TO OPTIMIZE PROCESS PARAMETERS OF TUNGSTEN INERT GAS WELDING OF MILD STEEL BY TAGUCHI METHOD

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ABSTRACT

A Welding technique is defined as the process of joining two different or same metals by fusion process, with or without application of pressure and with or without use of filler metal. Welding of different or same material are depends upon various factors like the metallurgical changes, chemical changes , physical changes that occur due to welding, change in hardness of material, in and around the welding bed and the extent of wear and tear or we can say cracking tendency of the joint. Welding processes have been developed for change, so far using single or combination of factors like pressure, heat and filler material used.

Keyword : - *Tungsten Inert Gas welding, Activated flux, Tensile test, Hardness test and A - TIG welding process.*

1. INTRODUCTION

Welding is a process of joining two similar or dissimilar metals by fusion, with or without application of pressure and with or without use of filler metal. Weld ability of the material depends upon various factors like the metallurgical changes that occur due to welding, change in hardness of material, in and around the weld and the extent of cracking tendency of the joint. A range of welding processes have been developed so far using single or combination of factors like pressure, heat and filler material used.

1.1 CLASSIFICATION OF WELDING PROCESS

I. Homogeneous welding
II. Heterogeneous welding
III. Autogenous welding

I. Homogeneous welding – Welding of thick plates using filler metal used as per needs according to thickness of plate. The filler material used to provide better strength to the joint. In this process filler material is same as base metal. Different types of homogeneous welding process commonly used are:

a) Arc welding – Filler material generally used as consumable electrode for manual arc welding and metal inert gas welding.
b) Gas welding – An external filler rod is required for gas welding.
c) Plasma arc welding – In case of Plasma arc welding also an external filler rod is necessary for welding.
d) Thermit welding – In case of thermit welding a molten material from some chemical reaction is added.

In case of homogeneous welding solidification occurs directly by growth mechanism without nucleation stage.

II. Heterogeneous welding – A filler material different from the base material is used for welding. The solidification in heterogeneous weld takes place in two stages *i.e.* nucleation and growth.

Homogeneous and Heterogeneous welding process required external filler material therefore an arrangement for this filler rod feeding (in case of automated system) make the process complex and costly.

III. Autogenous welding – A weld joint can be developed just by melting of edges of plates or sheets. This type of welding used especially if plate thickness is less than 5 mm. No filler is added during autogenous welding. All types of solid phase welding, resistance welding and fusion welding without filler rod corresponding thin category of welding are examples of this category. Following are the some specific advantages of autogenous welding process:

a) Suitable for high production rate.
b) Heating of the work piece is confined to very small parts which results in less distortion.
c) Possible to weld dissimilar metals as well metal plates of different thickness.
d) High speed welding is possible.
e) Since no external material is used, the process is very economical.
f) Since no filler rod is used, process can be automated easily.

Various types of Autogenous welding process

a) Resistance welding – Among these process resistance welding is limited for specific application and not useful for thick plate and complicated shape. Further for welding different thickness plate different diameter electrode is required.
b) Laser beam welding – Laser Beam Welding process is very expensive process not for small industry.
c) Electron Beam Welding – Similar to Laser Beam Welding process, Electron Beam Welding process is also very expensive process.
d) Friction Stir Welding – Friction Stir Welding is mainly limited to low melting temperature and soft material.
e) Gas welding without filler rod
f) TIG welding without filler rod

