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EXPERIMENTAL STUDY OF THE EFFECT OF WELDING ELECTRODE TYPES ON TENSILE PROPERTIES OF LOW CARBON STEEL AISI1010

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ABSTRACT

This paper discussed the effect of welding variables on the heat-affected zone (HAZ) by using a tensile test of welded 10 mm thick low carbon steel AISI1010 commercial plate, which is welded using the Shielded Metal Arc Welding (SMAW) method. Different welding electrodes E6013 and E7018 were considered as welding parameters investigated. After that, the welded specimens were cut and machined to standard configurations for tensile test. The results showed that selecting different welding electrodes had a remarkable effect on the mechanical properties such as the ultimate tensile strength, elongation percentage, and yield strength of the welded specimens. The increment in the electrical current for each electrode in the welding processes led to decrease in yield strength and tensile strength. The initial decrease in tensile strength and yield strengths were observed. This behavior was attributed to the fact that different welding electrodes and increased the required electrical current to melting for the welding electrode, increased the electrical current led to increased heat input on heat affected zone (HAZ), then the observed change mechanical properties [which could create area for defect. The welding processes and tensile test at a room temperature was performed

KEYWORDS: welding Electrodes types, Arc Welding, Tensile Strength, Heat Affected Zone.

1. INTRODUCTION

Steel is an important engineering material. It has been used widely in many applications such as, vehicle parts, truck bed floors, automobile doors, domestic appliances etc. It is capable of presenting economically a very wide range of mechanical and other properties

Traditionally, mechanical components have been joined using fasteners, rivet joints, etc. In order to reduce manufacturing time and weight and to improve the mechanical properties, welding is usually used as fasteners. Today, a variety of different welding processes are available, welding is widely used as a fabrication process for joining materials in a wide range of compositions, part shapes, and sizes. Welding is an important joining process because of high joint efficiency, simple set up, flexibility, and low fabrication costs. (Armentani et al., 2007).

Rohit and Jha (2014) investigated the effect of process parameter such as welding current on tensile strength of mild steel weldment by using welding current as varying parameter. In this work, mild steel alloy plates were joined by Shielded Metal Arc Welding (SMAW). The welding currents considered in this study were 100A, 110A, 120A, 130A, and 140 A. They showed that the maximum tensile strength was achieved when the welding current is 120A. With the increase in welding use, which were considered as a variable parameter, the ultimate tensile strength (UTS) of 515.185 MPa was recorded. Hence, it can be concluded that with the increase in welding current the UTS will increase until an optimum value. Increasing the current beyond this optimum value will result in decreasing UTS.

Mattoo and Kumar (2015) performed an experimental study to investigate the effect of using different filler rods via Shielded Metal Arc Welding. The filler rods used in this" work are austenitic stainless steel, ferritic stainless steel, and mild steel. The different welded samples have been tested and similar significant parameters like Tensile Strength and Brinell Hardness Number have been determined in order to be compared with the standards. They found that the tensile strength was a maximum when the Mild Steel 7018-filler rod was used and a maximum hardness was achieved when ferritic stainless steel 430-filler rod was used.

Abdulzara, (2011) used steel alloy instead of carbon steel for achieving of engineering industry requirements. Where in carbon steel, a tensile strength higher than 700 MPa with a suitable toughness and ductility, can't be recorded. It is also susceptible to mass effect and the low resistance to corrosion and oxidation… etc.

The manual metal arc welding of low alloy high strength steel were done using some of electrodes, which are different in their chemical composition and price as well as testing their effects on tensile strengths. He showed that the tensile strength and the weld joined efficiency increased when iron powder low hydrogen covering electrodes were used. The tensile strength was (484MPa) and the weld joint efficiency was (56.9%), when (OK 48.04) electrode was used. Also, the tensile strength increased to (720MPa) and the weld joint efficiency was increased to (84.7%), when (OK 76.18) electrode was used.

