MANUFACTURING AND TESTING OF MATERIALS' THERMAL CONDUCTIVITY TEST EQUIPMENT

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

FINAL PROJECT

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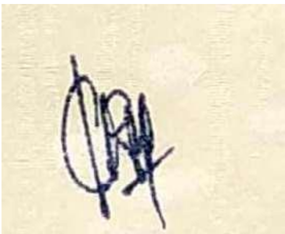

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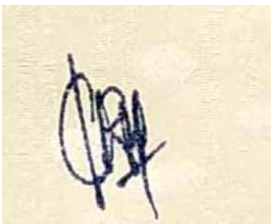

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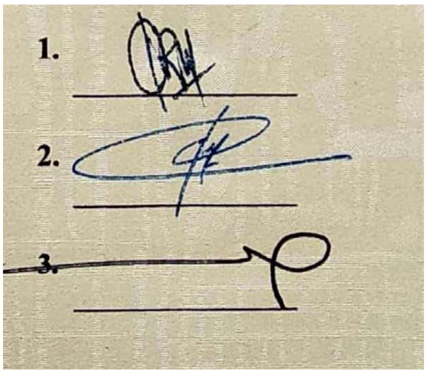

DECLARATION

I hereby confirm that:

1. My final project, title “Manufacturing and Testing of Materials’ Thermal Conductivity Test Equipment” 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, August 2019

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ABSTRACT

Rebi Okzama. 2019. ”Manufacturing and Testing of Materials’ Thermal Conductivity Test Equipment”. *Final Project.* Padang: Mechanical Engineering Vocational Education, Department of Mechanical Engineering, Faculty of Engineering Universitas Negeri Padang.

A material has properties different heat conductivity. To find out how fast and how much temperature can change in an object can transmit heat, how much temperature can change in the material, we must know the thermal conductivity of the material. The purpose of this research is to make and test the thermal conductivity test equipment.

This study uses an experimental method (a prototype) by using the thermal conductivity equation formula to calculate the value of the conductivity of the material being tested. The tested materials used were wood, brick, palm fiber composite, coconut fiber composite and a mixture of fibers and coconut fibers with a diameter of 38.5 mm and a thickness of 15 mm.

The average results of the increase in T2 of several samples, wood 0.075-1.225°C, brick 0.125-0.6°C, palm fiber composite 0.125-0.2°C, coconut composite .075-0.25 °C and mixture of palm fiber and coconut fiber composite from 0.025 to 0.225°C. Wood obtained the largest temperature increasing. The result of the thermal conductivity value (k) of the samples are wood 4,14 ($^W/_m$ ℃), brick 3,909 ($^W/_m$ ℃), palm fiber composite 3,7434($^W/_m$ ℃), coconut fiber composite 3,75 ($^W/_m$ ℃), and mixture of palm fiber and coconut fiber composite 3,777 ($^W/_m$ ℃).

FOREWORD

Praise the presence of Allah SWT who has elevated the degree of those who believe and have knowledge, thanks to His grace and grace the author can complete the final project entitled " Testing of Materials' Thermal Conductivity Test Equipment ". Further prayers and greetings may be conveyed by Allah SWT to the Prophet Muhammad SAW who was a role model in every attitude and action as a Muslim intellectual.

The purpose of this final project is a requirement in completing the undergraduate (S1) in the Mechanical Engineering Vocational Education Study Program, Faculty of Engineering, Universitas Negeri Padang. Successful of this project cannot be separated from the support, assistance, guidance and motivation of various parties, both morally and materially. For all that the authors would like to thank:

1. Allah SWT for the extraordinary blessings that have been given to me, so that I can complete this final project.
2. Both my parents and my beloved family who have given great support and prayers in completing this final project.
3. Mr. Dr. Ir. Arwizet K, ST, MT as the supervisor who has guided and directed the making of this final project.
4. Mr. Dr. Refdinal, MT as examiner lecturer I
5. Mr. Dr. Remon Lapisa, ST, MT, M.Sc. As examiner II

6. Mr/Ms, teaching staff and personnel administration, Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Padang.
7. Fellow students in the Mechanical Engineering Department, Faculty of Engineering, Padang State University.
8. All parties that cannot be mentioned one by one, who have provided assistance in completing this research proposal.

The author also thanks all parties whose names cannot be written down one by one who have participated in the process of making this final project. The making of this final project is inseparable from the shortcomings, therefore, it is intended that dear readers provide constructive criticism and suggestions for improvements in the future.

Padang, August 9, 2019

Rebi Oksama

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CHAPTER I

INTRODUCTION

A. Background

Along with the development and advancement of science and technology, today many scientists create technological tools that are very helpful in everyday life. One of the technologies currently being developed is technology with the principle of heat transfer. A simple example of the application of the principle of heat transfer in everyday life is a thermos where a thermos is used to store the liquid inside to keep it hot for a certain period of time. The inner wall system of the flask is made so that it prevents heat transfer by conduction, convection or radiation. Therefore it is necessary to know the amount of thermal conductivity of various materials in order to apply the principle of heat transfer as an effective tool that can help in human life.

Thermal conductivity is the ability of materials to transfer heat from one place to another (Arwizet, 2014: 16). Thermal conductivity is needed to classify a material belonging to a conductor or insulating material, this serves to facilitate the use of a material according to the material's thermal conductivity value. The ability to transfer heat to engineering materials, such as organic and inorganic materials, has yet to be identified the thermal conductivity value of the material. Thus, it is necessary to conduct a test to determine the value of the thermal conductivity of the material so that later it can become an alternative to new engineering materials in the industrial world amid the global energy crisis.

To find out the value of the thermal conductivity of a material, we can test it by using a material thermal conductivity tester. In examining the conductivity value of an existing material, this study has several problems. The unavailability of thermal conductivity test equipment and the cost involved in purchasing or procuring this thermal conductivity test equipment. Thus, it is important to have thermal conductivity test equipment at low cost. From the description above the authors are interested in conducting study with the title "Manufacturing and Testing of Materials’ Thermal Conductivity Test Equipment".

B. Identification of problems

Based on the background description above, the following problems can be identified:

1. Material thermal conductivity test equipment has long been found, but technology-based education sector has not been found much because this tool is expensive.
2. There are still many technical materials for which the value of their thermal conductivity has not yet been identified.
3. The unavailability of a material thermal conductivity tester at the Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Padang as a tool for conducting research and testing the value of thermal conductivity of a material.

4. The need for an alternative thermal conductivity tester for materials that are inexpensive and can be used in heat transfer practices.

C. Scope of problems

In making this final project, because of the extent of the problem and considering the number of components in the material thermal conductivity tester, scope of problem is limited to the manufacturing and testing of materials' thermal conductivity test equipment.

D. Research Problems

Based on the problem limitations above, research problems are:

1. How to test the materials' thermal conductivity test equipment?
2. What are the details of the equipment and materials used?
3. How is the performance of the equipment?

E. Research Objectives

1. To manufacture and perform tests on materials' thermal conductivity test equipment.
2. To identify required components in manufacturing material thermal conductivity test equipment.
3. To examine performance of manufactured equipment
4. To determine the thermal conductivity value of several tested materials.

F. Research Benefit

1. Academic benefits
   a. Is a requirement for awarding a bachelor's degree
   b. Increase the knowledge about the material thermal conductivity test equipment from manufacturing to testing.
2. Benefits of expertise
   a. Providing information on research development in the academic environment, especially in the Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Padang.
   b. Become a reference for developing research related to the study of thermal conductivity test equipment for materials in the academic environment, especially in the Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Padang.

CHAPTER II

LITERATURE REVIEW

A. Material Thermal Conductivity Test Equipment

1. Definition of Material Thermal Conductivity Test Equipment

Material thermal conductivity test equipment is a tool used to determine the ability of a material to transfer heat from one place to another. This tool is needed to determine the value of the thermal conductivity of a material. Materials that have a high thermal conductivity value are called conductors, while materials that have low conductivity values are called insulators. In measuring the thermal conductivity of the transfer mechanism by conduction, heat is flowed from the heating source to the material being tested so that we can find out the value of the thermal conductivity with the help of manual calculations using the formula.

2. Components of a Material Thermal Conductivity Test Equipment

a. Frame

The frame serves as a place to attach all the components of the material thermal conductivity test equipment.

b. Rail and threaded shaft morphs

The rail functions as a runway for runway 2 that works with the game back and forth to clamp the test specimen. The threaded shaft morphs together with the base which serves as the screw shaft for the clamp.

c. Anvil

This part serves as a base or a place to put aluminum or a conductor. The shape of this base is made in such a way that aluminum can be placed in the base.

d. Isolator Cover

The insulator cover functions as an insulator or heat barrier so that the heat from the aluminum that is heated by the heating element does not come out or is not affected by the outside temperature.

e. Alluminium

Alluminum functions as a surface that will act as a conductor as well as a component that will be in direct contact with the test specimen.

f. Threaded shaft

The threaded shaft serves to move the base so that the solid aluminum can clamp the specimen tightly. The working principle is the same as the vise, when the screw shaft is rotated, the vise's head will clamp the object.

g. Voltage Regulator

Voltage Regulator is a circuit that is often used in electronic equipment. The function of the voltage regulator is to maintain or ensure the voltage at a certain level automatically. That is, the DC output (output) voltage on the Voltage Regulator is not affected by changes in the input voltage (Input), the load at the output and also the temperature. A stable voltage that is free from all disturbances such as noise or fluctuation (fluctuation) is needed to operate electronic equipment, especially in digital electronic equipment such as micro controllers or picro processors.

This voltage regulator circuit is commonly found on adapters that provide DC voltage for laptops, cellphones, game consoles and so on. In electronic equipment whose power supply or power supply is integrated into the unit such as TV, DVD Player and Desktop Computer, a voltage regulator circuit is also a must so that the voltage given to other circuits is stable and free from fluctuations.

There are various types of voltage regulators, one of which is the voltage regulator using the Voltage Regulator IC. One type of IC Voltage Regulator that is most often found is the type 7805, namely IC Voltage Regulator which regulates a stable output voltage at a voltage of 5 Volts DC.

h. Heating Element

Heating Elementis a device that converts electrical energy into heat energy through the Joule Heating process. The working principle of a hot element is that the electric current flowing in the element meets its resistance. If current flows through the element, this high resistance prevents it from flowing easily (fast); this flow will act on the elements, with this work will generate heat. If the current is off, the elements gradually cool down. The heating element itself is made of metal with high electrical resistance.

Things to consider in choosing a heating element:

1. *Maximum element surface temperature* (MET)

Maximum element surface temperature (MET) is the temperature reached when the element material begins to change shape or when the life of the element material becomes short which results in the element breaking or being damaged.

2. *Maximum Power / Surface Loading*

*Maximum Power / Surface Loading y*i.e. the maximum energy used for heating the heating element.

i. Thermometer

A thermometer is a device used to measure temperature, or changes in temperature. The term thermometer comes from the Latin Thermo which means to measure. The thermometer has 2 types of temperature scales that are often used, namely the Celsius scale and the Fahrenheit scale. The difference between the two scales is when at a pressure of 1 atm, the temperature of the ice point for the thermometer on the Celsius scale = 0°C, while the thermometer on the thermometer scale for the Fahrenheit scale = 32 °F. Conversely, at a pressure of 1 atm, the vapor point temperature for a thermometer on a Celsius scale = 100°C, while for a thermometer on a Fahrenheit scale = 212°F.

