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EXPERIMENTAL ASSESSMENT OF BEAD FORMATION IN AUTOGENOUS TIG WELDING OF AISI 1020 STEEL

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2. ABSTRACT

Tungsten Inert Gas (TIG) welding, commonly referred to as Gas Tungsten Arc Welding (GTAW), is an advanced arc welding technique widely preferred for applications requiring superior weld quality and high precision. Despite its advantages, the TIG welding process is often limited by its relatively low welding speed and its difficulty in achieving full penetration in thicker materials during a single pass.

In the present study, autogenous TIG welding was carried out on 5 mm thick AISI 1020 mild steel plates without the addition of filler metal. Various combinations of welding current and travel speed were examined to achieve complete weld penetration. Additionally, activated flux was applied to enhance the penetration depth of the weld bead. Welding experiments were conducted by maintaining different root gaps between the plates, and the resulting weld bead geometry along with tensile strength were evaluated. The experimental results revealed that maintaining an optimum gap between the plates enables full penetration welding and produces joint strength nearly equivalent to that of the parent metal.

3. KEYWORDS: Gas Tungsten Arc Welding (GTAW), Activated Flux Technique, Mechanical Strength Evaluation, Hardness Measurement, and Activated TIG (A-TIG) Welding Method.

4. INTRODUCTION

Tungsten Inert Gas (TIG) welding, also referred to as Gas Tungsten Arc Welding (GTAW), is a fusion welding technique that employs a non-consumable tungsten electrode to generate the welding arc. During the process, the weld zone is shielded from atmospheric contamination using inert gases such as argon or helium. For welding thicker sections, filler metal is generally added to obtain a strong joint.

The tungsten electrode does not melt during welding because of its very high melting temperature, approximately 3400°C. To enhance arc stability, electron emission, and current-carrying capability, small amounts of thorium or zirconium are commonly alloyed with the tungsten electrode. A constant-current power supply is used to create and maintain the electric arc, where energy is transferred through a highly ionized gaseous medium called plasma.

One of the major advantages of the GTAW process is that the heat input can be controlled independently of the filler metal addition rate. This feature enables accurate heat control, resulting in high-quality welds with minimal distortion, smooth surface finish, and negligible spatter formation.

5. EXPERIMENTAL PLANNING AND PROCEDURE

For the current experimental investigation, an autogenous TIG welding setup was designed and fabricated to perform welding at a uniform travel speed without using any filler metal. In this arrangement, the TIG torch is mounted on a movable carriage that travels along a guided rail track. The setup ensures that a constant distance is maintained between the torch tip and the workpiece throughout the welding operation.

The movement speed of the carriage can be adjusted according to the required welding speed and desired heat input. This flexibility allows better control over the welding parameters and improves weld quality. Figure 3 illustrates the experimental arrangement used in the present study.

The autogenous TIG welding system mainly consists of the following components:

1. Welding torch
2. Tungsten electrode
3. Welding power source
4. Inert gas supply system
5. Workpiece holding fixture
6. Movable carriage for torch movement
7. Rail track guidance system

Fig. 1. Experimental setup of TIG welding.

In this stage of the experimental work, the feasibility of performing autogenous TIG welding on 5 mm thick mild steel plates was investigated without the use of filler metal. Mild steel specimens having dimensions of 50 mm × 50 mm were prepared using a band saw machine. The edges intended for welding were machined using a surface grinding process to ensure proper contact and alignment between the plates during welding. In addition, the plate surfaces were polished with silicon carbide emery paper to remove surface contaminants and obtain a smooth finish.

After specimen preparation, the plates were securely mounted on the work holding fixture using clamps and bolts. Welding was carried out using Direct Current (DC) with straight polarity, where the electrode was connected to the negative terminal and the workpiece to the positive terminal. A 2.4 mm diameter zirconiated tungsten electrode was employed for the welding operation.

To analyze the effect of welding parameters, three different values of welding current and travel speed were selected, as presented in Table 1. Based on these parameter combinations, a total of nine experimental trials were conducted.

