THE EFFECT OF COOLING PROCESS ON TENSILE STRESS OF POST-WELDING CARBON STEEL USING SHIELDED METAL ARC WELDING (SMAW) WITH ELECTRODE E7018

FINAL PROJECT

submitted in partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering Vocational Education

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SUPERVISOR APPROVAL PAGE

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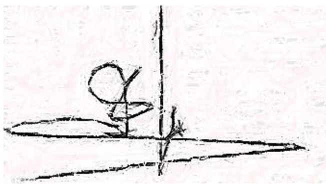

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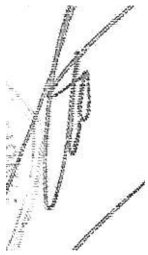

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The Effect of Cooling Process on Tensile Stress of Post-Welding Carbon Steel Using Shielded Metal Arc Welding (SMAW) With Electrode E7018

Padang, November 2020

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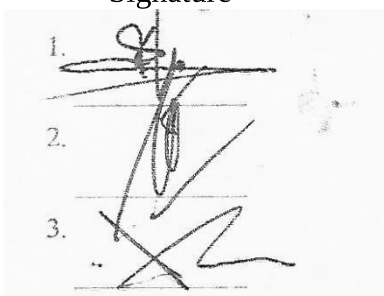

DECLARATION

I hereby confirm that:

1. My final project, title “The Effect of Cooling Process on Tensile Stress of Post-Welding Carbon Steel Using Shielded Metal Arc Welding (SMAW) With Electrode E7018” is my own;

2. This final project is my original work from aspects of idea, formulation, and research without other guidance, except from supervisor;

3. In this final project, no others works’ except for quotations and summaries which have been duly acknowledge;

4. I made this statement in truth and if there is a deviation in this statement, I am willing to accept academic punishment in the form of revocation of the academic title that have been obtained, as well as other punishment in accordance with the norms and legal provisions in force.

Padang, November 2020

STAMP

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ABSTRACT

Herman Zulhafril. 2020. "The Effect of Cooling Process on Tensile Stress of Post-Welding Carbon Steel Using Shielded Metal Arc Welding (SMAW) with Electrode E7018". *Final Project.* Padang: Mechanical Engineering Vocational Education, Department of Mechanical Engineering, Faculty of Engineering Universitas Negeri Padang.

The factor that affects the welding is the welding procedure. However, the selection of cooling media will affect the physical and mechanical properties of steel. Thus, this study aims to determine effect of cooling process on tensile stress of medium carbon steel post welding using electric welding with E7018 electrodes and appropriate cooling media.

This study also conducted by using Shielded Metal Arc Welding (SMAW). The use of cooling media is carried out after the welding process until the material that is ready to be welded reaches room temperature. This study compares the tensile stress of each cooling media (water, air, and coolant).

Results show that post-welding cooling media affects the tensile stress of medium carbon steel with the highest effect on the water as cooling media, then the coolant media, and the lowest is the air as cooling medium. As conclusion, cooling media effects significantly to the tensile stress of carbon steel being post-welding process.

FOREWORD

Alhamdulillaahirabbbil'alamin. Thanks to Allah SWT for all the gifts that are always poured out to the author so that the author can complete the thesis with the title ": The Effect of Cooling Process on Tensile Stress of Post-Welding Carbon Steel Using Shielded Metal Arc Welding (SMAW) with Electrode E7018”. Salawat and greetings are always bestowed on the Prophet Muhammad Salallahu Alaihi Wasallam by saying Allahhumaa Sholli'Ala Muhammad Wa Ala Alihi Muhammad, who has brought mankind to the present era with sophisticated and modern science.

During the writing of this thesis the writer received a lot of guidance, advice, motivation and assistance from various parties, either directly or indirectly. For that, with all humility the author would like to thank:

1. Allah Subhana Wa Ta'ala for the extraordinary blessings that have been given to me, so that I can complete this research proposal in a healthy state and without any shortcomings.
2. Drs. Jasman, M.Kes. as Supervisor and Academic Advisor who have provided guidance and assistance in completing this research.
3. Drs. Purwantono, M.Pd. as Head of the Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Padang.
4. All of lecturers and administrative staff of the Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Padang.
5. All of lecturers and staff of the Department of Civil Engineering, Faculty of Engineering, Universitas Negeri Padang.

6. Fellow in the Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Padang.
7. Both my parents and my beloved family have given great encouragement and prayers in completing this study.
8. All parties who have helped in writing this study that the author cannot mention one by one.

This thesis is unperfect, all constructive criticism and suggestions for the improvement of this study is welcoming. Finally, this thesis can be useful for readers and related parties in education for the advancement of science.

Padang, November 2020

Herman Zulhafril

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CHAPTER 1

INTRODUCTION

A. Background

Recently, steel is widely used for construction, equipment, household appliances, process technology and materials technology. For industrial equipment, steel is often operated in wide range of tempeture, both high temperature and low temperature. Steel is also as material for ship, engines, steam turbines and other purposes.

Steel is generally also widely used in welding methods. Welding methods develop in line with develoment of science and technology. Welding is the process of joining two or more metal parts using heat energy. It causes the metal around the welding area changes in metallurgical structure, deformation and thermal stress. Based on the definition of Deutche Industrie Normen (DIN), welding is a metallurgical bond in metal or alloy joints that is carried out in a melted or liquid state (Wiryosumarto & Okumura, 1996 : 20). Welding is an integral part of industrial growth and improvement as it plays a major role in the engineering and repairing of metal production. Thus, many advantages obtained from welding joints (Suharto, 1991 : 70).

The factor that affects the welding is the welding procedure. Planning which includes how to manufacture the welding construction according to the plan and specifications by determining all the things required in welding process. The factors are the manufacturing schedule, the manufacturing process, required tools and materials, the sequence of execution, the preparation of welding (including: welding instrument, welder, electrode, seam type) (Harsono Wiryosumarto, 2008 : 32).

Welding can be divided into three groups based on the classification of working methods: liquid welding, press welding and desoldering. Liquid welding is a method of welding where joined objects is heated until melts with a source of heat energy. The most widely used methods of welding are liquid arc welding (electric arc welding) and gas welding. There are 4 types of electric arc welding, namely arc welding with wrapped electrodes, gas arc welding (TIG, SMAW, CO_2 arc welding), gasless arc welding, submerged arc welding. One of the types of coated electrode arc welding is SMAW (Shielded Metal Arc Welding).

The result of the welding process is also influenced by the mechanical properties of a material. The mechanical properties of a material are the most important properties because they relate to the ability of the material to accept loads without causing damage or failure to certain materials / structures. The heat that occurs due to the welding process will change the crystal structure of the material, thus it decreases in the physical and mechanical properties of welded material. After welding, it is necessary to test the material, but most welders rarely performs mechanical strength analysis such as tensile stress. It impacts to the unknown quality of welding products.

The use of cooling media aims to get the martensite structure. The more element carbon, the more martensite structure formed. It is due to martensite is formed from the Austenite phase which is cooled rapidly and increases the hardness. The selection of cooling media will affect the physical and mechanical properties of steel.

Tensile stress testing is a test performed to determine the mechanical properties of a metal and its alloys. It is most often conducted due to it is the basic tests and studies on the strength of the material.

The purpose of this study was to determine the effect of the cooling process on the tensile stress of medium carbon steel after the welding process. The welding process is carried out using the SMAW method using several variations of the coolant, including coolant, air and water. Testing with several variations of this coolant is intended as a comparison in order to obtain a maximum tensile test and a minimal tensile test.

B. Identification of Problems

Based on the above background, it can be identified that existing problems are as follows:

1. Many welders do not know that the cooling process is carried out after welding will affects the tensile stress of the welded object.
2. Most of the welder rarely performs mechanical strength analysis such as tensile stress testing of objects that have cooled after welding.
3. The type of coolants will affect the tensile stress significantly. Thus, it is required to select proper cooling medium.

C. Scope of problems

Based on the identification of the above problems, thus the discussion in this study is more focused, this study limits the problem. It is to analyze the effect of the cooling process on the tensile stress of carbon steel being post-welding using electric welding (SMAW) with E7018 electrodes with only 3 cooling media (water, air and coolant).

D. Research Questions

Based on the limitations of the problems above, the problems examined in this study are as follows:

1. How does the cooling media affect the tensile stress of carbon steel after welding using electric welding (SMAW) with E7018 electrodes?
2. Which cooling medium has the most influence on the tensile stress of carbon steel after welding using electric welding (SMAW) with E7018 electrodes?
3. What cooling media has the maximum tensile stress and minimum stress?

E. Research Obejctives

The objectives of this study are as follows:

1. To examine effect of cooling process post welding to the tensile stress of medium carbon steel using electric welding (SMAW) with E7018 electrodes.

2. To examine proper cooling medium for post welding with electric welding uses E7018 electrodes.

F. Research Benefit

1. As guidance for welders in order to ensure the accuracy of selecting the coolant after the welding process.
2. Contribute a basic knowldege of testing materials, welding, and engineering materials.
3. As part of reference for related research in the context of technological development, especially in welding and material testing.

CHAPTER II

LITERATURE REVIEW

A. Theoritical review

1. Welding

Welding is a metal joining process where the metal becomes one due to heat with or without pressure. It can be defined as a result of metallurgy caused by attractive forces between atoms (Suharno, 2012: 51). The joining can be with or without added material (filler metal) with the same or different melting point or structure.

According to Deutsche Industrie Normen (DIN), welding is a metallurgical bond in metal or metal alloy joints which is carried out in a melted state. From this definition, it can be further explained that welding is a local connection of several metal rods using heat energy (Harsono Wiryosumarto, 2008: 1).

Welding can be defined as the process of joining two metals beyond the point of metal recitalization, with or without added materials and using heat energy as the liquefaction of the material being welded. Welding can also be defined as a fixed bond of heated objects or metals. Welding is not only heating two parts of the object until it melts and allowing it to freeze again, but making the weld intact by adding an additive or electrode when heated so that it has the desired strength.

The strength of the welded joint is affected in several ways. Those are the welding procedure, materials, electrodes, and the type of seam.

2. Shielded Metal Arc Welding (SMAW)

SMAW welding is a welding where heat is generated from an electric arc between the tip of the electrode and the metal tip to be welded (Suharno, 2008: 24). Main metal melt due to heating from the electric arc that arises between the tip of the electrode and workpiece surface. The electric arc is generated from a welding instrument. The electrode used is a wire wrapped in a protective flux. During welding, these electrodes will melt together with the main metal and frozen together to become part of the weld seam.

The process of removing the electrode metal occurs at the tip of the electrode melts and forms grains that are carried by the electric arc current. When a large electric current is used, the molten metal grains are carried over to become smooth and vice versa when the stream is small the grain becomes big.

The transfer pattern of molten metal affects significantly to the weldability of metal. Metals with high weldability produces fine grain. The fluid transfer pattern is influenced by the size of the current and the composition of the flux material. Material *flux* wrap the electrodes during welding melts and forms a slag which covers the molten metal that collects in the joint and works as an oxidation barrier.

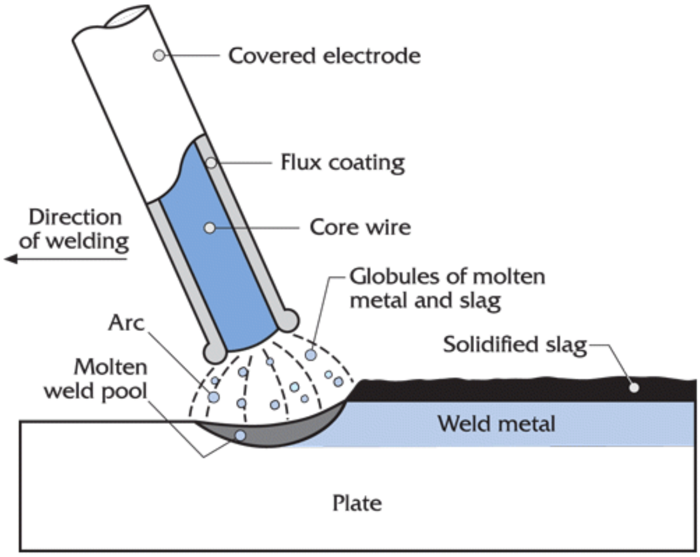

Figure 1. SMAW (Wiryosumarto, 2000: 30)

3. Electrode

SMAW requires wire welding (electrode) which consists of a single core made of coated metal layer of the chemical mixture. The electrode is used as a generator and added material. The electrode consists of two parts; the core as the base for clamping welding pliers and the coating (flux). Flux is to protect the molten metal from the air environment, generates shielding gas, and stabilizes the arc.

The flux material used for the E7018 type is iron powder and low hydrogen. It is sometimes called lime. It produces joints with low hydrogen levels , thus the connection sensitivity to cracks is very low and the toughness is satisfying (Joko Santoso: 2006). The electrode classification is regulated according to the AWS (American Welding Society) and ASTM (American Society Testing Materials) system standards. E7018 type electrodes can be used in all welding positions with AC or DC welding currents. The electrode with the code E7018 for each letter and each number has its own meaning, namely:

E = Electrodes for electric arc welding.

70 = The value of the minimum tensile stress as a result of welding multiplied by 1000 Psi (70000 Ib/in^2) or 49.2 kg / mm_2.

1 = The welding position, 1 means it can be used for all position welding.

8 = The type of low hydrogen iron powder coating film and the welding current interval suitable for the welding current.

Table 1. E7018 Electrode Test Requirements Specifications

Tensile strength (MPa)	Yield Strength (MPa)	Extension (%)
490	400	22

(American Welding Society A5.1, 2004)

4. Flow Rate

Welding current is the amount of flow or electric current that produced by the welding machine. The amount of the welding current can be adjusted using the existing tools on the welding machine. Welding current can be adjusted according to the type of material and the diameter of the electrodes in welding. The use of too small a current will result in a low penetration or weld penetration, while too large a current will cause the formation of an overly wide weld bead and deformation in the weld. The amount of welding current required depends on the diameter of the electrode, the thickness of the material being welded, the type of electrode, the geometry of the connection, the diameter of the electrode core,and the position of the welding. The welding area with high heat capacity requires high current.

Table 2. E7018 Relationship between Electrode Diameter and Welding Current

Electrode Diameter (mm)	Curren (A)
2.4- 2.5	70 - 110
3.2	105 - 155
4.0	130 - 200
5.0	200 - 275
5.6	260 - 340
6.0	315 - 400
8.0	375 - 470

(American Welding Society A5.1, 2004)

5. Cooling

Cooling is conducted to obtain a martensite structure, more and more element carbon, hence the martensite structure There will also be more and more formed. Because martensite is formed from the Austenite phase which is cooled quickly, so its hardness increases (Harsono Wiryosumarto, 2008 : 43).

The quenching method is a fast cooling process for materials from a temperature range of 815^0C to 870^0C for steel (Stevanus Arie, 2016 : 40). In general, the microstructure of steel depends on the rate of cooling from the temperature of the austenite region to room temperature. Due to this microstructure change, its mechanical properties also change. The relationship between cooling speed and the microstructure formed is usually depicted in a diagram with time, temperature, and a transformation (Continuous Cooling Transformation, CTT diagram).