The thermometer consists of several types, seen from the way the thermometer works, divided into:

1. Mechanical Bimetal Thermometer

A mechanical bimetallic thermometer is a thermometer made of two pieces of metal having different expansion coefficients riveted (plotted) together. The working principle is that when the temperature changes to high, the bimetal strip will bend towards the metal with a higher expansion coefficient, whereas if the temperature becomes low, the bimetal keeping will curve towards a lower expansion coefficient. Usually, bimetallic keeping is made of metals whose expansion coefficient is much different, such as iron and copper.

2. Thermocouple

In the world of electronics, thermocouples are temperature sensors that are widely used to convert temperature differences in objects into changes in electric voltage. A thermocouple which is simple to install and has the same standard connector type, can measure temperatures within a fairly large temperature range with a measurement limit of less than 1°C.

j. Table

The table is a place for the frame to sit so that the frame does not come into direct contact with the floor. This table is attached to the frame and secured with screws.

3. How the Material Thermal Conductivity Test Equipment Works

The way the thermal conductivity test tool works, the material that the author makes is the specimen of the test material clamped by the two solid metals, which is flowed by heat from the heating element which is in solid iron which has been installed with a thermometer so that the heat from the solid iron is immediately read, which is initial heat (T1). The heat flows into the clamped specimen to the other solid iron that has been fitted with a thermometer, the heat until it is the final heat (T2). After getting the final temperature, then look for the conductivity value of the material being tested using the formula.

B. Heat

Heat is the energy that moves across the system boundaries, from a high temperature system to a low temperature system. In thermodynamics, heat is denoted by the letter Q. The unit of heat energy in International Standards (SI) is called the Joule (J). In British (UK) it is called the British Thermal Unit (BTU). Heat can increase or decrease the temperature of an object. The greater the heat that enters an object, the higher the temperature of the object, conversely, the more heat that comes out of an object, the temperature of the object will decrease.

Then the heat relationship (Q) is directly proportional to or proportional to the increase in temperature (ΔT), if the mass (m) and specific heat of the substance (c) are constant. The greater the mass of the substance (m), the more heat (Q) is received. The smaller the mass of the substance (m), the less heat (Q) is received. Then the heat relationship (Q) is directly proportional to or proportional to the mass of the substance (m) if the increase in temperature (ΔT) and the specific heat of the substance (c) are constant.

The greater the specific heat of the substance (c), the more heat (Q) is received. The smaller the specific heat of the substance (c), the less heat (Q) is received. Then the heat relationship (Q) is directly proportional to or proportional to the specific heat of the substance (c) if the increase in temperature (ΔT) and the mass of the substance (m) are constant. The specific heat of the substance (c) is the amount of heat needed to raise the temperature of 1 Kg of the substance by 1°C. Mathematically, the relationship between heat (Q), mass of substance (m), specific heat (c) and temperature rise (T) are (Arwizet, 2014):

$$Q = m.\ c.\ \Delta T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ldots.. (2.1)$$

Where : Q = the amount of heat received by the object (J)

M = Mass of sample (Kg)

C = Heat type substance (J / Kg°C)

ΔT = Different temperature (°C)

C. Heat Transfer Process

Heat transfer is the science of predicting energy transfer in the form of heat that occurs due to differences in temperature between objects or materials. In the energy transfer process, of course there is a heat transfer rate that occurs, or what is better known as the heat transfer rate. So the science of heat transfer is also the science of predicting the rate of heat transfer that occurs under certain conditions. Heat transfer can be defined as a process of transferring an energy (heat) from one area to another due to the difference in temperature in that area. There are three known forms of heat transfer mechanisms, namely conduction, convection, and radiation.

1. Conduction Heat Transfer

Conduction heat transfer is a heat transfer process in which heat flows from an area of high temperature to an area of low temperature in a medium (solid, liquid or gas) or between different mediums which are in direct contact so that an exchange of energy and momentum occurs (Holman, 1994: 38).

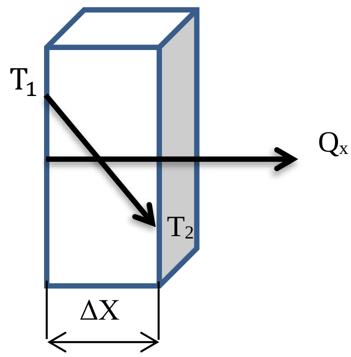

Figure 1. Conduction Heat Transfer to The Wall

The heat transfer rate that occurs in conduction heat transfer is proportional to the normal temperature gradient according to Basic Conduction Equations:

$$Q_k = -k.A.\frac{dT}{dX} \qquad \text{.............................. ... (2.2)}$$

Where: Q = Heat Transfer Rate (kj / sec, W)

k = Thermal Conductivity (W / m°C)

A = Cross-sectional Area (m^2)

dT = Temperature Difference (°C, °F)

dX = Distance difference (m / sec)

ΔT = Change in Temperature (°C, °F) (Holman, 1994)

dT / dx = temperature gradient towards heat transfer

The positive constant "k" is called the conductivity or thermal conductivity of the object, while the minus sign is inserted to fulfill the second law of thermodynamics, namely that heat flows to a lower place on the temperature scale (Holman, 1994: 46).

The basic relationship of heat flow through conduction is the ratio between the rate of heat flow across an isothermal surface and the gradient on that surface applies to every point in an object at every point in an object at any time known as Fourier's law.

In the application of Fourier's law (equation 2.1) to a flat wall, if the equation is integrated it will be obtained

$$Q_k = -\frac{dT}{dX}(T_2 - T_2) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ldots (2.3)$$

When the thermal conductivity is considered constant. Wall thickness is x, while T1 and T2 are wall face temperatures. If the conductivity changes according to a linear relationship with temperature, such as $k = k_0(1 + \beta T)$ then the heat flow equation becomes (Holman, 1994).

$$q_k = -\frac{k_0 A}{\Delta x}\left[T_2 - T_1 + \frac{\beta}{2}(T_2^2 - T_1^2)\right]$$

D. Thermal Conductivity of Materials

The basic conduction equation above is the basic equation for thermal conductivity. Based on this formulation, measurements can be carried out in an experiment to determine the thermal conductivity of various materials. Thermal conductivity of a material is the ability of a material to pass heat from one place to another. The thermal conductivity of a material is the same as the thermal conductivity of a material. Likewise in electrical science we know the term the electrical conductivity of a material. The electrical conductivity of a material is the ability of a material to pass an electric current from one end of the conductor to the other end of the material.

Almost all objects that are used in the engineering world, have a different thermal conductivity. The difference in thermal conductivity of this material is the inherent characteristics of each of these materials which are called the physical properties of the material. The table below shows the thermal conductivity of materials from several types of materials that are commonly found, solid, liquid, and gas.

Table 1. Thermal Conductivity Values of Several Engineering Materials

material	**K (W / m°C)**	**material**	**K (W / m °C)**
Metal		**Non Metal**	
Silver	410	Quartz	41.6
Copper	401	Magnesite	4.15
Aluminum	202	Marble	2.08-2.94
Nickel	93	Stone	1.83
Iron	73	Market	0.78
Carbon steel	43	Glass	0.17
Lead	35	Maple Wood	0.059
Chrome-Nickel Steel	16.3	Sawdust	0.038
Liquid		**Gas**	
Mercury	8.21	Hydrogen	0.175
Water	0.556	Helium	0.141
Lubricating Oil	0.147	Carbon dioxide	0.0146

E. Measuring the Thermal Conductivity of ASTM E Standard Materials 1530-99

The method of measuring thermal conductivity in this standard has a limitation for measuring the resistance to heat flow of the material with a measuring sample thickness of less than 25 mm and a diameter of 50.8 mm or 2 inches. The thermal resistance measured should range from 10 to 400×10^{-4}

m^2K/W and its thermal conductivity values range from 0.1 $<k<30$ W/(mK) at temperatures ranging from 150 to 600 °K.

CHAPTER III

METHODOLOGY

A. Research Design

This study is an experimental method. The experiment carried out was the manufacture of a materials' thermal conductivity test equpiment. Experiments were carried out to create a material thermal conductivity tester by analyzing the ability of the tool using formulas and theories applicable in heat transfer science according to the specimen used. The objective of manufacturing this equi0ment is to determine the value of the thermal conductivity of a material so can be applied at material according to the required standard values. The test results obtained from direct testing of the tested materials (samples).

Many factors or variables can affect the ability of the tool to be manufactured, therefore it requires a lot of references and additional information from books, articles, and other sources related to research to conduct this study.

B. Time and Place

Activities in the form of a final project start from the manufacture of a material thermal conductivity test kit to testing carried out in February 2019 to August 2019, starting from submitting proposals, the process of making material thermal conductivity test equipment, testing, analyzing data to making reports.The research is in the Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Padang.

C. Research Objects

The object of research is thermal conductivity test equipment.

D. Types and Sources of Data

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

E. Tools and Materials

1. Frame

The frame for this test equipment is made from a composite board which aims to make it easy to shape and cut. This board is chosen so that when operating the appliance, heat from the heating element does not flow to the frame. This frame has two forms, the first is a rectangular shape which is the base of the other components with a length of 360 mm, a width of 170 mm and a height of 10 mm. The second form is an angled triangle with a base size of 50 mm and a height of 110 mm.

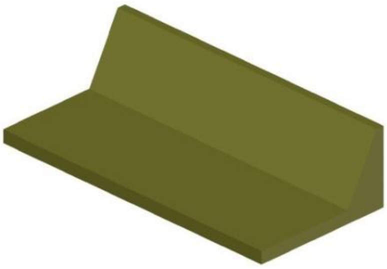

Figure 2. Frame

2. Thread Shaft Rails and Nuts

The rails are made using steel bars which have a length of 220 mm, a width of 14 mm and a thickness of 3 mm. The threaded shaft morph is made using angle steel measuring 40 x 40 x 3 mm and connected with M 12 nuts which are connected by electric welding.

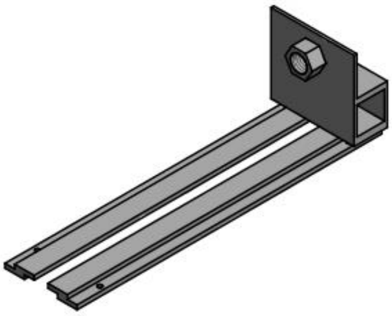

Figure 3. Rail and Threaded Shaft Nuts

3. Anvil (base)

This aluminum foundation is made of particle board so that when operating the tool, the heat from the solid iron does not spread to other components because the board is a good insulator. This runway has two dimensions, the first is 80 mm long, 70 mm wide and 90 mm high, then the second base measures 60 mm long, 50 mm wide and 90 mm high.

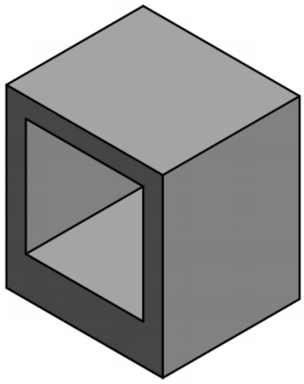

Figure 4. Anvil

4. Isolator Cover

The insulation cover is made of PVC PVC with two sizes. The first insulator cover measures 60 mm in diameter with a length of 70 mm and the second insulator cover measures 60 mm in diameter and 50 mm in length.

