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Analysis of the influence of groove welds of oxy-acetylene welding joints on tensile strength and microstructure on steel ST 37

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ABSTRACT

In this study, the authors conducted a study on the analysis of the effect of oxy-acetylene welding joints on tensile strength and microstructure in the HAZ and weld metal areas on st 37 steel plates. The results of this study indicate that the average value of the highest tensile strength value is at V groove weld with the average strength of the welded joint being 4.796 kgf/mm2. While the lowest tensile stress is on the I groove weld of 4.674 kgf/mm^2. Meanwhile, from the microstructure test, it can be seen that in the HAZ area each groove. Microstructure in the HAZ area shows that the double V groove weld types are fine ferrite, coarse pearlite, and martensite. In type V groove weld the structures formed are ferrite, coarse pearlite, and martensite. In type I groove weld the structures formed are ferrite, grain boundary ferrite, and fine pearlite. Whereas in the weld metal area, the results of the microstructure test of the weld area on the V seam, show a dense microstructure arrangement, the arrangement is identical to pearlite (dark color) so the specimen is harder.

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1. INTRODUCTION

One of the welding methods used is the Oxygen Acetylene Welding (OAW) method. Welding using Oxy-Acetylene gas as a heat source is a method of welding that is widely used in the field. This is because OAW is relatively cheaper, and can be done anywhere (does not require an electric current as in welding using electrodes or electric current)[1,6]. Oxy-acetylene welding is a manual welding process, in which the surfaces to be joined are heated until they melt by the flame of acetylene gas (ie burning C_2H_2 with O_2, with or without filler metal, where the joining process is without pressure. OAW welding is widely used for welding carbon steel, especially sheet metal, tanks, and thin-walled pipes. Although, almost all types of ferrous and non-ferrous metals can be welded with gas welding, either with or without added material.

The OAW welding process can affect and change the mechanical properties of low-carbon steel ST 37 [1, 6, 8, 11]. Many factors affect the quality of the OAW weld, one of which is the distance between the material gap being welded. The bigger the weld gap, the lower the weld strength will be [2, 7]. In addition to the gap distance between the material being welded, the strength of the OAW weld joint is also greatly influenced by the type of welding arc flame used. The oxidation process of the weld metal that occurs during welding will largely determine the type of arc used during the welding process [3]. The shape of the groove weld used in OAW welded joints in some cases also greatly determines the mechanical strength of the welded joint [4,5,7]. In some cases of OAW welding, the use of filler types also greatly determines the quality of the welded joint [6, 9, 10].

2 METHODS

The material in this study is ST 37 low-carbon steel, in the form of a plate with a length of 300 mm, a width of 150 mm, and a thickness of 1.5 mm. To ensure the type of steel used, a composition test is carried out. In this study, the type of welding used is OAW welding. The welding speed is 8 cm/minute, and the type of welding used is OAW welding using a neutral arc flame. After the OAW welding process, tensile testing was carried out using ASTM E8 Standard specimens. Then to support the results of the tensile test, microstructure observations were also carried out in the parent metal area, HAZ, and weld pool. When welding steel, particularly a common structural steel like ST 37 (or St37-2), the welding process can have significant effects on both the tensile strength and microstructure of the welded joint. Here are some considerations for welding joints on steel ST 37:

