Experimental Study on Autogenous TIG Welding of Mild Steel Material Using Lathe Machine

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Abstract: Tungsten Inert Gas welding (TIG) is additionally called Gas Tungsten Arc Welding (GTAW), is a kind of advance arc welding process which become a popular choice when a weld of high level quality or considerable precision welding is needed. However, the key issues of TIG welding process are its slow welding speed and restricted to lower thickness material in single pass. In this work, autogenous Tungsten Inert Gas (TIG) welding has been performed with the help of lathe machine on 5 millimeter thick AISI 1020 mild steel plate without using any kind of filler material. Here a wide range of welding current and scan speed has been tested for getting a full penetration type welding. Activated flux has additionally been accustomed to improve the weld depth. After performing the welding by maintaining completely different gap between plates to be welded, tensile strength and weld bead geometry of the weld has been investigated here. It is noted that, with the help of maintaining a suitable gap full penetration welding of the plate can be done which gives strength almost similar to the base material.

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

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I. INTRODUCTION

Term Tungsten Inert Gas welding is also known as Gas tungsten arc welding (GTAW), is a kind of arc welding process that uses a non-consumable electrode of tungsten to produce arc. Here the welded area is protected from atmospheric contamination with the help of an inert shielding gas (helium or argon), and a filler is generally used to weld thick plate. The electrode is non consumable since its melting point is about value of 3400^{o}C. In tungsten electrode a range of 1 to 2% thorium and zirconium are added to improve the electron emission, the arc stability and the current carrying capacity. A constant welding current power supply produces energy which is conducted across the arc through a column of the highly ionized gas and the metal vapors which are known as plasma. Heat input in GTAW does not depend on filler material rate. Hence consequently, the process allows a precise control of heat addiction and production of superior quality welds, with advantages as low distortion and free of the spatter.

II. EXPERIMENTAL SETUP

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

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1. Welding torch
2. Electrode
3. Power supply
4. Inert gas supply unit
5. Work piece holding device.
6. Welding Torch holding device
7. Lathe machine

Experimental planning for conventional autogenous TIG welding of mild steel

Exp. No.	Welding current (A)	Welding speed (mm/s)
1	150	2.04
2	150	2.52
3	150	3.02
4	170	2.04
5	170	2.52
6	170	3.02
7	190	2.04
8	190	2.52
9	190	3.02

Sample preparation for study the weld bead geometry

After performing the TIG welding process of mild steel plates, welded specimens were cut at perpendicular to the weld scan direction with a measurement of 20 mm x 10 mm for clicking optical microscope image of weld zone. Now these welded specimens were cut with the help of lathe machine. After cutting these samples, polishing & chemical etching were done at the weld cross section, before clicked the optical image. Specimens were prepared with the help of metallurgical polishing method using the different grit size SiC polishing paper and the subsequent diamond paste polishing. Nital solution consist of ethyl alcohol (97%) and concentrated HNO_3 (3%), has been used for etching the weld cross section by dipping polished surface in it for min 10 sec. The melting depth or weld penetration was examined for each weld sample from the change in microstructure with help of an optical microscope.

Sample preparation for tensile testing

For the tensile test of welded samples, these were cut into I shape as per the ASTM E8. Tensile testing of weld specimens was carried out in a Universal Testing Machine (UTM) with the maximum load capacity of about 600 KN. In order to tensile test fixing of the sample in UTM was done properly and then applying gradually increasing force until the shape transformation occurs in specimen and it finally break.

TIG welding process with TiO_2 Flux

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

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

It has been found from last performed experiments that, during the autogenous TIG welding of the thick mild steel plates either applying flux or without flux, when plates are put side by side and no gap provided between these plates, the melting depth or depth of penetration is limited to a fix value and the molten material does not flow towards the bottom side of the welding joint. It is noted from the literature, that during welding using the filler rod, for the flow of this molten material proper grooving is done or some gap is put between the plates to be joint. Therefore, in this present work, for increasing the depth of penetration in the weld, TIG welding was done by maintaining a gap between the workpieces to be joint. An attempt has also been made to examine the effect of gap between the plates during the autogenous TIG welding of mild steel for not using filler rod.