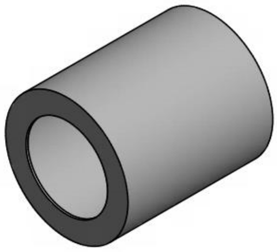

Figure 5. Isolator Cover

5. Allumunium

Allumunium which is used as a conductor and which will be in direct contact with the specimen. There are two sizes of allumunium in the form of cylinders, the first is 40 mm in diameter and 50 mm in length and the second is solid iron measuring 40 mm in diameter and 70 mm long, drilled with a 10 mm drill bit with a depth of 50 mm.

Figure 6. Alluminium

6. Thread Shaft

The threaded shaft used to move the base and clamp the specimen to be tested is 12 mm in diameter, 1.75 mm in range with a thread length of 55 mm and an overall length of 100 mm. The end of the threaded shaft in the welding of the bolt rod as a shaft lever.

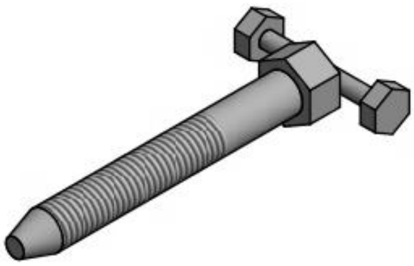

Figure 7. Thread Shaft

7. Heating Element

In the thermal conductivity test instrument for the material to be made, the heating element used is a tubular electric heating element. The tube-shaped electric heating element is inserted into the solid iron which has been drilled with a length of 50 mm and a diameter of 10 mm. The suitable tubular electric heating element is a cartridge heater. The cartridge heater is a pipe-shaped electric heating element with both terminals located on one side of the round section of the pipe. This element is effectively used to transfer the heat of the conduction system by inserting it into a hole which is the same diameter as the cartridge pipe. The specifications of this cartridge heater are made of stainless steel, voltage is 110 volts and power is 300 watts.

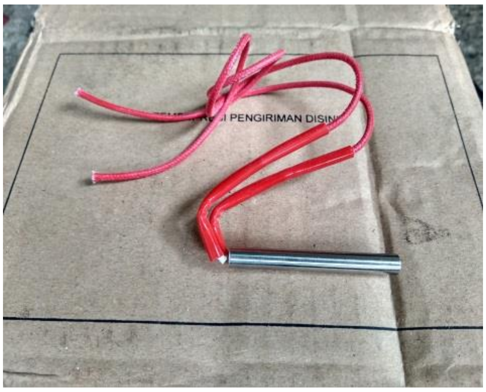

Figure 8. Cartridge Heater

8. Voltage Regulator

The voltage regulator used in the manufacture of this tool is the SCR voltage regulator. SCR voltage regulator is a potentiometer to adjust the min / max output voltage at 220 volts AC voltage. The specification of the SCR voltage regulator is a voltage of 220V, a maximum power of 2000 watts,*Voltage*

Regulator (Output Voltage) AC 90-220V. The power used in this tool is 12 watts due to 12 watts of power, a stable temperature range of 70 - 80 °C is obtained. If it is more than 12 watts, the stable temperature is higher than that and the power output is not accurately measured plus the stable temperature will exceed 100°C while the thermometer is only capable of a maximum temperature of 110°C.

To get 12 watts of power, we have to find the resistance on the voltage regulator with a multitester, the resistance is 3960 ohms. To find the current strength using the formula I = V/R, where V is the household electricity voltage, which is 220 Volts so that the aru strength obtained is

$$I = \frac{V}{R} = \frac{220}{3960} = 0.055$$

Then power of the voltage regulator determine with the formula

$$W = VI = 200 \times 0.055 = 12.22$$

So the power obtained is 12.22 watts, then rounded off to 12 watts.

Figure 3.8 SCR Voltage Regulator

9. Thermometer

The thermometer used in the material's thermal conductivity test equipment is a digital thermometer. This digital thermometer is used because when you see the temperature increase it can be seen easily. The thermometer that will be used has a temperature range between 0 °C - 500°C.

Figure 9. Digital Thermometer

10. Table

The table is made with a composite board material that functions as a seat for the frame. The table designed is 360 x 170 with a thickness of 14 mm. The table leg measures 170 x 80 with a thickness of 14 mm.

F. Research Procedures

1. Manufacturing

The manufacture of this thermal conductivity test equipment has components that are made manually, some component are purchased in the market due to several components, buying saves more money and time, while the components made are as follows:

a. Frame

The frame for the thermal conductivity tester uses a composite board with a thickness of 10 mm. The composite board is cut using a cutting tool such as a wood saw with the size that can be seen in the attached picture. Then the particle board is cleaned of the scraps that are still attached to the particle board.

b. Rail and Thread Shaft

Rail and Thread Shaft are made of steel rods that are cut according to the size attached, then the steel rods are joined together using electric welding by means of overlapping welding. Then fasten the nuts with steel angles with electric welding. Then the rails and threaded shaft nuts are joined by electric welding according to the attached drawing. Then drill for assembly to the frame.

c. Anvil (Base)

The material used to make this foundation is made of particle board. Then the boards are cut according to the size in the attached picture, after being cut, the boards are put together. After being put together, the foundation is puttyed to remove the uneven surface, then sanded to smooth the surface.

d. Isolator Cover

Isolator covers are made of pvc paralon which is cut to the size attached, cut using a hacksaw.

e. Alluminium

The aluminum used in the thermal conductivity tester is a cylinder cut with a chainsaw according to the size already in the attached drawing. then after being cut, the iron is turned to smooth the surface and adjust the existing size in the attached image.

f. Thread Shaft

The screw shaft in this test equipment is purchased and then the rod is connected to the end using electric welding. At the end of the screw shaft input is chamfered so that when inserting the nut it is not difficult later.

g. Table

The composite board is cut to size and then the legs are attached which are held together with screws. After the table is made, then the table is sanded to smooth the surface. After the table surface is smooth, it is polished so that the table surface is shiny.

2. Assembly

The assembly carried out in this case is to arrange all the components of the thermal conductivity test instrument into one complete test instrument. This assembly has an assembly procedure, including:

a. Prepare all components that have been made and purchased.
b. Attach the frame to the table with screws.
c. Place the thermometer in front of the frame where the thermometer holder has been made.
d. Install the rails and threaded axle nuts on the frame, then secure them using screws.
e. Put alluminum into the insulator cover that was previously given dacron. After that enter into the foundation.
f. Attach the base 2 to the rails, then fix the base 1 and secure it with screws to secure it to the frame.
g. Attach the threaded shaft to the threaded shaft mor, then attach the threaded shaft mor to the base 2 using a connector and then secure it with a screw.

h. Connect the power cable and heating cable to the SCR voltage regulator. Mount the tension regulator SCR to the frame with the cover and secure it with screws.
i. Attach the heating element to the drilled aluminum 1
j. The preparation of the components of the test equipment, in this case, assembles each component on the existing test equipment frame, then the installation test is carried out to see the mismatch or errors of the component manufacturing. After everything is installed, try out this tool.

3. Testing

This test is carried out on the thermal conductivity test equipment that has been made. The following test tools, materials and procedures:

a. Tools and Materials

The tool used in this test is the material thermal conductivity test tool that has been made, the following support tools and materials used for testing:

a) *Stopwatch*
b) Tabulated Paper
c) Wood
d) Brick
e) Palm Fiber Composite Fiber
f) Coconut Fiber Composites
g) Mixed Fiber and Coconut Fiber Composites

1. Testing Procedure

a) Preparation of tools and materials in advance

b) Put the specimen on alluminium conductors

c) Clamp the specimen firmly

d) Cover the specimen with dacron so that the heat flowing to the specimen does not spread.

e) Plug in the socket then turn the SCR voltage regulator so that current flows to the heating element.

f) Set up a stopwatch to see the temperature rise per 1 minute second.

g) Record the result of the temperature increase on the thermometer per 1 minute on tabulated paper.

h) Analysis of test results.

G. Data Analysis

Data analysis carried out in this case is to analyze the variables that have been obtained in the measurement tool and put into the conduction heat equation because this tool applies heat conductor science to obtain the conductivity value of a specimen. The equation used in determining the thermal conductivity of the specimen is:

$$Qk = -k\ A\ \frac{dT}{dX} \qquad \text{.............................. .... (3.1)}$$

then to get the thermal conductivity value becomes:

$$k = \frac{Qk\ dX}{A\ dT} \qquad \text{.................................. ... (3.2)}$$

where :

Q = Heat Transfer Rate (kj / sec, W)

K = Thermal Conductivity (W / m. ° C)

A = Cross-sectional Area (m^2)

dX = Distance difference (m / sec)

ΔT = Change in Temperature (° C, ° F)

In this study, the large budget for making material thermal conductivity test equipment can be seen in the Table 1.

Table 1. Budget Design for Tool Manufacturing Costs

No.	Name of Material	Size		Price (Rp)	Total Price (Rp)
		amount	Unit		
1	Composite Board	1	Sheet	125,000	125,000
2	Steel	1	Trunk	135,000	135,000
3	SCR Module	1	Fruit	89,000	89,000
4	Heating Element	1	Fruit	225,000	225,000
5	Allumunium	1	Fruit	440,000	444,000
6	Thermometer	2	Fruit	90,000	180,000
7	Unforeseen expenses				300,000
	Total expenses				**IDR 1,498,000**

H. Research Flow Chart

This research was conducted from January to July 2019 with the flowchart of the research carried out in Figure 10.

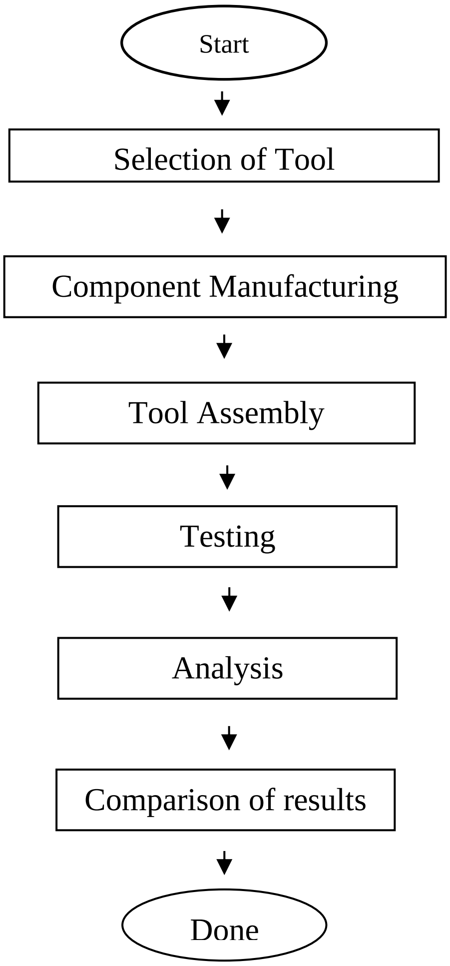

Figure 10. Research Flow Chart

CHAPTER IV

RESULT AND DISCUSSION

A. Result

After carrying out several activities starting from planning, preparation of tools and materials, manufacturing and assembly, this final project can be completed according to planning. The results of the research are presented at table of data. One of the main steps of this research is to make a material thermal conductivity test equipment. The equipment as presented in Figure 11.

