EXPERIMENTAL INVESTIGATION ON AUTOGENOUS TUNGSTEN INERT GAS (TIG) OF AISI 1020 MILD STEEL

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***Abstract*— Tungsten Inert Gas welding is also known as Gas Tungsten Arc Welding (GTAW), is an advance arc welding process become a popular choice when a high level of weld quality or considerable precision welding is required. However, the major problems of TIG welding process are its slow welding speed and limited to lower thickness material in single pass. In this work, autogenous TIG welding has been performed on 5 mm thick AISI 1020 mild steel plate without using any filler material. Wide range of welding current and scan speed has-been tested for obtaining a full penetration welding. Activated flux has also been used to improve the weld depth. After performing welding by maintaining different gap between the platest obewelded, weld bead geometry and tensile strength of the weld has been investigated. It is observed that, by maintaining an appropriate gap full penetration welding of plateis possible which gives strength almost similar to base material.**

***Index Terms*— Tungsten Inert Gas welding, Activated flux, Tensile test, Hardness test and A -TIG welding process.**

I. 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 depend sup on 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 ten deny of the joint. Arrange of welding processes have been developed so far using single or combination of factors like pressure ,heat and filler material used.

Tungsten 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 3400oC. 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.

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 joint different parts of work piece.

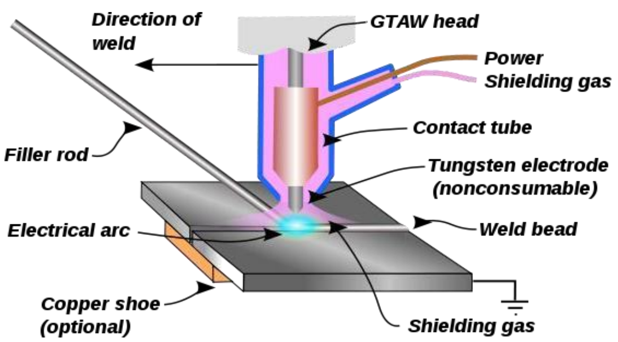


Fig.1Schematic diagram of working principle of TIG welding[Ref. 1]

Autogenous TIG welding

A weld joint produced by melting the contacted surfaces and subsequently solidifying it at room temperature (without addition of any filler metal) is called “auto genius weld”. Thus, the composition of the autogenously weld metal corresponds to the base metal only. However, autogenous weld is crack sensitive when solidification temperature range of the base metal to be welded is significantly high. TIG welding process performed without application of filler material is known as autogenous TIG welding process. Autogenous TIG welding is preferred especially for less than 5 mm thick plate. The advantages of this process are that, it is economical process as compare to heterogeneous or homogenous welding process as no edge preparation and filler material are required. Figure 2 shows schematic diagram of autogenous TIGw elding process.

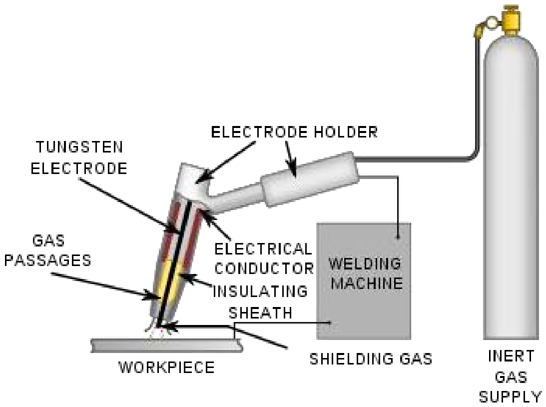


Fig.2 Schematic diagram of Autogenous TIG welding[Ref.1]

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 Arrange 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.

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

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

Table2 Percentage composition in Mild Steel [Ref.8]

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

Applications of Mild steel

Mild steel materials are available in a variety of structural shapes and easily welded into tube, tubing and pipe. Mild steel pipes are used for pipelines in gas and oil industry.

Mild steel has balance strength and ductility and good wear resistance so used in automobile industries, large structures, forging, nozzle and automotive components.

Mild steel is used to produce dissimilar joint with stainless steel, application of this dissimilar joint in thermal power industry.

Welding of mild steel plate is required to give different shapes to produce various machine components.

II. Literature Review

TIG welding is widely used for different types of metal & alloy and still lots of research work is going for better performance by TIG welding process.

