturing process in which two workpices are joined by fusion process. TIG welding was developed at the start of Second World War in 1940.It is also called as Gas Tungsten Arc welding. It is one of the best welding method for joining of difficult materials such as aluminium, magnesium, steel and their alloys [1]. Basic components of TIG welding system are power source, welding torch (air/water cooled), tungsten electrode and gas nozzle, inert gas for preventing weld and controls for moving torch [2]. In TIG welding process electric arc is produced between tungsten electrode and work piece. Shielding gas generally argon or helium or mixture of both can also be used to prevent weld pool from atmospheric contamination [3-4]. Stainless steels are the corrosion resistance steel having major composition of chromium and nickel with low percentage of carbon [1, 3, 4,]. Depending upon the chromium and nickel percentage stainless steel is again classified into different categories a0ustenite, ferrite and martensite stainless steel [5].

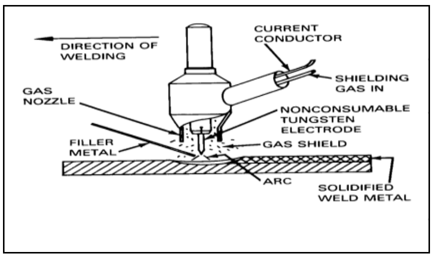

Fig.1Basic Mechanism of TIG Welding

WELDING CURRENT

Weld quality depends upon the proper selection and control of the welding current.

1 Direct Current Straight Polarity (DCSP)

In this type tungsten electrode is connected to the negative terminal. This is most commonly used DC type welding. As tungsten electrode is connected to negative terminal. As current flows from negative terminal to positive 70% of heat is transferred to the work piece and 30% on electrode which results in deep penetration and narrow bead width [6,7]. DCSP is mostly used to thick sections.

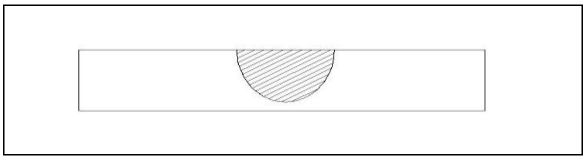

Fig.2 Direct Current Straight Polarity Gives Narrow Bed Width and Deep Penetration

2 Direct Current Reverse Polarity (DCRP)

The tungsten electrode is connected to the positive terminal. This connection is rarely used because more heat is on tungsten and it can easily burn away. DCRP produces shallow penetration and wide bead profile.

Because of lack of penetration large diameter tungsten electrode is required [7,8]. Good cleaning action takes place in this type of connection.

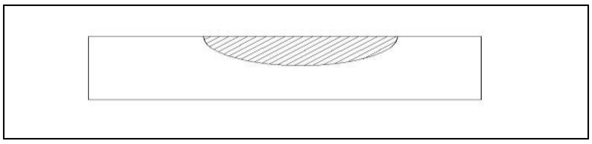

Fig.3 Direct Current Reverse Polarity Gives the Shallow Penetration and Wide Bead Width

3 Alternating Current

This is preferred for the welding of aluminium and magnesium. For half cycle tungsten is positive and current flows from work piece to electrode will result in lifting of any oxide layer on base metal so called as cleaning half while other half cycle is called as penetration half in which tungsten is negative.

TUNGSTEN ELECTRODE

Tungsten is very hard material with melting temperature of 3422C Tungsten retains its hardness even at hot red condition. The non-consumable tungsten electrode establishes and maintains the arc[6-9]. Electrodes are available in different sizes and lengths. They are made of pure tungsten or combination of tungsten and other elements and oxides. Most commonly used alloying elements are thorium, zirconium, cerium and lanthanum. Alloyed electrodes have more current carrying capacity than pure tungsten electrodes [9]. Types of tungsten electrode are classified according to the chemical composition. The diameter of tungsten electrode is often determined from the thickness of base metal. Tungsten electrode available is 0.30mm to 8mm in diameter. Lengths of tungsten electrode are often determined from the torch used for particular application. Types of electrodes, standard diameters and lengths are given in the table.

