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STUDY ON THE EXPERIMENT OF MEDIUM CARBON STEEL WELDED WITH SMAW AND QUENCHED WITH SEA WATER

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ABSTRACT

This research was conducted to find the effect of sea water cooling media on mechanical properties and physical properties of the medium carbon steel welded SMAW. Testing performed on 2 types of specimens are medium carbon steel welded and non-welded, quenching performed at temperatures of 850ºC, then tested the hardness, tensile strength and microstructure testing. The results of the study of media influence sea water cooling on mechanical properties of carbon steel welded medium SMAW on tensile test is known that the average tensile ductility in the welded specimens is lower than that is not welded. In both specimens were quenched welded and non-welded experienced an average increase in tensile ductility (σu). However, the average value of tensile ductility (σu) on welded specimens and quenched lower than that is not welded. In the hardness test shown to increase an average of hardness against Vickers. Likewise welded specimens and quenched on average HAZ area hardness increases (higher), whereas in the weld area is not quenched hardness higher than that is not welded. However, the weld area is lower than the hardness quenched specimens quenched and not welded. Test results on the microstructure of specimens made quenching the metal HAZ area was clear and its martensite Ferrite grain boundaries and the area looks ferrite weld metal and its martensite dominant

Keywords: welding SMAW, hardness test, pull test, quenching with sea water.

1. INTRODUCTION

The process of connecting plates or metal by welding at the moment a lot of use, this is because the switching process is faster and more powerful welding connection pooling [6]. Welding is the process of switching between two or more metal parts using heat energy. With an electric arc welding process or encased electrodes are often called Shielded Metal Arc Welding (SMAW) welding process is the most widely used, due to the welding process in this way can produce a strong connection is also easy to use.

In the world of industry, steel is a metal that is important and the most widely used material in construction engineering. There are several types of metal armor that can be selected as the material of construction materials, as well as engine components, one of which is a medium carbon steel. Medium carbon steel is widely used as a dynamic moving engine parts with good strength, and type of steel has the advantage of mechanical properties can be enhanced by heat treatment, but has the disadvantage that is susceptible to weld cracking.

Medium carbon steel has carbon content (C) between 0.2-0.5 percent. The nature of hardness is relatively low, soft and high tenacity. Medium carbon steel is widely used in the form of plates, profiles, screw, screw and bolt. This type of steel can be hardened, can be welded and is easier to work on a machine either [10]. In the process is often carried out by the method of welding. In this process the metallurgical changes are complicated, deformation and thermal stresses on the area around the weld because the area is experiencing rapid thermal cycles [9].

The heat treatment process will reduce or increase the hardness of steel. Therefore, the

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cooling medium used will greatly affect the increase in hardness of steel. Cooling medium used is water, oil, seawater or salt water, oil, air. The heat treatment process is one of quenching can cause changes in the microstructure. In general, the microstructure of the steel depends on the cooling rate from austenite temperature area up to room temperature. Due to a change in the structure of its mechanical properties will change as well.

The main properties of the mechanical properties of metals, is strongly influenced by the microstructure of metals in addition to the position of the chemical, such as a metal or alloy will have different mechanical properties depending if the micro structure changed. Warming or cooling at a certain speed the materials of metals and alloys exhibit changes in its structure. An alloy with the same chemical composition can have different microstructure, and mechanical properties will be different. Microstructure depends on the process of experienced, especially heat-treatment received during the construction process.

The heat treatment process is a combination of heating and cooling operation at a certain speed that made the metal or alloy in the solid state, as an attempt to obtain certain properties. In other words, the heat treatment process basically consists of several stages, starting with a warm-up to a certain temperature, followed by detention for a few moments, and then cooling at a particular speed. Cooling rate and temperature limits is crucial.

2. METHODOLOGY/ EXPERIMENTAL

The materials used are medium carbon steel of 10 mm in diameter, were cut using a chainsaw as many as 12 specimens with a size of 300 mm, for tensile testing without welded and cut as many as 24 pieces of the specimens with a size of 150 mm for welded connection to 12 specimens, previously cleaned in the surface of the former sawmill using a machine wheel machine to clean and flat.