Table 1: 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

Table 2: 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

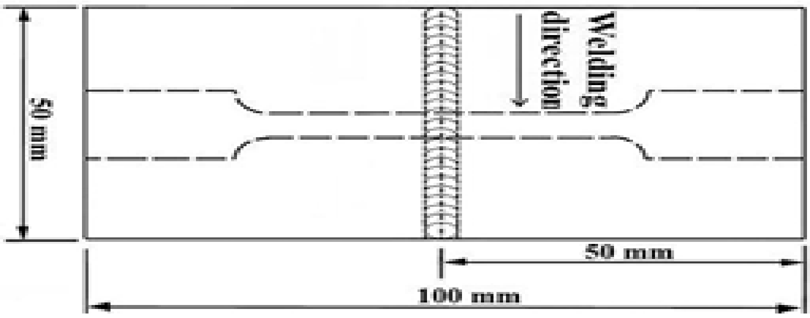
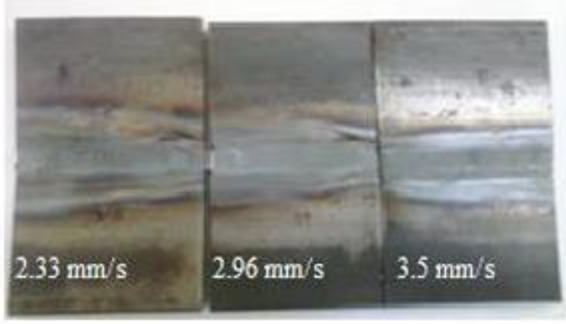
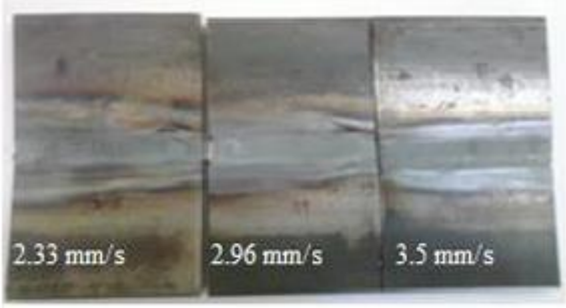


Fig. 2. Schematic Diagram of specimen for tensile testing.

6. RESULTS AND DISCUSSION

Welded specimen performed by conventional auto genius TIG welding:

Sl. No.	Welding current	Welded sample at different speeds
1	170 A	
2	190 A	

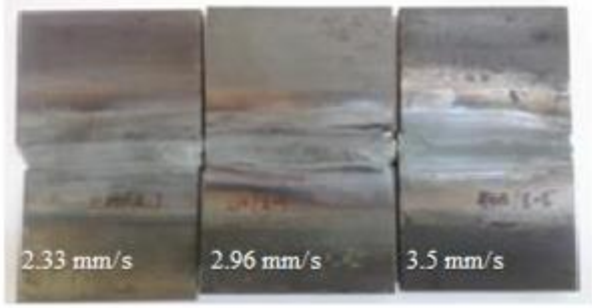
3	210 A	

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

The results obtained from the first series of experiments clearly indicated that the combination of higher welding current and lower travel speed generated a greater heat input to the workpiece. Under these conditions, the weld exhibited the maximum depth of penetration.

In the second phase of the experimentation, activated TIG welding was carried out using TiO_2 flux with a constant welding current of 210 A. Welding trials were performed at three different travel speeds to study the influence of activated flux on weld penetration and bead characteristics. The A-TIG welding results obtained with TiO_2 flux at 210 A and varying welding speeds are illustrated in Figure 4.

