Jurnal Edukasi Sebelas April (JESA)
Volume 6, No. 1, February 2022

https://ejournal.unsap.ac.id/index.php/jesa

THE EFFECT OF STRONG WELDING ELECTRIC CURRENT ON TENSILE STRENGTH AND SMAW WELDING MICROSTRUCTURE WITH E6027 ELECTRODE

Bambang Eko Saputro
Sebelas April University Sumedang
Department of Mechanical Engineering Education

Article Info

Article history:

Keywords:

mechanical properties,
SMAW welding,
low carbon steel

ABSTRACT (10 PT)

Welding is a metal joining technique by melting some of the parent metal and filler metal or without adding metal and producing a continuous metal. In the world of welding engineering or the industrial world today, low carbon steel is one of the metals that is often used in construction. One of the problems that often occurs in the use of steel as a basic construction material is that steel is prone to fracture. This study aims to determine how the mechanical properties and microstructure and the relationship between the two SMAW welding results with variations in welding current strength using E6027 electrodes. This research uses experimental research methods and this type of research is quantitative research. To obtain results regarding the analysis of the magnitude of tensile strength and microstructure of low carbon steel that has undergone SMAW welding with variations in current strength, the data obtained were analyzed using descriptive analysis, which describes the comparison of specimens treated differently during the welding process. The value of the tensile strength test results of each group is averaged and then compared with the average value of the other groups' tests. The results of the comparison of tensile strength tests and groups were then analyzed. For each variation of current strength, 1 microstructure specimen was taken on HAZ, weld metal and base metal. The research object used is low carbon steel. The tensile strength test specimen refers to the ASTM E8/E8M-09 standard. The results showed that the tensile strength of the welding raw material was 36,711 kgf/mm2. the value of the tensile strength with a current of 100 Ampere decreased by 31,863 kgf/mm2. Meanwhile, with a strong welding current of 125 Amperes an increase of 40,827 kgf/mm2. At a welding current of 150 Amperes an increase of 48,503 kgf/mm2 The microstructure of the parent metal consists of pearlite and ferrite, the microstructure of the HAZ region. The microstructure of the HAZ region and the weld metal with a welding current of 150 Ampere consisted of bainite and widmanstatten ferrite. The microstructure of the HAZ region and the weld metal with a welding current of 100 and 125 Ampere consisted of residual asutenit and widmanstatten ferrite.

Corresponding Author:

Bambang Eko Saputro
Department of Mechanical Engineering Education
Universitas Sebelas April
Angkrek Street No. 99 Sumedang, West Java
Email: *b3kos72@gmail.com*

1. INTRODUCTION

The development of technology in the increasingly advanced construction sector cannot be separated from welding because it has an important role in metal engineering and repair. The construction of metal construction nowadays involves a lot of welding elements, especially in the field of design, because welding is one of the connections that technically requires high skills for the welder in order to obtain a good quality connection. Welding is a metal joining technique by melting some of the parent metal and filler metal with or without metal additions and producing continuous metal (Siswanto, 2011).

The scope of use of welding techniques in construction is very broad, including shipping, bridges, steel frames, pressure vessels, transportation facilities, rails, pipelines and so on.

For industries involving metal or steel, especially in the construction sector using welding, various studies are needed to obtain high-quality welded joints, because they involve safety and service life. Along with the increasing use of steel welded joints, process technology related to changes in properties and characteristics has an equally important role.

The factor that influences welding is the welding procedure, which is a plan for the implementation of research which includes how to make welding construction according to plans and specifications by determining all things needed in the implementation. Welding production factors are the manufacturing schedule, manufacturing process, tools and materials needed, sequence of execution, welding preparation (including: welding machine selection, welder appointment, electrode selection, use of seam type) (Wryosumarto, 1988).

Welding based on the classification of working methods can be divided into three groups, namely liquid welding, compression welding, and desoldering. Liquid welding is a welding method in which the object to be joined is heated until it melts with a heat energy source. The most widely used welding methods are liquid arc welding (electric arc welding) and gas. There are 4 types of electric arc welding, namely arc welding with wrapped electrodes, gas arc welding (TIG, MIG, CO2 arc welding), arc welding without gas, and submerged arc welding. One of the types of wrapped electrode arc welding is SMAW (Shielding Metal Arc Welding) welding (Wryosumarto, 1988).