6. Tensile Testing

Tensile testing is a test performed to determine the mechanical properties of a metal and its alloys. This test is most often done because it is the basis of tests and studies on the strength of the material.

Tensile test is carried out to examine strenght of welding joint and location of fracture. Tensile loading is loading that is applied to the object by exerting a force of attraction in the opposite direction to one end of the object. The tensile force against the load will result the change in shape (deformation) of the material.

In the tensile test, the load is given continuously and slowly increases in weight, at the same time observing the elongation experienced by the test object. Then stress and strain can be generated.

$$\sigma = \frac{F}{A}$$

Where :

σ = Voltage (N / mm^2)

F = Style (N)

A = Initial area (mm^2)

The strain used on the curve is obtained by dividing the length of the measuring length by the initial length, the equation is:

$$\varepsilon = \frac{L_{f} - L_{O}}{L_{O}} \, x \, 100 \, \%$$

ε = strain (%)

L_f = initial length (mm)

L_O = final length (mm)

Tensile test is conducted by tensile testing machine which record all the deformation until ultimate state, also at the same time will illustrate the test object tensile diagram. Length L_1 will be determined after the test object is fracture by using normal measurements. The ultimate stress is the highest stress acting on its original cross-sectional area. The diagrams obtained from the tensile test are generally described as stress-strain diagrams.

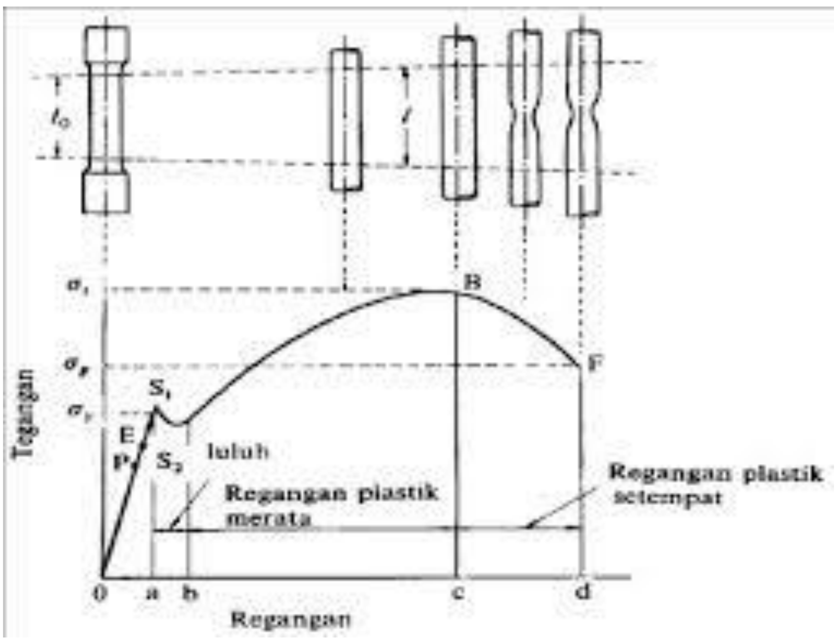

Figure 2. Stress-Strain Curve (Wiryosumarto, 2004 : 25)

7. Carbon Steel

a. Carbon Steel Classification

Carbon steel is an alloy between iron and carbon with small amounts of Si, Mn, P, S, and Cu. The nature of carbon steel depends on the carbon content, therefore these steels are grouped based on their carbon content. Low carbon steels are steels with carbon content less than 0.30%, medium carbon steels contain 0.30 to 0.60% carbon and high carbon steels contain between 0.60% to 1.50% carbon.

As the carbon content increases, the strength and hardness also increase but the elongation decreases. The following is the classification of carbon steels:

1) Low Carbon Steel

Low carbon steel has a carbon content below 0.3%. Steel low carbon is often referred to as mild steel or steel utensil. Common and widely used of steel are cold roll steel with 0.08% - 0.30% carbon content for thin plates, wire rods, and general construction (Wiryosumarto, 2004 : 20).

2) Medium Carbon Steel

Medium carbon steel is steel that has a carbon content 0.30% - 0.60%. Medium carbon steel has more strength of low carbon steel and has excellent heat treatment qualities. This medium carbon steel is usually used for the manufacturing process of machine tools (Wiryosumarto, 2004 : 22).

3) High Carbon Steel

High carbon steel has the highest carbon content if compared to other carbon steels, around 0.60% - 1.50%. Most high carbon steels are difficult to weld in comparison with low and medium carbon steels. This steel is often used for the manufacturing process (Wiryosumarto, 2004: 23).

b. Medium and high carbon steel welding

Medium and high-carbon steels contain a lot of carbon and other elements that harden the steel. Therefore, the area of influence of heat or HAZ on this steel is easy to become hard when compared to low carbon steels.

Table 3. Preheating temperature for welding medium and high carbon steels

Cabon content (%)	Initial heating temperature (^{0}C)
0.20 max.	90 (Max)
0.20 - 0.30	90 - 150
0.30 - 0.45	150-260
0.45 - 0.80	260 - 420

(Wiryosumarto, 2004 : 92)

c. AISI 1050 steel

AISI 1050 steel is a medium carbon steel with a carbon content ranging from 0.48 to 0.55% and is included in the medium carbon steel group. The choice of AISI 1050 steel is because it is widely used in the manufacture of machining components, cheap and available in market. Machine components made of steel, for example, shafts, gears and chains. The data from this steel are as follows:

Table 4. Chemical composition of AISI 1050 steel

C	Si	M N	P	S	B	Cr
0.48	0.27	0.74	0.008	0.0005	0.0002	0.33

(Mill Certificate)

B. Related Research

a. Hendi Saputra, Achmad Syarief, Yassyir Maulana (2014) studied analysis of the effect of cooling media on the tensile strength of ST37 Steel Post-welding using electric welding concluded that the highest tensile strength value was using used oil with an average value of tensile strength, 53.158. kg/mm^2. Cooling process is conducted to improve the tensile strength and welding result of ST37 steel.

b. Lagiyono, Suwandono, and Mukhamad Masykur (2011) studied the effect of temperature on mechanical properties of medium Carbon Steel ST 60 concluded that the relationship between temperature and tensile strength had a negative relationship. The higher the temperature, material tend to be brittle and hard.

c. Syaifudin Yuri et al. (2016) studied the effect of cooling media on the hardening process of S45C Steel materials concluded that the variation of cooling media affects the hardness of the S45C steel.

d. Fakhrizal Yusman (2018) studied the effect of cooling media in the quenching process on hardness and microstructure on steel AISI 1045 concluded that the heat treatment quenching process with various cooling media can increase the hardness of AISI 1045 steel compared to without treatment.

e. Muhammad Zuchry (2011) studied the effect of carburizing temperature and holding time on the tensile strength of carbon steel with cooling variations concluded that the carburizing process affects the tensile strength specimen. The higher the temperature carburizing, the lower the tensile strength of the specimen. The tensile strength carburizing specimens at 900^{o}C (1.0599 kN/mm^2) higher than carburizing specimens at 950^{o}C (0.9352 kN/mm^2). Carbonizing process at higher temperatures causes specimen more brittle. For coolant medium, tensile stress is affected by the cooling time. Slower cooling time, more strenght the tensile. Thus, tensile strength water is higher than sea water, oil and air, respectively.

CHAPTER III

METHODOLOGY

A. Research Design

In a study, it is absolutely necessary to use the research method that will be used. Because by using the method, there are ways to solve problems in a study. According to Sugiyono (2008 : 2), the research method is a scientific way to obtain data with specific purposes and uses. This means that through the use of methods and selecting the proper method will answer research questions. Based on research problems, research questions, and research objectives, thus this study is the experimental method.

According to Sugiono (2012 : 72), the experimental research method can be interpreted as a research method used to examine the effect of certain treatments on others under controlled conditions. Experimental research is a quantitative research design that is carried out to determine effect of treatment on research objects (Creswell, 2016). This experimental research method is conducted to determine cause and effect between 2 factors that are deliberately caused in this study.

B. Time and Place

This study was carried out during July-December 2020. It begins from submitting proposals, manufacture of specimens, testing, and reports. It is also conduected in the Mechanical Engineering Fabrication Laboratory, Faculty of Engineering, Universitas Negeri Padang. Meanwhile welding process was conducted in the Mechanical Engineering Fabrication Workshop, Faculty of Engineering, Universitas Negeri Padang. Tensile test is at the Civil Engineering Tensile Testing Laboratory, Department of Civil Engineering, Faculty of Engineering, Universitas Negeri Padang.

Table 5. Research Schedule

No.	Activities	May				June				July				August				Sept				October			
1	Proposal Writing	■	■	■	■																				
2	Seminar					■	■	■																	
3	Preparation of Test Specimens								■	■	■	■	■	■	■	■	■								
4	Testing and data collecting																	■	■	■	■				
5	Data Processing and Analysis																			■	■	■			
6	Reports																				■	■	■	■	■

C. Research Objects

The object of research is medium carbon steel with a thickness of 12 mm. Electrode is E7018 with a diameter of 2.6 - 3.2 mm and using a V seam, then after welding the specimen cooled using a variety of water coolants, coolants, and air until the steel cools to normal temperatures. Further, tensile test is carried out.

D. Types and Sources of Data

1. Type of Data

The type of data used in this study are primary and secondary data. Primary data are obtained directly by the author from the results of research and testing of each specimen. Meanwhile, secondary data are a supporting theory obtained from various sources.

2. Data Sources

Sources of data from this study are obtained from various sources, library of Universitas Negeri Padang, articles from indexed jurnal, and online media as well as research data.

E. Tools and Materials

1. Tool

a. Tools for the welding process

1) SMAW welding machine

2) Welding wire

3) Mass welding handlebar

4) Wire feeder

5) Welding goggles / welding helmet

6) E7018 electrode diameter 2,6-3,2 mm

7) Welding clothes

8) Welding aids

b. Tool for tensile testing

1) Hydraulic Universal Material Testing Machine

2) 1 unit of computer and printer

3) Calipers

2. Materials

a. Material for welding

The material used as the test specimen in the study is AISI 1050 medium carbon steel plate. By determining the dimensions of the tensile test specimen following the ASTM E-8 standard:

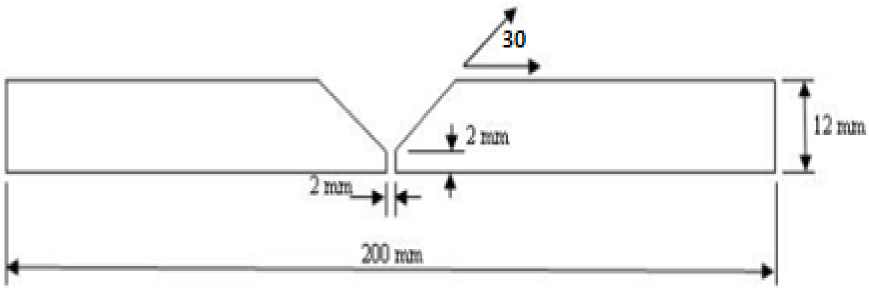

Figure 3. Tensile Test Specimens

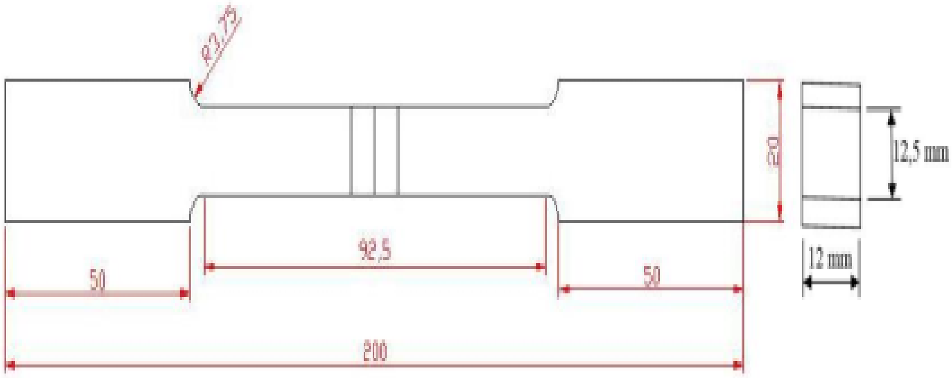

Figure 4. Tensile Test Specimens

L = Length of Specimen = 200 mm

Lo = Length of Initial Specimen = 92.5 mm

Wo = Initial Width = 12.5 mm

t = Thickness of Steel Plates = 12 mm

θ = Adhere to Angle V = 600

b. Material for the cooling process

The media used for the cooling process of the welding results are coolant, water, and air.

F. Research Procedures

The research procedures used in this study are as follows:

1. Material Measurement

Measurements are made on the material or metal to be welded to get the specimen shape according to the predetermined size.

2. Cutting

The cutting is carried out after the measuring process. Cutting serves to determine the material to be used as a specimen in testing. Specimen cutting is conducted in the middle of the specimen with the same size into 2 parts. It is intended to make a single seam V on the cut results with an angle of approximately 60 ° using a grinding machine.

3. Specimen Making

The specimen manufacturing process aims to obtain the size and shape of the specimen according to the standards for a specimen in a test process. In tensile testing, specimens made refer to the ASTM E8 standard. The test specimen is formed by cutting using a saw machine with a size of 200 mm x 20 mm x 12 mm.

4. Welding

The working principle of welding is to join two or more metal parts using heat energy (Suranto, 2006). SMAW welding is a shielded electric arc welding where heat is generated from an electric arc between the tip of the electrode and the metal tip to be welded (Suharno, 2008 : 24). The welding process can be done by following the steps as follows:

a. Connect the welding machine to a power source.
b. Determine the welding current and voltage.
c. Place the specimen to be welded on the welding table using seam V.
d. Adjust the welding position using the under hand position for all specimens.

e. Turn on the welding machine at the desired current conditions.
f. Flow the electric current by touching the electrode / welding wire to the workpiece so that an electric arc occurs.
g. After all specimens have been welded, cool all specimens on the specified cooling medium

5. Process Cooling

Cooling process aims to obtain a martensite structure, and more element carbon. Due to martensite is formed from the Austenite phase which is cooled quickly, so its hardness increases (Harsono Wiryosumarto 2008 : 43). The cooling process carried out in this study uses coolant media, water and air. This cooling process is carried out in the following steps:

a. Provide cooling media to be tested
b. Place the specimen after welding into the cooling medium.
c. Let stand some time for the maximum cooling process.
d. After the cooling process is right, the specimen is removed from the cooling medium
e. Tensile test of cooled specimens.

6. Tensile Testing

Tensile testing is carried out at the Civil Engineering Tensile Testing Laboratory Faculty of Engineering UNP. This tensile test is carried out perpendicular to the direction of the welding. The equipment used for tensile testing is the tensometer tensile testing machine.

Figure 5. Universal Tensile Testing Machine with The Brand Hidraulic Universal Material Testing Machine Made in China
(Source: Civil Engineering Concrete Labor Padang State University)

Table 6. Tensile Testing Machine Specifications

Brand	*Hidraulic Universal Material Testing Machine*
Type	WE-1000
Year	2000
Artificial	China
Capacity	1000 kN
No. Serial	1057

It has three load measurement scales, namely: A = 0 to 20 kN. A + B = 0 to 50 kN. A + B + C = 0 to 100 kN.