Figure 11. Material's Thermal Conductivity Test Equipment

Table 2. Specifications of Material Thermal Conductivity Test Equipment

no	Component	No.	Component
1	Order 360 x 170 x 110 mm	6	Thread Shaft Ø12 x 100 mm, M12
2	Thread Shaft Rails and Nuts Rail: 220 x 14 x 3 mm Screw Shaft Nut: 40 x 40 x 3, M12	7	Alluminium 1. Ø40 x 50 mm 2. Ø40 x 70 mm
3	Base 1. 80 x 70 x 90 mm 2. 60 x 50 x 90 mm	8	Isolator Cover 1. Ø60 x 70 mm 2. Ø60 x 50 mm
4	Heating Element 220 V, 2000 Watt	9	Voltage Regulator SCR 220 V, 2000 Watt
5	Thermometer Digital thermometer 0 ° C - 110 ° C	10	Table 360 x 170 x 94 mm

1. Testing Objective

The test tool aims to see whether the tool that has been made is functioning properly, to find out whether this test tool can transfer heat to the specimen properly so that at the time of testing the thermal conductivity value is obtained in the specimen.

The test is carried out on:

Date and time : Thursday, July 1, 2019

The place : Department of Mechanical Engineering, FT UNP

Duration of Testing : 60 Minutes

The things that need to be considered before carrying out this testing process are

1. Check the condition of the thermal conductivity tester in good condition.
2. Check whether the resources have been installed properly
3. Check if the thermometer is in good shape.
4. Check if the SCR voltage regulator is functioning properly.
5. Check if the heating element is working properly when supplied with power by the voltage regulator SCR
6. Check if the anvil moves properly on the rails.

2. Tools and Materials

a. Tool

1) Material thermal conductivity tester

2) *Stopwatch*

b. Material

1) Test specimens

Table 3. Test Specimens or Samples

No.	Specimens (samples)	Diameter	Thickness
1	 Wood	37 mm	15 mm
2	 Brick	38.5 mm	15 mm
3	 Palm Fiber composite	38.5 mm	15 mm
4	 Coconut Fiber composit	38.5 mm	15 mm
5	 Mixed Fiber and Coconut Fiber composite	38.5 mm	15 Mm

Testing of the material's thermal conductivity device is carried out by giving heat treatment to the specimen through an aluminum conductor which receives heat directly from the heating element, with a power of 12 Watt on the heating element. The alluminum conductor which receives direct heat from the heating element is called T1 (Input temperature). Then wait for the temperature at

T1 to reach a stable temperature. After stabilizing, place and clamp the test specimen with the aluminum conductor T2 (Exit Temperature). For the T2 temperature (Exit Temperature) is in the aluminum conductor which receives the temperature after the specimen. The temperature increase at T2 was seen per 1 minute of time for 6 minutes. This test is repeated 4 times so that the data can be more accurate.

1. The test results mean the temperature rise of T2

a. Wood Material Testing Results

Table 4. Wood Testing Results

Trial	0 minutes		1 minute		2 minutes		3 minutes		4 minutes		5 minutes		6 minutes	
	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
1	71.1	30.9	71.1	30.9	71.1	31	71.1	31.2	71.2	31.6	71.3	31.9	71.6	32.3
2	71.9	30.9	72	30.9	72	30.9	71.2	31	73.4	31.3	73.8	31.6	74.1	32
3	71.1	30.3	71.1	30.3	71.1	30.4	71.2	30.7	71.3	30.9	71.3	31.2	71.8	31.6
4	70.8	30.9	71.1	30.9	71.2	31	71.2	31.2	71.6	31.3	71.9	31.7	76.1	32
The average increase in T2			0		0.075		0.3		0.525		0.85		1.22	

b. Brick Testing Results

Table 5. Brick Testing Results

Trial	0 minutes		1 minute		2 minutes		3 minutes		4 minutes		5 minutes		6 minutes	
	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
1	70.3	31.5	70.7	31.5	70.7	31.5	70.8	31.6	71.1	31.8	71.5	32	71.8	32.2
2	70.9	31.9	71.2	31.9	71.2	31.9	71.6	32	71.8	31.1	72.1	32.3	72.2	32.5
3	70.1	31.4	70.5	31.4	70.5	31.4	70.9	31.5	71.1	31.6	71.2	31.7	71.4	31.9
4	70.2	31.6	70.5	31.6	70.7	31.6	70.8	31.8	71	31.9	71.3	32	71.7	32.2
The average T2			0		0		0.125		0.225		0.325		0.6	

c. Results of Testing for Palm Fiber Composite

Table 6. Results of Testing of Palm Fiber Composite

Trial	0 minutes		1 minute		2 minutes		3 minutes		4 minutes		5 minutes		6 minutes	
	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
1	71.4	30.7	71.7	30.7	71.9	30.8	72.2	30.8	72.3	30.8	72.6	30.9	72.6	31
2	71.3	30.8	71.4	30.8	71.4	30.8	71.8	30.8	72.2	30.8	72.8	30.8	73.3	30.9
3	70.6	30.9	71	30.9	71	30.9	71.2	30.9	71.4	30.9	71.6	31	71.9	31.1
4	70.3	30.9	70.6	30.9	70.9	30.9	71	31.9	71.1	31.9	71.2	31	71.5	31
The average increase in T2			0		0		0		0		0.125		0.2	

d. Results of Testing of Coconut Fiber Composite

Table 7. Coconut Fiber CompositeTesting Results

Trial	0 minutes		1 minute		2 minutes		3 minutes		4 minutes		5 minutes		6 minutes	
	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
1	70.6	30.2	70.8	30.2	70.8	30.2	71.2	30.2	71.6	30.2	71.8	30.3	71.9	30.4
2	70.6	30.6	70.7	30.6	70.8	30.6	71.1	30.6	71.4	30.6	72.2	30.7	72.6	30.8
3	70.5	30.9	70.6	30.9	70.7	30.9	71.2	30.9	71.3	30.9	71.7	30.9	72	31.1
4	70.3	30.7	70.6	30.7	70.8	30.7	71	30.7	71.1	30.7	71.2	30.8	71.5	31.1
The average increase in T2			0		0		0		0		0.075		0.25	

e. Results of Testing for Mixed Palm Fiber and Coconut Fiber Composite

Table 8. Mixed Palm Fiber and Coconut Fiber Composite Testing Results

Trial	0 minute		1 minute		2 minutes		3 minutes		4 minutes		5 minutes		6 minutes	
	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
1	70	30.6	70.1	30.6	70.3	30.6	70.6	30.6	70.9	30.6	71.1	30.7	71.8	30.8
2	70.1	30.7	70.1	30.7	70.2	30.7	70.6	30.7	71.2	30.9	71.6	30.9	72	30.9
3	70.5	31.3	70.8	31.3	70.8	31.3	71.1	31.3	71.4	31.3	71.9	31.4	72.2	31.5
4	70.2	30.8	70.5	30.8	70.7	30.8	70.9	30.8	71.2	30.9	71.3	30.9	71.9	31

The average increase in T2	0	0	0	0	0.025	0.125	0.225

B. Discussion

From all the test results above, it can be concluded that there are differences in the average temperature increase in each test specimen. Based on the result data that has been done, the following graph is obtained

a. Wood

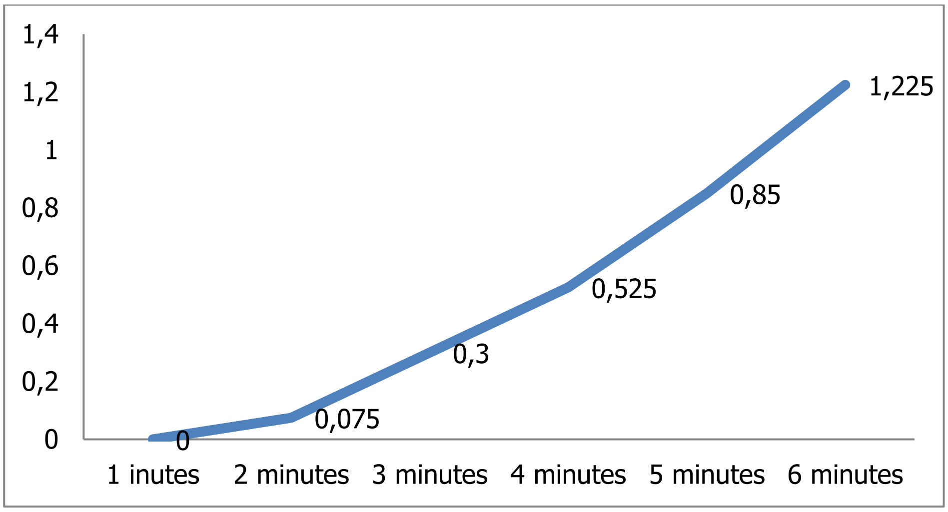

Figure 12. Graph of the Average Increase in T2 of wood

In the graph we can see that the average temperature increase of T2 in wood can be seen that ΔT is the temperature every 1 minute for 6 minutes of the experiment with four tests that the temperature rises in the second minute with an increase in the range from 0.075 to 1.225 °C.

b. Brick

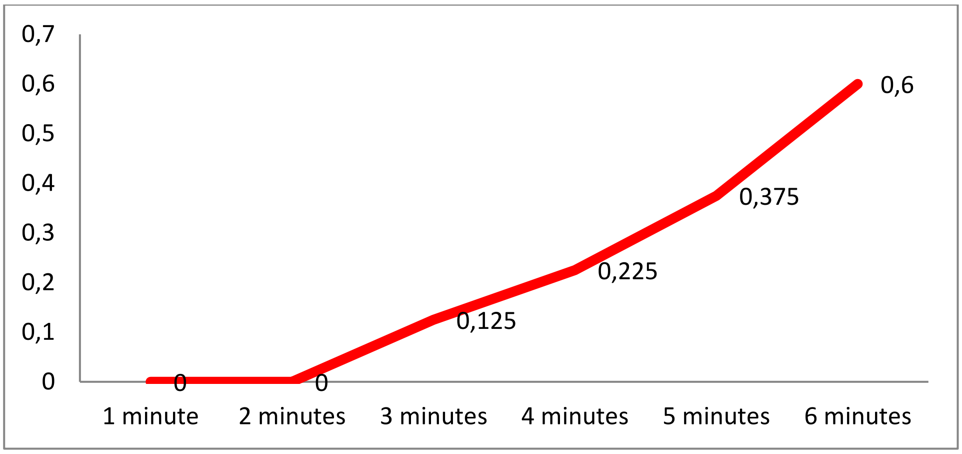

Figure 13. Graph of the Average Increase in T2 of brick

In the graph we can see that the average temperature increase of T2 in brick material can be seen that the temperature ΔT is every 1 minute for 6 minutes of the experiment with four tests that the temperature rises in the third minute with an increase in the range from 0.125 to 0. 6 °C, with a temperature increase in the third minute.

c. Palm Fiber Composite

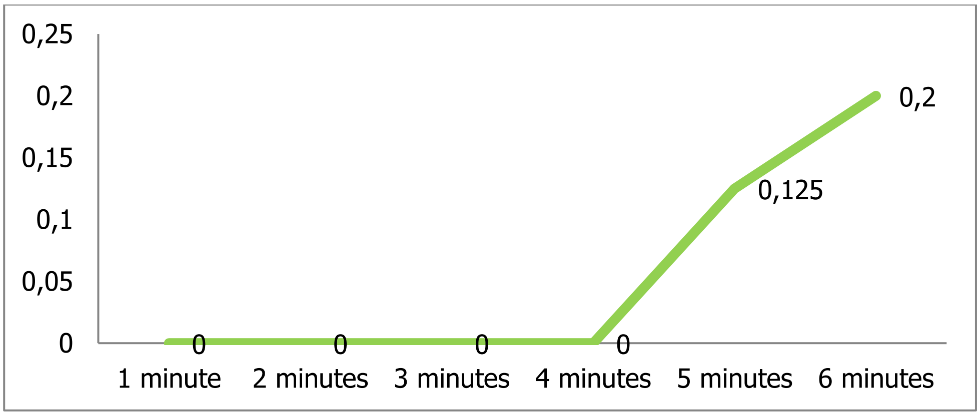

Figure 14. Graph of the Average Increase in T2 of Palm Fiber Composite

In the graph we can see that the average temperature increase of T2 in the palm fiber composite material can be seen that the ΔT temperature is every 1 minute for 6 minutes of the experiment with four tests that the temperature rises in the fifth minute with an increase in the range from 0.125 to 0.2 °C.

