VANOS
JOURNAL OF MECHANICAL ENGINEERING EDUCATION
http://jurnal.untirta.ac.id/index.php/vanos
ISSN 2528-2611, e-ISSN 2528-2700
Vol.3, No.2, December 2018, Page.111-118.

TENSILE STRENGTH AND VIOLENT CONNECTION LAS STEEL ST 40 WITH EMPLOYING VARIATIONS ELECTROTECHNICS AND VARIATIONS OF CURRENT

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Accepted: 5 December 2018. Approved: 11 December 2018. Published: 31 December 2018

ABSTRACT

Shield Metal arc welding (SMAW) is one of ways which are usually used for welding steel low carbon. The quality of the welding connection can be grouped by using pull testing, and Vickers method. This study aims to know the strength of pulling and hardness welding connection with the variation of electrodes and current. This study used carbon steel ST 40 with an electrode which is used E 6010 and E 7016 with the current variations 80 ampere, 90 ampere and 100 ampere. The result produced the result to the power of certainly drag out from a current of 80 a use electrodes 6010 was recorded at 34,92 kg / mm2. Of tensile strength with a current of 90 a shall be 37.43 kg / mm2 and tensile strength the use of a 100 a shall be 40,63. The force of attraction to the electrode 7016 is promoting the creation of ampere 80 is 33,11 kg / mm2, ampere 90 of tensile strength him it is the same 35,57 kg / mm2 while using ampere 100 of tensile strength that is produced is 37,76 kg / mm2. The difference between the value of the force of attraction for a current is 80 a 1,81 kg / mm2. A current of 90 a 1,86 kg / mm2 and with a current of 100 a 2,87 kg / mm2 for the material structure image on the fault of drag monitoring shows the material is ductile because the fault looks low and high.

Keywords: Welding, tensile strength, hardness, defects

INTRODUCTION

Welding technology has been widely used in connecting rods in steel building construction and construction of engine components. Using a welded joint becomes lighter and the manufacturing process is simple, so the overall cost is cheaper. The welding process can also be used to repair filling holes in castings, make the hard layer on the tool surface, and rebuild worn parts and to repair other engine components (Wiryosumarto and Okumura, 1991). Shield Metal Arc Welding (SMAW) is a welding process where heat from an electric arc is produced between feed electrodes wrapped by flux with a work piece (ASM Handbook, 1995). The heat that arises on the electric bus melts the electrode end and local specimens, then fuses and welds metal. During the welding process the flux material used to wrap the electrode melts and forms a slag which then covers the molten metal in the connection and acts as a protector against the influence of outside air. Figure 1 shows an arc weld with a wrapped electrode (SMAW).

The weld area is generally divided into 3 main regions, namely base metal (BM), weld metal (WM), and heat affected areas (HAZ) shown in Figure 2 (Weman, 2010).

(1) The weld metal area is an area where the weld metal melts during the welding process and the temperature is above the melting point (on pure metal) or above the liquid line (liquidus line).

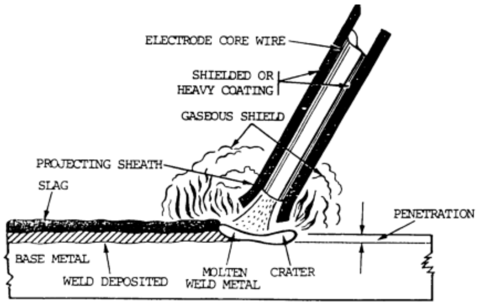

Fig 1. Arc welding with wrapped electrodes (Wiryosumarto and Okumura 1991)

For alloy metals. The effect of cooling speed on the microstructure of the weld metal will occur mixed phase, namely grain boundary ferrite, Widmanstatten ferrite or acicular ferrite, bainite which is an aggregate of ferrite and carbide (cementite), and martensite (Messler, 1999)

(2) Heat Affected Zone (HAZ). The HAZ zone is the parent metal area which is affected by heat, but the heat that occurs does not melt the parent metal. The HAZ zone undergoes a thermal cycle of rapid heating and cooling which results in fine-grain and coarse-grain regions.

(3) The main metal area has the same properties before and after the welding process. In this area, the heat that occurs is low enough so that it does not cause changes in microstructure. The weldability of steel is determined by the chemical composition of the main metal and is usually expressed by Carbon equivalent. According to the International Institute of Welding (IIW) to calculate checks of plain carbon steels and carbon manganese steels can be determined by equations (Lancaster, 1999).