SMAW welding machines according to the current are divided into three types, namely direct current welding machines or Direct Current (DC), alternating current welding machines or Alternating Current (AC) and dual current welding machines which are welding machines that can be used for welding with direct current. (DC) and welding with alternating current (AC). DC current welding machine can be used in two ways, namely straight polarity and reverse polarity. A straight polarity DC welding machine (DC-) is used when the melting point of the parent material is high and the capacity is large, the electrode holder is connected to the negative pole and the base metal is connected to the positive pole, while the reverse polarity DC welding machine (DC+) is used. when the melting point of the parent material is low and the capacity is small, the electrode holder is connected to the positive pole and the parent metal is connected to the negative pole. Not all metals have good weldability. Materials that have good weldability include low carbon steel. These steels can be welded by enveloped electrode arc welding, damping arc welding and MIG welding (noble gas metal welding). Low carbon steel is commonly used for thin plates and general construction (Wryosumarto, 1988).

The adjustment of the welding current strength will affect the weld result. If the current used is too low, it will be difficult to start the electric arc. The electric arc that occurs becomes unstable. The heat generated is not sufficient to melt the electrode and the base material, so the result is small, uneven weld ridges and poor penetration. On the other hand, if the current is too high, the electrode will water too quickly and will result in a wider weld surface and deeper penetration, resulting in low tensile strength and increasing the fragility of the weld (Arifin, 1997).

In the case that occurred in Bekasi, a broken railroad track between Bekasi Station and Kranji Station, West Java, was allegedly caused by damage to the weld joint. As a result, the rail broke and one part was dented towards the bottom. According to a PT KA maintenance officer who repaired the rail connection, the rail broke right at the joint using welding adhesive on the right side (from the direction of Jakarta), so that one part was dented down between the concrete pads, and the other part was normal. The position of the broken rail is about 300 meters ahead of Kranji Station from the direction of Bekasi. "We are fixing this. The rail is cracked and not strong. Want to flatten first, "said an officer at the location, Sunday (11/7/2010). A total of eight officers seemed to repair the rail section to make it easier to flatten. The position of the rail is dented down about 5 centimeters (http://news.okezone.com/read/2010/07/11/338/351802/rel-ka-di-bekasire-tak-dan-patah-di-sambungan-las).

The strength of the weld is affected by arc voltage, arc size, welding speed, penetration rate and electrical polarity. Determination of the magnitude of the current in metal joints using arc welding affects the efficiency of the work and welding materials. The determination of the magnitude of the current in this welding takes 100 A, 125 A, and 150 A.

2. RESEARCH METHODS

This research is an experimental type of research, to obtain a description of the effect of variations in welding current strength on tensile strength and microstructure in low-carbon steel welding. The data that has been obtained from the results of the tensile strength test during the study are filled in on the observation sheet. Meanwhile, to determine changes in the microstructure, the data obtained were analyzed using descriptive analysis. In the tensile strength and microstructure tests using the same specimens, a tensile test was carried out first and then the microstructure was examined.

The object of welding research used is low carbon steel, which has the size of each specimen with a length of 300 mm, a width of 50 mm, and a thickness of 8 mm, so a total of 10 specimens with the same size. The tensile test standard has dimensions of 200 mm long, 12.5 mm wide and 8 mm thick which refers to ASTM E8/E8M-09 concerning Standard Test Methods for Tension Testing of Metallic Materials. While the microstructure specimens are 20 mm long, 12.5 mm wide and 8 mm thick. For each variation of the welding current strength, 1 HAZ microstructure and 1 weld metal microstructure were taken. As a comparison microstructure, 1 photo of the parent metal microstructure was taken. The research instrument used is an observation sheet containing data on tensile strength figures on steel that has undergone a welding process with variations in the welding current of 100A, 125A, and 150A.

The procedure for collecting data in this study was to prepare low carbon steel materials, SMAW welding machines, milling machines, metallographic microscopes, scrap machines, and polishing machines.