The tensile test on the specimen can be done in the following steps:

a. Prepare test specimens from the results of the cooling process.

b. Prepare equipment and estimate the highest possible load.

c. Measure the initial length and width of the specimen.

d. Measure the initial cross-sectional area before drawing

e. Prepare the tensile testing machine to be used

f. Place the specimen on the chuck of the tensile testing machine. Then pull the specimen slowly until the specimen breaks.

g. Record the chart speed.

h. Record the length of the specimen after the tensile test.

i. Record the cross-sectional area after being drawn.

j. Analyze each test data generated.

The data collection instrument in this study was carried out by testing through testing with the following research aspects.

1. Preparing the tables needed.
2. Fill out the table according to the research results.

Table 7. Testing Data Tabulation

No.	Media Cooler	specimen	Lo (mm)	Fm (KN)	Fy (KN)	Li (mm)	ε (%)	σ		E	
								Mpa	Kgf / mm2	Gpa	Kgf / mm2
1	air	1									
		2									
		3									
		4									
		Average									
2	Water	1									
		2									
		3									
		4									
		Average									
3	coolant	1									
		2									

		3									
		4									
		Average									
4	AISI 1050 steel	1									

Where :

D = standard specimen test diameter (mm)

F = Pull Force (N)

Lo = specimen standard test length (mm)

σ = Tensile Stress (N / mm^2)

ΔL = Increase in Length (mm)

Fy = Yield Force (N)

ε = Strain (%)

G. Data Analysis

The amount of tensile strength that occurs in the specimen can be read directly on the tensile test result paper. Based on the theory of tensile strength, it can be calculated with the following formula:

1. Tensile strength (σ)

$$\sigma = \frac{F}{Ao}$$

Where :

σ = Stress (N / mm^2)

F = Style (N)

Ao = The cross-sectional area of the specimen (mm^2)

2. Stretch (ε)

$$\varepsilon = \frac{Li - Lo}{Lo} \text{ x } 100\ \%$$

Where;

ε = Stretch

Li = Length of specimen after testing (mm^2)

Lo = Length of specimen before testing (mm2)

3. Elastic Modulus (E)

$$E = \frac{\sigma}{\varepsilon}$$

Where:

E = Modulus of Elasticity (N / mm^2)

σ = Tensile stress (N /mm^2)

ε = Stretch

Experiments are carried out 12 replications for all specimens, with details of 4 replications for specimens with cooling water radiator, 4 replications for specimens with water media, 4 replications for specimens with air cooling media. Furthermore, the average tensile strength of each specimen using different cooling media is compared. Thus, the largest dan the smallest tensile stress can be determined. From this comparison, similarities and differences of each specimen were examined, followed by effect of the cooling medium on the tensile strength of medium carbon steel using Shield Metal Arc Welding (SMAW).

H. Research Flow Chart

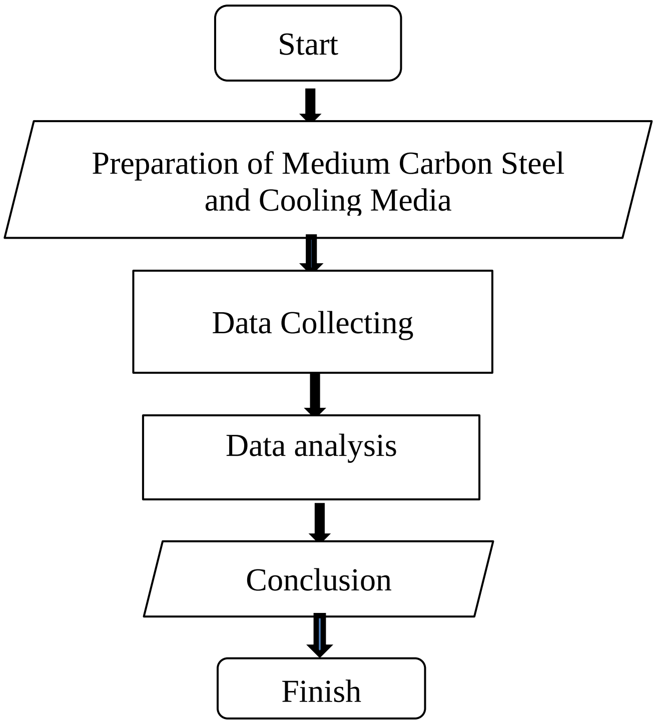

Figure 6. Research Flow Chart

CHAPTER IV

RESULTS AND DISCUSSIONS

A. Results

1. Object of Research

The object is AISI 1050 steel with a thickness of 12 mm, a length of 220 mm, and a width of 12.5 mm. The following is the shape of the steel plate after welding and cooling it with several cooling media.

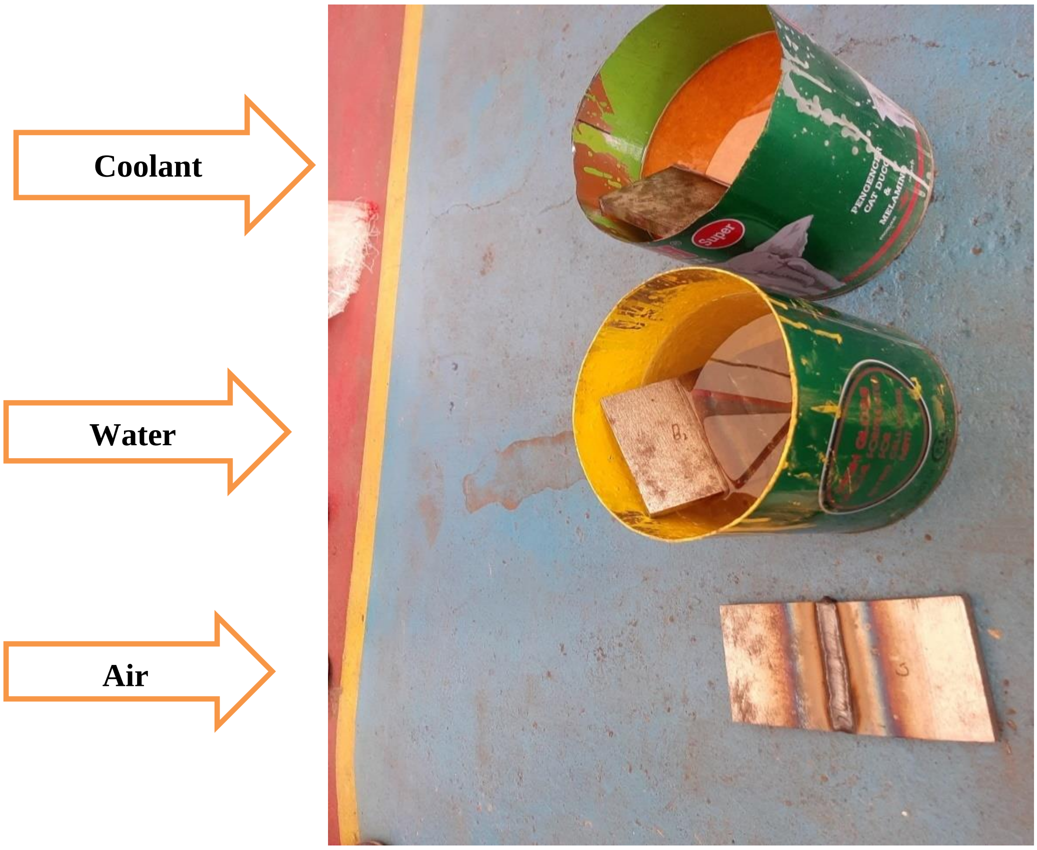

Figure 7. Steel Plate After Welding and Cooled by Cooling Medium

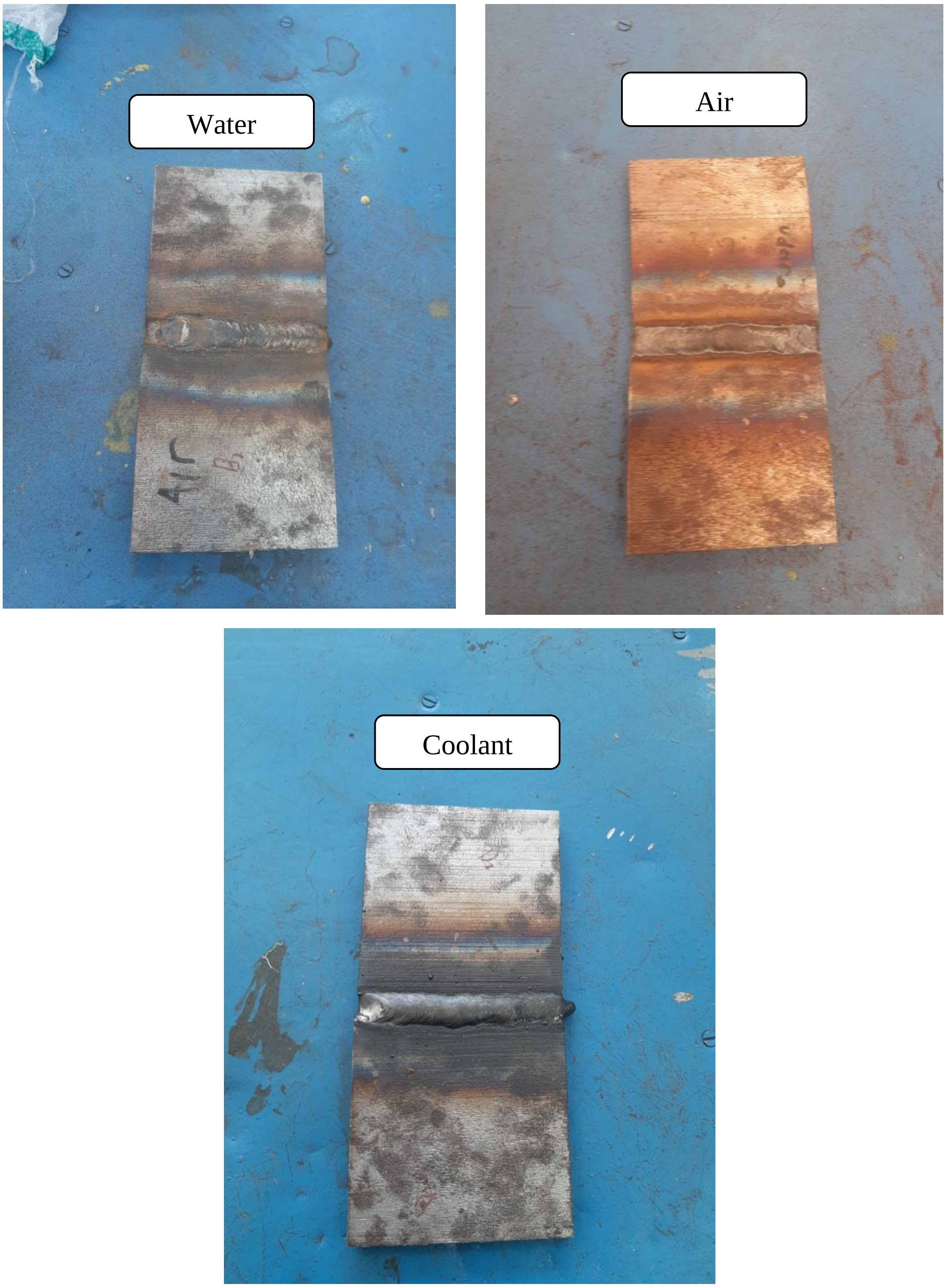

Figure 8. Steel After Cooling Process

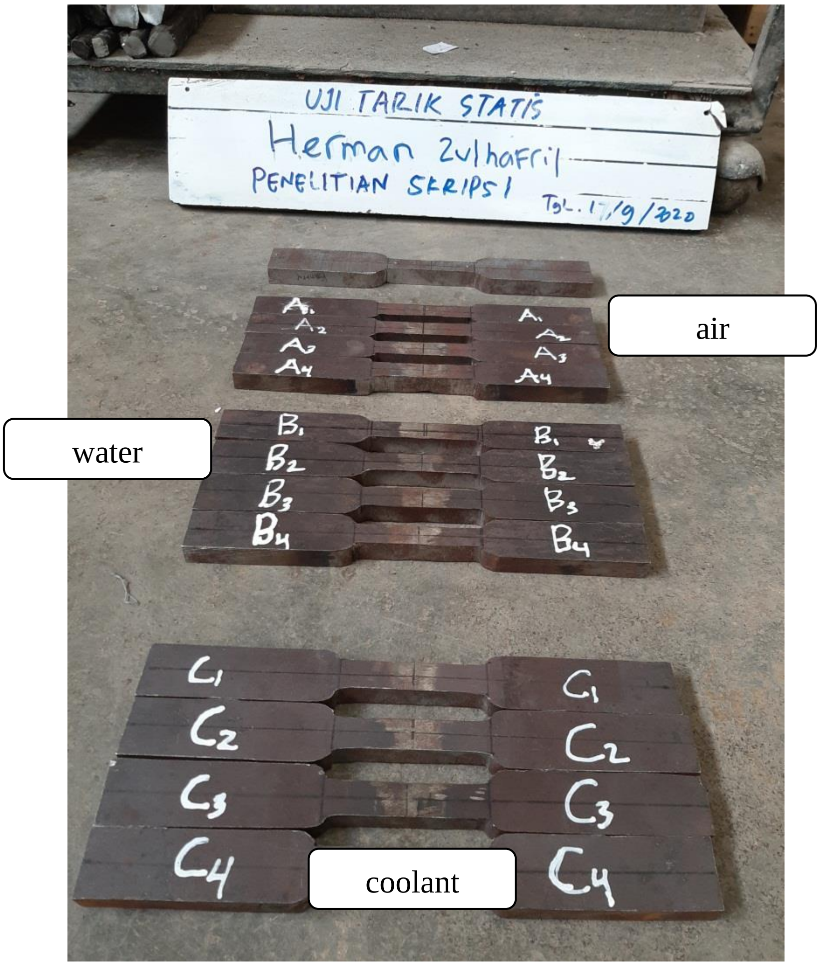

Figure 9. The Specimen

2. Tensile Test Results

The following is the data obtained from tests carried out at the Civil Engineering Tensile Testing Laboratory, Faculty of Engineering, UNP:

Table 8. Testing Results

No.	Cooler medium	specimen	Lo (mm)	Fm (kN)	Fy (kN)	Li (mm)	ε (%)	σ		E	
								MPa	Kgf / mm2	Gpa	Kgf / mm^2
1	air	1	50	90.26	65.94	6.65	13.3	601,733	61,359	4,524	461,319
		2	50	90.42	64.61	6.55	13.1	602.8	61,468	4,601	469,171
		3	50	90.6	65.44	5.65	11.3	604	61,590	5,345	545,038
		4	50	64.26	55.28	2,3	4,6	428.4	43,684	9,313	949,661
		Average				5,287	10,575	559,233	57,025	5,945	606,221
2	Water	1	50	113.24	67.34	4,9	9.8	754.93	76,981	7,703	785,487
		2	50	97.36	68.02	6.35	12.7	649.06	66,185	5,110	521,074
		3	50	81.6	69.34	3.5	7.0	544	55,472	7,771	792,421
		4	50	87.42	60.18	6	12	582.8	59,429	4,856	495,174
		Average				5,187	10,375	632,697	64,517	6.36	648,539
3	coolant	1	50	81.44	68.14	3,4	6.8	542.93	55,363	7,984	814,141
		2	50	99.66	68.68	5.1	10.2	664.4	67,749	6,513	664,141
		3	50	98.04	68.94	5	10	653.6	66,648	6,536	666,486
		4	50	96.88	68.28	6.4	12.8	645.86	65,859	5,045	514,446
		Average				4,975	9.95	626,697	63,905	6,519	664,752
4	Original	1	50	108.66	64.64	9.6	19.2	724.4	73,868	3,772	384,636

Where :

Fm = Maximum tensile force (kN)

Li = Length of specimen after testing (mm2)

Lo = Length of specimen before testing (mm2)

Fy = Yield Force (kN)

σ = Tensile Stress (MPa)

ε = Strain (%)

E = Modulus of Elasticity (Gpa)

Based on the results of research conducted at the Civil Engineering Tensile Testing Laboratory, Faculty of Engineering, UNP, each specimen has a different tensile stress, strain, and modulus of elasticity. The original/untreated specimen has a tensile strength of 73.868 Kgf/mm^2 or 724.4 MPa, strain is 19.2%, and the modulus elasticity is 3.772 Gpa or 384.636 Kgf/mm^2.