Krishnan et al. [6] done experiment to analyze the microstructure and oxidation resistance at different regions in the mild steel weld by TIG welding. During welding process a sharp change in the microstructure due to complex thermal cycle and rapid solidification was observed. This micro-structure change also affects the mechanical properties and oxidation resistance of the mild steel weld. Autogenously TIG welding was performed on 12 mm thick mild steel with 200 A current, 19 V voltage and 100 mm/min welding speed. Finer grain size was obtained at weld metal and heat affected zone.

Raj and Varghese [7] predict the distortion developed during TIG welding of low carbon steel. In their study, have developed three dimensional finite element model like longitudinal, angular or transverse distortion. Distortion in welding produced due to non-uniform heating and cooling. To validate the model welding was performed with welding current 150 A, electrodegap3 mm, gas flow rate25 l/min, and electrodediameter0.8 mm and Argon as shielding gas. They concluded that, maximum distortion occur sat surface opposite to the weld and along X direction of weld compare to other two directions.

Abhulimen and Achebo [8] performed experiments to identify the economical welding parameters using Response surface methodology (RSM) during TIG welding of mild steel pipe. Welding Parameters considered were gas flow rate 25 to 30 l/min, welding current 130to 180 A, arc voltage 10.5 to 13.5 volt and argon as shielding gas. Results showed that, busing TIG welding of mild steel maximum tensile and yield strength of 542 MPa and 547MPawas achieved respectively.

Mishra et al. [9] have done comparison of mechanical properties between TIG and MIG welded dissimilar joints. Mild steel and stainless steel dissimilar material joints are very common structural application. These dissimilar joints provide good combination of mechanical properties like corrosive resistance and tensile strength with lower cost. Welding parameters considered for MIG welding were welding current 80-400A and voltage 26-56 volt. TIG welding was performed with 50-76 A current & 10-14 volt voltage. TIG welded dissimilar joint provide better tensile strength because of less porosity. Both dissimilar join the vibes' ductility &yield strength for TIG and MIG welding.

Fujii et al. [10] developed an advanced activated TIG welding method for deep penetration of weld joint. Maragoni convection induced on the molten pool by surface tension gradient. In order to control Maragoni convection small amount of oxidizing gas was used. Welding process done with welding current 160 A, welding speed 0.75 mm/s, electrode gap of 1mmand Ar -O2 shielding gas. They observed that Maragoni convection changes from inward to outward and weld shape become wide and shallow.

III. EXPERIMENTAL PLANNING AND PROCEDURE

For the present work total experiments were performed in three different phases

In first phase autogenously TIG welding of 5 mm thick mild steel plates was performed without using any filler rod at different welding current and scan speed condition to see the effect of welding & speed and to obtain current and speed range for approximate welding.

In second phase TIG welding of 5 mm thick mild steel plate was performed after applying alayer of Tao2 flux and compared the weld properties with the welding done without flux.

In third phase, TIG welding was performed by main tainting different gap between the work pieces to be welded and study the effect of this gap on the welding performance mainly weld bead geometry and tensile strength of the weld.

Experimental setup

For the present project work an autogenously welding set up has been developed to perform welding with a fixed velocity without the application of filler material. A movable vehicle issued to hold TIG torch. The distance between work piece and torch tip will remain constant the welding process. The speed of movable vehicle is controllable and can be varied according to the requirement of the welding speed and amount of heat required. Figure 3shows experimental setup for present work. The welding setup for autogenously TIG welding process consists following components:

1. Welding torch
2. Electrode
3. Power supply
4. Inert gas supply unit
5. Work holding device
6. Movable vehicle holding the welding torch
7. Rail Track

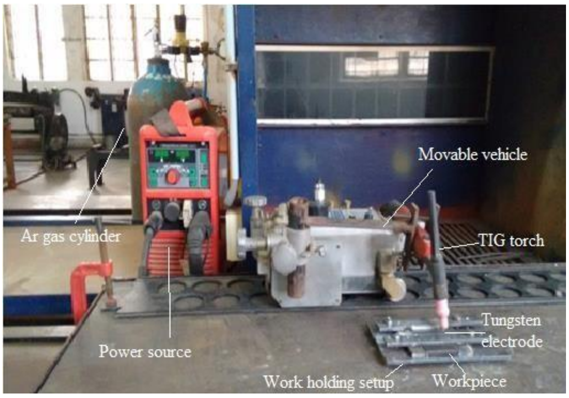


Fig.2 Experimental setup of TIG welding

Single pass auto genius TIG welding on Mild steel plate

In this phase of experiment, to study the feasibility of autogenously welding on 5 mammal steel plate, TIG welding has been performed without using any filler rod. 5 mm thick mild steel plates were cut in 50 mm x 50 mm dimension with the help of band saw. The edges to be welded were grinded with surface grinding machine, so that proper contact is possible between the plates to be joined. Other surfaces were also polished with emery paper (silicon carbide) to remove all impurities from the surface and to provider enquire surface finish.