Data collection began with the formation of welding specimens with an open V seam at an angle of 600, cut using a grinder. Welding specimens are 200 mm long, 50 mm wide, 8 mm thick. Then carry out the welding in accordance with the Welding Procedure Specification (WPS). The welded workpiece is then shaped into a tensile test specimen. The shape of the tensile test specimen is in accordance with ASTM E8/E8M-09. The formation of this specimen is done by using a saw and milling machine. The formation of the microstructure specimen is carried out after the specimen has gone through a tensile test. The weld joint area on the specimen was cut to a length of 20 mm, a width of 12.5 mm and a thickness of 8 mm.
Tensile testing steps are

1) Turn on the machine and computer.
2) Input data, namely the thickness and width of the specimen to be tested for tensile strength.
3) Mount the test specimen on the grips.
4) Start the tensile test by pressing the start button on the monitor screen. 5) After the specimen is broken, turn the panel on the manual control to the zero position.
5) Remove broken specimens after testing. 7) View the tensile test results on the computer and print them out.

The procedure for observing the microstructure is 1) Cutting the specimen to leave the HAZ region. 2) The side surface of the specimen is smoothed with rubbing paper from grids of 100, 220, 500, 800 and 1000. 3) Buffed using a flannel cloth + autosol. 4) Specimens are dripped with Nital solution, which is a mixture of 2% HNO3 + 98% Alcohol. This solution serves to scrape the surface so that the structure is more visible when photographed. 5) The specimen is placed on the microscope table. 6) The lens is focused on the image. 7) Observations were then made with a micro microscope until a clear image was obtained with a magnification of 400X after it was photographed.

3. RESULTS AND DISCUSSION

3.1. Tensile Strength Test

Based on the results of the tensile test for low carbon steel that has undergone the SMAW welding process with variations in the welding current of 100 A, 125A, and 150 A, the tensile strength figures for low carbon steel are obtained which can be seen in the table and graph below.

Table 1. Average tensile test results on welding low carbon steel with variations in welding current strength

Kuat Arus	Data Pengujian Tarik		
	Kekauatan Luluh (kgf/mm^2)	**Kekuatan saat patah (kgf/mm^2)**	**Kekuatan tarik (kgf/mm^2)**
Raw Material	18,841	28,771	36,711
Kuat Arus 100 A	16,024	23,907	31,863
Kuat Arus 125 A	31,827	27,146	40,827
Kuat Arus 150 A	30,373	33,485	48,503