d. Coconut Fiber Composite

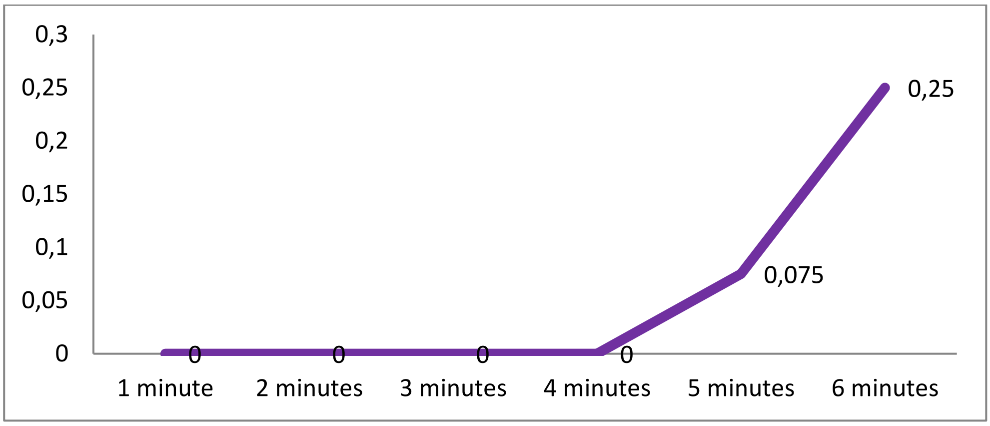

Figure 15 Graph of average increase in T2 of coconut fiber composite

In the graph, we can see that the average temperature increase of T2 in the coconut fiber composite material can be seen that the ΔT temperature is every 1 minute for 6 minutes of the experiment with four tests that the temperature rises in the fifth minute with an increase in the range of 0.075 to 0.25 °C.

e. Mixed Palm Fiber and Coconut Fiber Composites

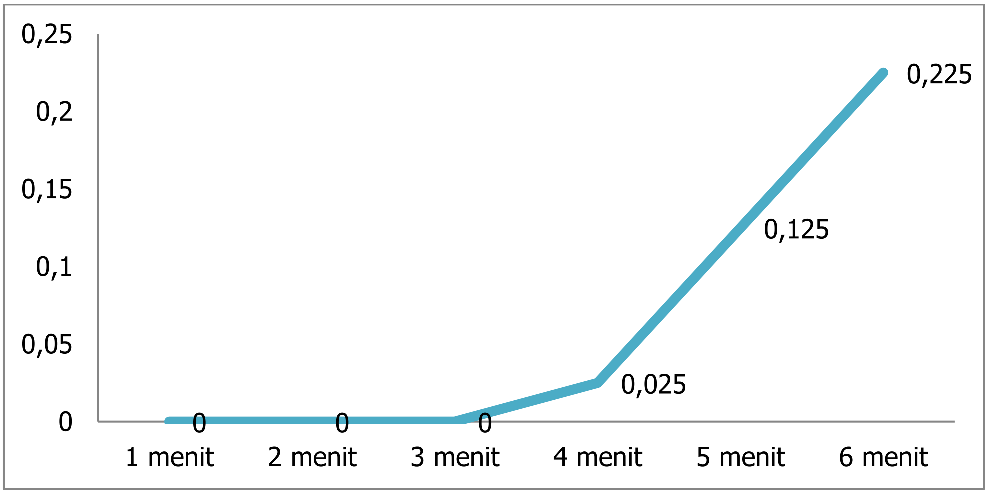

Figure 16. The Graph of The Average Increase in T2 of The Composite Material for Palm Fiber and Coconut Fiber Composites

In the graph, we can see that the average temperature increase of T2 in the mixture of palm fiber and coconut fiber composites can be seen that the ΔT temperature is every 1 minute for 6 minutes of the experiment with four tests that the temperature rises in the fourth minute with a range of increases, namely 0.025 to 0.225 °C.

f. Comparison of the average increase in T2 of all materials

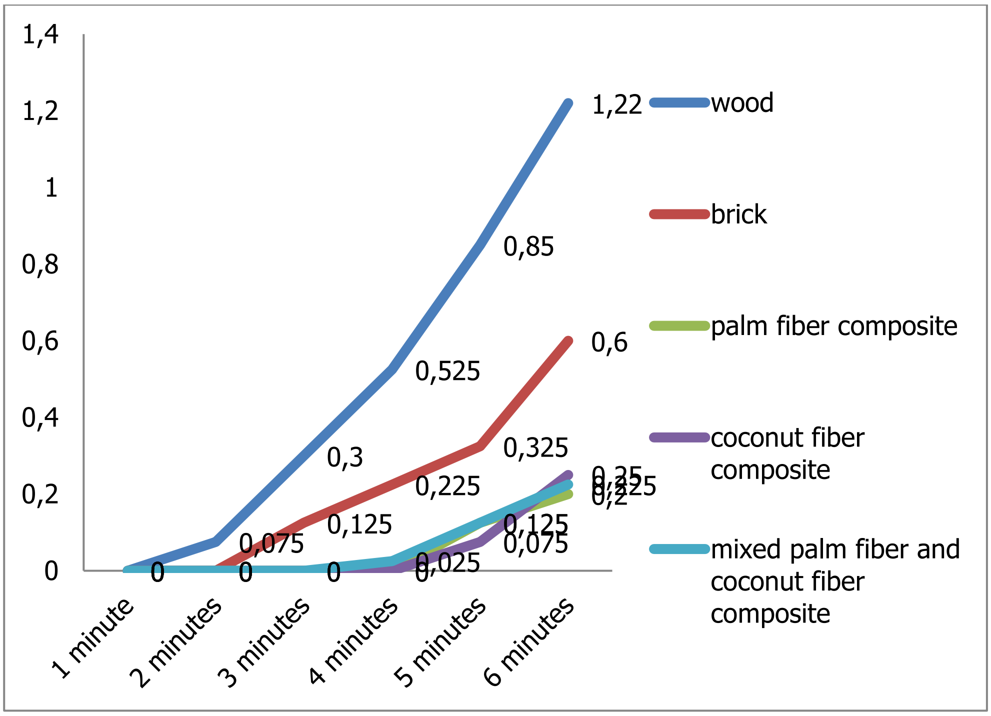

Figure 17. Comparison Graph of The Average Increase in T2 of All Materials

In the graph, we can see that the highest average increase in T2 is for wood, which reaches 1.22 °C, then for bricks with an average temperature increase of 0.6 ° C. For palm fibers composite, coconut fibers composite and a mixture of palm fiber and coconutfiber composite are relatively the same, the average increase in T2 is due to the additives, namely using 70% resin additives and 30 fiber materials, so the values are close to all, 0.2 °C, coconut 0.25 °C, and a mixture of palm fiber and coconut 0.225 °C.

The results of the test specimen test material thermal conductivity obtained ΔT stable temperature in every four experiments and the value of the material's thermal conductivity can be seen in the table below.

Table 9. ΔT stable temperature at each experiment

Specimens	T1	T2	ΔT (T1-T1) ° C	Average ΔT ° C	K
Wood	71.6 74.1 71.8 72.1	32.3 32 31.6 32	39.3 42 40.2 40.1	40.4	4.14
Brick	71.8 72.2 71.4 71.7	32.2 32.5 31.9 32.2	39.6 39.7 39.5 39.5	39.57	3,909
Fiber Composite Fiber	72.6 73.3 71.9 71.5	31 30.9 31.1 31	41.6 42.4 40.8 40.5	41,325	3,7434
Coconut Fiber Composite	71.9 72.6 72 71.5	30.5 30.3 31.3 31.1	41.5 41.5 40.9 40.9	41.15	3.75
Composite A mixture of fibers and coconut fiber	71.8 72.1 72.2 71.9	30.8 30.9 31.5 31	41 41.2 40.7 40.9	40.95	3,777

The ΔT value of the specimen temperature above after data analysis is carried out through the applicable equation, namely:

$$K = \frac{Q}{A}\frac{dX}{dT}$$

Where :

Q = Heat Transfer Rate (kj / sec, W)

K = Thermal Conductivity (W / m. ° C)

A = Cross-sectional Area (m^2)

dT = Temperature Difference (° C)

dX = Distance difference (m / sec)

1. Calculation of the value of thermal conductivity in wood

It is known: Q = 12 Watts

dX = 15 mm (0.015 m)

dT = 40.4 ° C

A = 38mm = 0.038 → $A = \frac{1}{4}\pi d^2$

$= \frac{1}{4} 3{,}14\ (0{,}038)^2$

= 0, 00113354 m

$$K = \frac{12 \text{ x } 0{,}015}{0{,}00113354 \text{ x } 40{,}4}$$

$$= \frac{0{,}18}{0{,}045795012}$$

= 4, 14 ($^W/_m$ °C)

2. Calculation of the value of thermal conductivity in brick

It is known: Q = 12 Watts

dX = 15 mm (0.015 m)

dT = 39.57 ℃

A = 38mm = 0.038 → $A = \frac{1}{4}\pi d^2$

$= \frac{1}{4} 3{,}14\ (0{,}038)^2$

= 0, 00113354 m

$$K = \frac{12 \text{ x } 0{,}015}{0{,}00113354 \text{ x } 39{,}57}$$

$$= \frac{0{,}18}{0{,}0448541718}$$

= 3, 91($^W/_m$ ℃)

3. Calculation of the value of thermal conductivity in palm fiber composites

It is known: Q = 12 Watts

dX = 15 mm (0.015 m)

dT = 41,325 ℃

A = 38, 5 mm = 0.0385 → A = $\frac{1}{4}\pi d^2$

= $\frac{1}{4}$ 3,14 (0,0385)^2

= 0, 0011635663 m

$$K = \frac{12 \text{ x } 0{,}015}{0{,}0011635663 \text{ x } 41{,}325}$$

$$= \frac{0{,}18}{0{,}0480843753}$$

= 3, 7434($^W/_m$ ℃)

4. Calculation of the value of thermal conductivity on coconut belt composites

It is known: Q = 12 Watts

dX = 15 mm (0.015 m)

dT = 41.15 ℃

A = 38, 5 mm = 0.0385 > A = $\frac{1}{4}\pi d^2$

= $\frac{1}{4}$ 3,14 (0,0385)^2

= 0, 0011635663

$$K = \frac{12 \text{ x } 0{,}015}{0{,}0011635663 \text{ x } 41{,}325}$$

$$= \frac{0{,}18}{0{,}0478807532}$$

= 3, 7593($^W/_m$ ℃)

5. Calculation of the value of thermal conductivity in the composite mixture of fibers and coconut fiber

It is known: Q = 12 Watts

dX = 15 mm (0.015 m)

dT = 40.95 ℃

A = 38, 5 mm = 0.0385→ A = $\frac{1}{4}\pi d^2$

$= \frac{1}{4} 3{,}14\ (0{,}0385)^2$

= 0, 0011635663 m

$$K = \frac{12 \text{ x } 0{,}015}{0{,}0011635663 \text{ x } 40{,}95}$$

$$= \frac{0{,}18}{0{,}04764804}$$

= 3, 77769($^{W}/_{m}$ ℃)

After calculating the value of thermal conductivity of several specimens, it can be seen in the graph comparison of the thermal conductivity values below.