2.1 Welding

Welding specimens welded specimens were cut 24 to 12 specimens to be connected by using a type of welding wire AWS : A5.1 E7016 and made Kampu V is then welded to the brim filled with circumferential weld wire, after all welding is finished let it cool until smooth in a new grinded part of the weld joint.

2.2 Heating

Heating the material to a temperature of 850ºC with a holding time 30 minutes and then cooled with sea water until it reaches room temperature.

2.3 Tensile Test

To determine the mechanical properties above the maximum strength of a material with a tensile testing (tensile test). Tensile testing is a type of testing materials most widely performed because it can provide information representative and mechanical behavior of the material. The principle of this test is a sample or specimen with the size and shape of a predetermined tensile load coaxial given that grew continuously at both ends of the tensile specimens to drop, along with the observations made regarding the extension experienced by the test specimen. The voltage applied to the curves is an average longitudinal stress from tensile testing. In the middle part of the specimen length is smaller than the broad cross section at both ends, so that a fault occurs in the middle. The data were measured manually i.e.: specimen diameter, cross-sectional area and the data recorded from the tensile machine, in the form of (F) is given (lead cell) and a ∈ strains were unreadable. Reducible to stress strain curve where:

$$T=F.\ F/A \quad \text{dan} \quad T= \in .E \qquad (1)$$

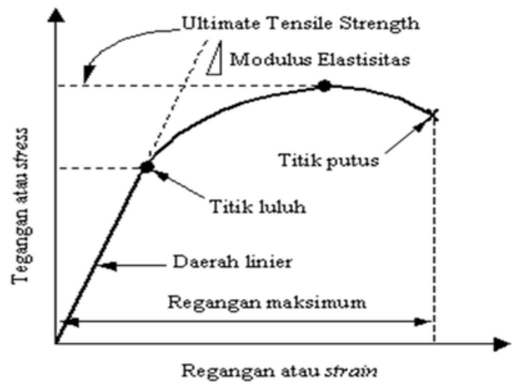

Figure 1. Stress strain curve

In the cross head speed tensile testing remains for testing. Tensile load is necessary and long thickening happens recorded by the existing tools on the tensile testing machine in the form of

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diagrams between the load and increase in length (Δl) mechanical properties strongly influenced by external load both elastic and plastic.

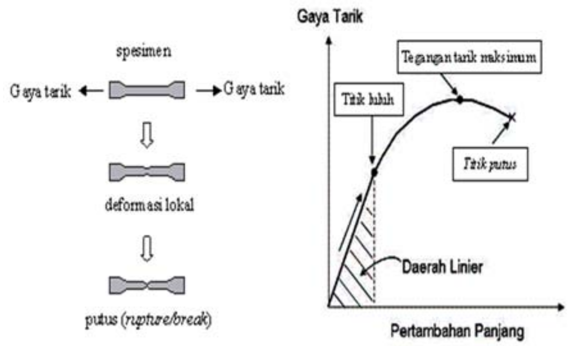

Figure 2. Curves P-Δl

Elastic limit of the material in which the material will return to its original length when the external voltage is removed. The area is part of the proportionality elastic limit when the load continues to be given, then the elastic limit will eventually be exceeded so that the material is not returned to its original size. Elastic limit is the point at which the applied voltage will cause plastic deformation for the first time, most engineering materials have elastic limits almost coincide with the boundary its proportionality.

Limit of proportionality is defined: areas where voltages have links to other proportionality, any additional stress will be followed by the addition of the voltage linear proportionality in the relationship, Δl is a straight line with the load. The nature of the load here follows Hook's Law, namely:

$$\Delta l = C\,(l_0 .\, P) / (A_0) \qquad (2)$$

where;

Δl = extension
C = constant
l_0 = initial length
p = load
A_0 = initial cross-section

Where C = 1/(∈) and E is called the elastic modulus of the initial start point A metal creep, reaches point B as the maximum load and eventually it will break at the point C.