Specimens with air conditioning medium, the average tensile strength is 57.025 Kgf/mm^2 or 559.223 MPa, average strain is 10.575%, and the average modulus elasticity is 5.945 Gpa or 606.221 Kgf/mm^2. Meanwhile specimens with water cooling medium have the highest tensile stress compared to other cooling medium. It is 64.517 Kgf/mm^2 or equivalent to 632.697 MPa, strain is 10.375%, and the modulus elasticity is 6.36 GPa or 648.539 Kgf/mm^2. Then the last specimen with coolant cooling medium has an average tensile stress 63.905 Kgf/mm^2 or 626.697 MPa, average strain is 9.95%, and the average modulus elasticity is 6.519 GPa or 664.752 Kgf/mm^2.

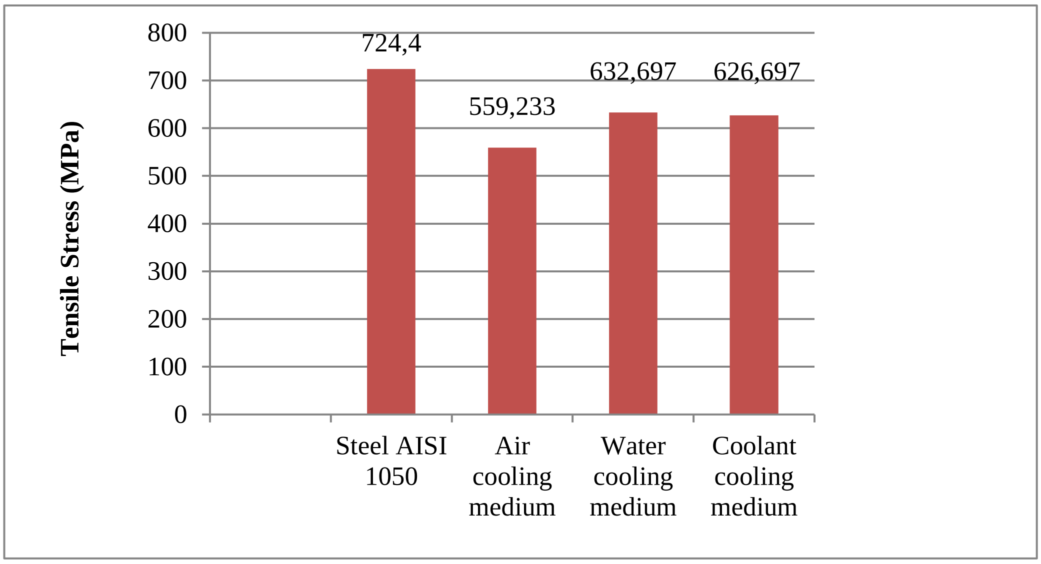

Figure 10. Comparison of Tensile Stress Among Cooling Medium

B. Discussions

The material used in this study is AISI 1050 Medium Carbon Steel. AISI 1050 Steel was selected due to its availability in market and widely used in the manufacture of engine components such as gears, shafts, and chains. The number of specimens used in this study was 13 specimens with details of 1 control specimen to equalize the results of tensile strength with Mill Certificate obtained from the market. Four specimens with air cooling medium, 4 specimens with water cooling medium, and 4 specimens with coolant cooling medium.

Each specimen is welded and subjected to the cooling process. It aims to determine which cooling medium has the highest effect on the tensile strength of AISI 1050 Steel after welding and which cooling medium has the lowest effect on the tensile strength of AISI 1050 Steel after the welding process.

The results show the differences in tensile strength, strain and modulus elasticity of AISI 1050 steel using post-welding cooling medium.

1. Calculations and Discussions

After the tensile strength testing process, it can be determined the amount of tensile strength, strain, and modulus elasticity. Based on the theory, it can be obtained by calculating:

Tensile strength (σ)

$$\sigma = \frac{Fm}{Ao}$$

where:

σ = Tensile Strength (N / mm^2)

Fm = Maximum tensile force (N)

Ao = Cross-sectional area of specimens (mm^2)

Strain (ε)

$$\varepsilon = \frac{Li - Lo}{Lo} \text{ x } 100\ \%$$

Where :

ε = Stretch

Li = Length of specimen after testing (mm^2)

Lo = Length of specimen before testing (mm^2)

Elastic Modulus (E)

$$E = \frac{\sigma}{\varepsilon}$$

Where:

E = Modulus of Elasticity (N/mm^2)

σ = Tensile stress (N/mm^2)

ε = Stretch

1) Original specimen without treatment

- Tensile stress

$$\sigma = \frac{Fm}{Ao} = \frac{108,66\ kN}{150\ mm^2} = \frac{108660\ N}{150\ mm^2} = 724,4\ N/mm^2 = 724,4\ MPa$$

- Strain

$$\varepsilon = \frac{\text{Li} - \text{Lo}}{Lo} x100\%$$

$$= \frac{59,60 - 50}{50} x\ 100\% = \frac{9,60}{50} x\ 100\% = 0,192\ x\ 100 = 19,2\ \%$$

- Modulus elasticity

$$E = \frac{\sigma}{\varepsilon} = \frac{724,4\ MPa}{0,192} = \frac{724,4\ MPa}{192\ x\ 10^{-3}} = 3,772\ x\ 10^3\ Mp = 3,772\ GPa$$

The tensile stress of AISI 1050 steel is 724.4 MPa or 73.868 Kgf/mm^2. It is the highest tensile stress among all specimens. It due to no welding treatment and cooling process so its microsutructured is constant. The tensile stress is in accordance with Basuki Widodo and Aladin Eko Purnomo (2017) reported that the tensile stress of Medium Carbon Steel AISI 1050 is 600-800 MPa.

2) Specimens with air cooling medium

a) Specimen 1 (A1)

- Tensile stress

$$\sigma = \frac{Fm}{Ao} = \frac{90,26\ KN}{150\ mm^2} = \frac{90260\ N}{150\ mm^2} = 601,733\ N/mm^2 = 601,733\ Mpa$$

- Strain

$$\varepsilon = \frac{\text{Li} - \text{Lo}}{Lo} x100\%$$

$$= \frac{56{,}65 - 50}{50} x\ 100\%$$

$$= \frac{6{,}65}{50} x\ 100\% = 0{,}133\ x\ 100 = 13{,}3\ \%$$

- Modulus elasticity

$$E = \frac{\sigma}{\varepsilon} = \frac{601{,}733\ MPa}{0{,}133} = \frac{601{,}733\ MPa}{133\ x\ 10^{-3}} = 4{,}524\ x\ 10^{3}\ Mpa = 4{,}524\ GPa$$

b) Specimen 2 (A2)

- Tensile stress

$$\sigma = \frac{Fm}{Ao} = \frac{90{,}42kN}{150\ mm^2} = \frac{90420\ N}{150\ mm^2} = 602{,}8\ N/mm^2 = 602{,}8\ MPa$$

- Strain

$$\varepsilon = \frac{\text{Li} - \text{Lo}}{Lo} x100\%$$

$$= \frac{56{,}55 - 50}{50} x\ 100\% = \frac{6{,}55}{50} x\ 100\% = 0{,}131\ x\ 100 = 13{,}1\ \%$$

- Modulus elasticity

$$E = \frac{\sigma}{\varepsilon} = \frac{602{,}8\ MPa}{0{,}131} = \frac{602{,}8\ MPa}{131\ x\ 10^{-3}} = 4{,}601\ x\ 10^{3}\ MPa = 4{,}601\ GPa$$

c) Specimen 3 (A3)

- Tensile Stress

$$\sigma = \frac{Fm}{Ao} = \frac{90{,}60\ kN}{150\ mm^2} = \frac{90600\ N}{150\ mm^2} = 604\ N/mm^2 = 604\ MPa$$

- Strain

$$\varepsilon = \frac{\text{Li} - \text{Lo}}{Lo} x100\%$$

$$= \frac{55{,}65 - 50}{50} x\ 100\% = \frac{5{,}65}{50} x\ 100\% = 0{,}113\ x\ 100 = 11{,}3\ \%$$

- Modulus elasticity

$$E = \frac{\sigma}{\varepsilon} = \frac{604\ MPa}{0{,}113} = \frac{604\ MPa}{113\ x\ 10^{-3}} = 5{,}345\ x\ 10^{3}\ MPa = 5{,}345\ GPa$$

d) Specimen 4 (A4)

- Tensile Stress

$$\sigma = \frac{Fm}{Ao} = \frac{64{,}26\ kN}{150\ mm^2} = \frac{64260\ N}{150\ mm^2} = 428{,}4\ \frac{N}{mm}^{2} = 428{,}4\ MPa$$

- Strain

$$\varepsilon = \frac{\text{Li} - \text{Lo}}{Lo} x100\%$$

$$= \frac{52,30 - 50}{50} x\ 100\% = \frac{2,30}{50} x\ 100\% = 0,046\ x\ 100 = 4,6\ \%$$

- Modulus elasticity

$$E = \frac{\sigma}{\varepsilon} = \frac{428,4\ MPa}{0,046} = \frac{428,4\ MPa}{46\ x\ 10^{-3}} = 9,313\ x\ 10^{3}\ MPa\ = 9,313\ GPa$$

The average tensile stress for air cooling medium is 559.233 MPa or 57.025 Kgf/mm^2. For air cooling medium, the tensile stress of each specimen is almost the same and only 1 specimen has a significant difference (the last specimen). It is due to a welding defect in the welding filling process.

3) Specimens with water cooling medium

a) Specimen 1 (B1)

- Tensile stress

$$\sigma = \frac{Fm}{Ao} = \frac{113,24\ kN}{150\ mm^2} = \frac{113240\ N}{150\ mm^2} = 754,93\ N/mm^2 = 754,93\ MPa$$

- Strain

$$\varepsilon = \frac{\text{Li} - \text{Lo}}{Lo} x100\%$$

$$= \frac{54,90 - 50}{50} x\ 100\% = \frac{4,90}{50} x\ 100\% = 0,098\ x\ 100 = 9,8\ \%$$

- Modulus elasticity

$$E = \frac{\sigma}{\varepsilon} = \frac{754,93\ MPa}{0,098} = \frac{754,93\ MPa}{98\ x\ 10^{-3}} = 7,703\ x\ 10^{3}\ MPa\ = 7,703\ GPa$$

b) Specimen 2 (B2)

- Tensile stress

$$\sigma = \frac{Fm}{Ao} = \frac{97,36\ KN}{150\ mm^2} = \frac{97360\ N}{150\ mm^2} = 649,06\ N/mm^2 = 649,06\ Mpa$$

- Strain

$$\varepsilon = \frac{\text{Li} - \text{Lo}}{Lo} x100\%$$

$$= \frac{56,35 - 50}{50} x\ 100\% = \frac{6,35}{50} x\ 100\% = 0,127\ x\ 100 = 12,7\ \%$$

- Modulus elasticity

$$E = \frac{\sigma}{\varepsilon} = \frac{649,06\ MPa}{0,127} = \frac{649,06\ MPa}{127\ x\ 10^{-3}} = 5,110\ x\ 10^3\ MPa\ = 5,110\ GPa$$

c) Specimen 3 (B3)

- Tensile stress

$$\sigma = \frac{Fm}{Ao} = \frac{81,60\ KN}{150\ mm^2} = \frac{81600\ N}{150\ mm^2} = 544\ N/mm^2 = 544\ Mpa$$

- Strain

$$\varepsilon = \frac{\text{Li} - \text{Lo}}{Lo} x100\%$$

$$= \frac{53,50 - 50}{50} x\ 100\% = \frac{3,50}{50} x\ 100\% = 0,070\ x\ 100 = 7,0\ \%$$

- Modulus elasticity

$$E = \frac{\sigma}{\varepsilon} = \frac{544\ MPa}{0{,}070} = \frac{544\ MPa}{70\ x\ 10^{-3}} = 7{,}771\ x\ 10^{3}\ MPa\ = 7{,}771\ GPa$$

d) Specimen 4 (B4)

- Tensile stress

$$\sigma = \frac{Fm}{Ao} = \frac{87{,}42\ kN}{150\ mm^2} = \frac{87420\ N}{150\ mm^2} = 582{,}8\ N/mm^2 = 582{,}8\ MPa$$

- Strain

$$\varepsilon = \frac{\text{Li} - \text{Lo}}{Lo} x100\%$$

$$= \frac{56 - 50}{50} x\ 100\% = \frac{6}{50} x\ 100\% = 0{,}12\ x\ 100 = 12\ \%$$

- Modulus elasticity

$$E = \frac{\sigma}{\varepsilon} = \frac{582{,}8\ MPa}{0{,}12} = \frac{582{,}8\ MPa}{120\ x\ 10^{-3}} = 4{,}856\ x\ 10^{3}\ MPa\ = 4{,}856\ GPa$$

The average tensile stress for water cooling medium is 632.697 MPa or 64.517 Kgf/mm^2. It is the average value of the highest tensile strength among others. However, the tensile stress of each specimen has a significant difference due to the effect of water medium on the cooling shock effect of post-welding steel. Thus, the changing of microstructure in the steel is not homogen that similar with Akhrizal Yusman (2018). He reported that water has 2 weaknesses as a cooling medium. First, a fast cooling rate at lower temperatures where distortion and cracks are more likely to occur, so that water cooling is usually limited to simple coolers. The second, using water cooling media can usually cause steam trapping and produces heterogen hardness and unfavorable stress distribution, causing distortion, and soft spots.