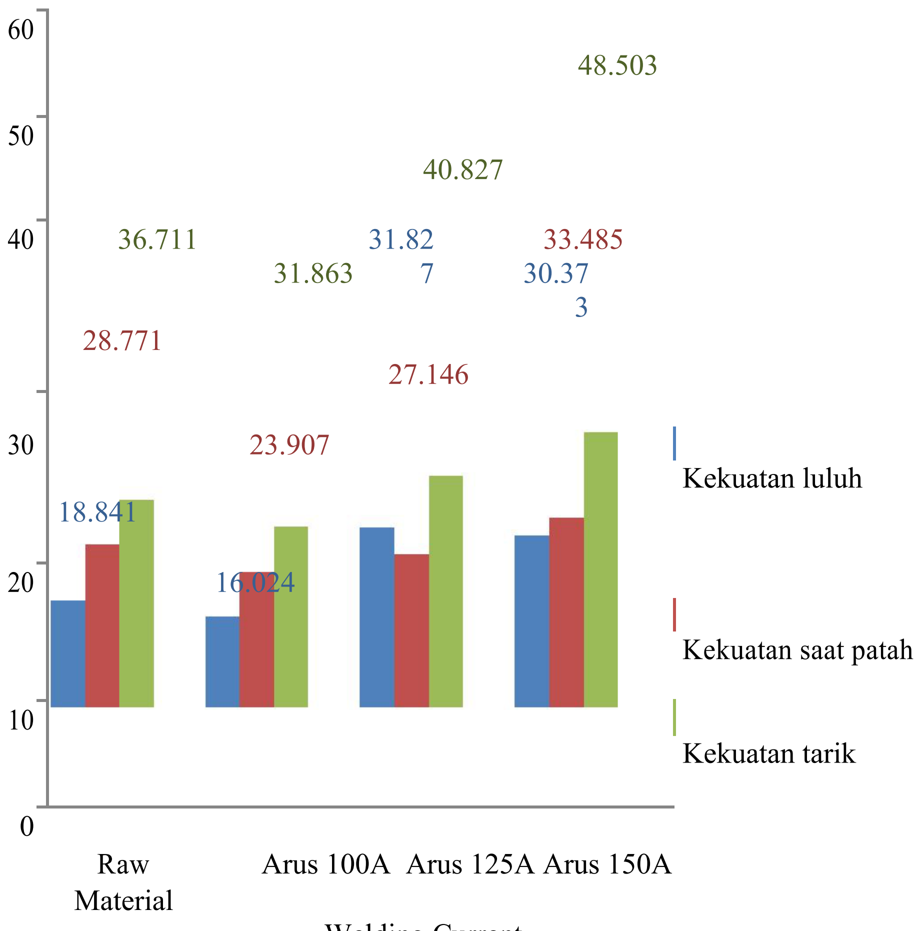

Figure 1. Tensile Test Result Diagram

From the diagram of the tensile test results, it can be seen that there are differences in the average tensile strength, yield strength and strength at fracture for each variation of the welding current strength. The highest average yield of tensile strength, yield strength and fracture strength occurred at the use of a welding current of 150 A of 48,503 kgf/mm2; 30.373 kgf/mm2; and 33,485 kgf/mm2. While the lowest average results of tensile strength, yield strength and strength at fracture, occurred at the use of a current of 100 A of 31,863 kgf/mm2; 16.024 kgf/mm2; 23,907.

3.2. Microstructure Observation

In this study, photos of the microstructure were taken on 3 parts of the welded joint. The first part is on the base metal. Taking photos of the base metal is used as a comparison (raw materials). The second part is taken in the HAZ region and the third part is on the weld metal.

From Figure 2 it can be seen that the microstructure of the parent metal consists of pearlite and ferrite. The base metal is dominated by ferrite. Ferrite is soft and ductile.

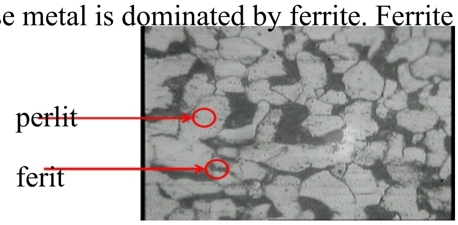

Figure 2. Microstructure of the Parent Metal (Raw Materials)