In the diagram can be caused between the elastic and plastic areas. Similarly, areas of uniform strain and stress are not uniform. The introduction of the cross-sectional area of the test length (style length) is intended to change the shape or deformation will only occur in the area after the tensile load reaches the maximum price. Then the test will occur on the trunk cross-section of local diminution or necking tensile load decreases and eventually the test material fracture. Based on the length of the tensile load can also be calculate:

Tensile stress : $\sigma = P / A$ (MPA)
Tensile ductility: $\sigma u = (P\ max) / A$ (MPA)
Yield limit : $\sigma y = ky / (A_0)$

2.4 Hardness testing

Hardness testing aims to determine the hardness of materials and methods of testing conducted for research using Vicker hardness. Method using a Vickers diamond pyramid with a square angle between two opposite incline was 136º. In this test, the material being tested is pressed with a certain style for a certain time, after the pyramid was appointed the former emphasis measured diagonally.

VHN = (Expense)/(broad emphasis)
VHN = $1.854.\ p/d^2$
where;
P = Load used (kgf)
d1 = Diagonal vertical direction (mm)
d2 = Diagonal horizontal direction (mm)
d = the average Diagonal (mm)

In specimens that have been welded, tested twice testing consisted of 5 points with each point distance of 3mm. Hardness testing is done along the point and be numbered so that it can be seen at the point of how there is an increase and a decrease in violence. Load used in this test is 30 kgf.

2.5 Metallography Testing

Metallography testing aims to observe and assess changes in the micro and macro structures on metal. The steps Metallography testing is as follows:

Smoothing the surface.
The initial step of the test specimen surface smoothing Metallography is to be tested, which is done by flattening process by using grinding and sanding machines.

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The process begins with sanding specimen sized sandpaper rough. Used for rough sanding sandpaper and sanding next size i.e. 120 fine sanding using sandpaper sizes 220, 400, 600, 800, 1000, 1200 to the most delicate sanding sandpaper size is 1500. Sanding is done with the same direction and to avoid scratches caused by abrasive dust and metal that has been sanded then sanding is done in running water.

Polishing.
Once the process is finished sanding scratches characterized by reduced then wash specimens by using detergent. The next step is the polishing stage (polishing) using alumina paste or by using velvet as polishing media. The purpose of polishing is to remove the scratches are still remaining as a result of the sanding process is done.

Testing.
After the polishing process is done using nital etching is 2.5 % which is 2.5 % HNO3 solution in ethanol, etching process is done for 5-10 seconds or until the color changes on the surface of etched after it is rinsed with water and washed with detergent and rinsed with clean water and then doused with alcohol , then dry with a dryer. Specimens prepared for micro structure was observed using an optical microscope and photographed in the laboratory or on the production of CNC Laboratory.

3. RESULTS AND DISCUSSION

1.1 Pull Testing

From the tensile test results (universal testing machine) on medium carbon steel as follows :

1. Test on specimens without welding.
   Obtained the average value of medium carbon steel tensile ductility of non-treatment σu 58.55 kgf/mm².
   After getting the heat treatment (quenching) at a temperature of 850ºC holding time 30 minutes, cooled sea water use and tested tensile strength changes, the average number σu be 74.56 kgf/mm².
   Difference σu medium carbon steel after being quenched with sea water at 850ºC holding time 30 minutes are as follows 74.56 kgf/mm² - 8.55 kgf/mm² = 16.01 kgf/mm².
2. Tests on specimens welded.
   Obtained average value of tensile ductility welded medium carbon steel welding wire type connection using AWS: A5.1 E7016 non- treatment mean values σu 37.46 kgf/mm².
   Medium-carbon steel that is welded connection using welding wire AWS type : A5.1 E7016 quenched at 850ºC holding time 30 min average value σu 40.25 kgf/mm².
   Difference in rate hikes following σu 40.25 kgf/mm² - 37.46 kgf/mm² = 2.79 kgf/mm².