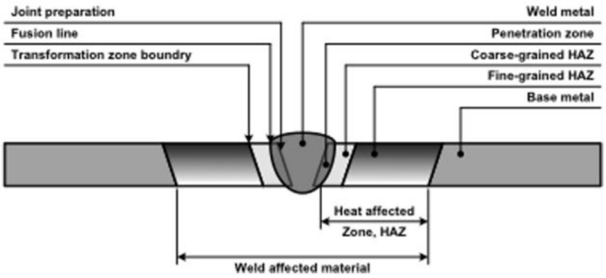

Fig 2. Zone naming system and heat affected area boundary (HAZ) (Weman, 2012)

$$C_{ek} = C + \frac{Mn}{6} + \frac{Cu}{15} + \frac{Cr+Mo+V}{5} \text{............ (1)}$$

In general, steel is said to have good weld ability if it has a Check value of <0.4-0.5. Basically the filler metal that will be used in the welding process must be similar to the main metal. According to Wiryosumarto and Okumura (1991), the main basis in choosing filler metals is the mechanical properties they have, the method of welding to be carried out and the expected properties of welds. E60xx type electrodes have a minimum tensile strength (430-460) MPa, minimum yield strength (340-380) MPa, and minimum extension (17-22)% (ASM Handbook, 1995).

Fatigue is a failure in a structure due to dynamic and variable stresses such as the structure of bridges, aircraft, and engine components. In dynamic loading it is possible to fail at a voltage below the yield stress on static loading. Fatigue is used because generally failure occurs after a certain period of time from a recurring voltage. Nearly 90% of failures in material from a structure are caused by fatigue (Callister and Rethwishch, 2010).

Fatigue can be defined as a decrease in mechanical properties, which encourages failure of a material or component due to the loading cycle (Meyers and Cahwla, 1999). A failure due to fatigue is very dangerous because it occurs in the absence of clear initial signs.

Fracture is the process of separating solid objects into two parts or more due to the presence of voltage (Dieter, 1988). Voltage can be in the form of tensile, compressive, shear and torque stresses. The fracture process consists of two stages, namely cracking and crack propagation. Broken can be classified into two general categories, namely brittle fracture and tenacious fracture. Cracks of cleavage are called trans granular because cracks occur by cutting crystal grains. The cross section of the fault surface looks shiny. The tendency of brittle fracture to increase in a material increases with a decrease in operational temperature and a high strain rate (Dieter, 1988). This study aims to determine the tensile strength and hardness of joints using electrode and current variations. Mechanical properties include tensile test, and Vickers hardness.

Welding is a method used to connect two parts of metal into one strong part by utilizing heat energy. At the base of this electric arc, heat is taken from the electric current flowing between two metals. Heat energy is channeled to the ends of the metal part to be joined until the part melts. At the same time the added material (which is also in a melting condition) is added to the melt of the two metal parts to be joined. Materials added along with the two melted metal parts combine to form metallurgical bonds so that after freezing cold and strong connection bonds are produced. During the welding process there is a fusion and a combination of added material and the two metal parts to be joined, the joint strength produced by the welding process is the same as the strength of the metal base material that is joined. Electric arc welding is a welding method that utilizes electric power as a heat source. High enough electric current is used to create an electric arc so that a high welding temperature is produced, reaching 4000̊C.

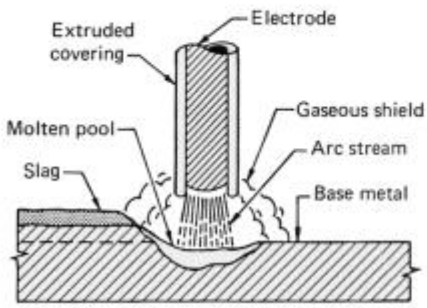

Fig 3. Electrode melting

Based on the type of metal, electrode wire is divided into five, namely: soft steel, high carbon steel, alloy steel, cast iron and nonferrous metal. Because metal filler must have the same properties as the parent metal, then at the same time this means that no electrodes can be used for all types of welding. Many wrapped electrodes are standardized using the table.

