TIG WELDING PROCESS PARAMETERS SELECTION FOR ALLUMINIUM ALLOYS -: A REVIEW

[1]Vikarm, [2]Yajvinder, Ghanshyam Das[3]

[1]Assistant professor, Department of Mechanical Engineering, Manav Institute of Technology & Management, Hisar, Haryana (India)

[2]Research Scholar, Department of Mechanical Engineering, Guru Jambheshwar University of Science & Technology, Hisar, Haryana (India)

[3]Reseach Scholar, Department of Mechanical Engineering, Punjab Technical University, Jalandhar, Punjab (India)

Abstract: The main objective of industries reveals with production and manufacturing produce better quality product at low cost and higher efficiency. So in this paper we will study in detail about TIG welding techniques and its parameters which play an important role in the cost and quality of the welding process. TIG welding is an operation which is used mostly joining the dissimilar metal and non-metals at less time and cost constrain. In this review papers we will study the welding parameters like electric current, voltage, shielding gas, polarity, electrode diameter and size, gas flow rate etc. and also study the effect of these parameters on the welding quality. The main purpose of this study is to consider a best method to decide near optimal setting of the welding process parameters in the TIG and MIG welding. This paper present the introduction of TIG welding process and various parameters used in this techniques. This study is important in the view of material and parameters selection in the welding process.

Keywords: **TIG welding, aluminum alloy, process parameters.**

• Introduction

TIG welding is a welding process which is used to weld different types of materials like aluminum and magnesium it was developed during 1940 at the start of Second World War. Now a day, TIG welding is used to a variety of metals like stainless mild and high tensile steels. TIG welding is a type of arc welding. Arc welding is widely used in industries to melt and join different materials. TIG welding is sometimes referred to as gas tungsten arc welding (GTAW). During welding, either the base metal melts and flows together or a filler metal is added into the molten pool. In their molten state, most of the metals oxidize rapidly. To prevent oxidation of the metals, an inert gas is used which flows but of the welding torch, surrounds the hot tungsten and molten weld metal shielding from atmospheric air. Although the other welding processes are faster and less expensive, clean and slag free welds, GTAW are used due to their ease of finishing and appearance. TIG welding is used in high-tech industries such as nuclear, aircraft, maintenance and repair work and some manufacturing areas [1]. TIG welding uses a power source, shielding gas and TIG hand piece. Electric arc is created between tungsten electrode and work piece. The tungsten electrode and melt metal are protected from the surrounding by an inert gas.

2. Working principle of TIG welding

In TIG welding, an arc is maintained which transfers heat from torch to the work piece. The heated area is protected from the atmospheric air by inert gases (Ar, He, Ar-He mixture). The filler metal can be introduced automatically or manually depending on the types of process. The power supply can be direct or alternating current [2]. The process can be manual, partly mechanized or fully automatic.

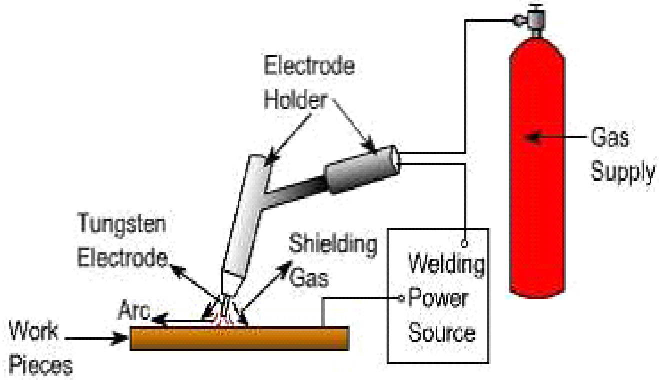


Fig.1 Diagram of TIG welding system

3. TIG welding equipment

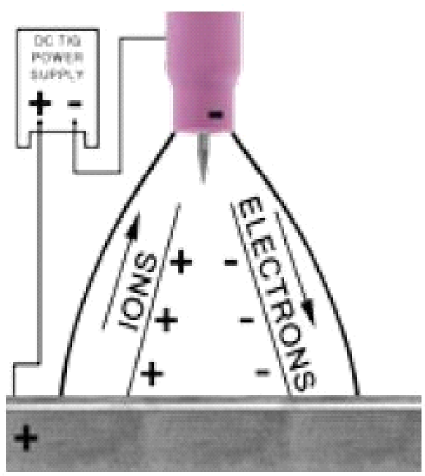
The basic equipment for TIG welding comprises of a power source, welding torch, supply of inert gas, filler wire and cooling water. An electric arc is maintained between a non-consumable electrode and the metal. Mostly, argon and helium gases are preferred to as shielding gases because they do not chemically react [3]. The shielding gases perform the following functions