Ogbunnaoffor et al., (2016) investigated the effect of welding current on the structure, tensile properties, and performance of mild steel weld joints. Mild steel plate (AISI 1018) having 4mm thickness was used as a base metal for preparing butt-weld joints. The SMAW process was employed by using a 2.5mm diameter welding electrodes E6011 and E6013. E6011 produced a maximum yield strength and ultimate tensile strength values of 358.50 MPa, 421.70MPa respectively, while E6013 gave a maximum ultimate tensile strength and a yield strength values of 383.20 MPa and 319.37 MPa respectively. The best combination of the tensile properties tested for weldments was found when the electrode was made of E6011 and E6013 and then percentage elongation of the base metal is lower than that of the weld joints.

Djukic, (2014) studied hydrogen embrittlement (HE). of steels is extremely interesting topic in many industrial applications. The specific mechanism of hydrogen embrittlement is manifested, depending on the experimental conditions investigation. The results presented in this paper, indicate the simultaneous action of the hydrogen-enhanced decohesion HEDE. and hydrogen enhanced localized plasticity HELP. mechanisms of HE, depending on the local concentration of hydrogen in investigated steel. Simultaneous effect is responsible for the decline in ductility.

The effect of welding with different electrodes on the mechanical properties of low carbon steel arc welded joints were studied in this research paper. The experiment was carried out with the aim to find out how these individual different electrodes affect the mechanical properties of the welded low carbon steel AISI1010 specimen.

2. EXPERIMENTAL WORK

2.1. Materials

In this paper, low carbon steel plates (AISI1010) having a thickness of 10mm (3/8 in) is used as a base metal for the experimental work. It is widely used in pressure vessels, tanks, and pipeline for petroleum industries. These plates are cut to dimensions of (40 mm x 450 mm) and (40 mm x 225 mm). Both surfaces are cleaned to remove dirt and oxides on the plate surfaces before welding. One small specimen plate of carbon steel was analyzed to examine its chemical composition by Spectrometer device as shown in the Fig. 1. The chemical composition and carbon percentage especially for 0.08% carbon by Spectrometer device, the base metal that obtained from the Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates (Djukic, 2014). Table 1 shows the chemical composition of (AISI1010) Plates carbon steel. Fig. 2. shows the stress-strain curve of the base metal.

Fig. 1. Spectrometer device.

Table 1. The Chemical composition of the base metal shown in the figure.

C%	Si%	Mn%	P%	S%	Cr%	Mo%	Ni%	Al%	Co%	Cu%
0.08	0.13	0.44	0.038	0.047	0.059	0.0086	0.071	0.0046	<0.0085	0.29

Nb%	Ti%	V%	W%	Pb%	Sn%	Mg%	As%	Zr%	B%	Fe%
<0.005	<0.001	<0.002	<0.04	<0.01	0.036	0.0075	0.17	<0.003	0.0094	98.6