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III. RESULTS AND DISCUSSION

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

Sl. No.	Current (A)	Speed (mm/s)	Width (mm)	Depth (mm)
1	170	2.04	6.27	2.31
2	170	2.52	5.72	1.25
3	170	3.02	5.85	1.56
4	190	2.04	6.97	2.45
5	190	2.52	5.82	2.07
6	190	3.02	6.14	1.88

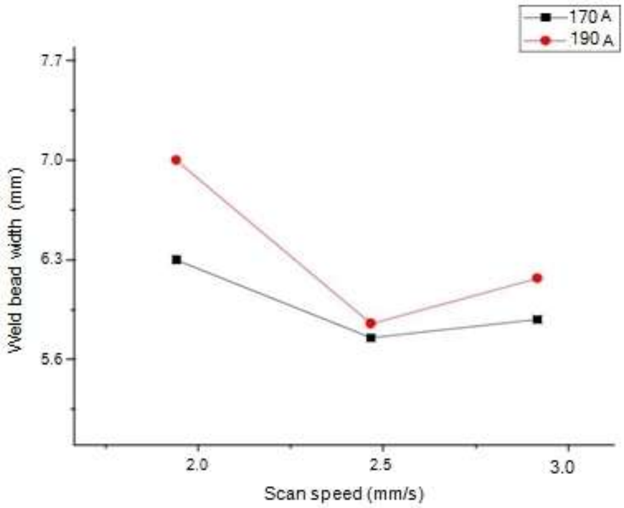

Fig. 1 Variation of the weld bead width against scan speed for the different welding current

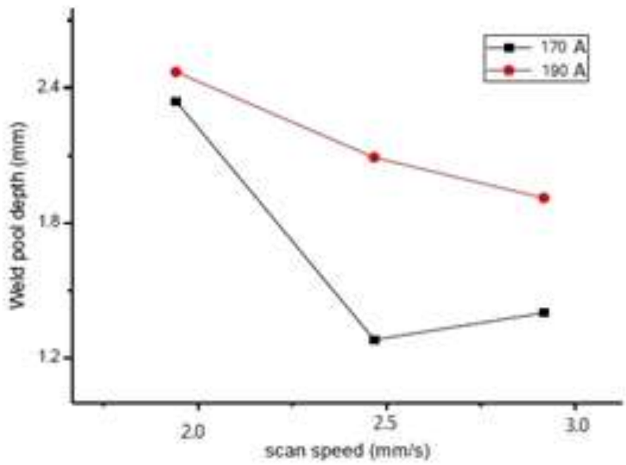

Fig. 2 Variation of weld pool depth against scan speed for different welding current

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

Sl. no.	Current (A)	Speed (mm/s)	Width (mm)	Depth (mm)
1	190	2.04	7.13	2.62
2	190	2.52	5.49	3.06
3	190	3.02	6.25	2.92