1.2 Hardness Testing

1. Hardness testing on specimens without weld
   From the results of hardness testing (vickers) obtained an average price of medium carbon steel non-hardness treatment of 144.82 VHN.
   Quenched medium carbon steel at 850ºC holding.
   Time 30 minutes refrigerated sea water use average value 213.02 VHN hardness.
   The difference between the increase in the hardness value of non- treated medium carbon steel and are heat treated at 850ºC quenched holding time 30 and cooled by seawater following VHN 213.02 - 144.82 VHN = 68.2 VHN.
2. Hardness testing on welded specimens
   Comparative figures HAZ area hardness non- treated medium carbon steel HAZ area average value of 173.59 VHN. Numbers of medium carbon steel hardness HAZ area with heat treatment at 850º i.e. quenching C within 30 minutes quenched with sea water with the average value of 226.24 VHN. There is an increased rate of violence in areas of medium carbon steel HAZ following VHN 226.24 - 173.59 = 52.65 VHN.

While the area of medium carbon steel welded non-treatment rate averaged 168.82 VHN and quenching weld area at 850ºC within 30 minutes quenched with sea water with averaged rate 174.35 VHN, the results of this study increase in hardness the weld area using a Vickers type of welding wire AWS: A5.1 E7016 is in quenching with sea water at 850ºC holding time is 30 minutes to change the increase in hardness is VHN 174.35 - 168.82 VHN = 5.53 VHN.

1.3 Testing of Micro Structures

1. Microstructure specimen welded non-treatment Microstructure of the parent metal.

From the results of testing the microstructure, the microstructure of the parent metal non- treatment objective magnification of 50x or 1000x, can be clearly seen between pearlite and ferrite following picture: (taken from the G - Measuring Microscope STM LM taken at the Lab. CNC – CAD/CAM Mechanical Engineering Sriwijaya University).

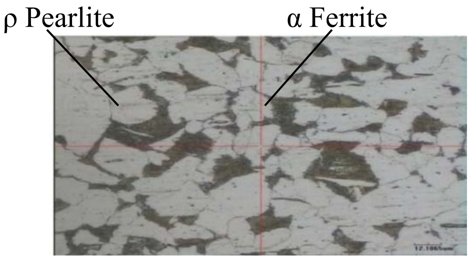


Figure 1. The microstructure of the main Steel, magnification 1000x

Microstructure of the HAZ metal. HAZ metal microstructure on non-treatment with 50x objective magnification 1000x. It can be seen faintly visible its martensite is unclear. Picture taken from Measuring Microscope STM G-LM (taken at the Lab. CNC - CAD / CAM Mechanical Engineering Sriwijaya University).

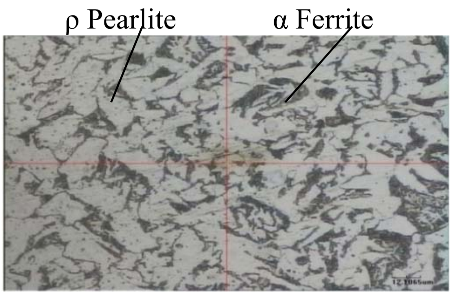


Figure 2. Metal microstructure on HAZ magnification 1000x

Microstructure of weld metal non-treatment. Microstructure with a 50x objective magnification 1000x, the area looks much weld metal ferrite and its martensite can be seen the image below: Picture taken from Measuring Microscope STM G-LM (taken in the Lab. CNC - CAD / CAM Mechanical Engineering Sriwijaya University).

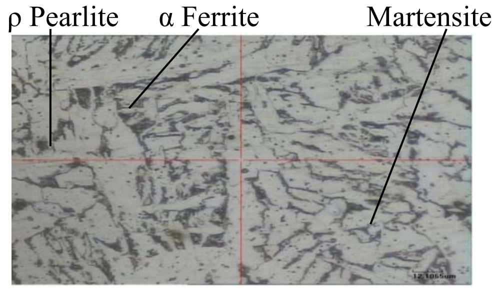


Figure 3. Weld metal microstructure of non treatment, magnification 1000x

Testing of the welded specimens and quenched . Microstructure of quenched Main Steel Magnification 50x Objective or 1000x, here seen a lot of Ferrite and martensite. Picture taken from Measuring Microscope STM G-LM (taken at the Lab. CNC - CAD / CAM Mechanical Engineering Sriwijaya University).