4) Specimens with coolant cooling medium

a) Specimen 1 (C1)

- Tensile stress

$$\sigma = \frac{Fm}{Ao} = \frac{81{,}44\ kN}{150\ mm^2} = \frac{81440\ N}{150\ mm^2} = 542{,}93\ N/mm^2 = 542{,}93\ MPa$$

- Strain

$$\varepsilon = \frac{\text{Li} - \text{Lo}}{Lo} x100\%$$

$$= \frac{53{,}40 - 50}{50} x\ 100\% = \frac{3{,}40}{50} x\ 100\% = 0{,}068\ x\ 100 = 6{,}8\ \%$$

- Modulus elasticity

$$E = \frac{\sigma}{\varepsilon} = \frac{542{,}93\ MPa}{0{,}068} = \frac{542{,}93\ MPa}{68\ x\ 10^{-3}} = 7{,}984\ x\ 10^3\ MPa\ = 7{,}984\ GPa$$

b) Specimen 2 (C2)

- Tensile stress

$$\sigma = \frac{Fm}{Ao} = \frac{99{,}66\ kN}{150\ mm^2} = \frac{99660\ N}{150\ mm^2} = 664{,}4\ N/mm^2 = 664{,}4\ MPa$$

- Strain

$$\varepsilon = \frac{\text{Li} - \text{Lo}}{Lo} x100\%$$

$$= \frac{55{,}10 - 50}{50} x\ 100\% = \frac{5{,}10}{50} x\ 100\% = 0{,}102\ x\ 100 = 10{,}2\ \%$$

- Modulus elasticity

$$E = \frac{\sigma}{\varepsilon} = \frac{664{,}4\ MPa}{0{,}102} = \frac{664{,}4\ MPa}{102\ x\ 10^{-3}} = 6{,}513\ x\ 10^{3}\ MPa\ = 6{,}513\ GPa$$

c) Specimen 3 (C3)

- Tensile stress

$$\sigma = \frac{Fm}{Ao} = \frac{98{,}04\ kN}{150\ mm^2} = \frac{98040\ N}{150\ mm^2} = 653{,}6\ \frac{N}{mm}^{2}\ = 653{,}6\ MPa$$

- Strain

$$\varepsilon = \frac{\text{Li} - \text{Lo}}{Lo} x100\%$$

$$= \frac{55 - 50}{50} x\ 100\% = \frac{5}{50} x\ 100\% = 0{,}1\ x\ 100 = 10\ \%$$

- Modulus elasticity

$$E = \frac{\sigma}{\varepsilon} = \frac{653{,}6\ MPa}{0{,}1} = \frac{653{,}6\ MPa}{100\ x\ 10^{-3}} = 6{,}536\ x\ 10^{3}\ MPa\ = 6{,}536\ GPa$$

d) Specimen 4 (C4)

- Tensile stress

$$\sigma = \frac{Fm}{Ao} = \frac{96,88\ kN}{150\ mm^2} = \frac{96880\ N}{150\ mm^2} = 645,86\ N/mm^2 = 645,86\ MPa$$

- Strain

$$\varepsilon = \frac{\text{Li} - \text{Lo}}{Lo} x100\%$$

$$= \frac{56,40 - 50}{50} x\ 100\% = \frac{6,40}{50} x\ 100\% = 0,128\ x\ 100 = 12,8\ \%$$

- Modulus elasticity

$$E = \frac{\sigma}{\varepsilon} = \frac{645,86\ MPa}{0,128} = \frac{645,86\ MPa}{128\ x\ 10^{-3}} = 5,045\ x\ 10^3\ MPa\ = 5,045\ GPa$$

The average tensile stress of the coolant cooling medium is 626.697 MPa or 63.905 Kgf/mm^2. From the data obtained, there is no significant difference in tensile stress between each specimen. It is due to the presence of oil and water mixture in coolant.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

Based on data analysis and discussion, it can be concluded that:

1. Cooling medium of air, water, and coolant after the welding process have different effects on the tensile stress of the welding of AISI 1050 Medium Carbon Steel.
2. Water cooling medium has the highest average tensile stress (632.697 MPa) compared to other cooling medium.
3. Coolant medium has the second highest average tensile stress prior water (626.697 MPa).
4. Air cooling medium is a cooling medium with the lowest average tensile stress among all cooling medium (559.233 MPa).
5. The effect of the low tensile stress of the E7018 electrode is 490 MPa compared to the tensile stress of AISI 1050 Steel of 724.4 MPa which impact to decreasing in its tensile stress when welding.

B. Recommendations

Based on the results of the research and data analysis that have been carried out, there are several suggestions for future research:

1. In the welding process, the curent and the thickness of the specimen should take into considerations.
2. Precision of tensile test instruments should take into consideration
3. Other theories also should be considered.
4. Comparison the effect of other electrodes and welding.

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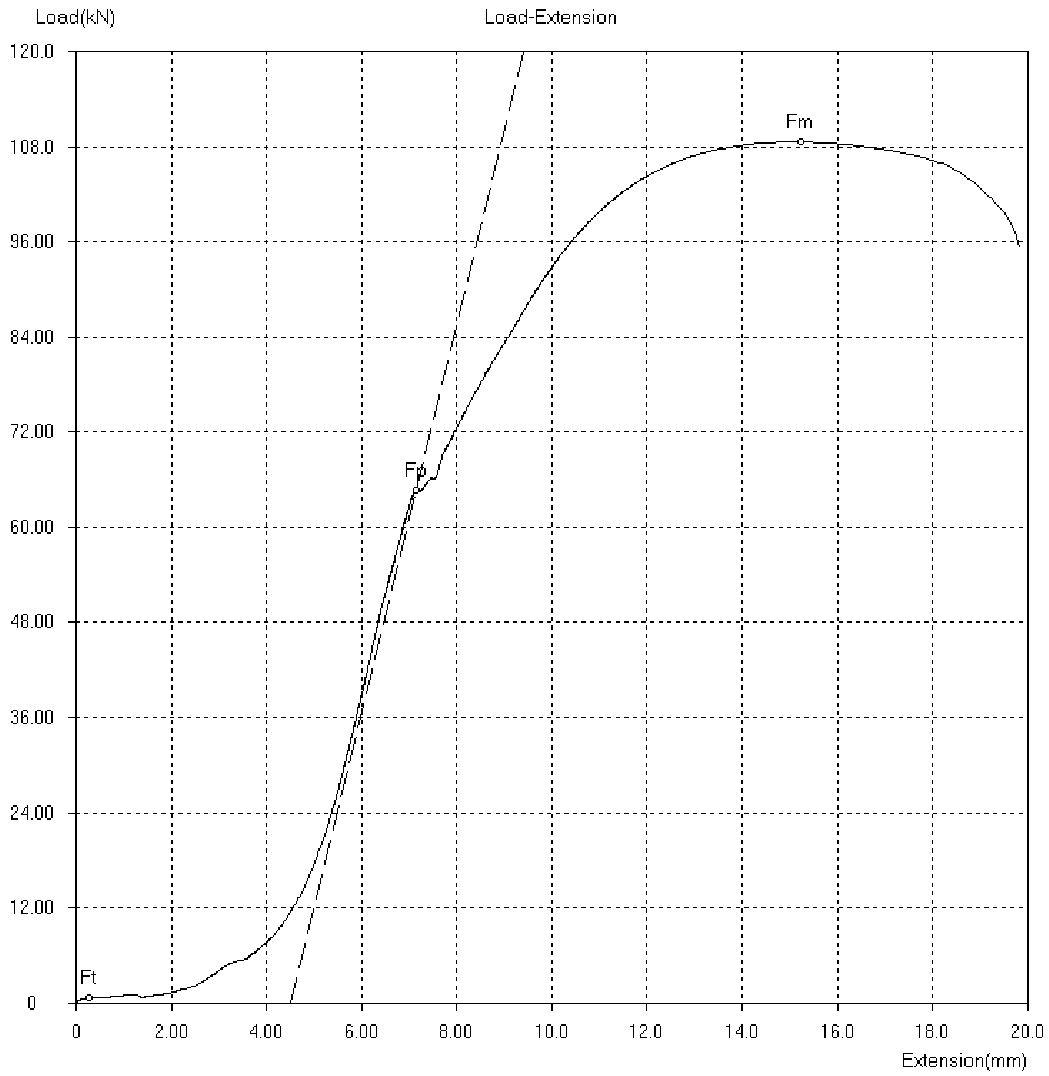
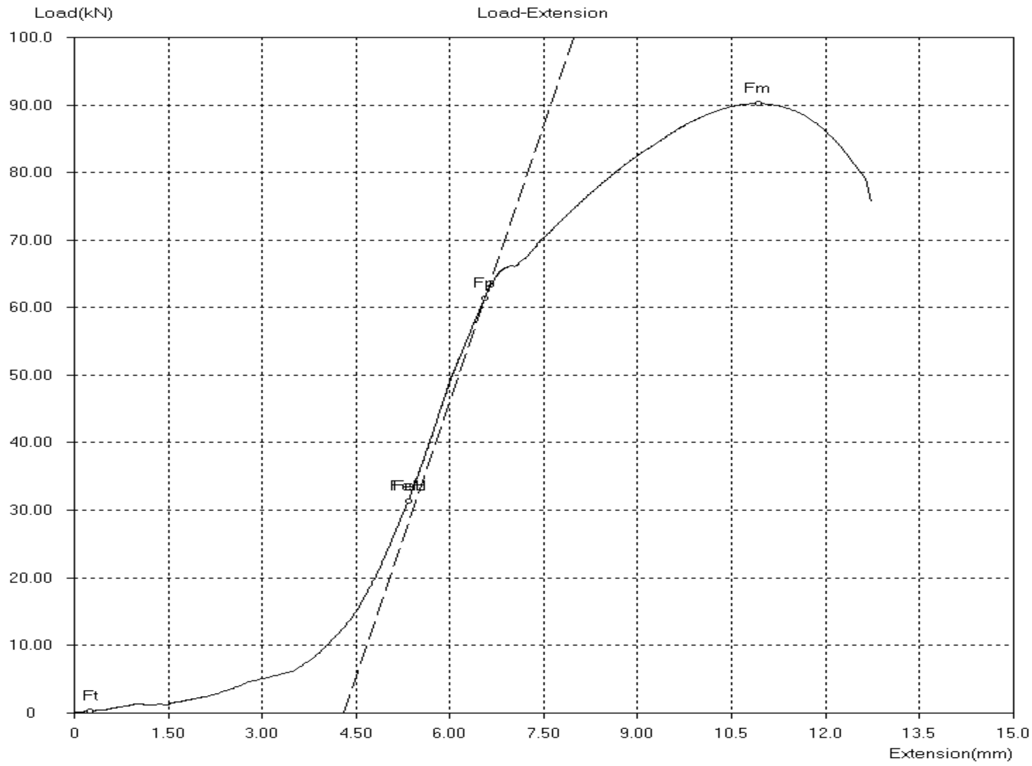
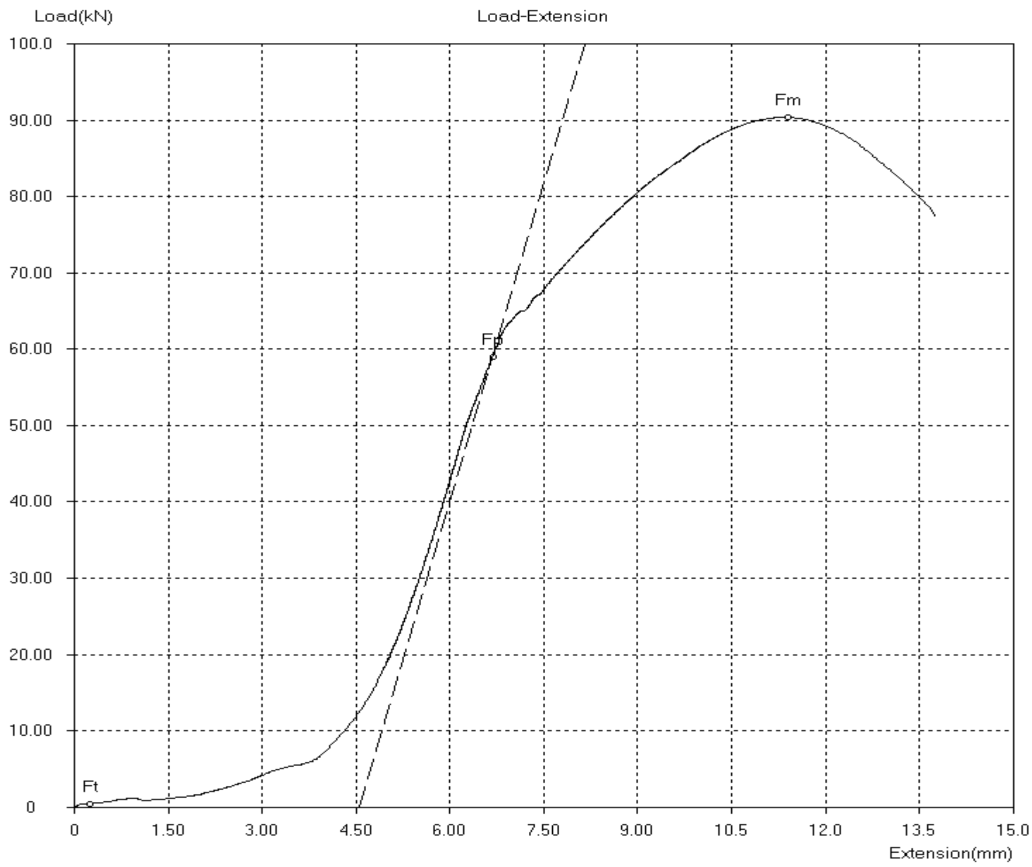
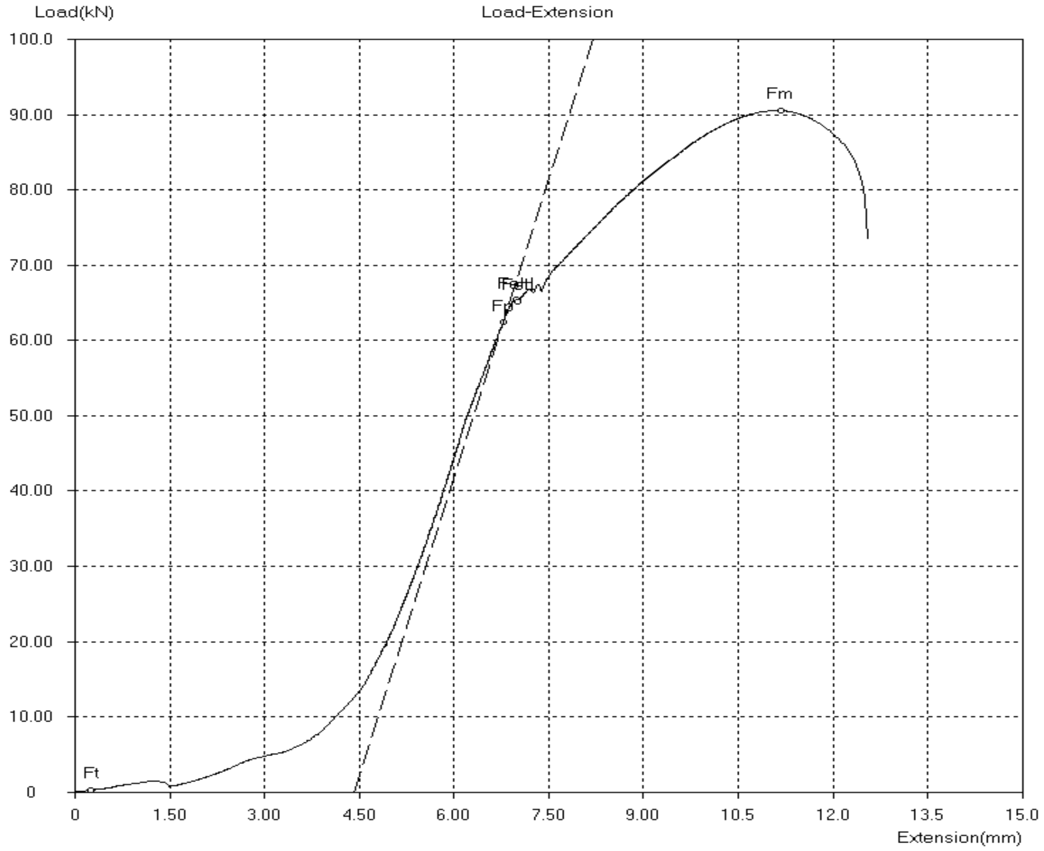
Attachment 1. AISI 1050 Steel Tensile Test Chart



