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Experimental Investigation on Autogenous Tungsten Inert Gas

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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 plates to be welded, 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 plate is possible which gives strength almost similar to base material.

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

I. Introduction

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.

1.2.1 Principle of TIG welding

In TIG welding process, the electrode is non consumable and reason for it just to make an arc. The warmth influenced zone, liquid metal and tungsten electrode are altogether protected room climatic sullying by a cover of inert gas nourished through the GTAW torch. Fig. 1 demonstrates schematic outline of the working guideline of TIG welding process. Welding torch comprise of light weight handle, with arrangement for holding a stationary tungsten electrode. In the welding torch, the protecting gas streams by or along the electrode through a spout into arc area. An electric arc is made among electrode and the workpiece material utilizing a steady current welding power source to deliver energy and directed over the arc through a segment of exceptionally ionized gas and metal vapors. The electric arc produce high temperature and warmth can be engaged to malt and join two unique pieces of workpiece

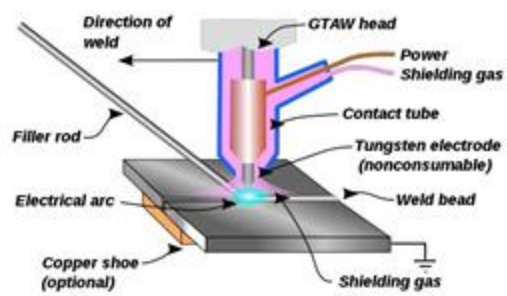

Fig.Schematic diagram of working principle of TIG welding

II. Experimental setup

For the present project work an autogenous welding set up has been developed to perform welding with a fixed velocity without the application of filler material. A movable vehicle is used to hold TIG torch. The distance between workpiece 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 3 shows experimental setup for present work. The welding setup for autogenous 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. Experimental setup of TIG welding

Table : 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 microscope 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. Specimens were prepared by usual metallurgical polishing method using different grit size SiC polishing paper and subsequent diamond paste polishing. Nital solution consist of ethyl alcohol (97%) and conc. HNO_3 (3%), has been used for etching the weld cross section by dipping the polished surface in it for 10 sec. Melting depth or weld penetration was checked for each weld sample from the change in microstructure 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 applying a gradually increasing force until shape transformation occurs in the specimen and it finally break.

TIG welding process with TiO2 Flux

TIG welding provides high quality weld and good weld bead surface. However, compare to other arc welding processes like plasma arc welding and submerged arc welding, TIG welding exhibit low penetration/melting depth in the workpiece. Therefore, it is required to improve the penetration/melting depth of TIG welded joint. This can be done with the help of inorganic powders generally called 'Activated flux'. Applications of activated fluxes in various arc welding process for ferrous, non-ferrous and dissimilar materials gives higher penetration compared to the welding done without using flux. The presence of flux narrow the arc concentrated energy in to a small area and reduces surface tension of the molten pool. This results in increases the depth of penetration of the weld joint.

Activated flux is prepared using single component of any oxides (Cao, Fe_2O_3, TiO_2, Zno, MnO_2 and Cr_2O_3) in powdered form or mixture of these powders. Activated flux then added in a liquid solvent like acetone of 5 to 10 ml of the flux powder and stirred to make it has homogenous paste, ready to be applied on the weld surfaces. A coating approximate 0.1mm thick was applied to the surface of strip using a paint brush (10-12 mm) width prior to the welding.

TIG welding of mild steel by varying gap between workpieces to be welded

It has been observed from the previous experiments that, during autogenous TIG welding of thick mild steel plates either using flux or without flux, when plates are kept side by side and no gap provided between them, the depth of penetration or melting depth is limited to a certain value and molten material does not flow towards the bottom side of the joint. It is found from the literature, that during welding using filler rod, for the flow of molten material proper grooving is provided or some gap is maintained between the plates to be weld. Therefore, in this work, in order to increase the depth of penetration in weld, TIG welding was performed by maintaining a gap between the workpiece to be welded. An attempt has also been made to study the effect of gap between the plates during autogenous TIG welding of mild steel for using no filler rod.

In conventional TIG welding method depth of penetration is low at weld zone in thick mild steel plate. For the purpose of increment of the depth of penetration in weld TIG welding was performing with maintain gap between workpiece. All this results increase in depth of penetration. The 100 mm length welds were obtained along welding direction without application of wire or filler material. Total 9 experiments were performed and welding. Welding process done with constant speed and same value of fixed parameters as conventional autogenous TIG welding process.