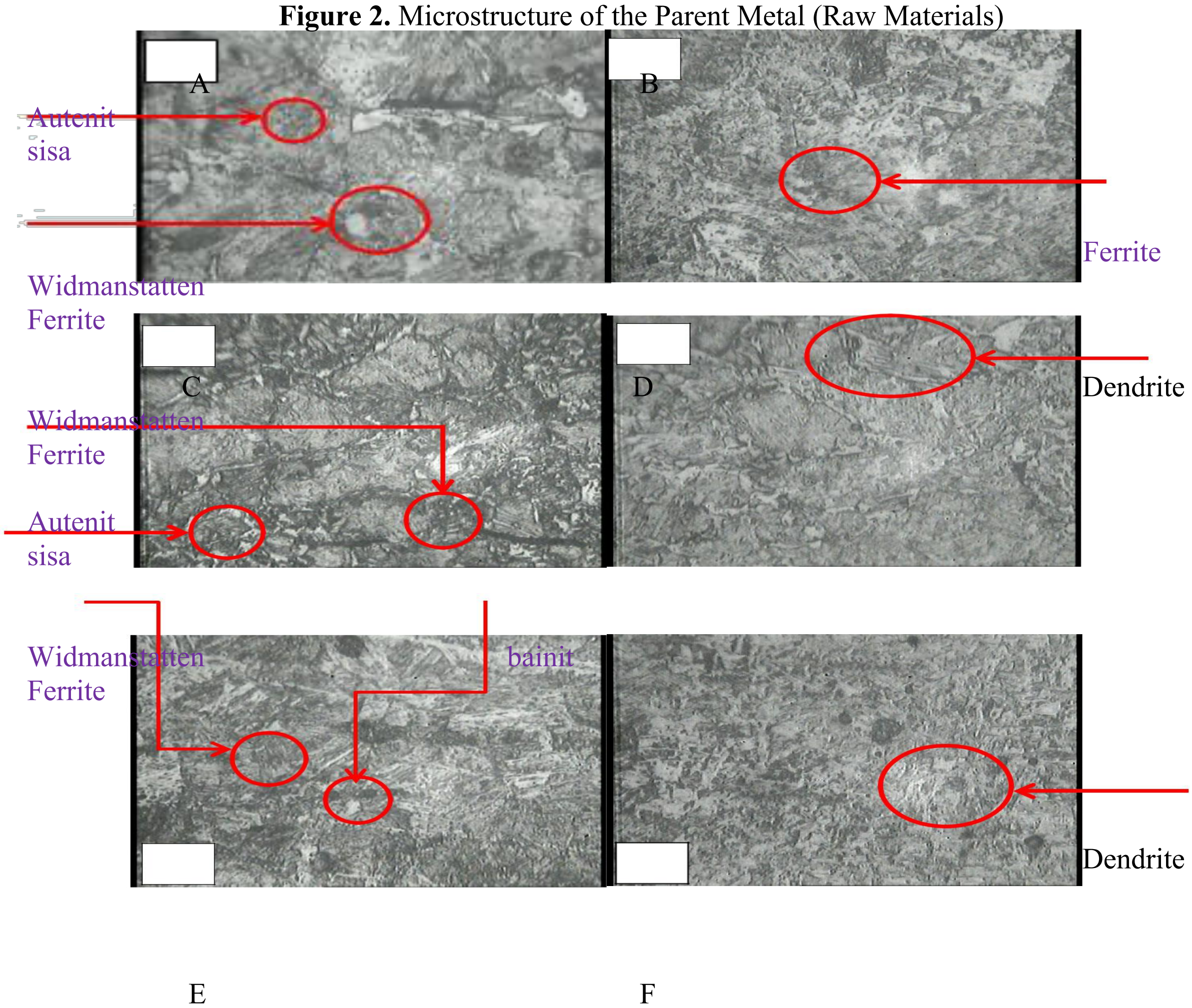

Figure 3. The microstructure of the HAZ (A) region and the welding metal (B) with a current of 100 Ampere, the microstructure of the HAZ region (C) and the weld metal (D) with a current of 125 Ampere, the microstructure of the HAZ region (E) and the weld metal (F)) strong current 150 Ampere

3.3. Effect of Current Strength Variation on Tensile Strength and Microstructure of Welded Joints

The results of this study indicate that there is an effect of variations in current strength on the tensile strength and microstructure of the welded joint. If the results of the tensile test for raw material used as a comparison are 36,711 kgf/mm2, then the value of tensile strength with a welding current of 100 Ampere has decreased, namely 100 Ampere has decreased, namely 31,863 kgf/mm2. Meanwhile, with a strong welding current of 125 Amperes an increase of 40,827 kgf/mm2. At a welding current of 150 Amperes an increase of 48,503 kgf/mm2.

When viewed from the microstructure, it is known that the increase in the welding current is followed by an increase in the amount of widmanstatten ferrite formed. So it can be ascertained that the value of hardness also increases. In this case, the variation of the welding current is very influential on the tensile strength and impact strength of a material. Starting from brittle, ie at a very low current strength. At this stage, due to the very low current strength, the grain size decreases so that the distance between the grains is further apart, the bond is weak and brittle (Raharjo, 2012).

Thus the material is very easy to break, so the energy required to pull and break it is very small. Furthermore, as the welding current increases, the grain size increases so that the distance is closer and the bond is strengthened and the tensile strength and toughness increase, but are still brittle (Rubijanto, 2012).

Thus the tensile strength and impact strength are increased. Then as the temperature increases, until the material reaches its ductility to its maximum temperature, the energy required to pull and break it will also increase to its maximum value. Furthermore, if it passes from this point, the energy will decrease due to deformation (Suherman, 1988).

In the microstructure drawing, the amount of widmanstatten ferrite formed is directly proportional to the magnitude of the given welding current. At a welding current of 150 Ampere, the presence of a bainite structure is able to improve the residual stress that appears. Bainite, which is stronger than pearlite, and tougher and more ductile than widmanstatten ferrite, covers the cracks that result when cooling. Bainite which has ductile properties and widmanstatten ferrite has hard properties, these two elements when combined will give good results. Good hardness and tensile strength are also followed by a good increase in length. This is in accordance with the statement of Wiryosumarto (1981:67) that the best toughness is obtained when a double structure is formed from widmanstatten ferrite and lower bainite.

Meanwhile, at the welding current of 100 and 125 Ampere, the amount of widmanstatten ferrite is very large. The hard and brittle nature of widmanstatten ferrite is not able to cover the effect of residual stresses when cooling occurs, so cracking in this area cannot be avoided. As a result, this area has a high hardness but its tensile strength is reduced due to the fracture defects formed during cooling and also this area is not capable of increasing in length during tensile testing.