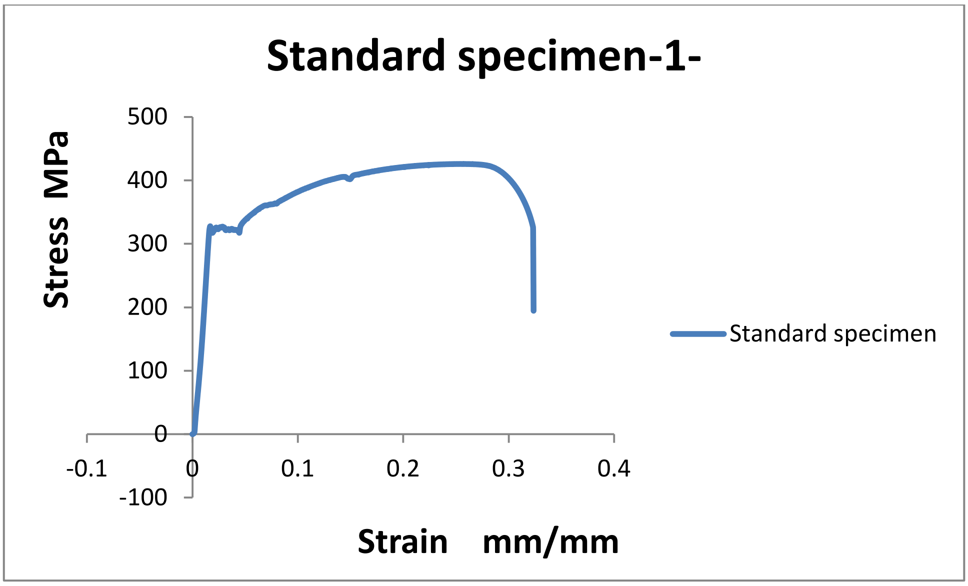

Fig. 2. Stress-strain curve of the base metal. (standard specimen) σu=426 MPa , σy=328 MPa.

2.2. Preparation of the specimens

Tensile test specimens are prepared according to ASTM standard (E8/E8M-9) as shows in the Fig. 3. Ten pieces of carbon steel plates have been prepared and machined to dimensions of (40 mm x450 mm) and (40 mm x 225 mm) to be used in this work. Single –V-groove butt joint with 3 mm root face and angle of 75^{o} with 2 mm opening was prepared to fabricate the SMAW welded joints as shown in Fig. 4. (STAM, 20110; Structural Welding Code – Steel, 2002). The preparation of all welding joint edges was done by welding machine. The specimens were linked by double pass arc welding with SMAW electrode type E7018 and E6013 with diameters equals to 3.25 mm .Table 2. shows the properties of the welding electrodes. The welding process was carried out using (SMAW) machine. One run in a flat welding position was used to produce a butt weld joint. The welding conditions and process parameters such as welding currents of 90A for E6013 and 180A for E7018 (Certification of ESAB company-7018, 2002; Certification of ESAB company-6013, 2002). The specimens welding processes and cooled specimens by the air at room temperature.