III. Results and discussion

Width and depth of weld zone of TIG welded sample by conventional TIG welding

Sl. No.	Current (A)	Speed (mm/s)	Width (mm)	Depth (mm)
1	190	2.33	6.3	2.34
2	190	2.96	5.75	1.28
3	190	3.5	5.88	1.59
4	210	2.33	7	2.47
5	210	2.96	5.85	2.09
6	210	3.5	6.17	1.91

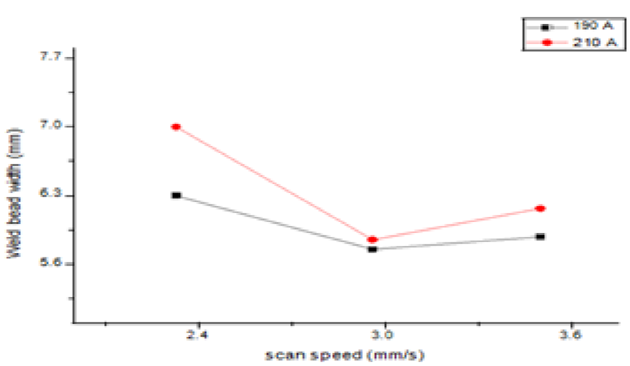

Fig: Variation of weld bead width against scan speed for different welding current

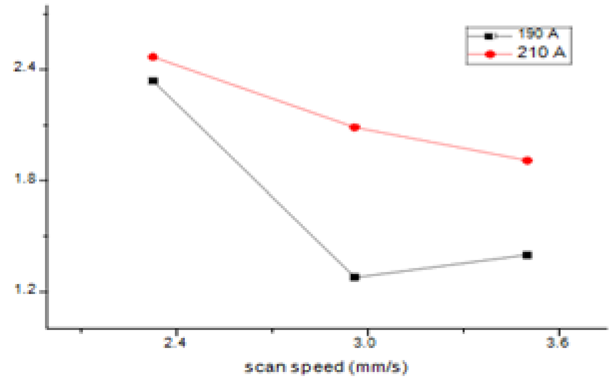

Fig : Variation of weld pool depth against scan speed for different welding current

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

Sl. No.	Current (A)	Speed (mm/s)	Depth (mm) without flux	Depth (mm) with flux
1	210	2.33	2.47	2.65
2	210	2.96	2.09	3.09
3	210	3.5	1.19	2.95

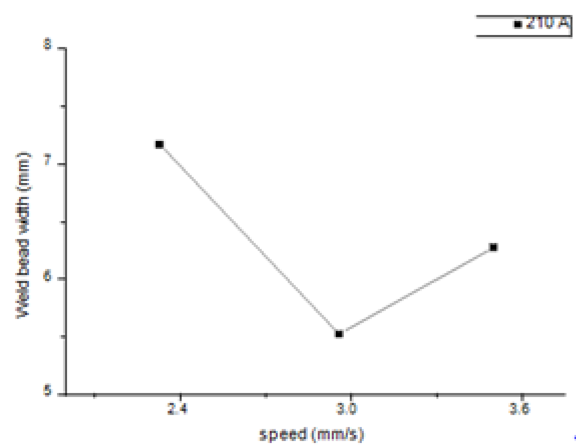

Fig : Variation of weld bead width against scan speed for A welding current

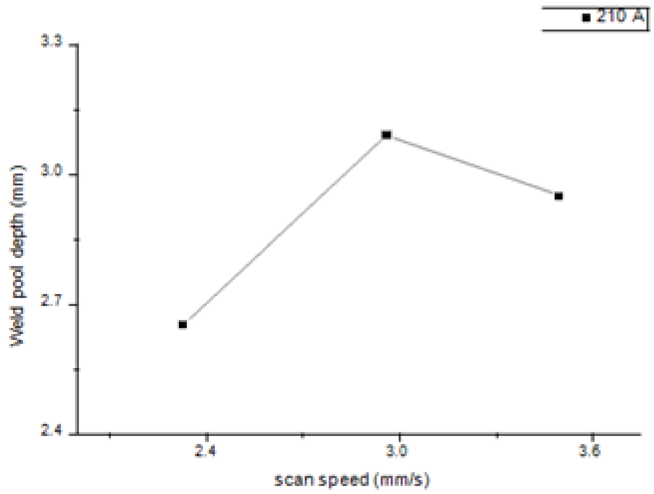

Fig : Variation of weld pool depth against scan speed for 210 A welding current

Table : Comparison of depth of penetration between without flux weld and with flux weld sample

Sl. No.	Current (A)	Speed (mm/s)	Depth (mm) without flux	Depth (mm) with flux
1	210	2.33	2.47	2.65
2	210	2.96	2.09	3.09
3	210	3.5	1.19	2.95

Table : Measurement of width, depth and crater of welded sample at weld zone for different current and gap maintain between workpiece