1. Base Metal Characteristics. ST 37 is a low carbon steel that is commonly used in structural applications. It is known for its relatively low tensile strength and good weldability. Understanding the base metal's composition and properties is essential for selecting appropriate welding parameters and techniques.
2. Joint Design. The type of joint design (butt joint, lap joint, fillet joint, etc.) can influence the distribution of stress in the welded structure. Proper joint preparation, including beveling or chamfering for specific joint types, can enhance the strength of the weld.
3. Welding Process. Common welding processes for steel, including ST 37, include shielded metal arc welding (SMAW), gas metal arc welding (GMAW/MIG), and flux-cored arc welding (FCAW). Each process has its own impact on the tensile strength and microstructure of the weld.
4. Welding Parameters. Adjusting welding parameters such as current, voltage, travel speed, and heat input is crucial for achieving the desired tensile strength and microstructure. Controlling these parameters helps prevent issues like undercuts, lack of fusion, or excessive heat-affected zone (HAZ).
5. Preheating and Post-Weld Heat Treatment (PWHT). Preheating the base metal before welding can reduce the cooling rate and minimize the risk of cracking. PWHT may be considered for certain applications to relieve residual stresses and improve the mechanical properties of the weld.
6. Welding Consumables. Selecting the appropriate welding consumables, including filler metals, is essential. Matching the chemical composition and mechanical properties of the filler metal to those of the base metal helps ensure a compatible weld.
7. Microstructure and Heat-Affected Zone (HAZ). The microstructure of the weld and HAZ is influenced by the heat input during welding. Rapid cooling can lead to the formation of undesirable phases in the HAZ, affecting both strength and toughness. Controlling the heat input and using proper welding techniques can help mitigate these effects.
8. Post-Weld Inspection. After welding, perform non-destructive testing (NDT) or visual inspection to identify any defects in the weld, such as cracks, porosity, or lack of fusion. This ensures the quality of the weld and its alignment with design specifications.

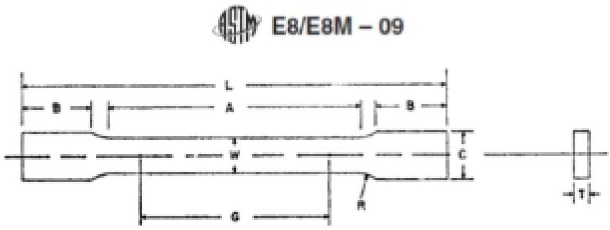


Fig.1. ASTM E8

3 RESULTS AND DISCUSSION

3.1 Composition test

The results of the composition test that has been carried out, the following results are obtained:

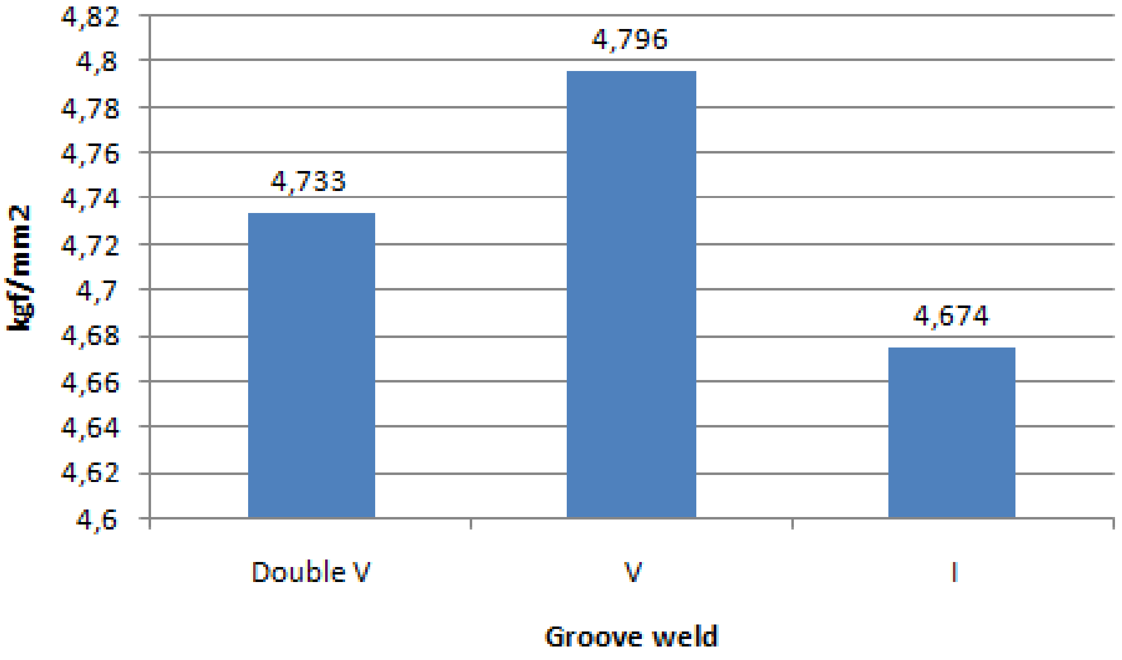
Table 1 The results of the composition test