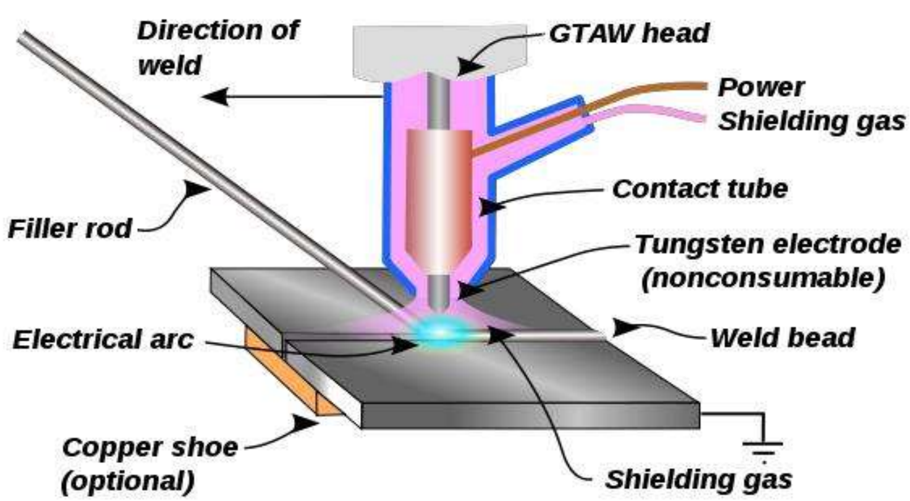
1.2Tungstan Inert Gas Welding

Tungsten Inert Gas welding is also known as Gas tungsten arc welding (GTAW), is an arc welding process that uses a non-consumable tungsten electrode to produce arc. The welded area is protected from atmospheric contamination by an inert shielding gas (argon or helium), and a filler is normally used to weld thick plate. The electrode is no consumable since its melting point is about 3400^{o}C. In tungsten electrode 1 to 2% thorium and zirconium are added to improve electron emission, arc stability and current carrying capacity. A constant current welding power supply produces energy which is conducted across the arc through a column of highly ionized gas and metal vapors known as plasma. Heat input in GTAW does not depend on the filler material rate. Consequently, the process allows a precise control of heat addiction and the production of superior quality welds, with low distortion and free of spatter.

2.Principle of TIG Welding

In TIG welding process, the electrode is non consumable and purpose of it only to create an arc. The heat-affected zone, molten metal and tungsten electrode are all shielded room atmospheric contamination by a blanket of inert gas fed through the GTAW torch. Fig. 1 shows schematic diagram of the working principle of TIG welding process. Welding torch consist of light weight handle, with provision for holding a stationary tungsten electrode. In the welding torch, the shielding gas flows by or along the electrode through a nozzle into arc region. An electric arc is created between electrode and the work piece material using a constant current welding power source to produce energy and conducted across the arc through a column of highly ionized gas and metal vapors. The electric arc produce high temperature and heat can be focused to malt and join two different parts of work piece.

Fig. 1 Schematic diagram of working principle of TIG welding [Ref. 1]



2.1 Different types of welding current

Both the direct current (DC) and alternating current (AC) may be used for TIG welding. When the work is connected to the positive terminal of DC welding machine and the negative terminal to an electrode the welding set up is said to have straight polarity. When work is connected to negative and electrode to positive terminal then the welding set up is said to have reversed polarity.

2.2 Areas of application of TIG welding

TIG welding is often used for jobs that demand high quality welding such as for instance.

- The offshore industry
- The petrochemical industry
- Power plants
- The chemical industry
- The food industry
- The nuclear industry
- Automobile
- Aerospace
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3. TIG welding on Mild Steel

TIG welding is widely used for fabrication of different types of materials like aluminum, mild steel and stainless steel. Maximum 6 mm thick mild steel plate can be weld by TIG welding. Mild Steel weld by TIG welding is more precise and cleaner than other arc welding process like manual arc welding or Metal Inert Gas welding. Mild steel is ductile material and can be easily machined. Welding of mild steel plate required to give different structural shape to produce various machine components. TIG welding is capable of achieving highest qualities weld and most versatile. TIG welding provides high integrity that is required at the root and in conjunction with weld speed. TIG welding machine are available in high current rating as well as low current rating. TIG welding provides 150 A to 350 A range of current which is useful for welding of thick mild steel plate. Table 2 and 3 shows mechanical properties and percentage composition of mild steel respectively.

Mechanical Property	Mild Steel
Density	7.85 g/cc
Young’s Modules	190 - 210 GPa
Tensile strength	394.7 MPa
Carbon percentage	< 1.5 % C
Hardness	111 HB
Yield strength	294.8 MPa

Table 1 Mechanical properties of Mild Steel [Ref. 5]

Alloy	Percentage (%)
Chromium	0.069
Nickel	0.01
Carbon	0.18
Manganese	0.8
Sulphur	0.04
Phosphorus	0.04
Silicon	0.4
Fe	Balance

Table 2 Percentage composition in Mild Steel [Ref. 8]

4. Welded specimens performed by activated TIG welding process

It was clearly observed from first set of experiment and results, that combination of maximum welding current and minimum speed provide high heat input to the workpiece material. However, maximum depth of penetration was obtained at this condition. Second set of experiment performed with the use of TiO_2 flux and 210 A welding current for three different welding speeds.TiO_2 activated TIG welding process performed with 210 A current and three different speeds shown in figure 2.

Fig. 2 TIG welded specimen with TiO_2 flux at 210 A current

4.1. Optical Image at weld zone of specimen performed by activated TIG welding process

Figure 16 shows optical microscopic image at weld zone performed by TiO_2 flux coated autogenous TIG welding process with 210 A current and different scan speed.
From the optical image it is observed that, melt pool depth is relatively larger for using TiO_2flux, but still full penetration welding was not obtained. Further, for using TiO_2 flux on the melt pool zone some crack has been form. This crack may reduce the strength of the welding. Similar observation was done by some other researcher for using activated flux in welding of different type of steel in TIG welding [11, 12, 13].