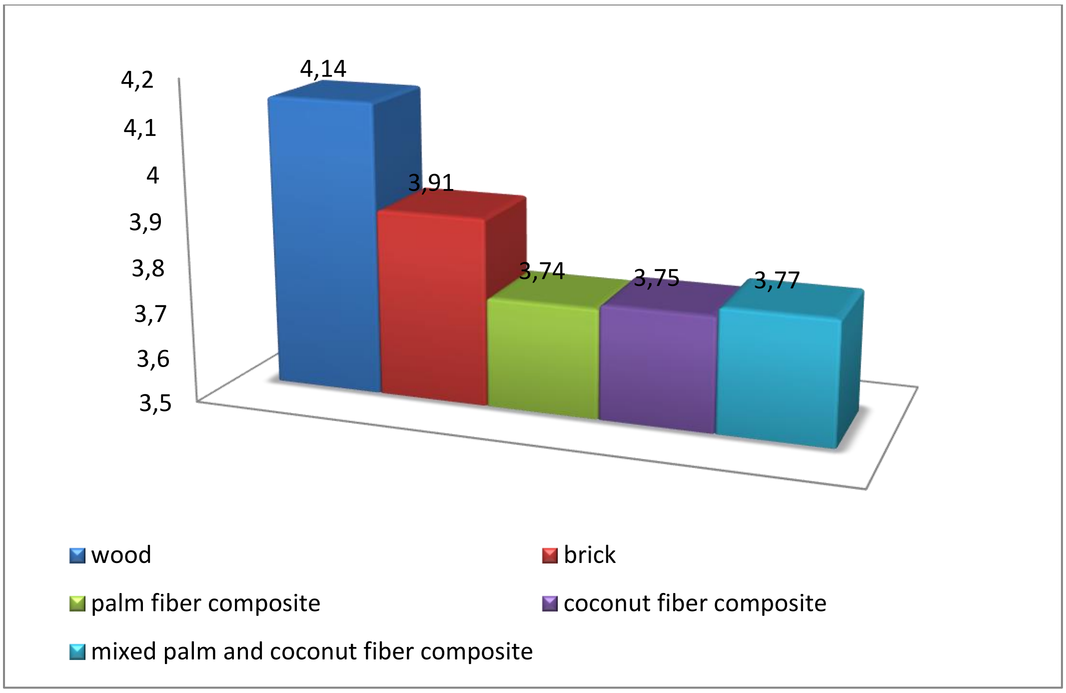

Figure 10. Comparison Chart of Test Material Thermal Conductivity Values

The highest material thermal conductivity value occurred in wood specimens of 4.14 W / m.0C. and so on are bricks 3.91 W / m. 0C, Composite for fibers and coconut coir 3.77 W / m. 0C, Composite for coconut fibers 3.75 W / m. 0C, and Composite for fibers fibers of 3.74 W /m°C. From these data it can be stated that wood has the ability to conduct heat better than other specimens.

After obtaining the thermal conductivity value in each material that has been tested, the conductivity value obtained in this test is compared with the thermal conductivity value that has been obtained previously in existing research. This comparison aims to see whether the results of the thermal conductivity values obtained are close to the existing literature. In this comparison, the researchers only compared one of the materials tested, namely the wood material with a conductivity value of 4.14 W/m°C, because no one has examined the conductivity value for other materials. Another study that has determined the value of the thermal conductivity of wood is the first reference, research conducted by Antonius Dian Putra, the value of the thermal conductivity of wood material obtained in this study is 3.6W /m°C. The second reference, research conducted by Trouve 'and Minnich, the thermal conductivity value of wood material obtained in this study was 1.6 W / m ° C. For comparison, see Figure 4.9.

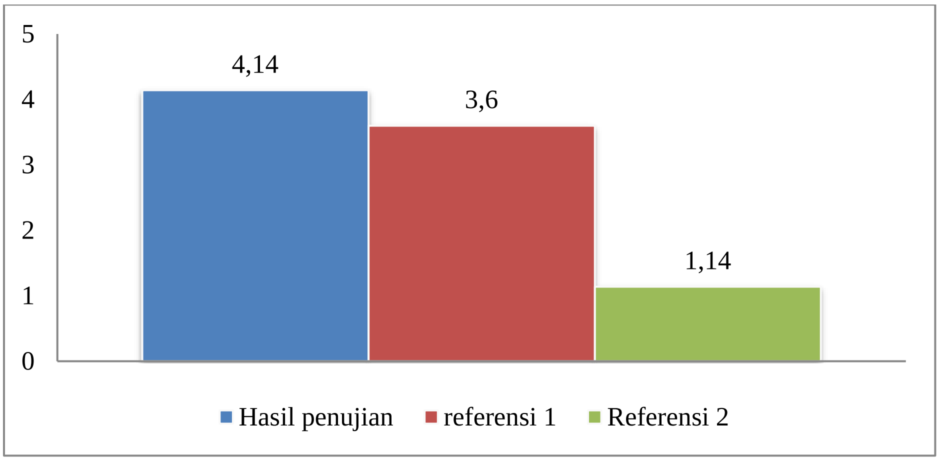

Figure 12. Comparison chart of the thermal conductivity of wood

On the graph we can see the conductivity value obtained in this study and the research that has been done previously Different values, this is because each wood has different physical properties including density, porosity, density and moisture content. The difference in value is relatively close, so it can be concluded that the tool that has been made is almost successful, because the comparison of the results of the research carried out is close to the results of previous research.

CHAPTER V

CONCLUSION AND RECOMMENDATION

A. Conclusions

Based on the objectives in this study, it can be concluded as follows:

1. Has been able to manufacture and test a prototype of a materials' thermal conductivity test equipment that can operate properly.
2. The components of the material's thermal conductivity test equipment are frame, Threaded shaft rail and nut, anvil, heating element, thermometer, aluminum tThreaded, insulator cover, SCR tension regulator and table.
3. In the graph of the highest average increase in T2 in wood, it reaches 1.22 °C, brick it is up to 0.6 °C, the palm fiber composite is up to 0.2 °C, the coconut fiber composite it is up. to 0.25 °C and a mixed palm fiber and coconut fiber composite up to 0.225 °C
4. The highest material thermal conductivity value occurred in wood specimens of 4.14 W/m^{o}C and so on are bricks 3.91 W/m^{o}C, Composite of fibers and coconut composite 3.77 W/m^{o}C, Composite of coconut fibers 3.75 W/m^{o}C, and Composites of palm of 3.74 W/m^{o}C. From these data it can be stated that wood has the ability to conduct heat better than other specimens.
5. After comparing the results of the test tools with the results that have been tested before, it can be stated that the tools made are close to being successful.

B. RECOMMENDATION

1. The precision of work is very influential on the performance results of the material's thermal conductivity tester, so pay attention to this very important point.
2. Because the manufacturing is not finished in a day, give the names of each component that has been made so that you don't get confused during the installation / assembly process.
3. At the time of testing, care must be taken because when the tool is turned on, the conductor will be hot, so do not get it on the hands or body parts.
4. In this tool there are still shortcomings, when after testing the heat on the old conductor or aluminum decreases so that it takes time to wait for the conductor to be at a stable temperature.
5. Don't procrastinate the build process as that will make the old tool complete.

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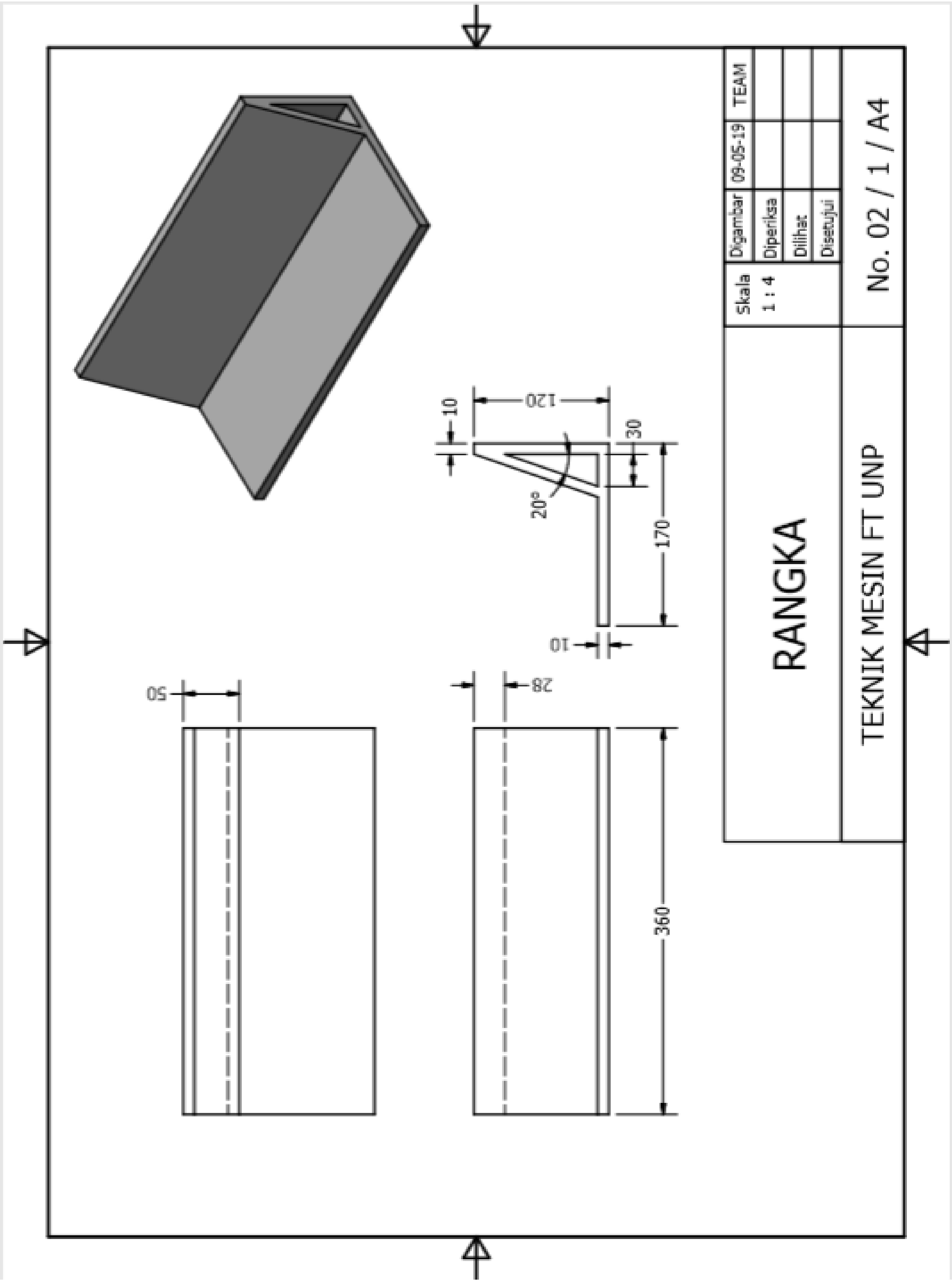
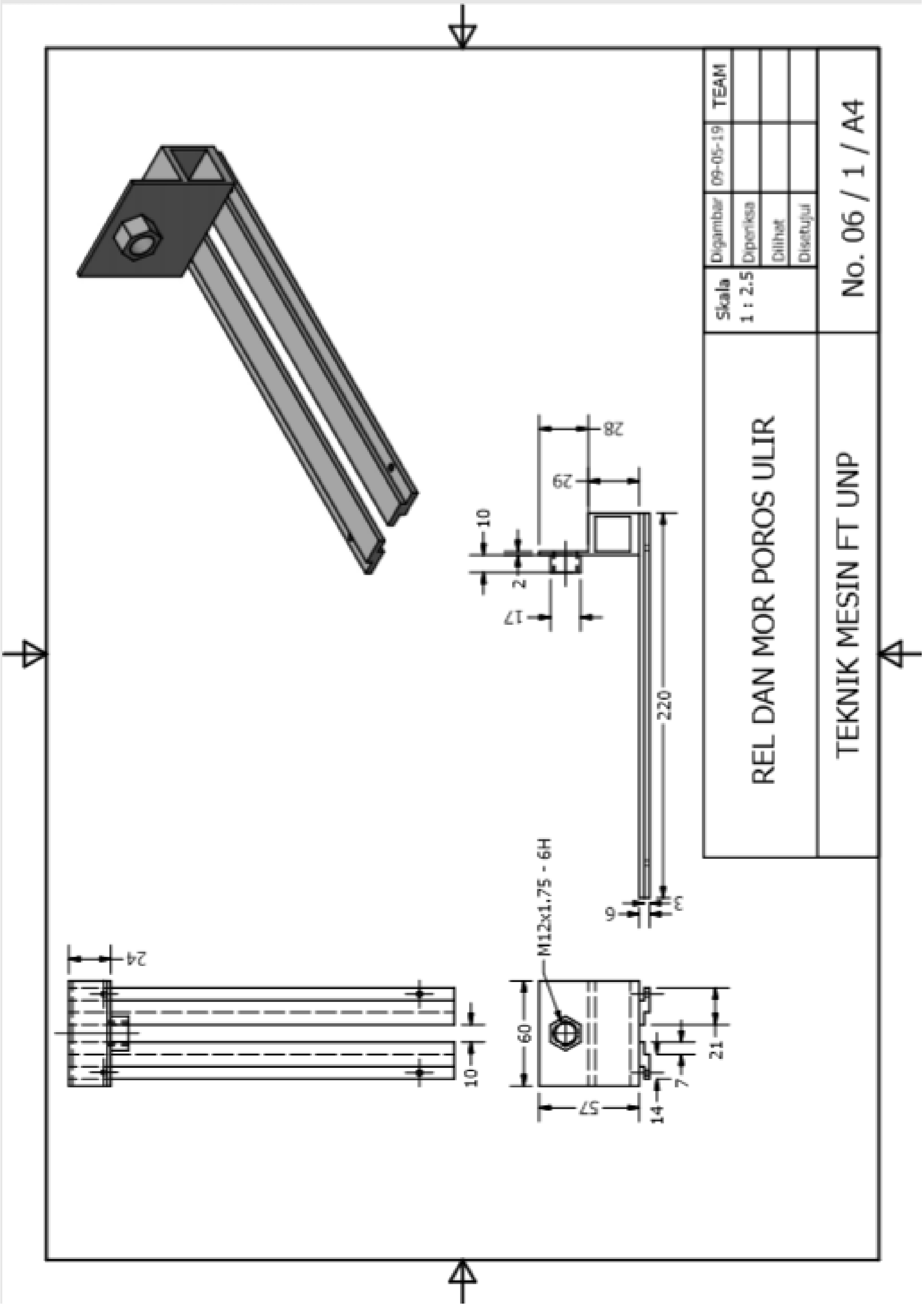
Attachment 1. Design