- Prevent the oxidation of the metal
- Transfer heat from the electrode to the metal
- Maintain a stable arc

3.1 Power source for TIG welding

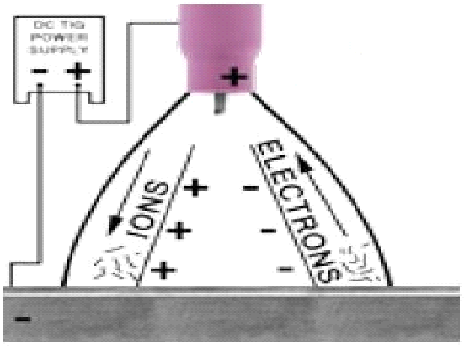
Power sources must be able to deliver a constant current. For DC welding, rectifier units are commonly used. Different types of welding current used for TIG welding are:

DCSP (direct current straight polarity): In this type of connection, tungsten electrode is negative terminal. It is mostly used in DC type welding connections. Here tungsten electrode will receive only 10% of welding heat. The weld will be of good penetration and narrow profile.



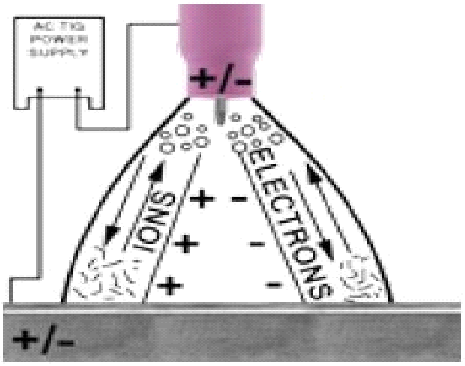
Direct current straight polarity

DCRP (direct current reverse polarity): In this type of connections, tungsten is positive terminal. It is used very rarely because tungsten electrode receives most of heat and becomes overheat and burns away. It produces a wide profile.



Direct current reverse polarity

AC (alternating current): It is preferred for welding of most white metals like aluminum and magnesium. The heat to the tungsten electrode is average.



Alternating current

TABLE: Electrode diameter and current range

Electrode diameter (mm)	Diameter tip (mm)	Current range (amp)	Pulsed current range (amp)
1.0	0.125	2-15	2-25
1.0	0.250	5-30	5-60
1.6	0.500	8-50	8-100
1.6	0.800	10-70	10-140
2.4	0.800	12-90	12-180
2.4	1.100	15-150	15-250
3.2	1.100	20-200	20-300
3.2	1.500	25-250	25-350

3.2 TIG welding torch: Welding torch provides a means for holding and changing tungsten electrode the conducts current to add and carry shielding gases, cooling water. The welding torches are either air-cooled or water-cooled. Air-cooled welding torches are used for welding thin metals under a current of 200A and water-cooled torches are used for medium and thick metals. The heat transferred in TIG welding is 20% and 80% of the heat generated remains in the torch. So, to remove this heat from the torch, it must be cooled.