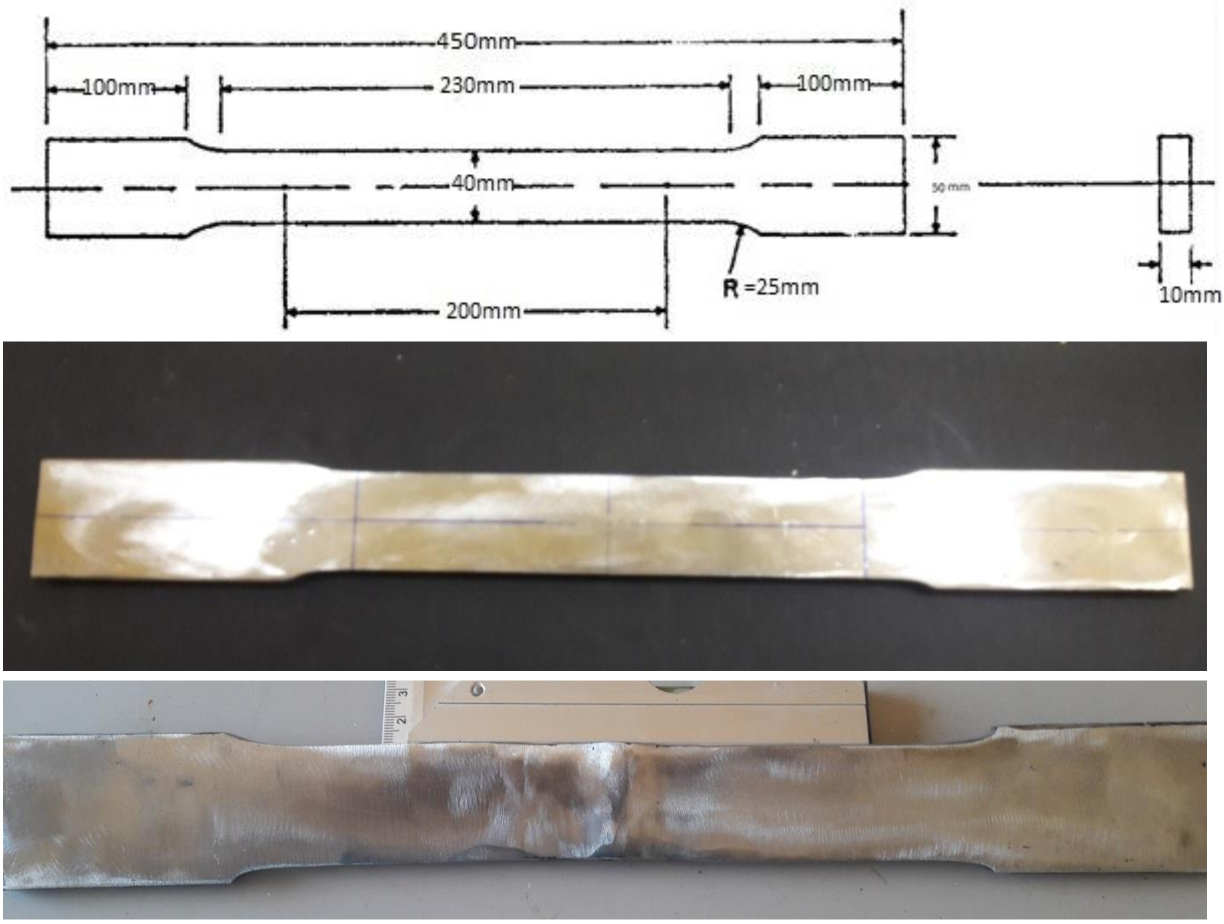

Fig. 3. Standard ASTM (E8/E8M-9).Dimensions of the specimen.

Table 2. Properties the Welding Electrodes.

Type Electrodes	Tensile Strength MPa	Yield Strength MPa	Elongation %	Range Amperage
E7018	550	450	32	130-220
E6013	510	400	28	80-150

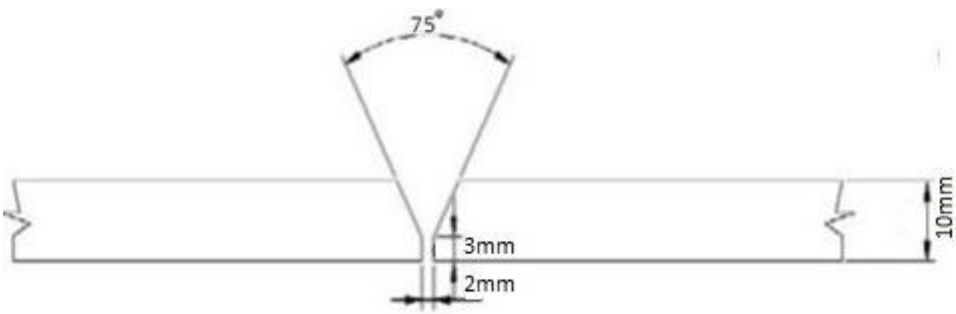

Fig. 4. Two pieces in the 37.5 Angle corners after the fixing.

2.3. Tensile Test

The welded specimens were tested for tensile strength using the Instron tensile machine having 600 KN capacities. The edges of the test specimen were fitted into the jaws of the testing machine and subjected to tensile stress until fracture of the specimen. During the test, various stress-strain diagrams were drawn for each of the specimens from where the tensile load is determined. This is used in determining the strength of the specimens .There are several reasons for performing tensile test (Structural Welding Code – Steel, 2002). The tensile tests results are used to select that a material is suitable to any engineering applications and to ensure quality the tensile properties are include materials specifications in frequently. The tensile properties often are measured during development of new materials and processes, so that different materials and processes can be compared. Finally, tensile properties often are used to predict the behavior of a material under forms of loading other than uniaxial tension. The weld test specimens are prepared according to (SMAW) welding and Brazing qualifications and tensile testing was carried out on specimens cut perpendicular to the welding direction (Sudhin and Nagarajan, 2016). Fig. 3. represents the dimension of testing specimen. Moreover, the average of the two tensile specimens was prepared to evaluate the transverse tensile properties such as tensile strength, yield tensile, and elongation of each welded joint. Fig. 5. shows the Instron testing machine that is used to evaluate the tensile properties of each joint at room temperature. Tensile strength, yield stress and total elongation can be obtained from the stress-strain curve the tensile test (Karcher, 2004).