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Dilihat
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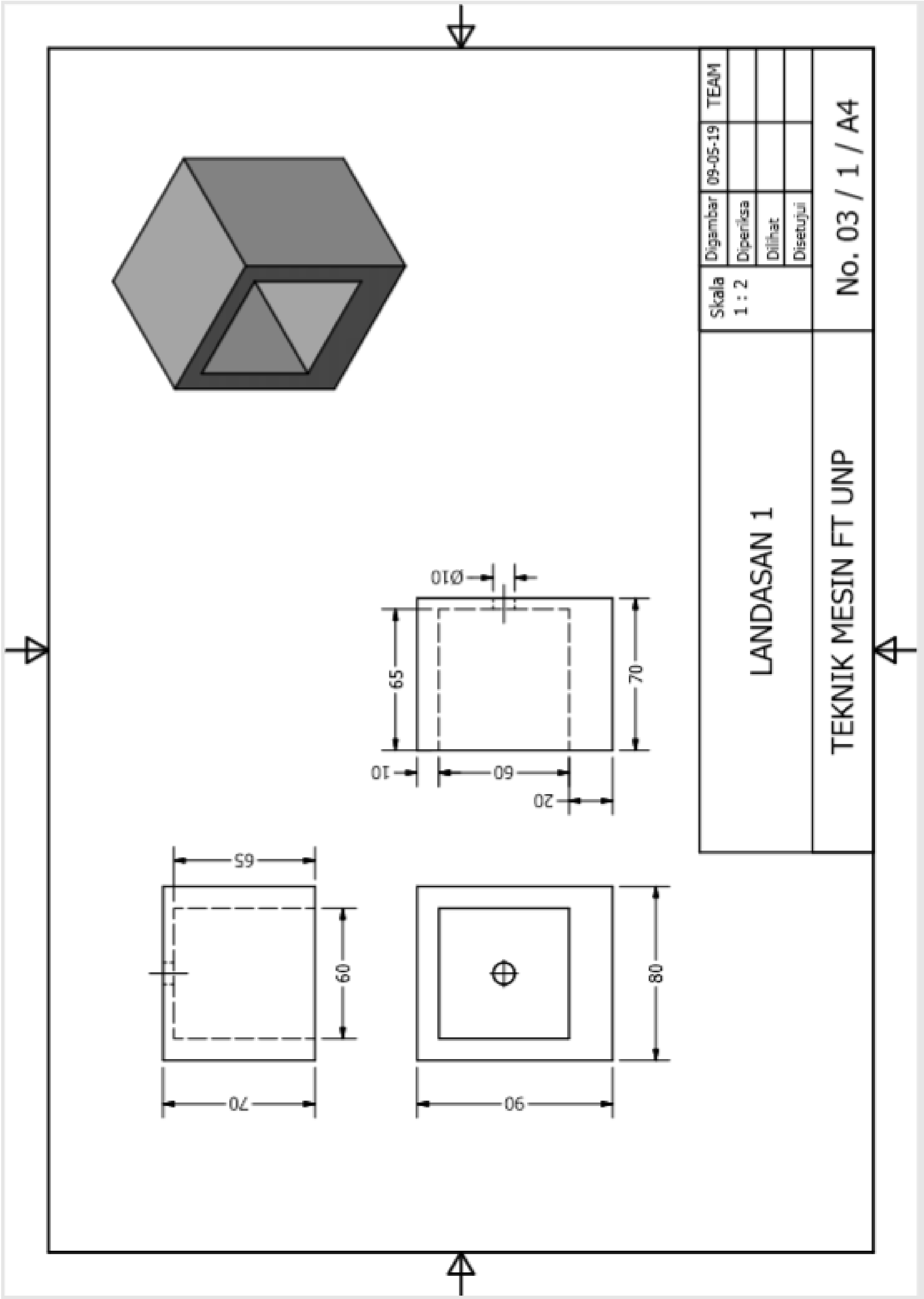

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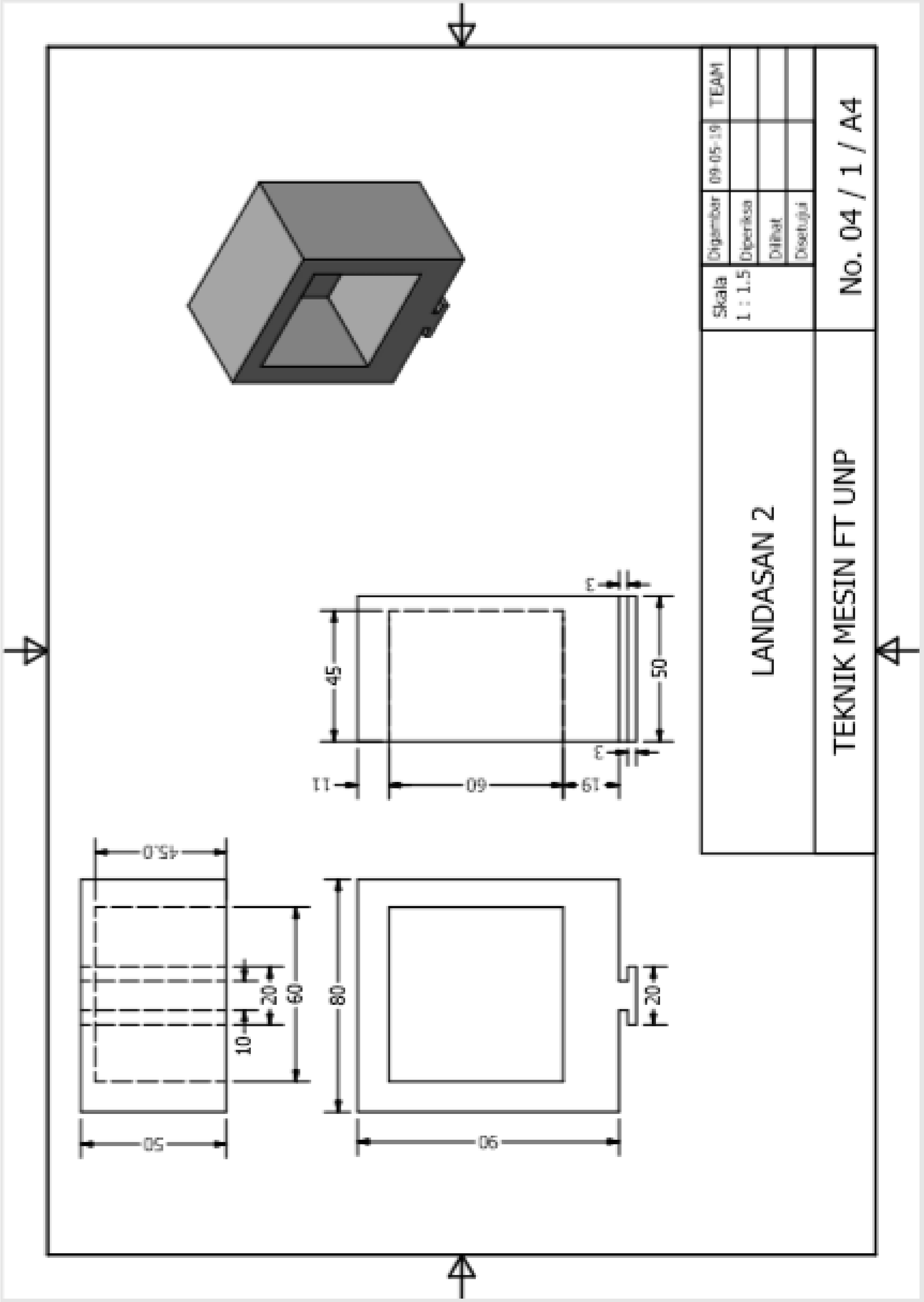
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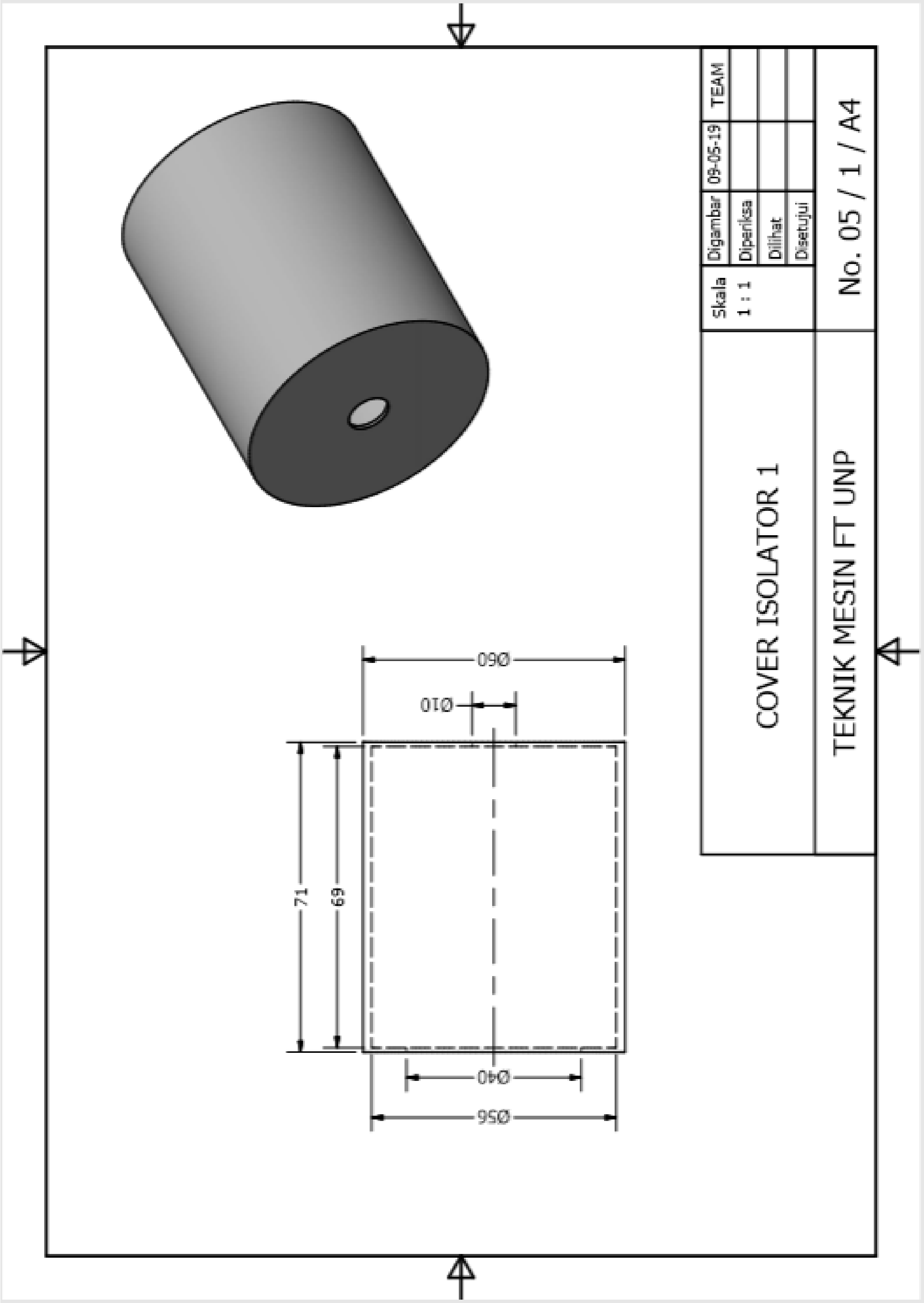