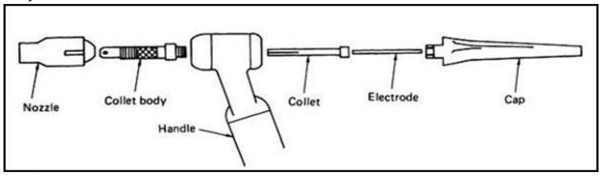


Fig.2 Exploded view of key components comprising GTAW torch

3.3 Shielding gases

The selection of shielding gases is very essential for efficiency, quality of the weld. The mixture can be of two, three and even four gases. For selecting the composition of the gases, various factors should be taken into consideration like type of base metal and reaction between gases and molten pool. Pure argon: it is suitable for all the metals. Alumaxx is used when we require faster welding and deeper penetration. This is mostly used for aluminum and copper and its alloys. Argon improves the oxide breakdown performance and better arc stability. Helium supplies more heat to the base metal and increase the welding rate, penetration. An increase in the amount of helium in shielding gases results in an increase in impact energy and crack growth and decrease in crack growth rate. Inomaxx gives lower zone emissions, less surface oxidation, improves weld profile and weld speed. It is mostly used for stainless steel and nickel alloys. The addition of hydrogen to argon increases the welding speed but it produces hydrogen cracks in the welds, so its usages are limited. Pure argon and helium used as shielding gas results in nitrogen loss.

3.4 Process variables in TIG and MIG welding

The following parameters affect the quality of the weld:

Welding current

When the current is high, TIG welding leads to splatter and work piece gets damaged. When the current is low, TIG welding leads to sticking of the filler wire. Fixed current mode varies the voltage to maintain a constant arc current. Larger heat affected zone (HAZ) can be found for lower welding current.

Welding voltage

Welding voltage may be fixed or adjusted. It depends upon the TIG welding equipment. A high initial voltage allows for easy arc initiation. Too high voltage, can lead to a large variable in welding quality.

Shielding gases

The selection of shielding gas depends on base metal and affects the welding temperature, welding speed, electrode life etc. Ar or He may be used for TIG welding applications. For very thin materials, pure argon is used. Helium is used for aluminum and copper. Argon helium mixture is used for welding of aluminum and copper alloys.

Welding speed

When the welding speed is increased, heat input per unit length of weld decreases and penetration of weld decreases. Welding speed controls the bead size and penetration of weld. It does not depend on current. Excessive high welding speed causes the uneven bead shapes, increase the tendency to porosity.

Activated TIG welding

In welding process, a high quality of weld is desired. The welding process is limited to the thickness of the base material that can be welded in single pass. If welding current is increased to increase the penetration, weld becomes wide with little gain in the penetration [4]. For this purpose, activating flux in TIG welding process is used. Activated tungsten inert gas (A-TIG) welding process increases the penetration to the base metal. It was first proposed by Paton Electric Welding Institute in 1960s. Activating flux is the mixture of inorganic materials in the volatile medium. A thin layer of this activating flux is applied on the surfaces of materials to be welded before welding. It is used by united States Navy Joining Center successfully to reduce cost and improve quality of ships and aircrafts. It is possible to join the thickness of 8-10mm by single pass full penetration welds by using this welding. The penetration ability is 300% as compared with conventional TIG welding process.

The activating flux changes the surface tension in weld a pool, the fluid flow is changed and increases the penetration.

4. problem statement and discussion

Temmar et al. [5] studied the effect of post-weld aging treatment on the mechanical properties of TIG-welded low thickness 7075 aluminum alloy joints; they found that the tensile strength, yield strength and elongation improved significantly after post-weld aging treatment. The effects of post-weld aging treatment on the properties of joints are studied. The post-weld aging treatment increases the tensile strength of TIG welded joints. The strengthening is due to a balance of dissolution, reversion and precipitation.

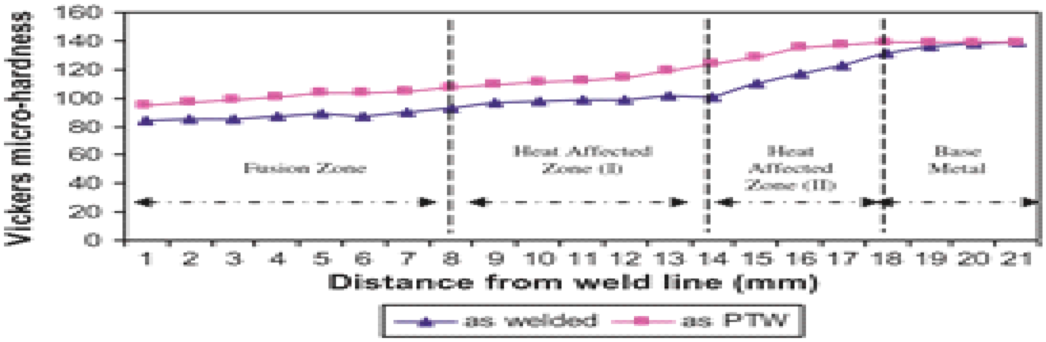


Fig.3 Hardness profile on weld section

Balasubramanian et al. [6] researched the effect of pulsed current and post-weld aging treatment on the tensile properties of TIG-welded and metal inert gas (MIG)-welded high-strength aluminum alloys; they pointed out that more precipitates are formed during post-weld aging treatment, and their uniform distribution results in a higher strength and hardness.