Fig. 5. INSTRON the tensile testing machine

3. RESULTS AND DISCUSSION

3.1. Tensile Result

Tensile strength Shielded Metal Arc Welding (SMAW) welds of low carbon steel for each observation. Three tests coupons are cut and the average strength values are noted. One standard specimen without weld was tested and two specimens were welded by using electrodes (E7018) and E6013). Similarly, butt joints of two specimens were made and the average values are given in Table .3. Ultimate tensile strengths of standard without weld test specimen is 426 MPa shown in the Fig. 2. The ultimate tensile strength specimen welded by E7018 is 419 MPa as shown in the Fig. 6. while the ultimate tensile strength of the last specimen welded by E6013 is 432 MPa as shown in the Fig. 7. The variety in the ultimate tensile strength of specimens due to the variation in welding conditions that mean the 10 mm thick with V groove .The tensile strength using V Groove surface preparation is due to high depth of penetration of molten metal in the joint. In both these processes, it is found that the increase in the plate thickness leads to increase the tensile strength moreover of depth of penetration is possible for higher thickness plates. In butt joint without surface preparation only the root joints on both sides are welded having un weld portion in the center, Hence the strength of weldment is poor .The Fig. 8. as shown explains the difference of comparing stress-strain curves

Table 3. Clarification and comparison the Relationship parameters between three specimens.

Type Specimen	Ultimate Tensile Strength (MPa)	Yield stress (MPa)	Elongation %
Standard -1-	426	328	32
Welded specimen-2-7018	419	317	29
Welded Specimen-2-6013	432	327	30

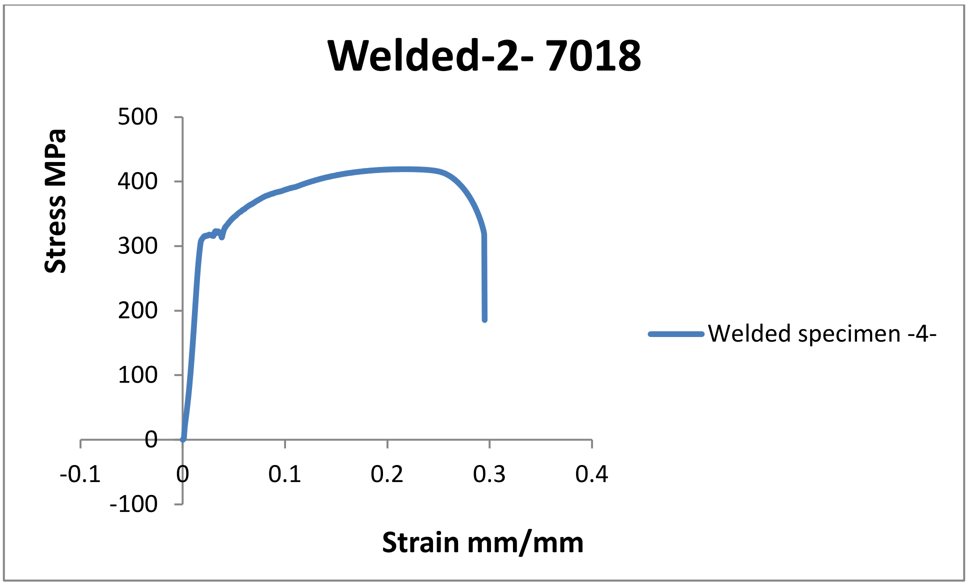

Fig. 6 Welded specimen 7018.

