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Experimental Investigation on Microstructure and Mechanical Properties of Mild Steel Weldments

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Abstract

The metal joints have been emerged as a structural material for various industrial applications which provides good combinations of mechanical properties with lower cost. Mild steel plates were welded with different welding processes such as Shielded Metal Arc Welding (SMAW) and Tungsten Inert Gas (TIG) welding respectively. Non-destructive testing (NDT) such as magnetic particle and ultrasonic testing are carried out on mild steel weldments. The weld specimens were prepared for mechanical testing and micro structural examination. From the results, it is observed that the joints made by TIG welding resulted in better mechanical properties as compared to SMAW weldments. The finer grains were observed in the weld zone microstructure of weldments made by TIG welding.

Keywords: *SMAW and TIG welding, Non Destructive Testing, Mechanical properties, Microstructure*.

1. Introduction

Welding is usually the most economical way to join components in terms of material usage and fabrication costs [1]. Low carbon steels that have less than 0.25% carbon, display good welding ability because they can be generally welded without special precautions using most of the available processes. Concerning the previous studies related to the welding of low carbon steel, there are limited publications [2-7]. The welding of mild steel plates can easily be carried out by Shielded Metal Arc Welding (SMAW) and Tungsten Inert Gas welding (TIG) because of the easy selection of the input parameters. TIG welding is a process that produces an electric arc maintained between a non-consumable tungsten electrode and the part to be welded where as in SMAW an electric arc is maintained between a consumable electrode and work material [8]. An alternative mechanical method of assembly requires more complex shape alterations and addition of fasteners. SMAW and TIG Welding are the most widely methods used for fabrication work in industries. The molten metal and the tungsten electrode are all shielded from atmospheric contamination by a blanket of inert gas fed through the TIG torch. Gural *et al.* [2] have studied the heat treatment in two phase regions and its effects on microstructure and mechanical strength after welding of the low carbon steel. On the other hand, *Eroglu and Aksoy* [3] investigated the effect of initial grain size on microstructure and toughness of intercritical heat-affected zone of low carbon steel. The objective the present work is to study the microstructure and mechanical properties of the mild steel weldments using SMAW and TIG welding techniques.

2. Experimental Procedure

The rolled plates of 18 mm thick mild steel were cut into the required dimension. The chemical composition of the base metal is shown in Table.1. SMAW and TIG Welding w carried out using Fig.1 shows welded joints fabricated by SMAW and TIG welding techniques.

Table.1 Chemical composition of the base metal (wt, %)

Material	C	Mn	Si	P	S	Fe
Base material (mild steel)	0.172	1.4	0.289	0.009	0.002	Balance

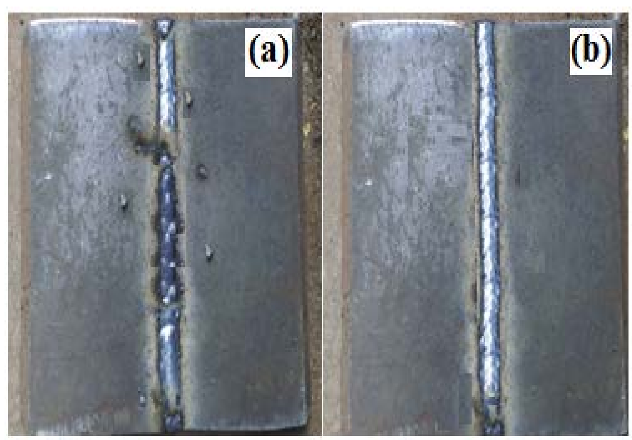

Fig.1. Surface Morphology of the weldments (a) SMAW (b) TIG.

2.1 Mechanical Testing

The objective of this section is to evaluate the Mechanical properties such as tensile strength, yield strength and percentage of elongation of mild steel weldments. Specimens for tensile testing were taken in transverse to the weld direction and machined as per ASTM E8/E8M-11 standards. Tensile test was carried out using computer controlled universal testing machine (Model: Autograph, Make: Shimatzu). Specimens for impact testing were taken in transverse to the weld direction and machined as per ASTM A370 standards. In order to observe the toughness of the weld joints, the charpy impact tests were carried out at room temperature using pendulum type impact testing machine.

2.2 Metallography

The specimens for metallographic examination were sectioned to the required size from the welded joints transverse to the welding direction, polished with different grades of emery papers. Final polishing was done using the diamond compound (1µm particle size) on the disc polishing machine and then etched with a solution 5 ml hydrochloric acid, 1 g picric acid and 100 ml methanol applied for 10–15s. The microstructure of the welds were studied and recorded using optical microscope (Model: NIKON; make Epiphot 200).

2.3 Rockwell Hardness measurement

Specimens were cut at the middle of the joints in transverse direction for conducting hardness survey. The Rockwell Hardness measurement based on the net increase in depth of impression on a material as a load is applied. The higher the number on the scale, the harder the material. The mild steel specimen of 18 mm thickness was placed on the surface of the Rockwell Hardness tester. A minor load is applied and the gauge is set to zero. Then different loads were applied by tripping a lever. After 15 seconds the major load is removed and the specimen was allowed to recover for 15 seconds and then the hardness was read off the dial with the minor load still applied.