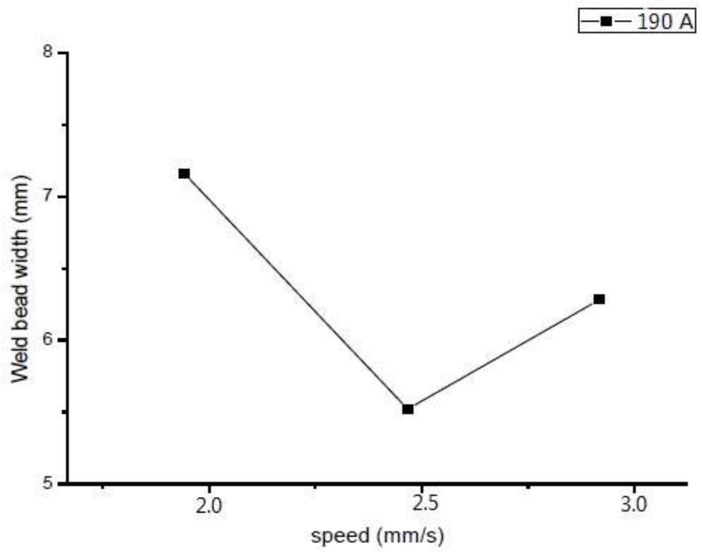

Fig. 3 Variation of weld bead width against scan speed for 190 A welding curren

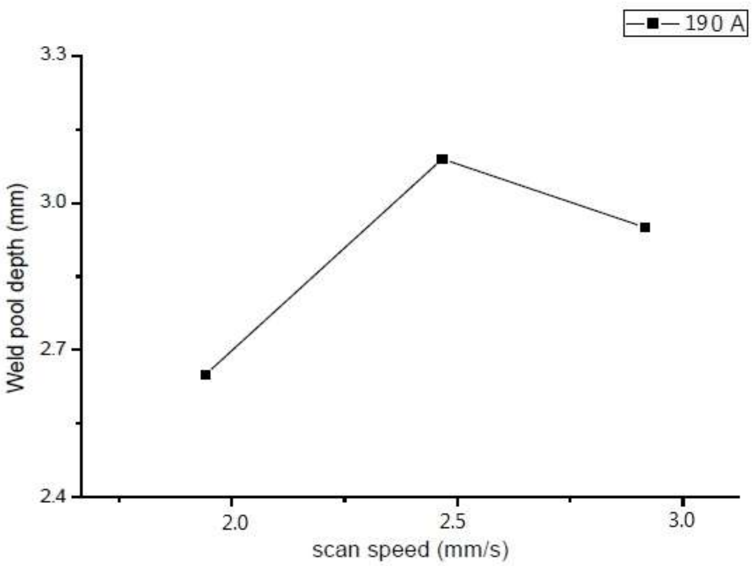

Fig. 4 Variation of weld pool depth against scan speed for 190 A welding current

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

Sl. No.	Current (A)	Speed (mm/s)	Depth (mm) without flux	Depth (mm) with flux
1	190	2.04	2.43	2.62
2	190	2.52	2.06	3.06
3	190	3.02	1.16	2.92

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

Sl. no.	Current (A)	Gap (mm)	Width (mm)	Depth (mm)	Crater (mm)
1	160	0.5	5.84	2.23	0.28
2	160	0.75	6.04	2.80	0.39
3	160	1	6.18	4.18	0.50
4	170	0.5	6.35	2.44	0.41
5	170	0.75	6.11	3.02	0.75
6	170	1	6.48	4.85	0.89
7	180	0.5	6.50	3.43	0.70
8	180	0.75	6.32	4.61	0.85
9	180	1	6.92	4.96	0.99

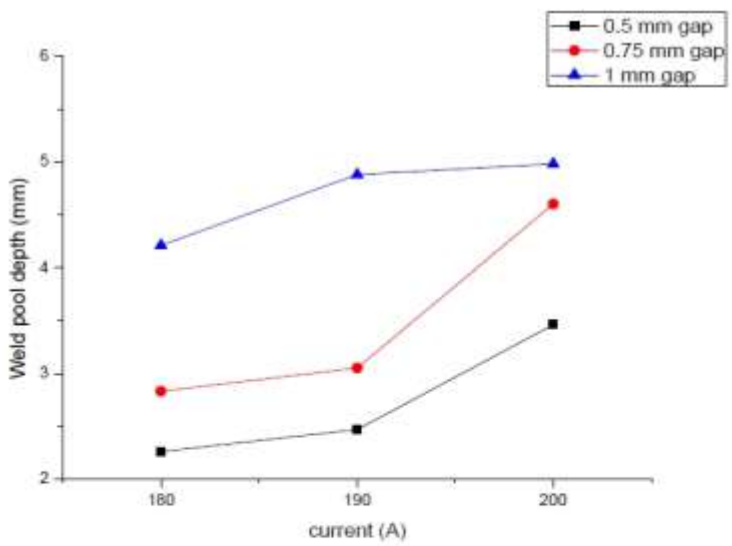

Fig. 5 indicates the variation of weld pool depth against welding current for different gap between workpiece

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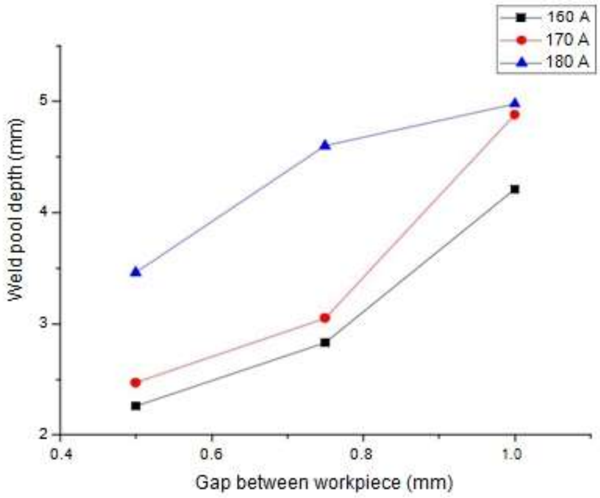