Sl. no.	Current (A)	Gap (mm)	Width (mm)	Depth (mm)	Crater (mm)
1	180	0.5	5.85	2.26	0.29
2	180	0.75	6.05	2.83	0.4
3	180	1	6.2	4.21	0.51
4	190	0.5	6.37	2.47	0.42
5	190	0.75	6.13	3.05	0.76
6	190	1	6.5	4.88	0.9
7	200	0.5	6.52	3.46	0.71
8	200	0.75	6.34	4.61	0.86
9	200	1	6.94	4.98	0.98

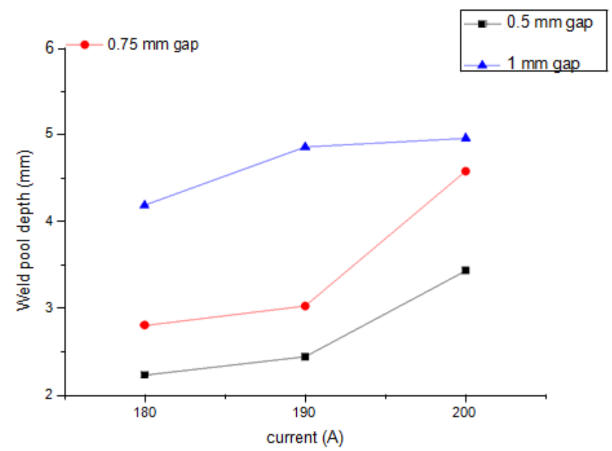

Fig : Variation of weld pool depth against welding current for different gap between workpiece to be welded

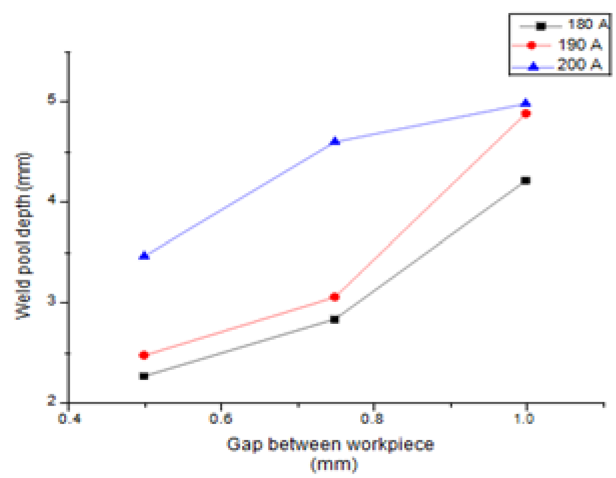

Fig : Variation of weld pool depth against gap between workpiece to be welded for different welding current

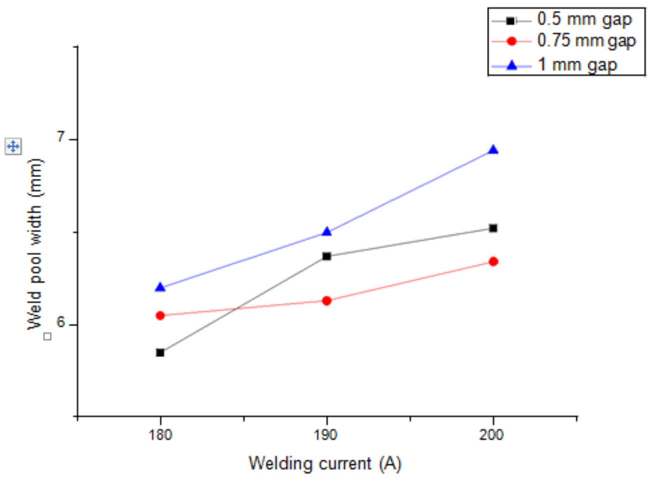

Fig : Variation of weld bead width against welding current for different gap between workpiece to be welded

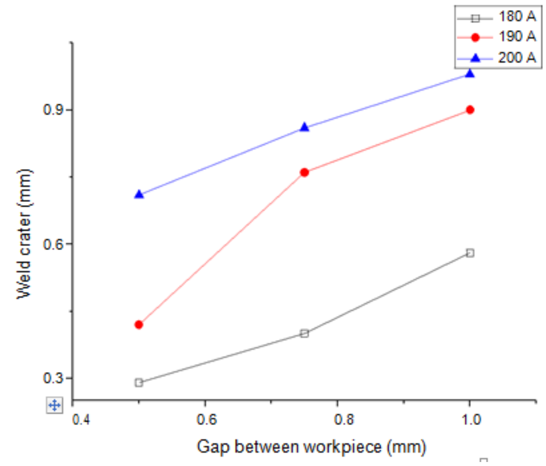

Fig : Variation of weld crater against gap between workpiece to be welded for different welding current