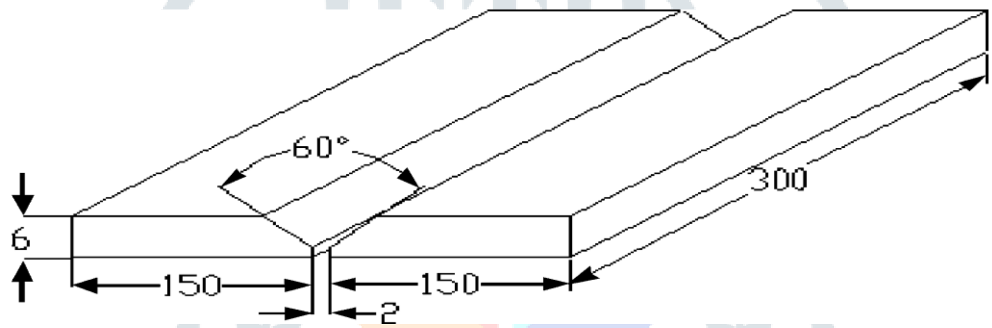


Fig.4 Dimension configuration of single V butt joint

Malarvizhi and Balasubramanian [7] discussed the effects of welding processes and post-weld aging treatment on the fatigue behavior of AA2219 aluminum alloy joints by TIG, electron beam welding, and friction stir welding; they concluded that fatigue strength of the welded joints is enhanced greatly after heat treatment

Peng et al. [8] studied the effects of aging treatment and heat input on the microstructures and mechanical properties of TIG-welded 6061-T6 alloy joints; they found that the hardness of the FZ is lower than those of the BM and HAZ, with an increase in heat input the hardness values of the HAZ decreases, whereas the hardness values of the FZ decreases initially and then increases slightly, an increase in heat input results in increases in width of the HAZ and grain size of the FZ of the 6061-T6 TIG welding joints, no appreciable changes in grain size have been noticed after post-weld aging treatment.

K. Elangovan et al. [9] studied the mechanical properties of GMAW, GTAW and FSW joints of AA6061 aluminium alloy; they found that of the three welded joints, the joints fabricated by FSW process exhibited higher strength values and the enhancement in strength value is approximately 34% compared to GMAW joints, and 15% compared to GTAW joints, hardness is lower in the weld metal (WM) region compared to the HAZ and BM regions irrespective of welding technique, the formation of fine, equiaxed grains and uniformly distributed, very fine strengthening precipitates in the weld region are the reasons for superior tensile properties of FSW joints compared to GTAW and GMAW.