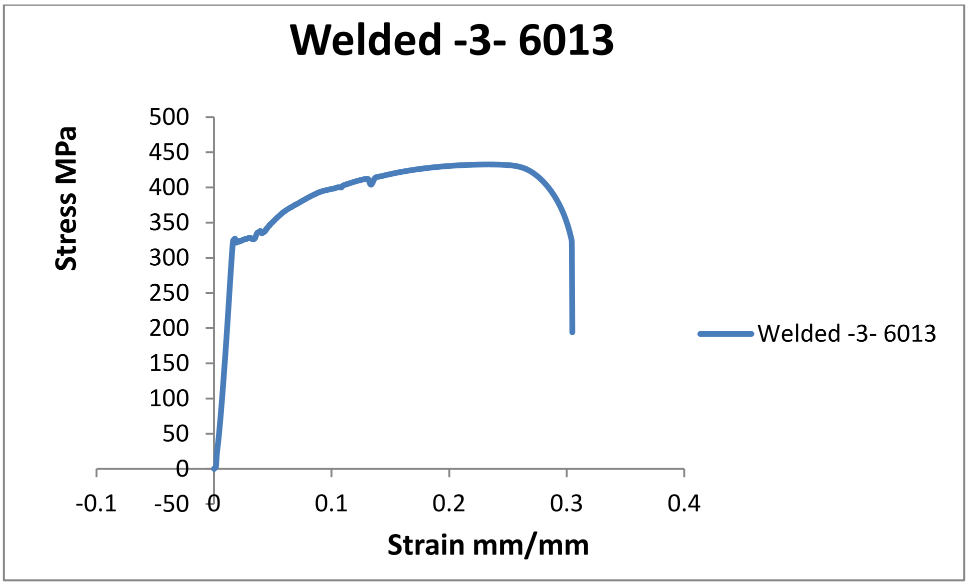

Fig. 7. Welded specimen 6013.

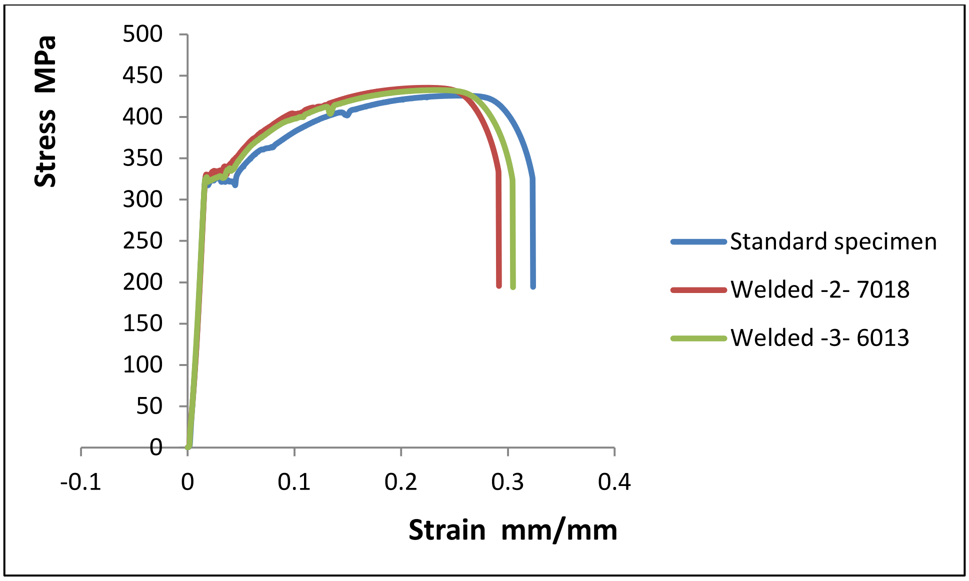

Fig. 8. Comparison lab curve Stress- strain curve.

4. CONCLUSIONS

From the results, the following can be concluded. The low carbon steel AISI1010 plates are joined using (SMAW) arc welding .The evidence that welding electrode type are important parameter that must be monitored in order to produce weld joints of enhanced mechanical properties .The tensile test properties such as ultimate tensile , yield stress , percentage of elongation and strength of welded joints are investigated. from the work, following are the conclusions.

1. The yield strength and ultimate tensile strength values of weld joints were lower than those of the base metal.

2. The specimens welded by E6013 has enhances in the ultimate tensile of the weld joint.

3. The fracture toughness of welded specimen in E6013 joint was found better than welded specimen in 7018 butt joint.

4. The percentage elongation of the base metal is higher than that of the weld joints.

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