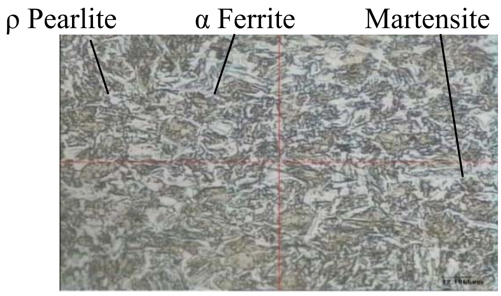


Figure 4. Main Steel microstructure in Quenching magnification 1000x

Microstructure of the weld metal and HAZ quenching. Magnification 50x Objective or 1000x, here it is clear and Martensite Ferrite grain boundaries are very clear. Picture taken from Measuring Microscope STM G-LM (taken at the Lab. CNC - CAD / CAM Mechanical Engineering Sriwijaya University).

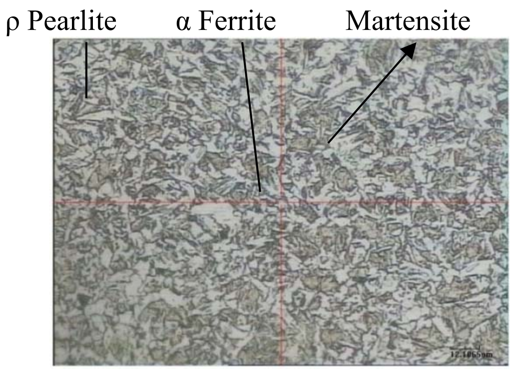
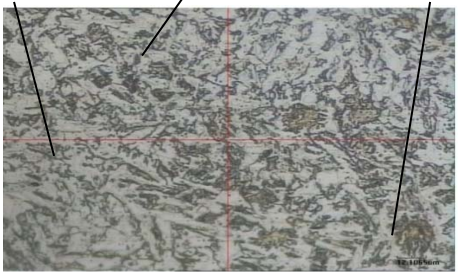


Figure 5. The microstructure of the weld metal and HAZ quenching) ,magnification 1000x

Microstructure of weld metal in Quenching. Magnification 50x Objective or 1000x, showed in Figure Ferrite and Martensite dominant. Picture taken from Measuring Microscope STM G-LM (taken at the Lab. CNC - CAD/CAM Mechanical Engineering Sriwijaya University).



Size 3 R (8,9 x12 , 7 cm), magnification 1000x
Figure 6. The microstructure of quenched weld metal

5. CONCLUSION

Comparative analysis that the influence of the sea water cooling media on mechanical properties of carbon steel welded medium SMAW on tensile test can be seen that the average tensile ductility in the welded specimens is lower than that is not welded. In both specimens quenching welded and non -welded experienced an average increase in tensile ductility (σu). However, the average value of tensile ductility (σu) on welded specimens and lower quenching.

Comparative analysis of the influence of quenching with seawater cooling medium carbon steel welded medium of the SMAW hardness test shown to increase an average of violence against Vickers. Likewise welded specimens and quenching on average HAZ area hardness increases (higher), whereas in the weld area is not quenching hardness higher than that is not welded. However, the weld area is lower than the hardness quenching specimens quenching and not welded.

The influence of the cooling medium using sea water on the physical properties of medium carbon steels can be determined through the results of metallographic test / test that the microstructure of the specimen is performed on the local quenching metal HAZ was evident and martensite Ferrite grain boundaries and the area looks ferrite weld metal and its martensite dominant, this is because the sea water cooling media properties regularly and rapidly cool the resulting bond is becoming harder due to the surface of the work piece will increase carbon.

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