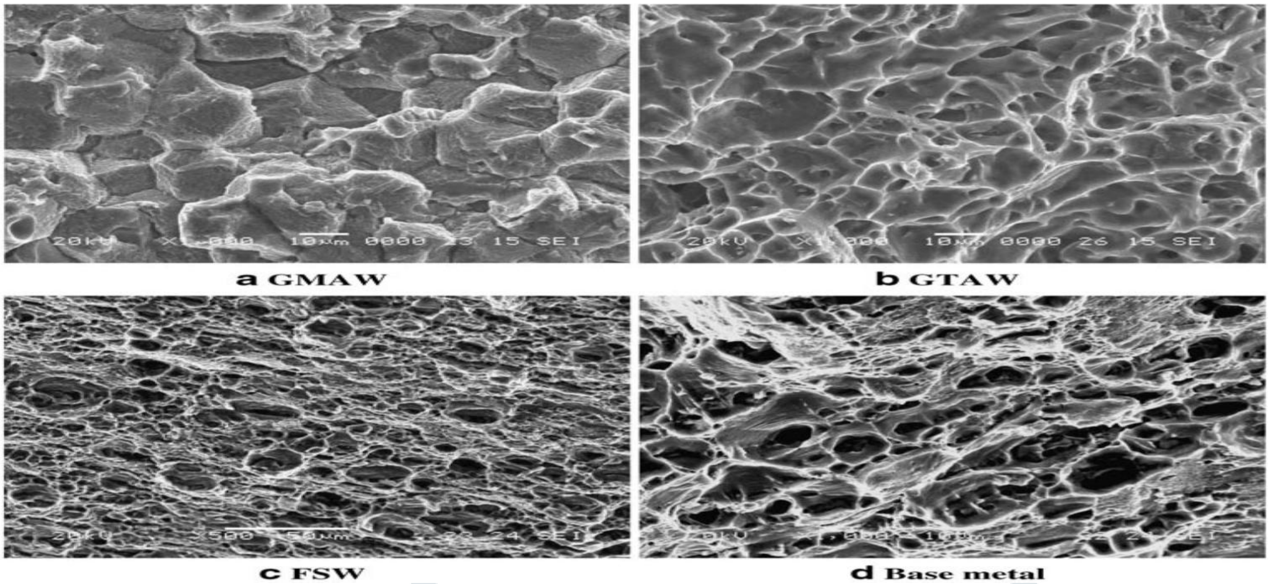


Fig.5 SEM fractograph of tensile specimen

Kumar and S. Sundarrajan [10] studied the effect of welding parameters on mechanical properties and optimization of pulsed TIG welding of Al-Mg-Si alloy; they found that the behavior of the welded joints at the optimum condition of process parameters is attributed to the higher dilution of the base metal into the weld, resulting in an increased amount of Mg_2Si precipitates that are formed in the aluminum matrix, the metallographic analysis reveals a fine grain structure at the weld center, which results in higher mechanical properties.

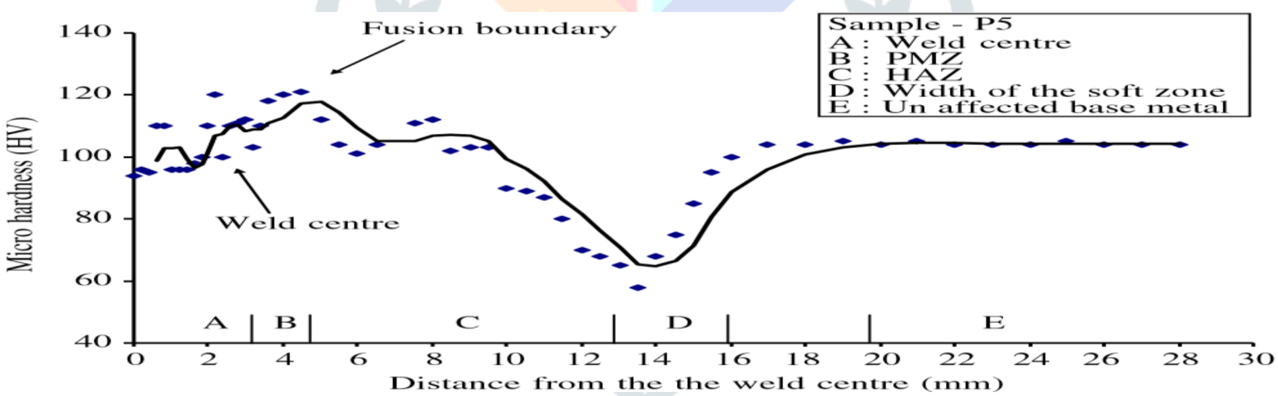
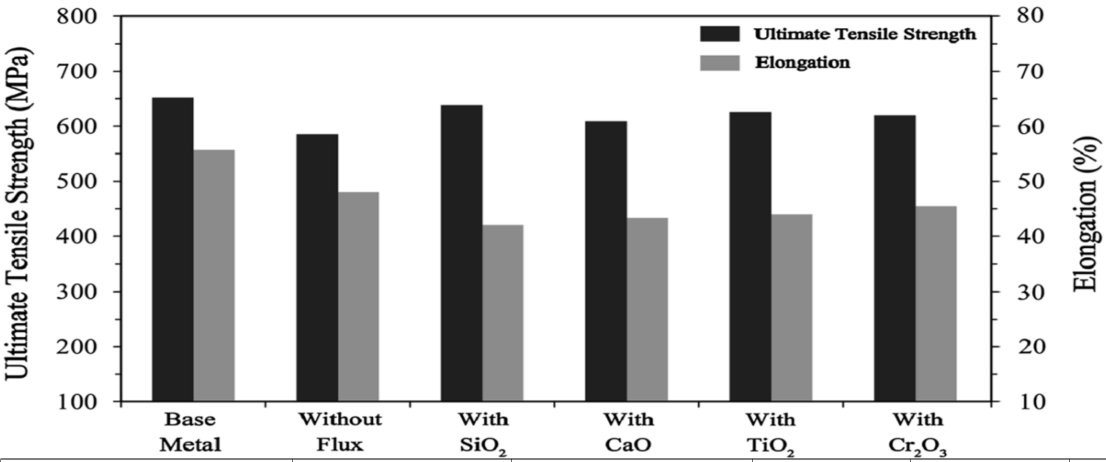