TABLE II Different Tungsten Electrodes

AWS Classification	Colour code	Alloying element (oxide)	Weight %
EWP	Green	-	-
EWCe-2	Orange	Cerium (CeO_2)	2
EWLa-1	Black	Lanthanum (La_2O_3)	1
EWTh-1	Yellow	Thorium (ThO_2)	1
EWTh-2	Red	Thorium (ThO_2)	2
EWZr-1	Brown	Zirconium (ZrO_2)	0.25

In above table in first column

- E is the designation of electrode
- W is the designation for chemical composition of tungsten.
- The next one or two letters designate the alloying elements.
- Number "1","2" indicate approximate percentage of alloying elements.

TABLE II Standard Diameters of Tungsten Electrode (in mm)

0.30	0.50	1.00	1.60
2.40	3.20	4.00	4.80

TABLE III Standard Lengths of Tungsten Electrode (mm)

76	152	178	305	457	610

SHIELDING GAS

Mostly all arc welding process uses shielding gas to protect the weld pool otherwise molten metal reacts with atmosphere and produces porosity in the weld [1, 2, 10]. Primarily argon and helium are used in TIG welding to protect the weld pool. To take the advantage of both the gases some time mixtures of these gases also be used. As the density of helium is lower than the argon gas flow rate required is more [12]. Hydrogen and nitrogen are also used with the argon in mixture. The hydrogen with argon increases the travel speed. But addition of hydrogen will increase the risk of hydrogen cracking. Nitrogen with argon increases the capability of producing more energy to work than argon alone. This can be beneficial for welding high conductivity materials such as copper but cannot be used to weld the stainless steel because nitrogen in weld pool reduces the weld strength [13]. Other than shielding the type of gas has the influence on characteristic and behaviour of the arc. Argon is the by-product in manufacturing of the oxygen. While selecting the shielding gas ionization potential of gas must be taken into account. Ionization potential is the voltage required to electrically charge the gas so that it will conduct the electricity. So this is the minimum voltage required to maintain and stabilize the arc [14]

Table IV Comparison of Argon and Helium as Shielding Gas

Argon	Helium
Since ionization potential is low (15.7eV) easy arc starting at low amperage also.	Because of higher ionization potential (24.58eV) difficult to start an arc at lower amperage.
Density of argon is 1.5 times more than air and ten times than helium so lower flow rates are required.	Density of helium is much less than argon so gas flow rate required is more.
Thermal conductivity is low results in concentrated arc.	Thermal conductivity is more so arc column become wider.
Argon provides good cleaning action.	Lesser cleaning action than argon

1 Pre Flow and Post Flow

The purpose of pre flow and post flow is to prevent weld pool from contamination. When the torch is not in use air will enter through nozzle. Moisture in air can condense inside the nozzle and then causes hydrogen contamination during initial stages of the weld result in hydrogen cracking in heat affected zone. This is the main problem occurs while welding the stainless steel. Pre flow will clean the moisture. Post flow works in different manner. Immediately after weld tungsten, filler rod and weld remains too hot so that it can react with atmosphere will result in oxidizing of all of the above. So postflow prevent oxidation [15].

Table V Post Flow Time of Shielding Gas

Electrode diameter(mm)	Postflow time(sec)
0.30	5
0.50	5
1.0	8
1.6	8
2.4	10
3.2	10
4.0	15
4.8	15

WELDING TORCH

TIG welding torch mainly consist of three parts tungsten electrode, collet and nozzle. Primary function of collet is to hold the tungsten electrode. Nozzle helps to form a firm jet of inert gas around the arc, weld pool and tungsten electrode. Gas nozzles or cups are made up of heat resistant material. Ceramic and alumina are most commonly used nozzle material. Tig welding torch is rated on the basis of weld current carrying capacity. Depending upon weld carrying capacity welding torch are either water cooled or either air cooled. Water cooled torch are having more heat carrying capacity than that of air cooled [6, 7,8].