2.4 Non-Destructive Testing

NDT is used to detect internal defects formed in the weld region. NDT is a wide group of analysis techniques used in science and industry to evaluate the characteristics of a material or component without causing damage to it. Many different types of NDT methods exist, the most commonly used ones being ultrasonic testing, magnetic particle testing, liquid penetrate inspection, radiographic testing and eddy current testing. NDT is used in almost every field of engineering and can be applied to any types of materials including metals, ceramics, plastics and composites. The detection of these flaws is critical for the safety criteria of all designs. These flaws include cracks, internal voids, surface cavities, defective welds and any sort of imperfection in the welds. Successful attempts have been made on NDT techniques on TIG and SMAW welds of mild steel plates.

3. Results and Discussion

The weld zone microstructure of the weldments was studied using optical microscope. From the results it is observed that the finer grains of ferrite and pearlite were observed and no Martensite formation at the weld zone of the joints fabricated by TIG weldments compared to the joints made by SMAW. The microstructure of the base metal, weldments of the TIG and SMA weldments were shown in Figure.2.

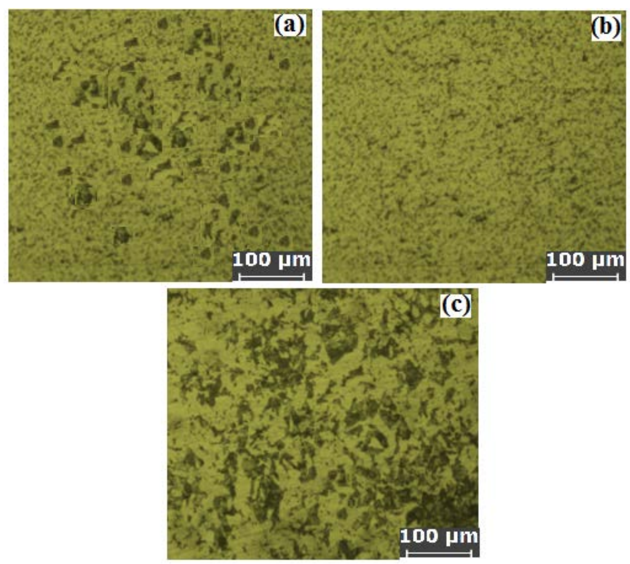

Fig.2. weld zone microstructure of welds made by (a) SMAW (b) TIG and (c) Base metal

The various non-destructive testing such as ultrasonic testing and magnetic particle testing were carried out on the SMAW and TIG welded mild steel joints. The Figure.3 and Figure.4 shows the ultrasonic and magnetic particle testing of weldments respectively. From the results, it is observed that the weldments made by TIG were defect free as compared to the SMAW.

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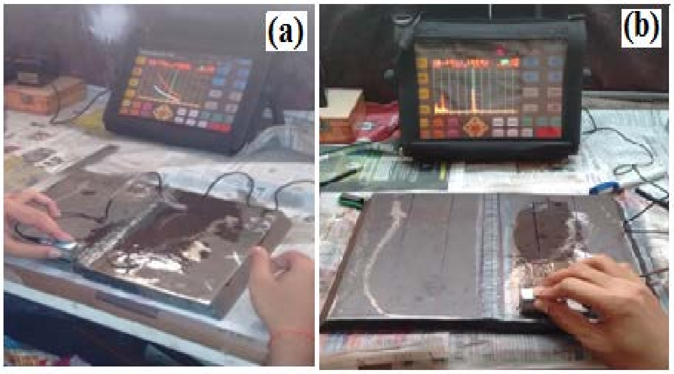

Fig.3. Ultrasonic testing of the weldments
(a) SMAW (b) TIG

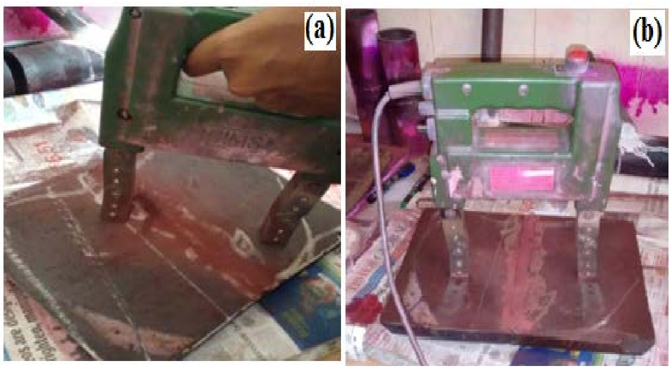

Fig.4. Magnetic particle testing of the weldments
(a) SMAW (b) TIG

Table.2 Mechanical properties of mild steel weldments and base metal

Weld Joint	Ultimate Tensile Strength (MPa)	Yield Strength (MPa)	Elongation (%)	Impact Toughness (J)	Rockwell hardness (R_B)
SMA Weldments	291	231	3.26	62	65
TIG weldments	421	326	6.60	65	82
Base Metal	244	199	7	61	76

Mechanical properties of the joints fabricated by SMAW and TIG welding techniques are shown in Table. 2. TIG weldments are defect free as compared to weldments made by SMAW, hence the better mechanical properties were observed in the TIG weldments as compared to SMAW weldments.

4. Conclusions

From the results the following conclusion can be derived.

- .The finer grains of ferrite and pearlite were observed in the microstructure of the TIG weldments as compared to the SMA weldments.
- The Ultimate tensile strength is higher in TIG weldments as compared to the SMA weldments.
- Defect free TIG weldments were observed using Ultrasonic and Magnetic particle testing

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