Fig. 6 Variation of the weld pool depth versus gap between workpiece to be welded for the different welding current

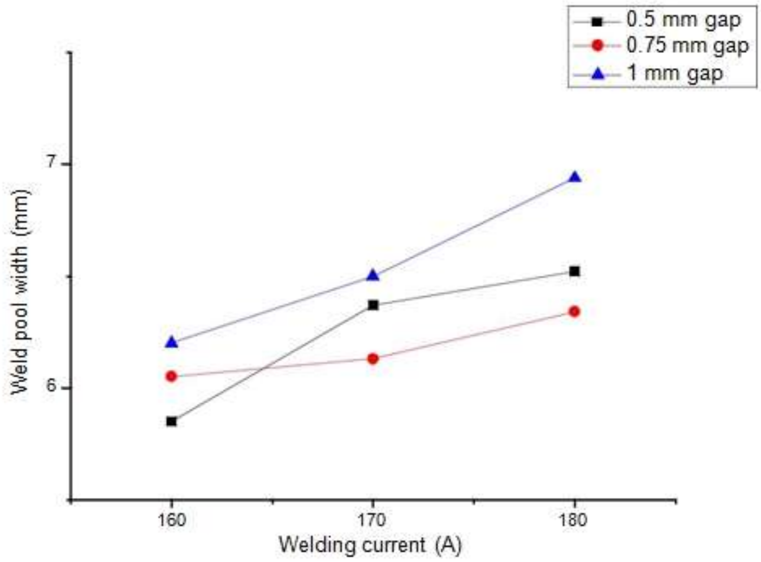

Fig. 7 Variation of weld bead width versus welding current for the different gap kept between workpiece to be welded

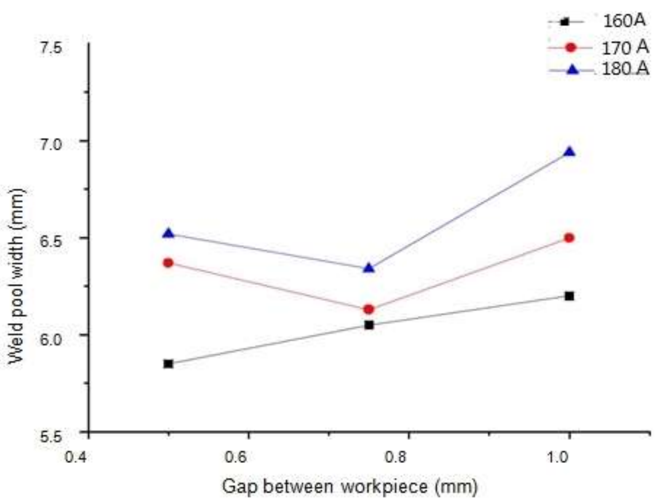

Fig. 8 Variation of weld bead width versus gap between the workpiece to be welded for different welding current

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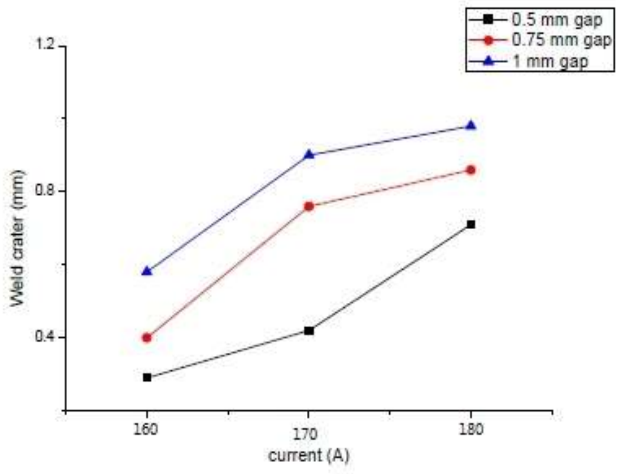

Fig. 9 Variation of weld crater versus welding current for different gap between the workpiece to be welded