WELDING OF STAINLESS STEEL

Stainless steel or corrosion resistance steels are a family of iron base alloys having excellent resistance to corrosion. Stainless steel consist iron, nickel and at least 10.5% chromium as main elements. Depending upon the other alloying elements stainless steels are again classified into different group. Austenite stainless steel consists of 200 and 300 series of which 304 is most common [15,16]. Primarily nickel and chromium are added. Ferrite stainless steel is non hardenable steel. Martensitic stainless steel are similar in composition of that ferriitic group but contains more carbon and lower chromium content to permit hardening by heat treatment. Both ferrite and martensite stainless steel consist of 400 series. Duplex stainless steel microstructure contains equal amount of ferrite and austenite. They contain roughly 24% chromium and 5% nickel [17]. Most stainless steel are considered to have good weldability and are welded by several welding techniques. Heat input can be critical in many applications. It is desirable to keep as minimum as possible. In the weld and heat affected zone metallurgical changes takes place [18,19]. At high temperature chromium and carbon reacts and forms the chromium carbide in heat affected zone results in depletion of chromium. Most of the carbon found at the grain boundaries so carbide precipitation takes place near boundaries reduces the corrosion resistance property of the steel. This phenomenon is also called as intergranular corrosion or sensitization [20]. This problem can be remedied by using low carbon base metal and filler material to reduce the amount of carbon available to react with carbon [21]. Weld should be made without preheat and low heat input. Proper precaution should be taken while preparing the stainless steel for weld. Only brushes should be used while cleaning [22]. steel wire

TABLE VI TIG Welding Parameters for Stainless Steel with Argon as Shielding Gas

Material size(mm)	Tungsten Size(mm)	Filler size (mm)	Current (A)	Gas flow (LPM)
1.6	1.6	1.6	80-100	3-5
2.4	1.6	1.6	80-120	3-5
3.2	1.6	2.4	100-160	6-10
4.8	2.4	3.2	150-250	8-12
6.4	3.2	4.8	275-300	8-12

Some key parameters in TIG welding of stainless steel.

- Thoriated, ceriated and lanthanated electrodes are used.
- Direct current straight polarity should be used.
- Argon as shielding gas.
- Nozzle made of ceramic.

CONCLUSION

Weld quality of stainless steel depends upon the proper selection and control of the parameters. DCSP gives deep penetration while DCRP gives shallow penetration. Alternating current gives good cleaning action against oxides. Alloyed tungsten electrodes have the high current carrying capacity. By selecting low carbon base metal and low heat input intergranular corrosion can be avoided. Proper preflow and post flow of shield gas helps to avoid the porosity defect. Argon gives the better weld quality than helium because of its low ionization potential and produces concentrated arc.

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REFERENCES

[1] Anand Rao& Dr.R.Deivanathan” Experimental Investigation for Welding Aspects of Stainless Steel310 for the Process of TIG Welding” 12th Global congress on manufacturing and management, GCMM 2014 procedia engineering, vol 97,2014 pp.902-908.

[2] Larry F. Jeffus. Welding Principles and Applications Publisher Cengage Learning. 2002

[3] Larry F. Jeffus Welding and Metal Fabrication Publisher Cengage Learning. 2012.

[4] Miller: Guidelines for gas tungsten arc welding (GTAW**).**

[5] N.Jeyprakash, Adisu Hail&, M.Arunprakash“The parameters and equipments used in TIG welding: A Review”, The International Journal of Engineering and Science D Vol. 4, 2015, pp 11-20.

[6] Edwin Raja Dhas J, Jenkin Hexley Dhas”A review on optimization of welding process” International Conference on Modeling, Optimization and Computing Proceedia Engineering vol 38 ,2012,pp.544-554.