Attachment 2. Tensile Stress Testing Graph on Air Cooling Medium






Load(kN)
Load-Extension
Fm
Ft
Extension(mm)
100.0
90.00
80.00
70.00
60.00
50.00
40.00
30.00
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12.0
13.5
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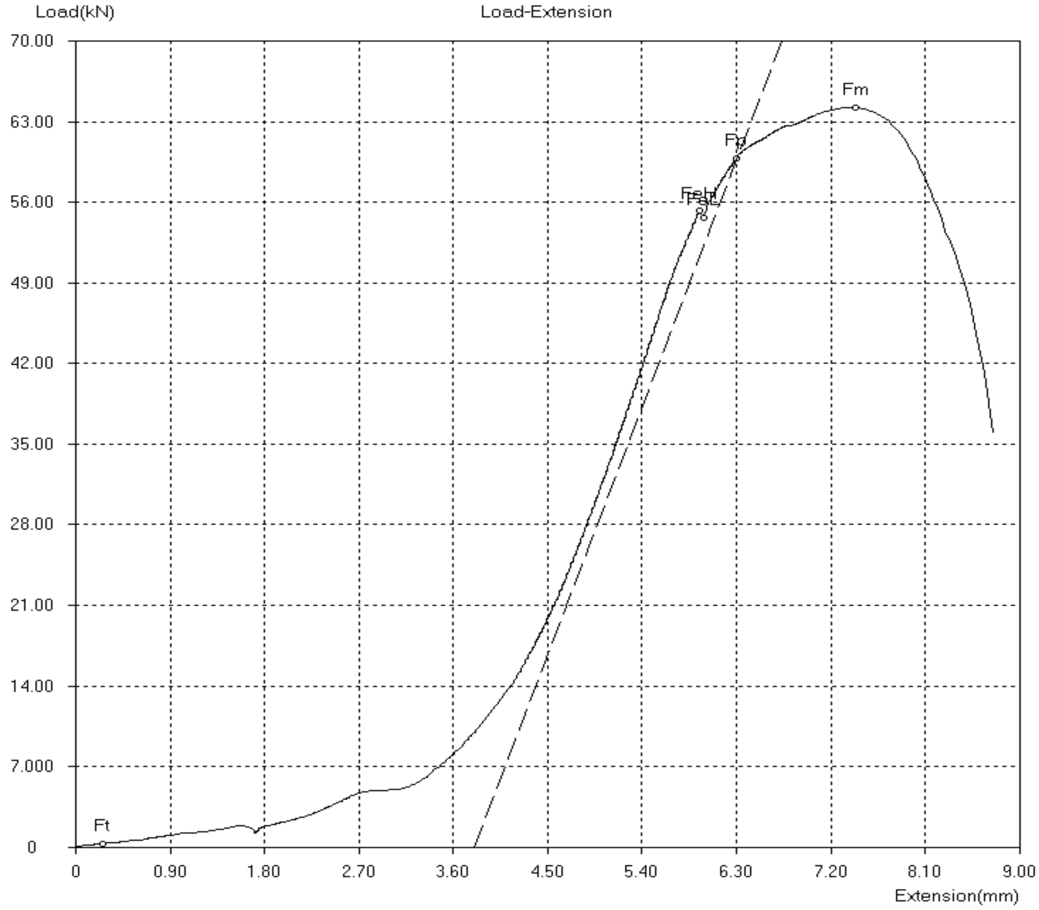
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Fm
Ft
Extension(mm)
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14.00
7.000
0
0.90
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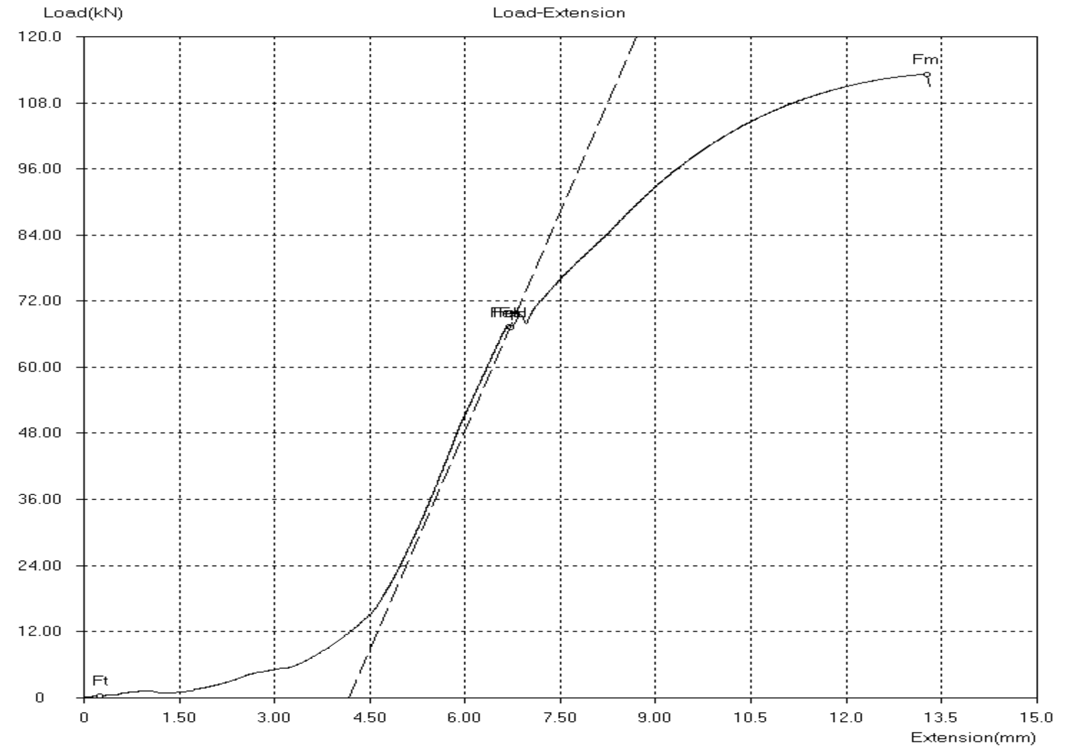
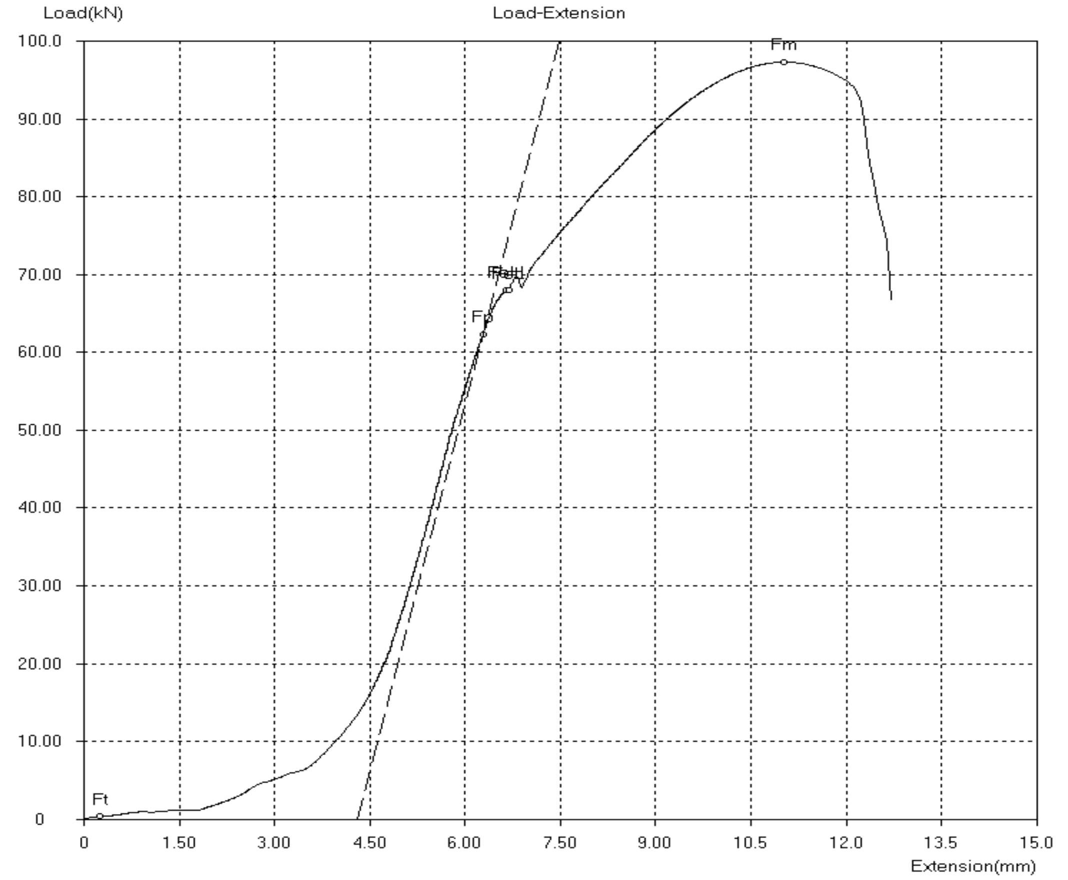
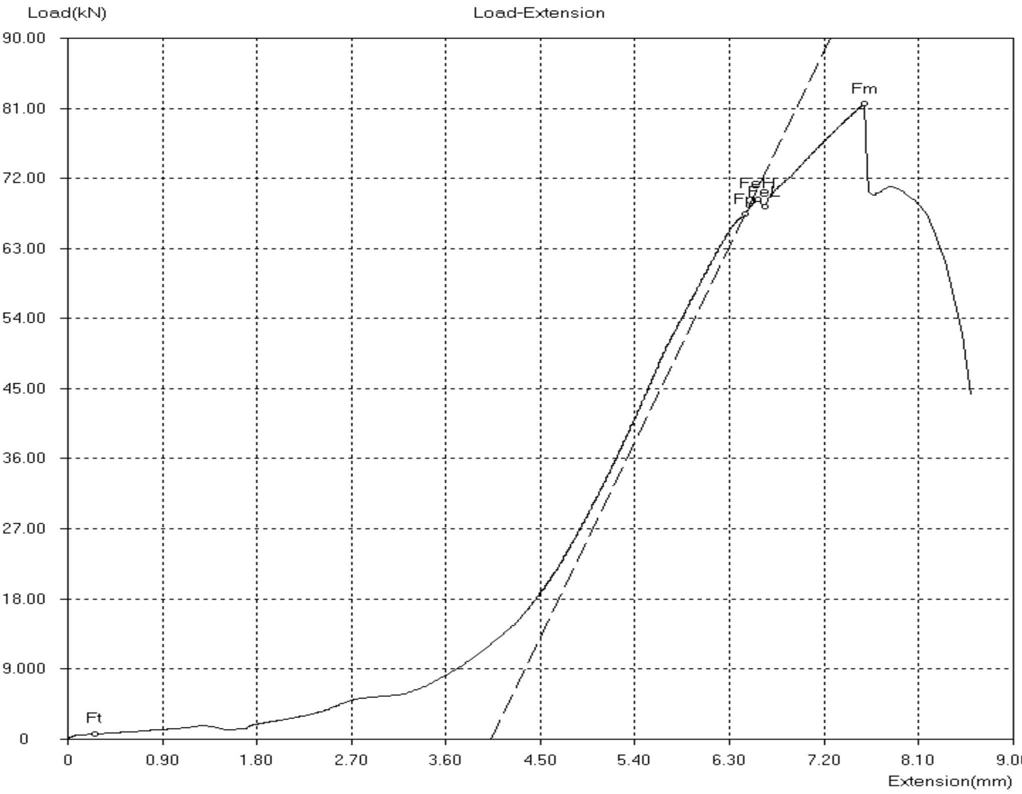
4.50
5.40
6.30
7.20
8.10
9.00