Table 1. Electrode Specifications of Soft Steel (AWS A5.1-64T) Harsono W. 1988

Qualification AWS-ASTM	Flux type	Welding Position	Type of Electricity	Tensile strength (MPa)	Yield Strength (MPa)	Extension (%)
E6010	High Cellulose	F,V,OH,H	DC Reverse Polarity	510	430	27
E6013	High Tytania	F,V,OH,H	AC/DC Double Polarity	510	450	25
E6019	Ilmeenit	F,V,OH,H	AC/DC Double Polarity	460	410	32
E7016	Low Hydrogen	F,V,OH,H	AC/DC Reverse Polarity	570	500	32
E7018	Iron Powder Low Hydrogen	F,V,OH,H	AC/DC Reverse Polarity	560	500	31
E7024	Iron Powder Tytania	H-S,F	AC/DC Double Polarity	540	480	29

Table 2. Relationship of Electrode Diameter with Welding Flow (Howard B.C, 1998)

Diameter elektroda (mm)	Arus (Ampere)
2,5	60 – 90
2,6	60 – 90
3,2	80 - 130
4,0	150 – 190
5,0	180 - 250

RESEARCH METHODS

The research was conducted at the Laboratory of Laboratory of Department of Mechanical Engineering, UNY and BLK Subang. When the research was conducted for 3 months.

Research Materials

This study uses Baja ST 40, types of electrodes E 6010 and E 7016. The composition and size of weld specimens are as follows:

Table 3. ST 40 steel composition

Carbon Steel ST 40	
Element Name	**Percentage (% wt)**
Iron (fe)	98,23
Chrome (Cr)	0,0313
Manganese (Mn)	1,0593
Carbon (C)	0,2267
Silicon (Si)	0,2552
Molybdenum (Mo)	0,0050
Copper (Cu)	0,0815
Nickel (Ni)	0,0194
Aluminum (Al)	0.0203
Zinc (Zn)	0,0051
Titanium (Ti)	0,0043
Phosphorus (P)	0,0016
Sulfur (S)	0,0111
Calcium (Ca)	0,0028
Tin (Sn)	0,0041

Based on Table 3, it can be seen that the ST 40 steel test material has a Fe content of 98.23% and a C content of 0.2667%. By knowing these two elements, the ST 40 steel material can be classified as low carbon steel because low carbon steel is steel which has a carbon content below 0.3%.

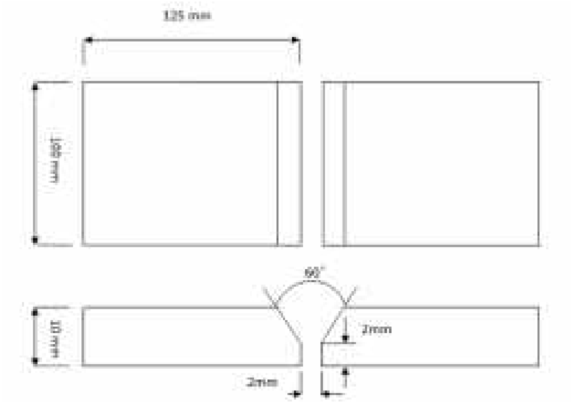

Fig 4. Welding Test Specimen

Table 4. Electrode composition

Electrode	C	Si	Mn	P	S
E 6010	0,08	0,30	0,37	0,012	0,010
E 7016	0,080	0,60	0,94	0,011	0,006

Test equipment

a. Tensile test
b. Hardness Test

Data analysis method

- Tensile test
  $\sigma = \frac{F}{A_0} \quad (N/mm^2)$
- Strain
  $\varepsilon = \frac{L_f - L_0}{L_0} \times 100\%$
- Modulus of elasticity
  $E = \frac{\sigma}{\varepsilon} \quad (N/mm^2)$
- Hardness test
  $VHN = \frac{2P \, Sin\left(\frac{\theta}{2}\right)}{d^2} = \frac{(1{,}854)P}{d^2}$

 ISSN 2528-2611, e-ISSN 2528-2700

RESULTS AND DISCUSSION

Pull Test Results

Data from the pull test results are written in graphical form as follows.