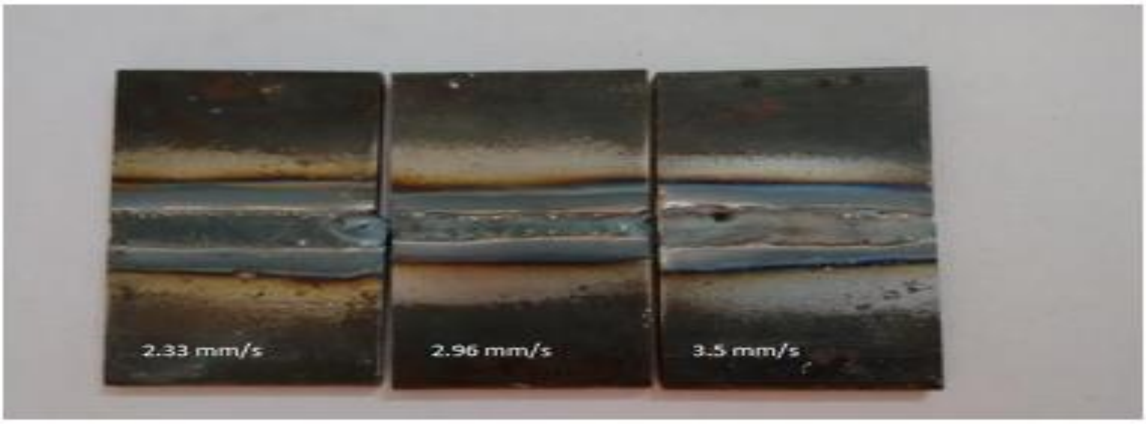


Fig. 4. TIG welded specimen with TiO_2 flux at 210 A current.

Figure 5 presents the optical microscopic images of the weld zone obtained from the autogenous Activated TIG (A-TIG) welding process using TiO_2 flux coating. The welding experiments were conducted at a constant current of 210 A with different welding travel speeds. The micrographs illustrate the effect of scan speed on the weld bead structure and metallurgical characteristics of the welded region.

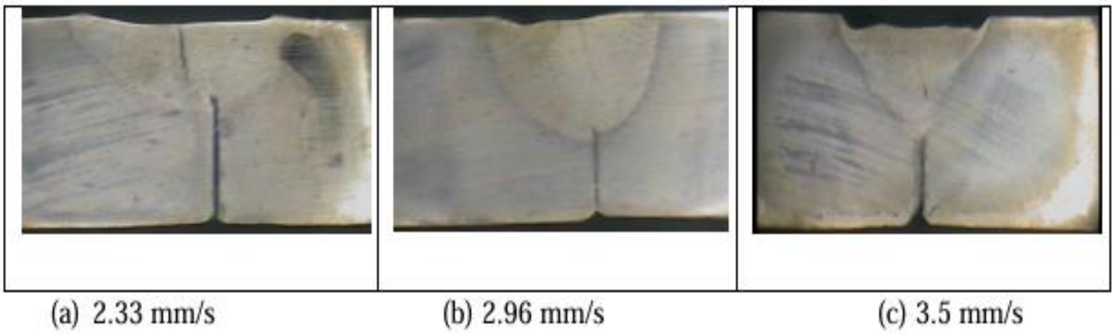


Fig. 5 Optical microscopic Image at weld zone of TIG welded specimen with use of TiO_2 flux.

7. CONCLUSION

The major findings obtained from the present experimental study are summarized below:

- The experimental results of conventional TIG welding revealed that the greatest weld penetration was achieved at the combination of high welding current and low travel speed.
- When the welding process was repeated using TiO_2 activated flux, the penetration depth increased significantly compared to conventional TIG welding. However, minor cracks were observed in the weld zone due to the application of flux.
- Another series of experiments was conducted by maintaining a constant welding speed while introducing different gaps between the plates to be joined. It was found that a root gap of 1 mm produced defect-free welds with proper molten metal flow, particularly at higher welding currents.
- Among the three welding approaches investigated, the maximum weld penetration and tensile strength were achieved when an appropriate gap was maintained between the workpieces during TIG welding.
- Analysis of the plotted graphs indicated that both weld bead width and penetration depth increased with an increase in welding current as well as the gap maintained between the plates being welded.

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