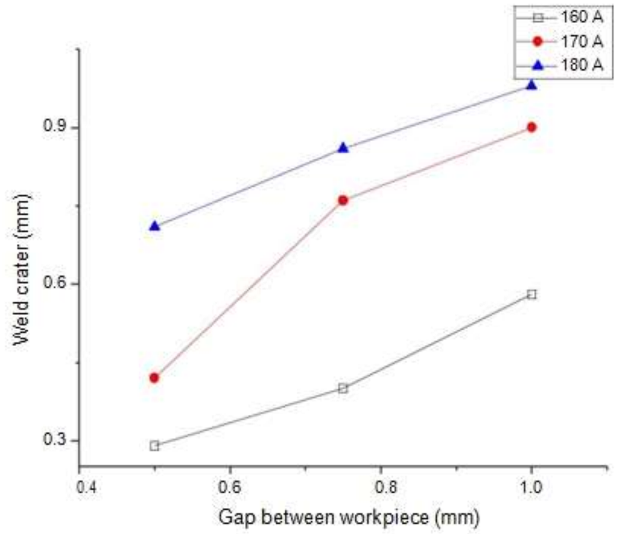

Fig. 10 represents variation of weld crater versus gap between the workpiece to be welded for different welding current

Table : Tensile strength at the weld joint by Tungsten Inert Gas (TIG) welding of varying gap between the workpiece

Sl. No.	Welding current (A)	Gap between workpiece (mm)	Tensile strength (MPa)
1	160	0.5	115.13
2	160	0.75	225.05
3	160	1	264.12
4	170	0.5	318.80
5	170	0.75	345.78
6	170	1	500.87
7	180	0.5	442.08
8	180	0.75	394.95
9	180	1	616.63

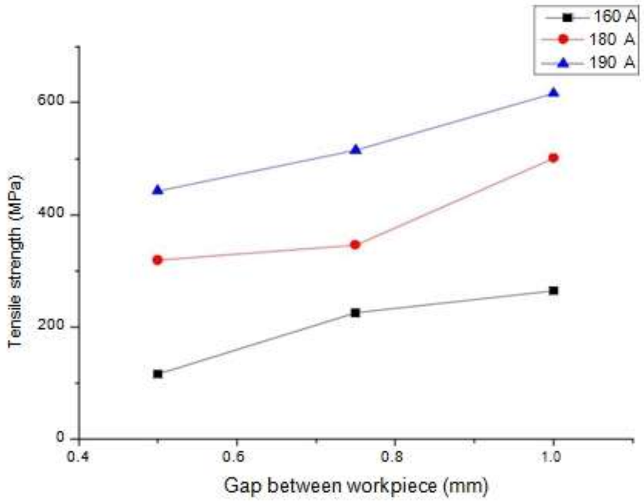

Fig. 11 Variation of tensile strength versus gap between workpiece to be welded for the different welding current

Table 15 Hardness value for sample

Sample No.	Welding current (A)	Welding speed (mm/s)	Gap between workpiece (mm)	Hardness value at molten metal zone	Hardness value at heat affected zone	Hardness value at base material zone
1	170	2.04	0.5	192.6 HV	158.5 HV	149 HV
2	180	2.04	0.75	198.5 HV	176.8 HV	146.4 HV

IV. CONCLUSIONS

Findings of this investigation can be summarized into the following points

- The results of the conventional Tungsten Inert Gas (TIG) welding process conducted show that, maximum depth of penetration was acquired with parametric combination of maximum current and minimum welding speed.
- When this same procedure is repeated with the additional utilization of TiO2 flux, depth of penetration increases in comparison to conventional welding, but some crack on the weld zone was seen for using flux.
- With the constant welding speed, another set of experiments were performed by keeping a gap between the workpiece to be welded. It is found that, with a gap of 1 millimeter, defect-free welding with the proper material flow was obtained throughout the joint for the higher welding current.
- Comparing there three methods of TIG welding, the depth of penetration and the tensile strength of weld joint is maximum when adequate gap is kept between the the components to be welded.
- From the graphs plotted here, it can be concluded that welding width and depth increases with the increase in welding current and gap kept between the components to be welded.

Future aspects

If the welding is feasible with minimum welding speed, depth of penetration can increase. Optimum gap maintain between two workpieces to be welded thus got higher melting depth. All these end in to produce higher strength to weld joint.

GTAW/TIG welding process performed by employing filler material so welds thick plates and provides the higher depth of penetration and the better strength.

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