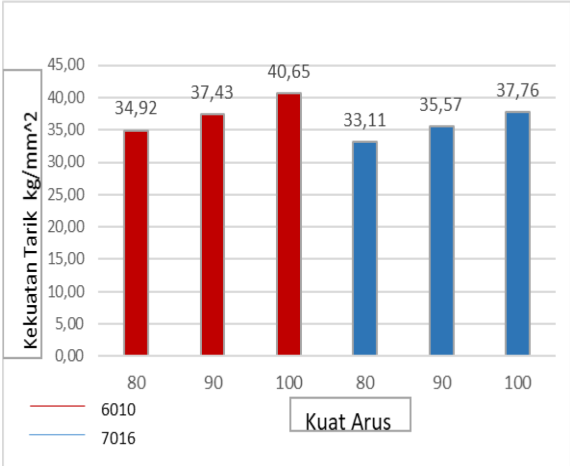

Fig 5. Comparison of current and strength

Tensile strength of 80 A current using a 6010 electrode is 34.92 kg/mm². The tensile strength with a current of 90 A is 37.43 kg/mm² and the tensile strength using 100 A current is 40.63 kg/mm². Tensile strength for 7016 electrode is with ampere 80 is 33.11 kg/mm², the amperage of 90 Tensile strength is 35.57 kg / mm² while using amperage 100 Tensile strength produced is 37.76 kg/mm². the difference in tensile strength values for 80 A current is 1.81 kg/mm², 90 A current is 1.86 kg/mm², and with Flow 100 A 2.87 kg/mm².

Vickers hardness test

Vickers' hardness test results are explained in the graph below.

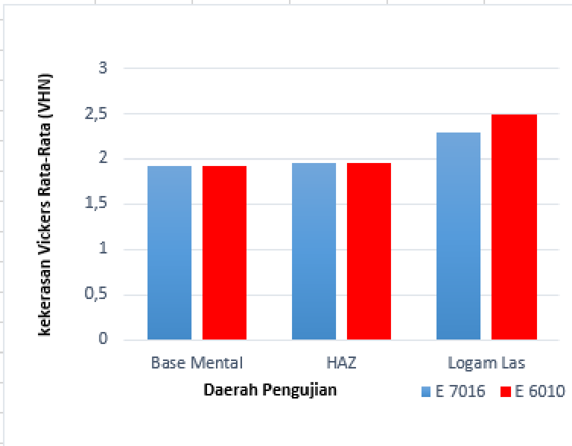

Fig 6. Comparison chart of Vickers strength

From the graph of the Vickers hardness value on the same base metal and HAZ namely VHN the average = 1.92 for each weld connection on the E 6010 and E 7016 electrodes. The Vickers hardness value on the weld metal has the greatest value, for the E 6010 electrode VHN mean = 2.12 while for type E 7016 electrode is VHN average = 2.06. The hardness of the E 6010 electrode is greater than the E 7016 electrode with a difference of 0.063. The difference in the average VHN value in weld metal is due to the specifications of the type of electrode.

Microstructure Testing Results Data

Microstructure testing was carried out by taking two specimens from each variation on the fracture tensile test specimens.

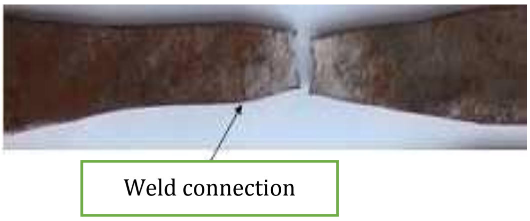

Fig 7. Friction test tensile material with E 6010 electrode

In figure 7 shows a broken test material on ST 40 material, while the weld joint is stronger. From the tensile test fracture, there was a dimension reduction at the end of the fault, this material was ductile seen from the dimension reduction of the tip of the tensile test specimen fracture.

Fig 8. Friction test tensile material with E 7016 electrode

In figure 8 shows a broken test material on ST 40 material, while the weld joint is stronger. From the tensile test fracture, there was a dimension reduction at the end of the fault, this material was ductile seen from the dimension reduction of the tip of the tensile test specimen fracture.

CONCLUSION

Based on the results of the research conducted, the following conclusions can be drawn:

In the type of E 6010 electrode Tensile strength from 80 A current using a 6010 electrode is 34.92 kg/mm^2. Tensile strength with a current of 90 A is 37.43 kg/mm^2, and the tensile strength using 100 A current is 40.63. Tensile strength for 7016 electrode is 80 amperes is 33.11 kg/mm^2, 90 amperes of tensile strength is 35.57 kg/mm^2, while using 100 amperes of tensile strength produced is 37.76 kg/mm^2. the difference in the value of tensile strength for 80 A current is 1.81 kg/mm^2, the current of 90 A is 1.86 kg/mm^2, and with Flow 100 A 2.87 kg/mm^2. For a picture of the material structure in the fault tensile test shows the material is ductile because the fault looks low and high.

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