After the sample preparation mild steel plates were fixed in the work holding device with proper clamp through bolts. Direct Current (DC) with direct polarity (negative electrode and positive work piece) was used to perform welding. Zirconiated tungsten electrode of 2.4mm diameter was used as electrode. Three different current value and scan speed has been selected as shown in the table3 and total 9experimentswereperformed.

Table3 Welding parameters for autogenous TIG welding of mild steel

Dimension of mild steel	50mmx50mmx5mm
Welding speed	2.33mm/s,2.96mm/sand3.5 mm/s
Arc voltage	14 – 15 V
Welding current	170A, 190 A& 210 A
Gas flow rate	12 l/min
Current type	DC(positive work piece & negative electrode)
Distance between tipand weld center	3 mm
Shielding gas	Argon

Table4 Experimental planning for autogenous TIG welding of mild steel

Exp .No.	Welding current(A)	Welding speed (mm/s)
1	170	2.33
2	170	2.96
3	170	3.5
4	190	2.33
5	190	2.96
6	190	3.5
7	210	2.33
8	210	2.96
9	210	3.5

Sample preparation for study the weld bead geometry

After performing the TIG welding of mild steel plate, welded specimens were cut at the perpendicular to the weld scan direction with the dimension of 20 mm x 10 mm for taking optical micro scope image of the weld zone. These welded specimens were cut with the help of wire electro discharge machine. After cutting the samples, polishing & chemical etching were performed at the weld cross section, before taken the optical image. Specimen’s were prepared by usual metallurgical polishing method using different grit size Sic polishing paper and subsequent diamond paste polishing. Natal solution consists of ethyl alcohol (97%) andconc. HNO3 (3%), has been used for etching the weld cross section by dipping the polishedsurface in it for 10 sec. Melting depth or weld penetration was checked for each weld sample from the change in micro structure using an optical microscope.

Sample preparation for tensile testing

For tensile testing of welded samples were cut into I shape as per ASTM E8. Tensile testing of the weld specimens were carried out in an INSTRON Universal Testing Machine (UTM) with maximum load capacity of 600 KN. The tensile testing involved fixing the sample in UTM properly and then apply in gradually increasing for council shape transformation occurs in the specimen and It finally break.

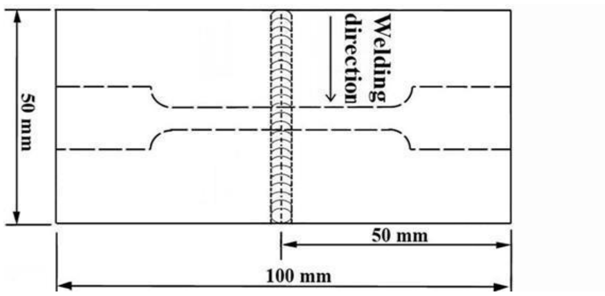


Fig.3 Schematic Diagram of specimen for tensile testing

Fig. 3 Schematic diagram for 5 mm thick plate as per ASTM E8 standard [Ref. 4]Table7Dimension for tensile test as per ASTM E8standard[Ref. 4]

Overall length(L)	100mm
Gauge length(G)	25 mm
Width of grip section(C)	10 mm
Length of grip section(B)	30 mm
Radius of fillet(R)	6 mm
Width(W)	6 mm