From the previous description, it can be concluded that SMAW welding on low carbon steel using E6027 electrodes, the higher the welding current given, the higher the tensile strength value.

4. Conclusion

Variations in the strength of the welding current have an effect on the value of the tensile strength of the welded joint. The tensile strength of the raw material weld joint is 36.711 kgf/mm2. the value of tensile strength with a welding current of 100 Ampere decreased by 31,863 kgf/mm2. Meanwhile, with a strong welding current of 125 Ampere an increase of 40,827 kgf/mm2. At 150 Ampere, the welding current increased by 48,503 kgf/mm2.

The variation of the welding current has an influence on the microstructure of the HAZ region and the weld metal. The microstructure of the parent metal consists of pearlite and ferrite,

The variation of the welding current has an influence on the microstructure of the HAZ region and the weld metal. The microstructure of the parent metal consists of pearlite and ferrite, the microstructure of the HAZ region. The microstructure of the HAZ region and the weld metal with a welding current of 150 Ampere consisted of bainite and widmanstatten ferrite. The microstructure of the HAZ region and the weld metal with a welding current of 100 and 125 Ampere consisted of residual asutenit and widmanstatten ferrite.

From the research results, if SMAW welding uses an E.7016 electrode, the recommended current is 150 Ampere.

5. Recommendation

For the welding industry: (a) It is necessary to pay attention to the selection of electrodes in SMAW welding in order to obtain welds with good mechanical properties. It is recommended to use E6027 electrode to produce welded joints with good tensile strength; (b) It is necessary to pay attention to the selection of current strength in SMAW welding in order to obtain welds with good mechanical properties. It is recommended to use a current of 150 Ampere to produce welded joints with good tensile strength.

For further researchers: (a) Further research is needed on the effect of variations in current strength on SMAW welding to produce mechanical properties such as hardness, bending strength, tensile strength and others to produce good welded products; (b) Research with more specimens is needed to get more accurate results.

REFERENCES

Adam, Kaharuddin. 2011. Fracture and Fatigue Factors on the Strength of Materials. Journal of Mechanical Engineering. 6-12.

Alip, Muhammad. 1989. Welding Theory and Practice. Jakarta: Project for the development of educational institutions for education workers in Jakarta.

Aljufri. 2013. The Toughness of AISI 1050 Steel Material Due to Impact Loading from SMAW Welding Results that have undergone a Hardening Process and without a Hardening Process. Thesis is not published. Aceh: Faculty of Engineering, Malikussaleh University.

ASTM International (E8/E8M - 09). Standard Test Methods for Tension Testing of Metallic Materials. 2010. United States of America.

ASTM International G48, Standard Test Methods for Pitting and Crevice Corrosion Resistance of Stainless Steels and Related Alloys by Use of Ferric Chloride Solution. 2003. United States of America.

Hanafi, Ahmad. 2012. The effect of the type of cooling medium on the tensile strength of welded metal joints of St-60 steel plate.

with MIG/MAG welding. Thesis is not published. Malang: Faculty of Engineering, State University of Malang.

Marihot, Goklas MTB. 1984. Welding Metal and Selection of Welding Wire. Jakarta : P.T. grammar.

PPKI. 2010. Guidelines for Writing Scientific Papers. Malang: State University of Malang.

Raharjo, Samsudi & Rubijanto J.P. 2012. Variation of Electric Current on Mechanical Properties of Shielding Metal Arc Welding (SMAW) Welding Connections. Journal of FT UMS, 1412-9612.

Santosa, Joko. 2006. Effect of Welding Current on Tensile Strength and Toughness of SMAW Welding with E7018 Electrodes. Unpublished Thesis. Semarang. Semarang State University.

Saroso. 1980. Electric Welding Guidelines.Jakarta: Djambatan.

Sindo, Kou. 2002. Welding Metallurgy (2nd Ed.). New York: John Wiley & Sons, Inc.

Siswanto. 2011. Basic Concepts of Welding Techniques (Theory and Practice). Jakarta : P.T. Library Achievement.

Suherman. 1987. Metal Science I. Ten November Institute of Technology : Surabaya.

Widharto, Sri. 2003. Welding Work Instructions.Jakarta: Pradnya Paramita.

Wiryosumarto. 2000. Metal Welding Technology. Jakarta: Pradnya Paramita.

Zainuri, A. Muhib. 2008. Strength of materials.Yogyakarta. Andi Publisher.