[7] Jun Yan, Ming Gao, Xiaoyan Zeng “Study on microstructure and mechanical properties of 304L stainless steel joints by TIG, laser and Laser-TIG hybrid welding” Optics and Lasers in Engineering vol 48,2014 pp.512-517.

[8] P. Bharath, V.G. Sridhar, M. Senthil kumar “Optimization of 316 stainless steel weld joint characteristics using taguchi technique” 12th Global Congress on Manufacturing and Management, GCMM 2014 procedia engineering, vol 97,2014 pp. 881-891.

[9] Radha Raman Mishra, Visnu Kumar Tiwari and Rajesha .S ” A study of tensile strength of MIG and TIG welded dissimilar joints of mild steel and stainless steel”. International Journal of Advances in Material Science and Engineering vol 2,no3, 2014.

[10] Manoj Saini, Navneet Arora, Chandan Pandey, Husain Mehdi” Mechanical Properties of bimetallic weld joint between SA 516 grade 65 carbon steel and ss 304L for steam generator application” International Journal of Research in Engineering and Technology.vol 3,2014.

[11] Gulwade S.H. and Arakerimath R.R 'Parameter optimization of TIG welding using austenitic stainless steel', International Journal of Innovative and Emerging Research in Engineering vol 01,2015. pp. 120-124.

[12] Ravinder, S. K. Jarial" Parametric optimization of TIG welding on stainless steel (202) & mild steel by using Taguchi method" International Journal of Enhanced Research in Science Technology & Engineering, vol 4,2015,pp 488-494.

[13] D.Devakumar,D.B.Jabaraj "Research on gas tungsten inert gas welding of stainless steel-an overview" International Journal of Scientific and Engineering Research, vol5, 2014,pp.1612-1618.

[14] Lalit S .Patel, Tejas C.Patel "Optimization of welding parameters for TIG welding 304L stainless steel using Taguchi approach" International journal of Engineering Development and Research, vol 3,2014,pp-1165-1169.

[15] Hussain Zuhailwai et al."Welding investigation and prediction of tensile strength of 304 stainless steel sheet metal joint by response surface method"5th International Conference on Recent Advances In Materials, Minerals and Environment(RAMM)& 2nd International Postgraduate Conference on Materials, Minerals and Polymers(MAMIP). Procedia chemistry, August 2015, pp.217-221.

[16] Sudhakaran et al."The effect of welding process parameters on pitting corrosion and microstructure of chromium and manganese stainless steel gas tungsten arc welding" 12th Global Congress on Manufacturing and Management, procedia engineering, vol 97, 2014, pp.790-799.

[17] F.Souza Neto"An analysis of the mechanical behavior of AISI 4140 steel after TIG and laser welding process" International Conference On Structural Integrity, procedia engineering, vol114,2015,pp.181-188.

[18] Gracia Renteria Marco Arturo "Electrochemical characterization of AISI 2025 duplex stainless steel joint with electromagnetic interaction "International Congress Of Science and Technology of Metallurgy And Materials SAM-CONAMET 2013, procedia material science, vol 8,2015, pp.950-958.

[19] Mohammed Al Hajri "Premature failure of dissimilar metal weld joint at intermediate temperature super heater tube "Case Studies In Engineering Failure Analysis,vol 3,2015,pp.96-103.

[20] G.Mugudeeswaran et al."Optimization of process parameters of the activated tungsten inert gas welding for aspect ratio of UNS S32205 duplex stainless steel" Defence Technology ,vol 10,2014,pp.251-260.

[21] S.Raghu Nathan "Effect welding processes on mechanical and microstructural characteristics of high strength alloy naval grade joints" Defence Technology.vol 11, 2015, pp.308-317.

[22] Meenakshi Vaghani, Dr. S. A. Vasanwala, Dr .A. K. Desai "Stainless steel as a structural material: State of review" International Journal of Engineering Research and Applications, vol4, March 2014, pp.-657-662.

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