Attachment 3. Tensile Stress Testing Graph on Water Cooling Medium



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0.90
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5.40
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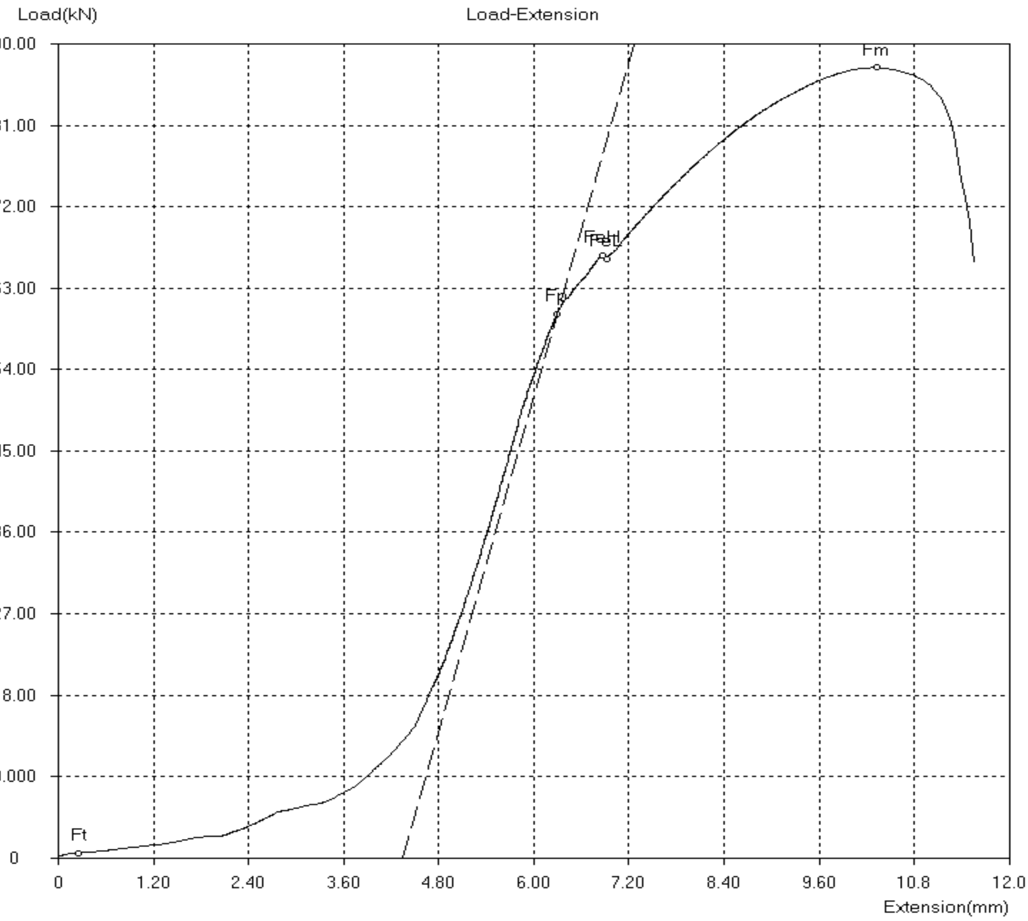
Extension(mm)
Fm
Ft
Fp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0
0
1.20
2.40
3.60
4.80
6.00
7.20
8.40
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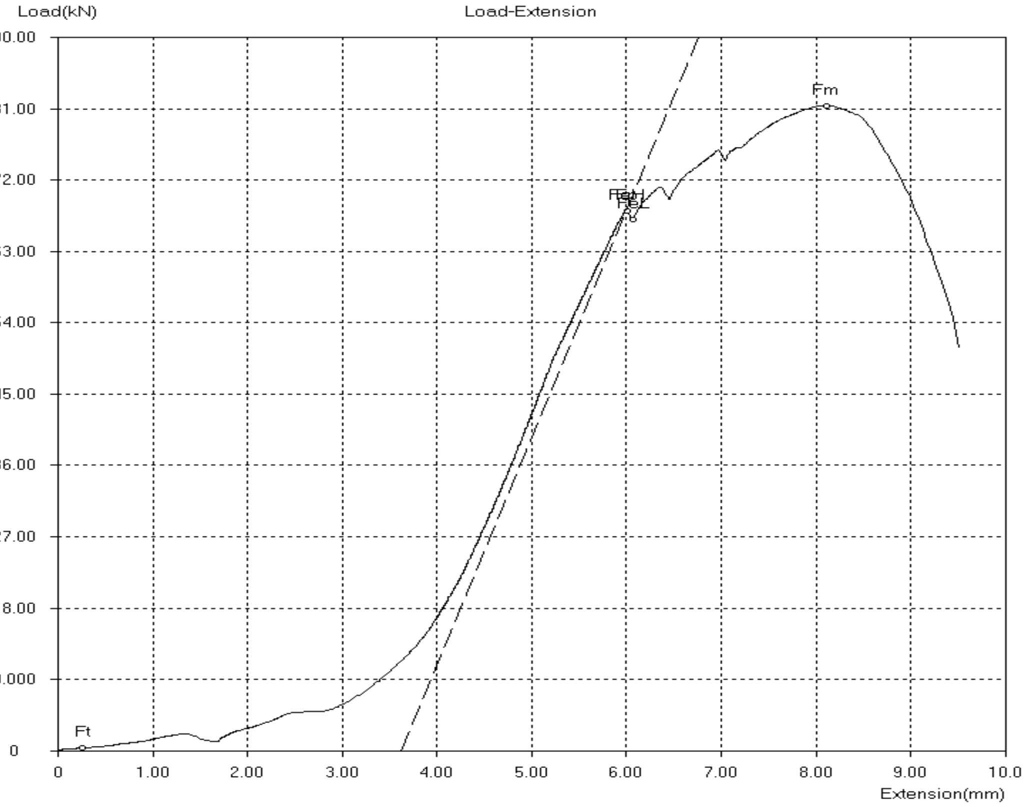
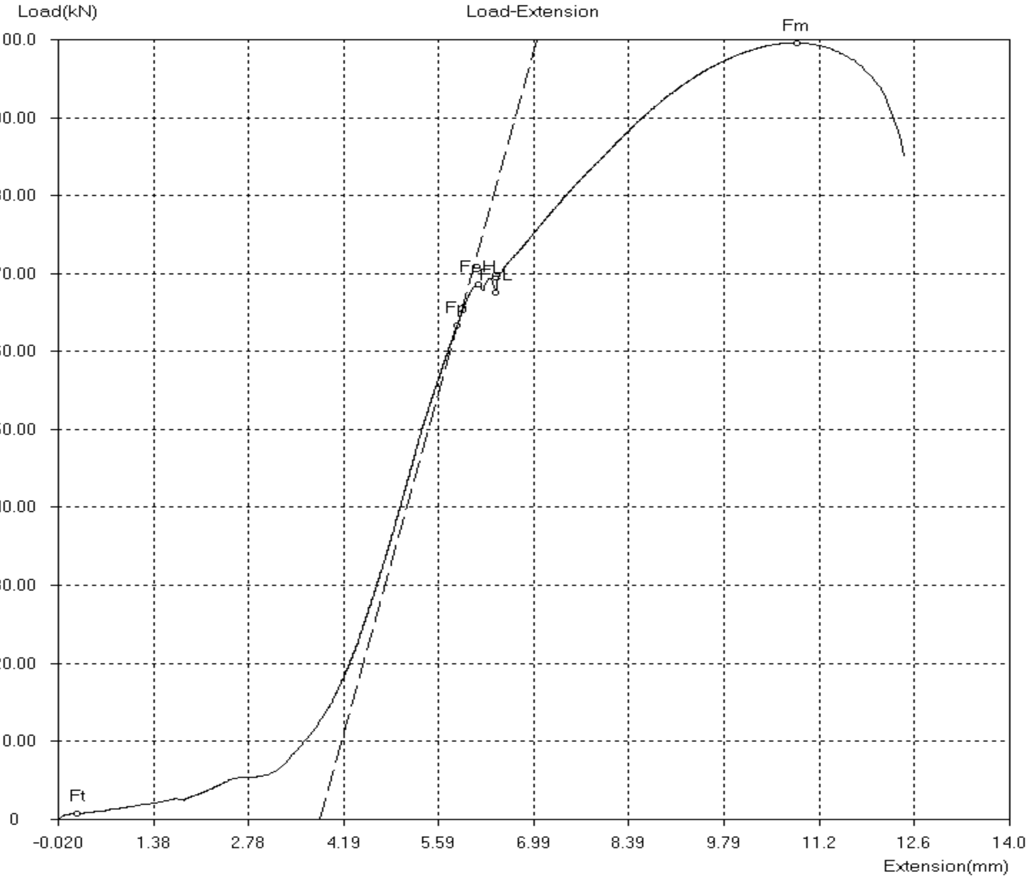
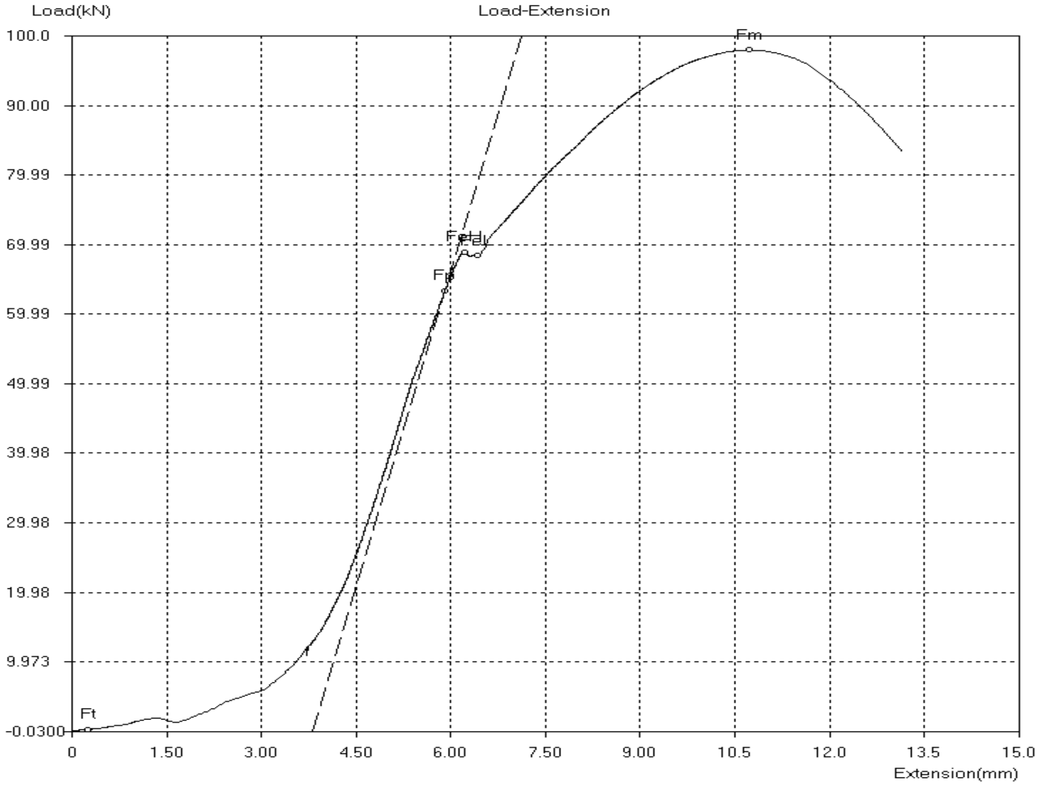
10.8
12.0
Extension(mm)
Fm
Ft
Fp
FeL

Attachment 4. Tensile Stress Testing Graph on Coolant Cooling Medium



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FeL
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19.98
9.973
-0.0300
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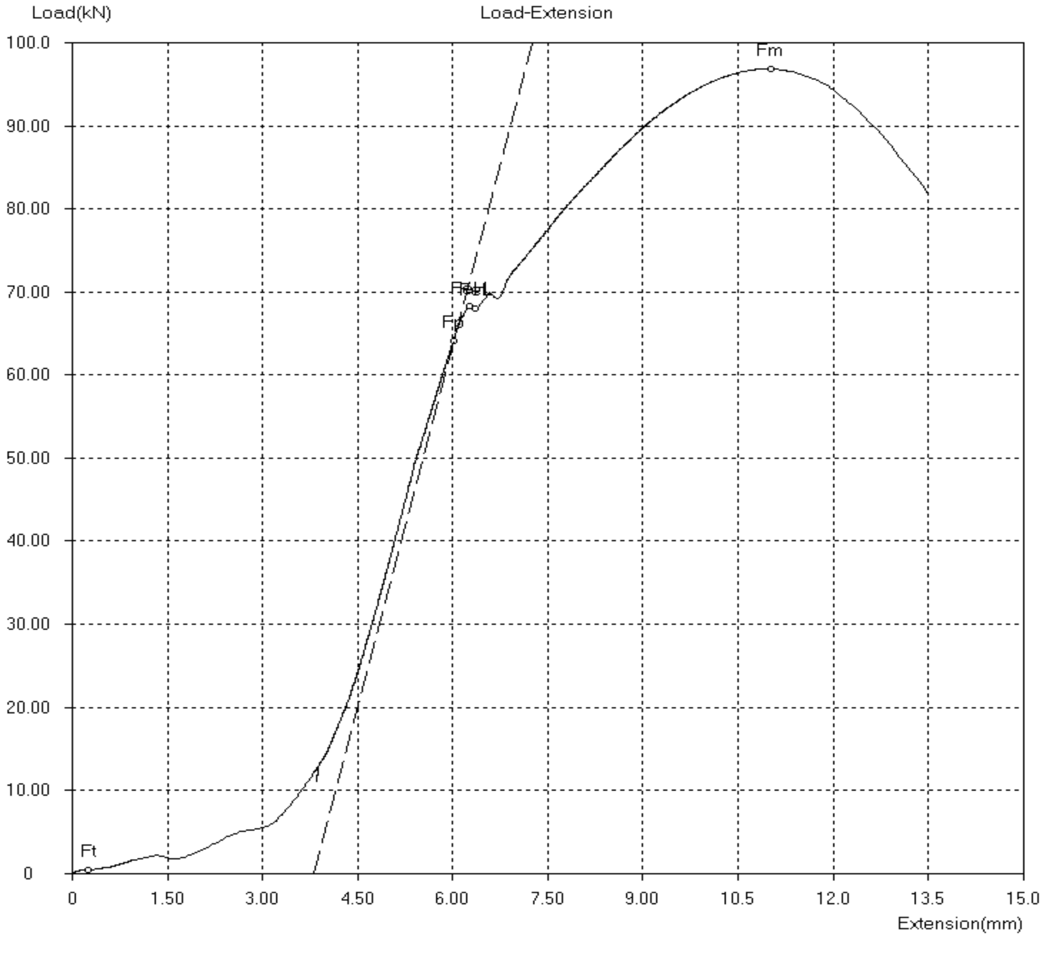
6.00
7.50
9.00
10.5
12.0
13.5
15.0
Extension(mm)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Load-Extension
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FeH
FeL
Fp
Ft
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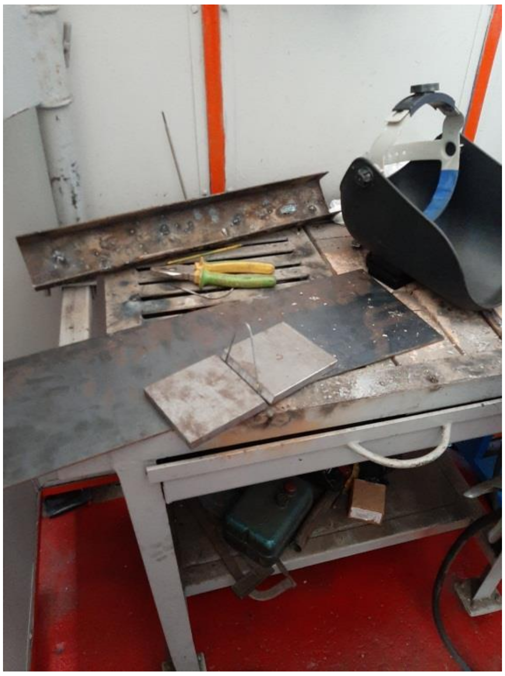
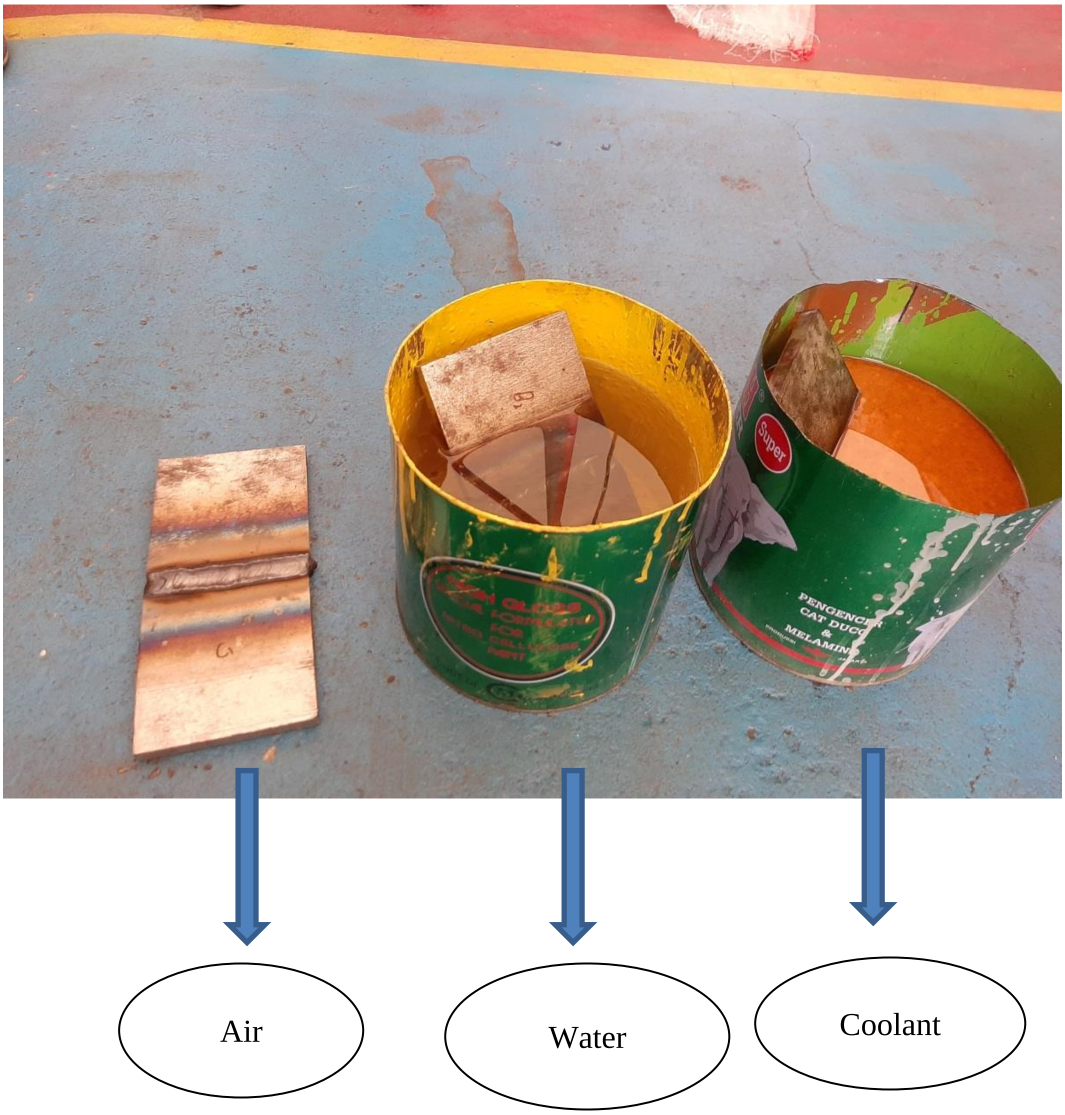
0
0
1.50
3.00
4.50
6.00
7.50
9.00
10.5
12.0
13.5
15.0
Extension(mm)