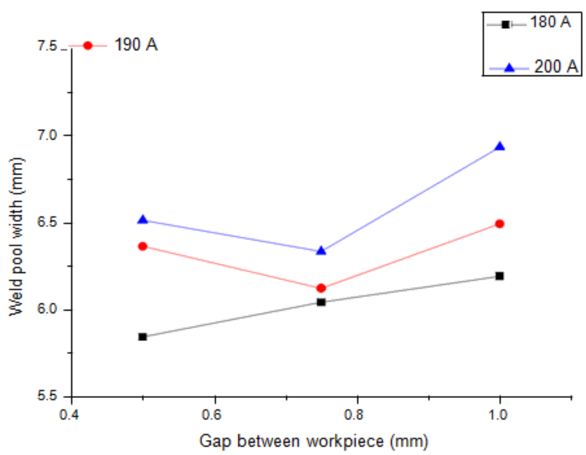

Fig : Variation of weld bead width against gap between workpiece to be welded for different welding current

Table : Tensile strength at weld joint by TIG welding of varying gap between workpiece

Sl. No.	Welding current (A)	Gap between workpiece (mm)	Tensile strength (MPa)
1	180	0.5	115.95
2	180	0.75	225.21
3	180	1	264.54
4	190	0.5	319.10
5	190	0.75	346.38
6	190	1	501.173
7	200	0.5	442.98
8	200	0.75	395.45
9	200	1	617.22

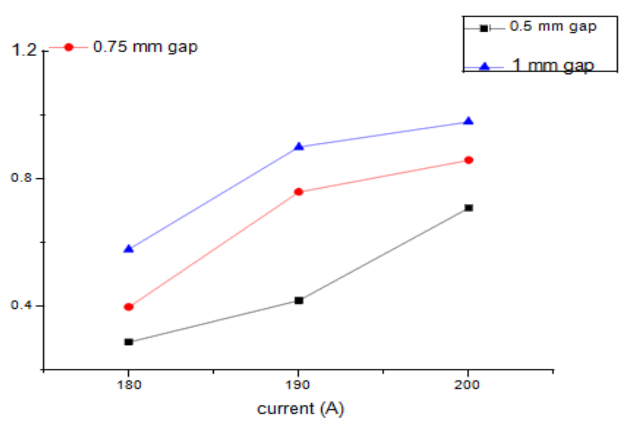

Fig : Variation of weld crater against welding current for different gap between workpiece to be welded

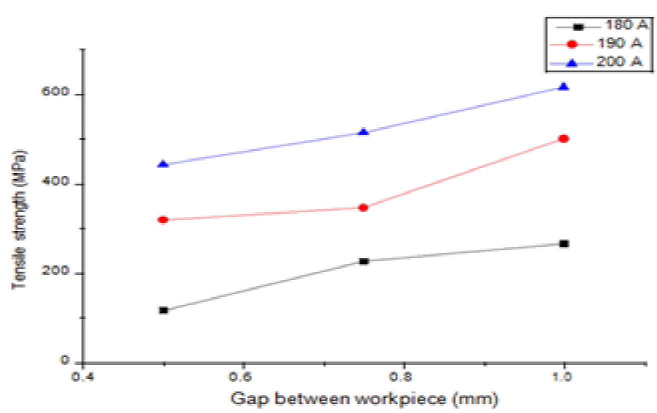

Fig : Variation of tensile strength against gap between workpiece to be welded for different welding current

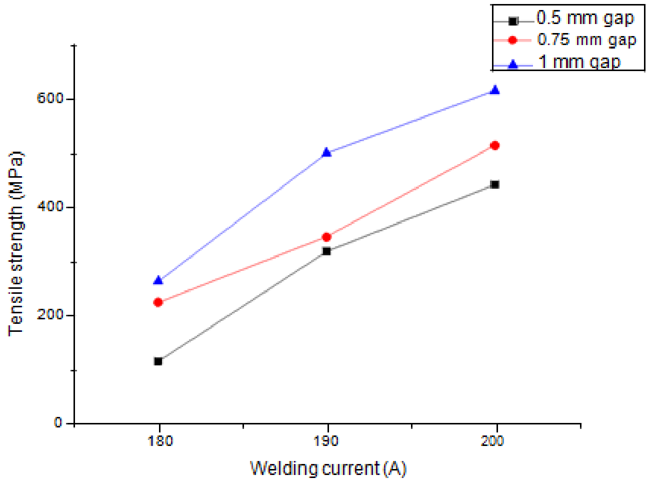

Fig : Variation of tensile strength against welding current for different gap between workpiece to be welded

Table : Hardness value for sample

S. No.	Welding current (A)	Welding speed (mm/s)	Gap between work piece (mm)	Hardness value at molten metal zone	Hardness value at heat Affected Zone	Hardness value at base material zone
1	190	2.33	0.5	192.6 HV	158.5 HV	149 HV
2	200	2.33	0.75	198.5 HV	176.8 HV	146.4 HV

IV. 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 workpiece 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.

5.1 Future aspects

If welding is possible with minimum welding speed, depth of penetration will increase. Optimum gap maintain between two workpieces 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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