Element	Content (%)	Element	Content (%)
Fe	99.310	S	0,015
Mn	0.375	Co	0,007
C	0.118	Nb	0,006
Si	0.055	Cu	Max.. 0,004
W	0,046	Mo	Max. 0,003
Ni	0,026	Al	Max. 0,002
Cr	0,021	V	Max. 0,001
P	0,017	-	-

Based on the results of the composition test, it can be ascertained that the specimen materials used in this study met the ST 37 low-carbon steel standard.

3.2. Tensile Strength Testing

Tensile strength testing was carried out to determine the mechanical properties of the ST 37 low-carbon steel material as the test material in this study. The results of the tensile testing of the double V groove weld, V groove weld and I groove weld specimens are shown in the following figure:



Figr. 2. Tensile Strength – Groove weld Graph

Figure 2 shows the average tensile test results of the objects tested with groove variations, namely double V groove weld, V groove weld, and I groove weld. In the double V groove weld specimens, the average maximum tensile stress was 4.733 kgf/mm2. In the V groove weld specimen, the average maximum tensile stress is 4.795 kgf/mm2. In the I groove weld specimens the average maximum tensile stress is 4.674 kgf/mm2. The data from the tensile test results show that the weld breaks in the heat-affected zone (HAZ).

The shape of the groove weld used has a significant effect on the strength of OAW welding on low-carbon steel ST 37. It will cause differences in metal deposits in the weld area which in turn will also affect the cooling rate of the molten metal in the weld area. The difference in the cooling rate and the amount of shrinkage causes a difference in the tensile strength of the material.

3.3. Microstructure testing

In testing the microstructure of the area analyzed is the HAZ area and the weld area. For the weld area, of course, the content that occurs is a mixture of the base metal and the welding wire. In general, the shape of the microstructure of the specimen depends on the speed of cooling from the austenite region to room temperature. Changes in the microstructure can change the properties of the steel.

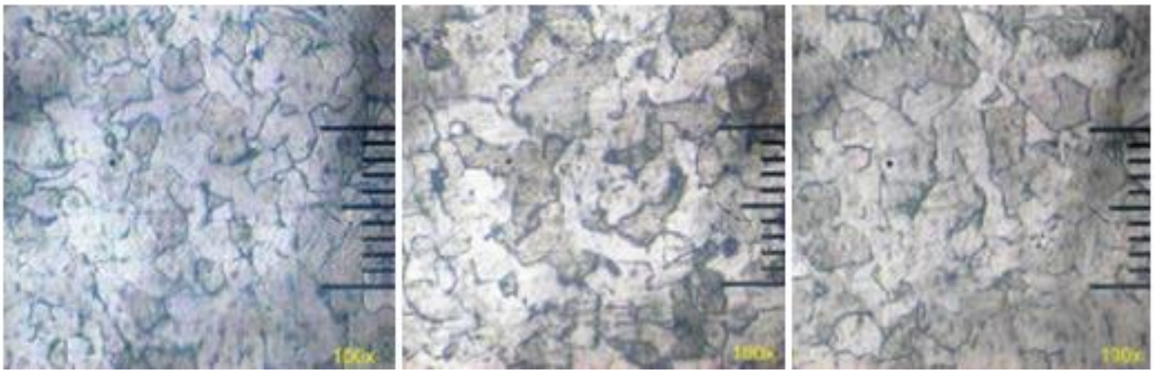


Figure 3. Heat Affected Zone of
(a) double V groove weld, (b) V groove weld, (c) I groove weld