Fig.6 Micro-hardness survey in transverse to the weld direction of Aluminum

Subbaiah et al. [11] studied the comparative evaluation of tungsten inert gas and laser beam welding of AA5083-H321; they found that LB welds have higher yield strength than TIG welds by 26%, the UTS value of LB welding was inferior to the UTS value of TIG welding by 7.5%, vaporization of volatile elements such as magnesium is more in TIG welding than in LB welding, whereas the vaporization of manganese and zinc is more in LB welding.

Ahmadi and ebrahimi [13] studied the welding of 316L austenitic stainless steel with activated tungsten inert gas process; they found that the weld penetration is increased while the weld metal width decreased, among the fluxes SiO_2 flux had a significant effect on enhancing the weld penetration in A-TIG, A-TIG welding can increase ultimate tensile strength of weldment because of increasing the retained delta ferrite content of stainless steel welds.



Ferrite content (FN)	0.87	6.5	7.6	6.8	7.3	7.7

Fig. 7 Value of tensile strength and elongation at different ferrite content

Kah and Martikainen [13] studied the influence of shielding gases in the welding of metals; they found that for carbon steel, increasing the oxidation potential of the shielding gas decreases the toughness and tensile strength of the weld deposit, for ferritic stainless steel, increasing the amount of carbon dioxide in shielding gases can increase the martensite content at the grain boundary, for ferritic stainless steel, increasing the amount of carbon dioxide in shielding gases can increase the martensite content at the grain boundary.

Sahin et al. [14] studied the weldability of heat-treated 6061 and 7075 aluminum alloy in various combination; they found that the hardness value of the welded samples can increase significantly depending on aging temperature and time, the tensile strengths at the joints of the aged samples on similar and dissimilar weld joints increase for both alloys, the micro hardness experiment showed that the highest hardness values are in the base metals of aged samples.

Yazdipour et at. [15] studied the investigation of the microstructures and properties of metal inert gas and friction stir welds in aluminum alloy 5083; they found that FSW weld samples have higher strength in comparison to the MIG samples, FSW samples consisted of fine-equiaxed recrystalized grains, the weld metal of MIG samples composed of dendrites formed during solidification.

Jiang et al. [16] studied microstructure and mechanical properties of laser-MIG hybrid welding of 1420 Al-Li alloy; they found that the tensile strengths of joints before and after heat treatment were 223 and 267MPa, reaching up to 57 and 68% of the parent material strength, after heat treatment the microstructure change from a dendritic structure to a spheroidal crystal, the grain size of the HAZ is larger than that of base metal whereas the fusion zone showed the largest grain size.

5. CONCLUSION

TIG mechanism and shielding gases are important and necessary to determine the arc stability, defects free weld and arc penetration. Ductility is higher in MIG welding as compared to TIG welding. TIG welding specimen component can bear higher tensile yield strength and load. Width of HAZ is increase when increase the heat input rate. When the welding speed is high the tensile strength is low. Hardness of TIG welding is less than the base metal. The transverse shrinkage is produced in the TIG welding is more as compared to MIG welding. TIG welding parameters are effected the weld strength in the form of weld bead geometry and mechanical strength.

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