IV. RESULTS AND DISCUSSION

Welded specimen performed by conventional auto genius TIG welding

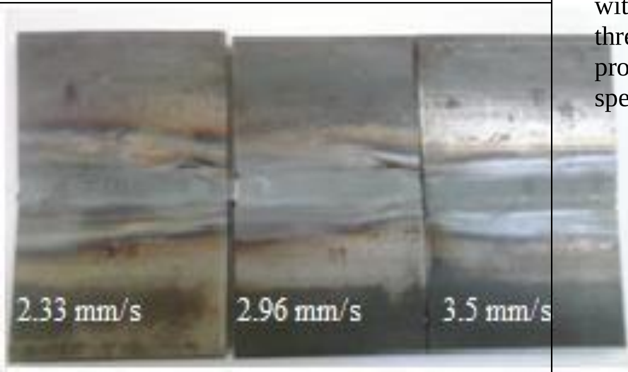
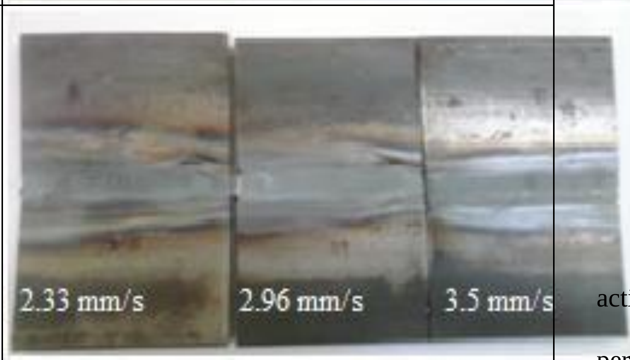
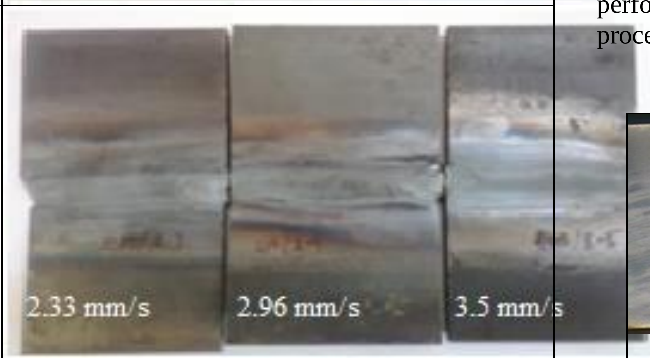
.Sl. No.	Welding current	Welded sample at different speed
1	170 A	
2	190 A	
3	210 A	

Fig. 4 Welded specimens performed with 3 different speed and current setting by conventional auto genius TIG welding process

Macroscopic inspection of the samples produced from 9 experiments clearly reveal that weld joints formed with170A current for different welding speed did not satisfy the requirements of the welding. Therefore, these particular samples were discarded for further study. The remaining samples were considered for further testing, which has been described below.

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 work piece material. However, maximum depth of penetration was obtained at this condition. Second setof experiment performed with the use of TiO2flux and 210 A welding current for threedifferent welding speeds.TiO2 activated TIG welding process performed with 210 A current and three different speeds shown in figure5.

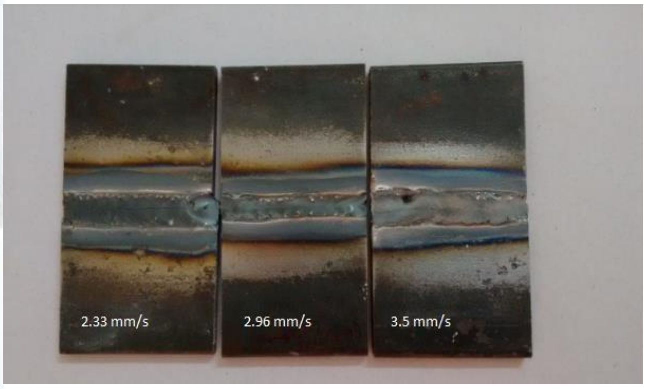
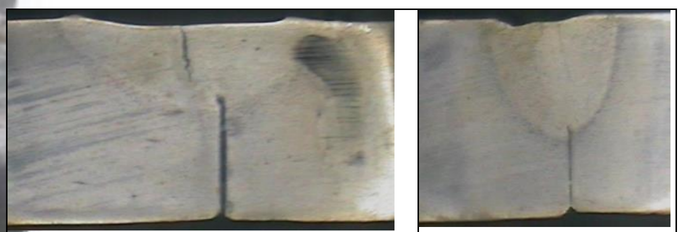


Fig.5 TIG welded specimen with TiO2fluxat210Acurrent

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

Figure 6 shows optical microscopic image at weld zone performed by TiO2 flux coated auto genius TIG welding process with 210A current and different scan speed.



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

Fig. 6 Optical microscopic Image at weld zone of TIG welded specimen with use of TiO2flux

From the optical image it is observed that, melt pool depth is relatively larger for using TiO2flux, but still full penetration welding was not obtained. Further, for using TiO2 flux onthe 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 steeling TIG welding.

V. CONCLUSIONS

Finding so 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 ofpenetration 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 through out the join for higher welding current.
- Comparing the three method so 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.

VI. FUTURE ASPECTS

- If welding is possible with minimum welding speed, depth of penetration will increase. Optimum gap maintain between two work pieces to be welded so obtained higher melting depth. All these result to provide better strength to the weld joint.
- TIG welding process performed with using filler material so thick plate weld and provides higher depth of penetration and better strength.

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