Attachment 5. The Process of Manufacture Seam V

Attachment 6. Welding Process

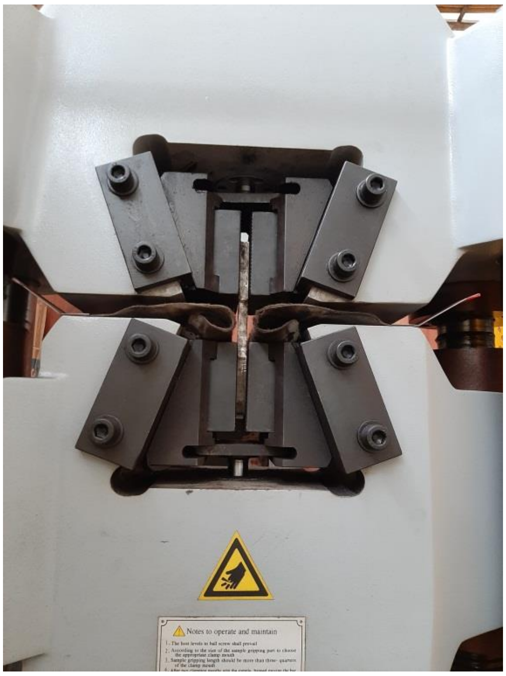


Attachment 7. Cooling Process with Various Cooling Medium



Attachment 8. Specimen manufacture

Attachment 9. Tensile Stress Testing



Attachment 10. Steel Mill Certificate AISI 1050

XINGCHENG STEEL

JIANGYIN XING CHENG SPECIAL STEEL WORKS CO., LTD.

NO. 297, BINJANG (E) ROAD, JIANGYIN CITY, JIANGSU PROVINCE CHINA PC: 214429

MILL CERTIFICATE

WARRANTY DEDICATED JIANGYIN XINGCHENG SPECIAL STEEL WORKS CO.,LTD. INSPECTION ID:Y16000S6060287

CERTIFIED TRUE COPY

Your Ref. 2016/KSJ-042
Part / Drg No 32 x 210 x 1000mm
Grade S50C
Heat No S522264
Salesperson PK 3/3/18

TO: KIM ANN ENGINEERING PTE LTD

DESCRIPTION OF MATERIAL: HOT ROLLED STEEL PLATE

DATE: 2016-06-17

CONTRACT NO: XPSGP16007KIM　INVOICE NO: XPSGP16007KIMC　QUANTITY SHIPPED IN MT: 167.23MT

APPLICANT'S PURCHASE ORDER NUMBER: 161204　APPLICANT HQ NUMBER: 161204　L/C NUMBER: LC5TF61017851

钢种 GRADE S50C(Cr)

交货状态 CONDITION OF DELIVERY AR(As rolled)

标准 SPECIFICATION XCJS62-746-2016-02

探伤标准 U.T Test EN10160: 1999

边缘状态 EDGE Front and Rear Cut

质保书号 CERTIFICATE NO. Y16000S6060287

许可证号 LICENSE NO.

序号 NO.	钢板号 PLATE NO.	炉号 HEAT NO.	厚度 THICK (mm)	宽度 WIDTH (mm)	长度 LENGTH (mm)	张数 PIECES	重量 WEIGHT (t)	C X10²	Si X10²	Mn X10²	P X10³	S X10³	B X10⁴	Cr X10²
1	Q6522173020	S522264	32	1950	5550	1	2.790	48	27	74	8	5	2	33
2	Q6522173010	S522264	32	1950	5000	1	2.510	48	27	74	8	5	2	33
3	Q6522172010	S522264	32	1950	5000	1	2.520	46	27	74	8	5	2	33
4	Q6522171020	S522264	32	1950	5400	1	2.720	48	27	74	8	5	2	33
5	Q6522171010	S522264	32	1960	5000	1	2.510	48	27	74	8	5	2	33

拉伸试验 TENSILE TEST (Re, Rm: MPa; A, Z: %; Re/Rm) · 冲击试验 Impact Test (V型冲击功 V-Impact Energy (J); 剪切面积 Shearing area (SA%)) · 厚度方向性能 THROUGH-THICK 断面收缩率 REDUCTION OF AREA (RA) (%) · 硬度 HARDNESS (表面硬度 SURFACE HB; 心部硬度 CORE HB) · 低倍 Macro-structure (C, S, R LEVEL) · 落锤撕裂试验 DWTT · 晶粒度 Grain size · 带状组织 Banded · 纯净度 DS · 非金属夹杂物 Non-Metallic Inclusions (A, B, C, D: T H)

序号 NO.	钢板号 PLATE NO.	硬度 HARDNESS 表面硬度 SURFACE HB
1	Q6522173020	244
2	Q6522173010	244
3	Q6522172010	218
4	Q6522171020	217
5	Q6522171010	217

弯曲角度 Bend Angle:　弯曲直径 Bend Dia:　弯曲结果 Bend Test:　U.T 级别 U.T Classes: S3E3　U.T 检验 U.T Inspection: OK

本页总计 (PAGE TOTAL): 张数 PIECES 5　重量 t 13.050

外观及尺寸合格 Acceptable Visual and size　备注 REMARK S

我们保证材料合格。有异议时，来函请标明钢牌号、炉号、钢板号、尺寸、发货日期、原因，并将实物保管好。We hereby certify that the material hasn't any impermissible defects. When there is any complaint, you are kindly requested to mark the Steel Grade, Heat No, Plate No, Size, Delivery Data, Causes and material in the condition.

注释 NOTES: 1. ① 位置方向 LOCATION AND ORIENTATION: B=尾部BOTTOM, T=头部TOP, C=横向TRANS, L=纵向LONGL, Z=板厚方向THROUGH-THICK。2. 冲击试样尺寸 (IMPACT SAMPLE SIZE)：板厚分别为 (PLATE THICKNESS, RESPECTIVELY) t≥6-8mm\8<t<12mm\t≥12mm，试样尺寸分别为 (SAMPLE SIZE, RESPECTIVELY) 10×5×55\10×7.5×55\10×10×55mm，标准或协议另有要求的除外。② 试验温度 TEMPRATURE (℃)

PT. KARYA SENTOOSA JAYA
RUKO VILLA HANG LEKIR BLK DD2 NO.03
BATAM 29463 - INDONESIA
TLP. +62 778-469261

6 / 14

QUALITY MANAGER

Attachment 11. Permit to Use Labor and Workshop

Hal : ***Permohonan Pemakaian Labor dan ALat***

Kepada Yth.
Kepala Laboratorium Fabrikasi
Bapak Bulkia Rahim S,Pd., M,Pd.T,
di
Tempat

Dengan hormat,

Sehubungan dengan penelitian kami mahasiswa Program Studi Pendidikan Teknik Mesin FT-UNP dengan nama tersebut dibawah ini:

Nama	: Herman zulhafril
Nim/TM	: 16067013/2016
Jurusan/Prodi	: Teknik Mesin / S1
No. Hp	: 0822 8534 6947
Judul Skripsi	: **"*Pengaruh Proses Pendingin terhadap Tegangan Tarik Baja Karbon Sedang Pasca Pengelasan Menggunakan Las Listrik (SMAW) dengan Elektroda E6013* "**

Dengan ini bermaksud untuk meminta izin kepada bapak agar dapat kiranya menggunakan fasilitas Laboratorium Fabrikasi di Jurusan Teknik Mesin FT-UNP.

Demikianlah surat ini disampaikan, atas perhatian dan bantuan bapak kami ucapkan terima kasih.

Mengetahui	Padang, 5 Agustus 2020
Pembimbing Skripsi,	Mahasiswa ybs,
Drs. Jasman, M.Kes.	Herman Zulhafril
NIP. 19621228 198703 1 003	NIM/TM. 16067013/2016

Attachment 12. Permit on Using Testing Instrument

Print http://akama.ft.unp.ac.id/operator/izin_dekan_ulang/6189

KEMENTERIAN PENDIDIKAN DAN KEBUDAYAAN
UNIVERSITAS NEGERI PADANG
FAKULTAS TEKNIK
Jl. Prof. Dr. Hamka, Kampus UNP Air Tawar, Padang 25171
Telp. (0751) 7055644, 445118 Fax (0751) 7055644, 7055628
website : www.ft.unp.ac.id e-mail : info@ft.unp.ac.id

IZIN UJI COBA DAN PENELITIAN
Nomor : 2094/UN35.2.1/LT/2020

Dekan Fakultas Teknik Universitas Negeri Padang, dengan ini memberi izin kepada mahasiswa yang tersebut di bawah ini :

Nama : Herman Zulhafril
BP/NIM : 2016 / 16067013
Prodi : Pendidikan Teknik Mesin
Jenjang Program : S1

Untuk melakukan Uji Coba dan Penelitian di Laboratorium Pengujian Tarik Teknik Sipil Fakultas Teknik Universitas Negeri Padang Fakultas Teknik Universitas Negeri Padang yang dilaksanakan pada tanggal 10 September 2020 s/d 10 Oktober 2020 dengan judul Skripsi/Tugas Akhir **"Pengaruh Proses Pendingin Terhadap Tegangan Tarik Baja Karbon Sedang Pasca Pengelasan Menggunakan Las Listrik (SMAW) Dengan Elektroda E7018"**.

Demikian surat izin ini dikeluarkan untuk dapat dipergunakan dengan sebaik-baiknya.

Padang, 08 September 2020
Dekan,

Dr. Fahmi Rizal, M.Pd., MT.
NIP. 19591204 198503 1004

Acc untuk pengujian
di: Lab Uji Tarik – T.Sipil UNP

5152
14/9-2020.

Diuji Kamis 17/9-20
Pukul : 9.00 WIB

1 of 1 9/8/2020, 1:42 PM

Attachment 13. Supervising Form

KEMENTERIAN PENDIDIKAN DAN KEBUDAYAAN
UNIVERSITAS NEGERI PADANG
FAKULTAS TEKNIK
JURUSAN TEKNIK MESIN
Jl. Prof. Dr. Hamka Air Tawar, Padang 25131 Telp. (0751) 7051260 Fax (0751) 7055628
website: www.ft.unp.ac.id e-mail: info@ft.unp.ac.id

LEMBARAN KONSULTASI

SKRIPSI/PROYEK AKHIR

Nama : Herman Zulhafril

NIM/TM : 16067013/2016

Prog. Studi : Pendidikan Teknik Mesin

Pembimbing : Drs. Jasman, M.Kes.

Judul : *"Pengaruh Proses Pendingin terhadap Tegangan Tarik Baja Karbon Sedang Pasca Pengelasan Menggunakan Las Listrik (SMAW) dengan Elektroda E7018"*

No	Hari, Tanggal	Uraian Konsultasi	T. Tangan Pembimbing
1.	14/11/2019	Konfirmasi Judul dan tahap penyusunan proposal	
2.	20/12/2019	Penyusunan Bab I dan penyempurnaan	
3.	29/12/2019	Penyusunan Bab II	
4.	3/01/2020	Penyusunan Bab III	
5.	07/05/2020	Bimbingan akhir untuk acc seminar	
6.	07/05/2020	acc untuk seminar online	
7.	07/07/2020	Perbaikan pasca seminar proposal	

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JURUSAN TEKNIK MESIN
Jl. Prof. Dr. Hamka Air Tawar, Padang 25131 Telp. (0751) 7051260 Fax (0751) 7055628
website: www.ft.unp.ac.id e-mail: info@ft.unp.ac.id

8.	5/8/2020	Konfirmasi untuk Penelitian	[signature]
9.	10/9/2020	Konsultasi tempat penelitian dan prosedur penelitian	[signature]
10.	22/9/2020	TTd untuk surat penelitian	[signature]
11.	06/10/2020	bimbingan Jurnal Teknomekanik	[signature]
12.	15/10/2020	bimbingan Bab IV dan Bab V	[signature]
13.	20/10/2020	bimbingan Jurnal tahap II dan Penambahan gambar dan daftar Pustaka	[signature]
14.	22/10/2020	Acc Jurnal untuk disubmit di tekno mekanik	[signature]
15.	23/10/2020	Penyerahan skripsi secara keseluruhan	[signature]
16.	02/11/2020	Acc ujian skripsi	[signature]