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Figure 3 shows the microstructure of the HAZ area in low-carbon steel OAW welding ST 37. In the HAZ area which is close to the ferrite melting line, it will experience rapid growth during the welding process so that the structure changes according to the thermal cycle that occurs when welding is carried out. this causes the HAZ area to experience a decrease in strength which results in a brittle-prone area. Because this area is between the base metal and the weld metal. In the image, it is clear that the grains in the HAZ area are clearly visible. The microstructure in the HAZ region shows that the double V groove weld is fine ferrite, coarse pearlite. In V groove weld, the structure formed is ferrite, coarse pearlite. In I groove weld, the structures formed are ferrite, grain boundary ferrite, and fine pearlite

Figure 4. is a microstructure of the OAW weld area on low-carbon steel ST 37. In that area the size and shape of ferrite and perite change to be irregular. This is because at the time of welding it produces heat at high temperatures which affects the structure of ferrite and pearlite. The faster the cooling, the smaller the pearlite content and the greater the ferrite content.

Differences in the microstructure of the weld area indicate that welding with the double V groove weld produces widmanstatten ferrite and grain boundary ferrite as well as martensite. The shape of this microstructure is blade or long. Welding with double V groove weld produces soft grain boundary ferrite, widmanstatten ferrite and blade martensite. Widmanstatten ferrite and martensite in this figure are quite numerous and are found in the columnar structure lines. Welding with seam type I produces soft grain boundary ferrite, widmanstatten ferrite and blade martensite. Widmanstatten ferrite and grain boundary ferrite predominate and are quite abundant and are present in the columnar structure lines.

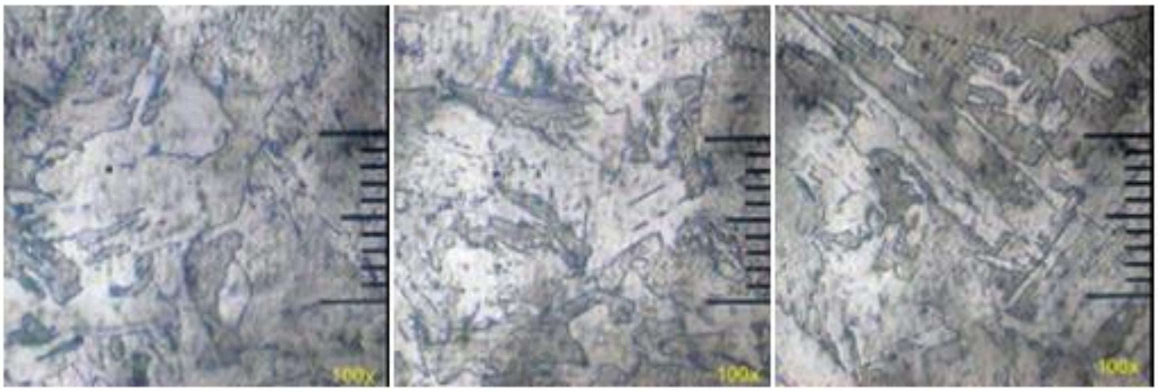

Figure 3. Weld pool of
(a) double V groove weld, (b) V groove weld, (c) I groove weld

4 CONCLUSIONS

1. The highest tensile strength value in OAW welded joints on ST 37 low carbon steel is in the V groove weld of 4.795 kgf/mm2, while the lowest tensile strength is in the I groove weld of 4.674 kgf/mm2.
2. The microstructure test results show that the microstructure in the HAZ area shows that in the double V groove weld are fine ferrite, coarse pearlite and martensite. In V groove weld, the structures formed are ferrite, coarse pearlite, and martensite. In I groove weld, the structures formed are ferrite, grain boundary ferrite, and fine pearlite. Whereas in the weld metal area, and the results of the microstructure test of the weld area in V groove weld show a dense microstructure arrangement, in this arrangement it is identical to pearlite (dark color) so that it makes the specimen harder

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