(a) 2.33 mm/s (b) 2.96 mm/s (c) 3.5 mm/s

Fig. 3 Optical microscopic Image at weld zone of TIG welded specimen with use of TiO_2 flux

4.2. Weld bead geometry at cross section of weld zone by TIG welding with TiO_2 flux

Sl. no.	Current (A)	Speed (mm/s)	Width (mm)	Depth (mm)
1	210	2.33	7.16	2.65
2	210	2.96	5.52	3.09
3	210	3.5	6.28	2.95

Table 3 Width and depth of weld zone of TIG welding with TiO2 flux

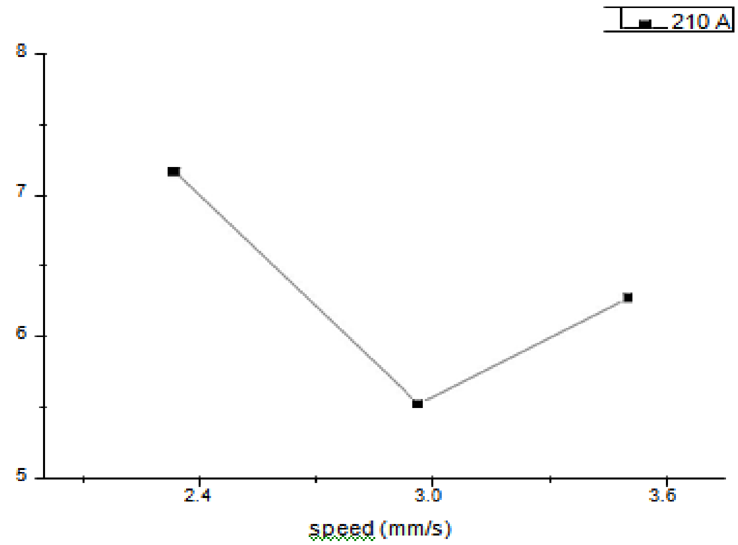

Fig. 3 Variation of weld bead width against scan speed for 210 A welding current

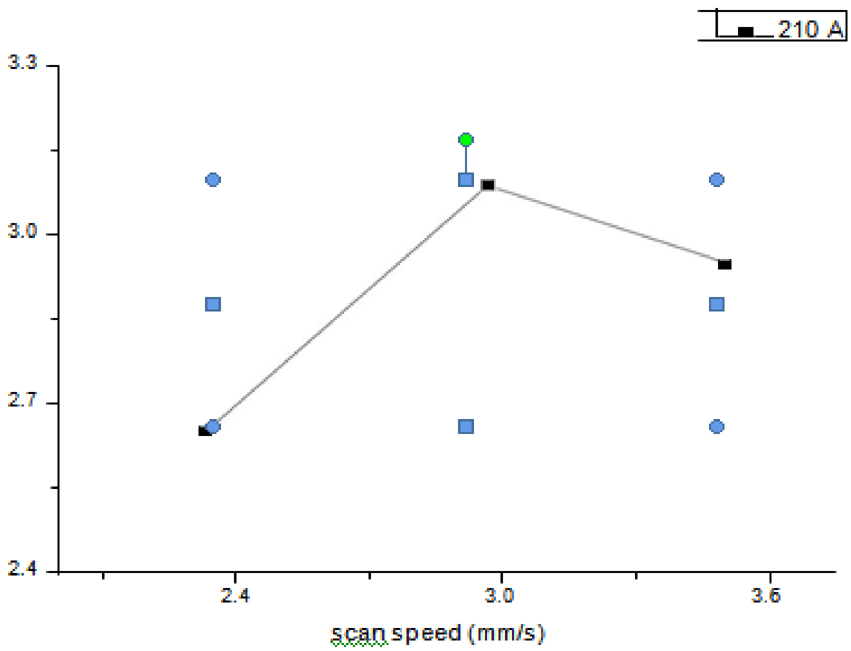

Fig. 4 Variation of weld pool depth against scan speed for 210 A welding current

6. CONCLUSIONS

Findings of the present investigation can be summarized into following points

- The results of the conventional TIG welding process performed show that, maximum depth of penetration was obtained with parametric combination of minimum welding speed and maximum current.
- When the same procedure is repeated with additional utilization of TiO2 flux, depth of penetration increases in comparison to the conventional welding, but some crack on the weld zone was observed for using flux.
- With constant welding speed, another set of experiments were done by maintaining a gap between work piece to be welded. It is observed that, with a gap of 1 mm, defect-free welding with proper material flow obtained throughout the joint for higher welding current.
- Comparing the three methods of TIG welding, depth of penetration and tensile strength of weld joint is maximum when adequate gap is maintained between the components to be welded.
- From the graphs plotted, it can be inferred that welding width and depth increases with increase in welding current and gap maintained between the components to be welded.

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