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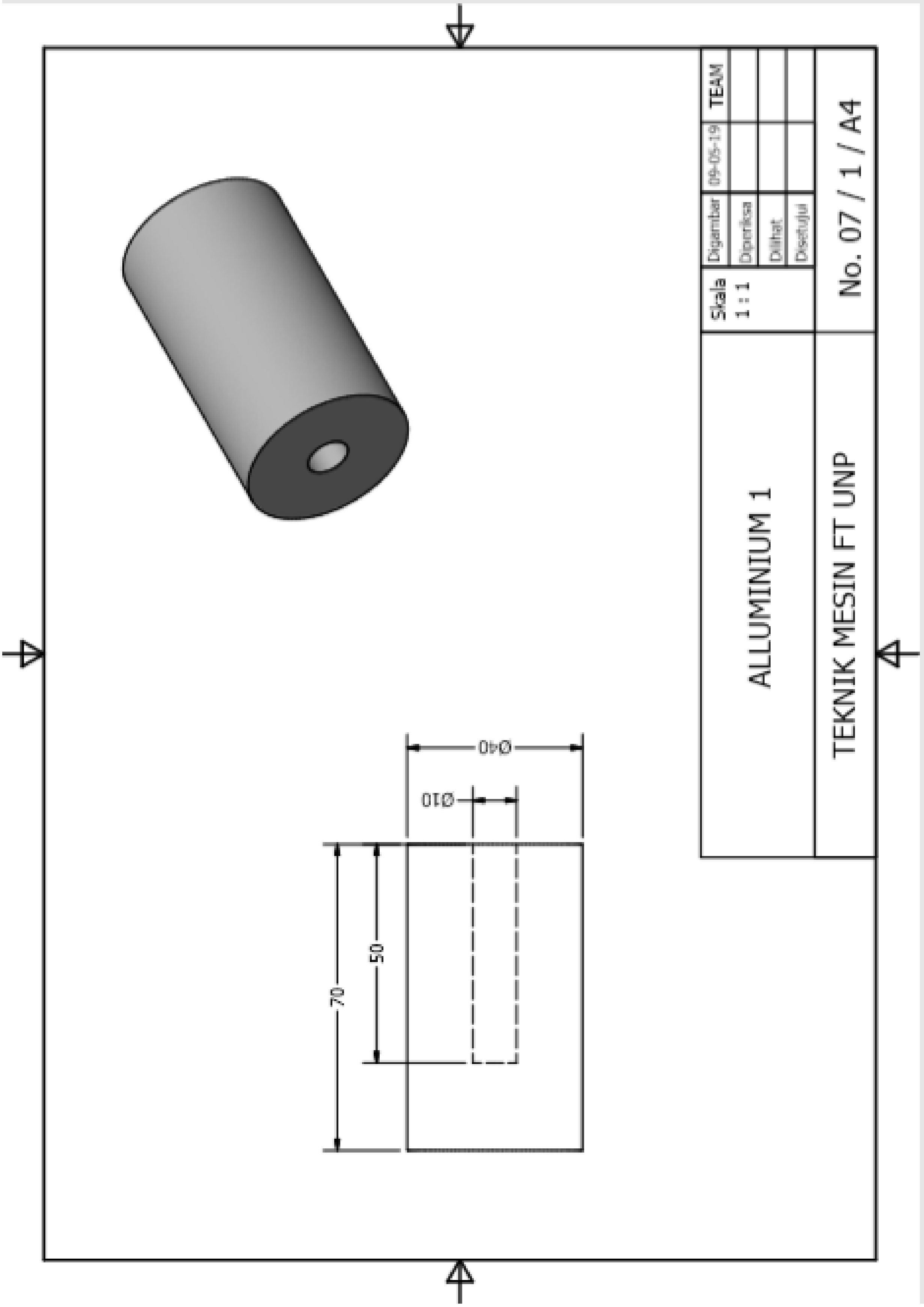

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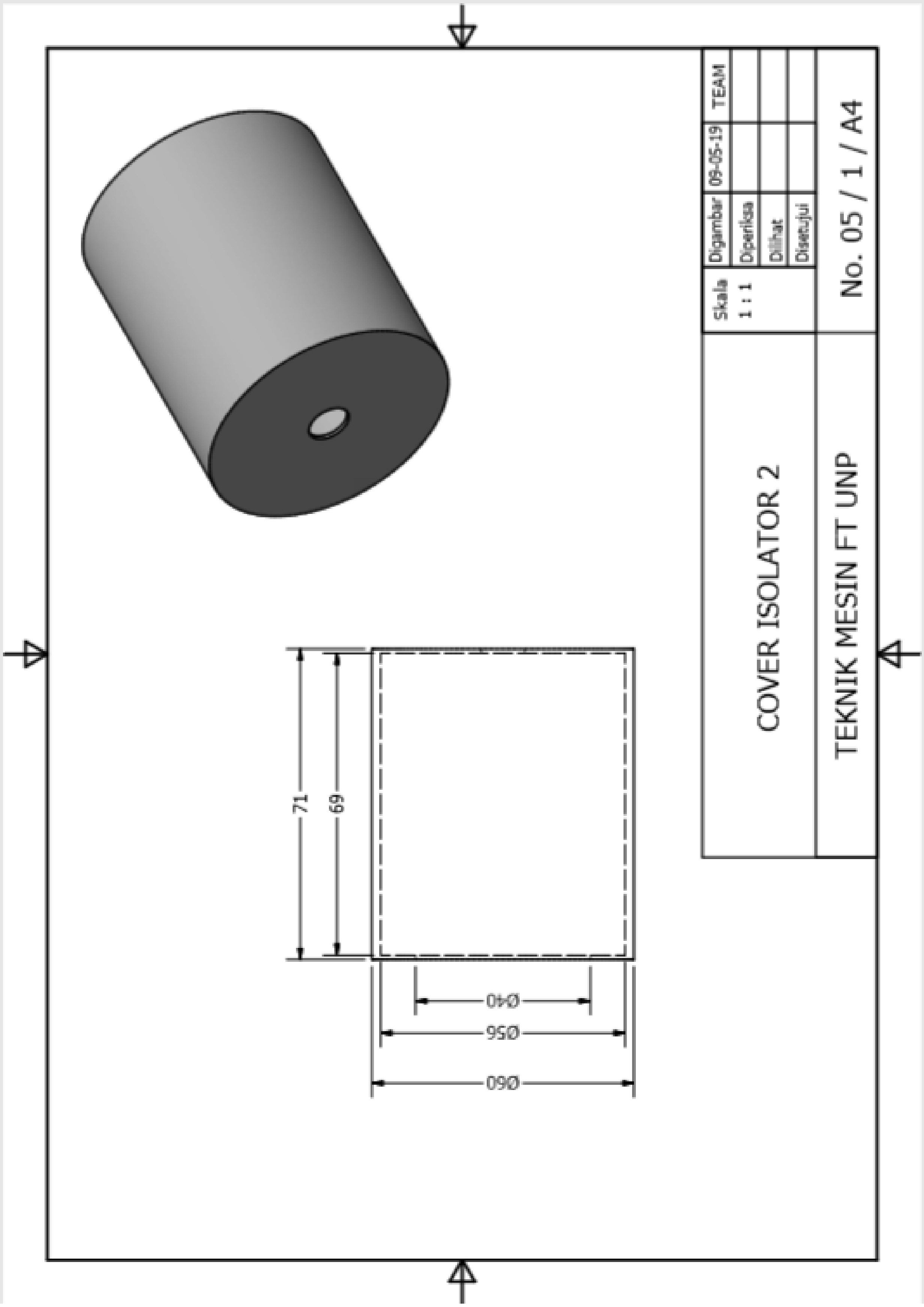

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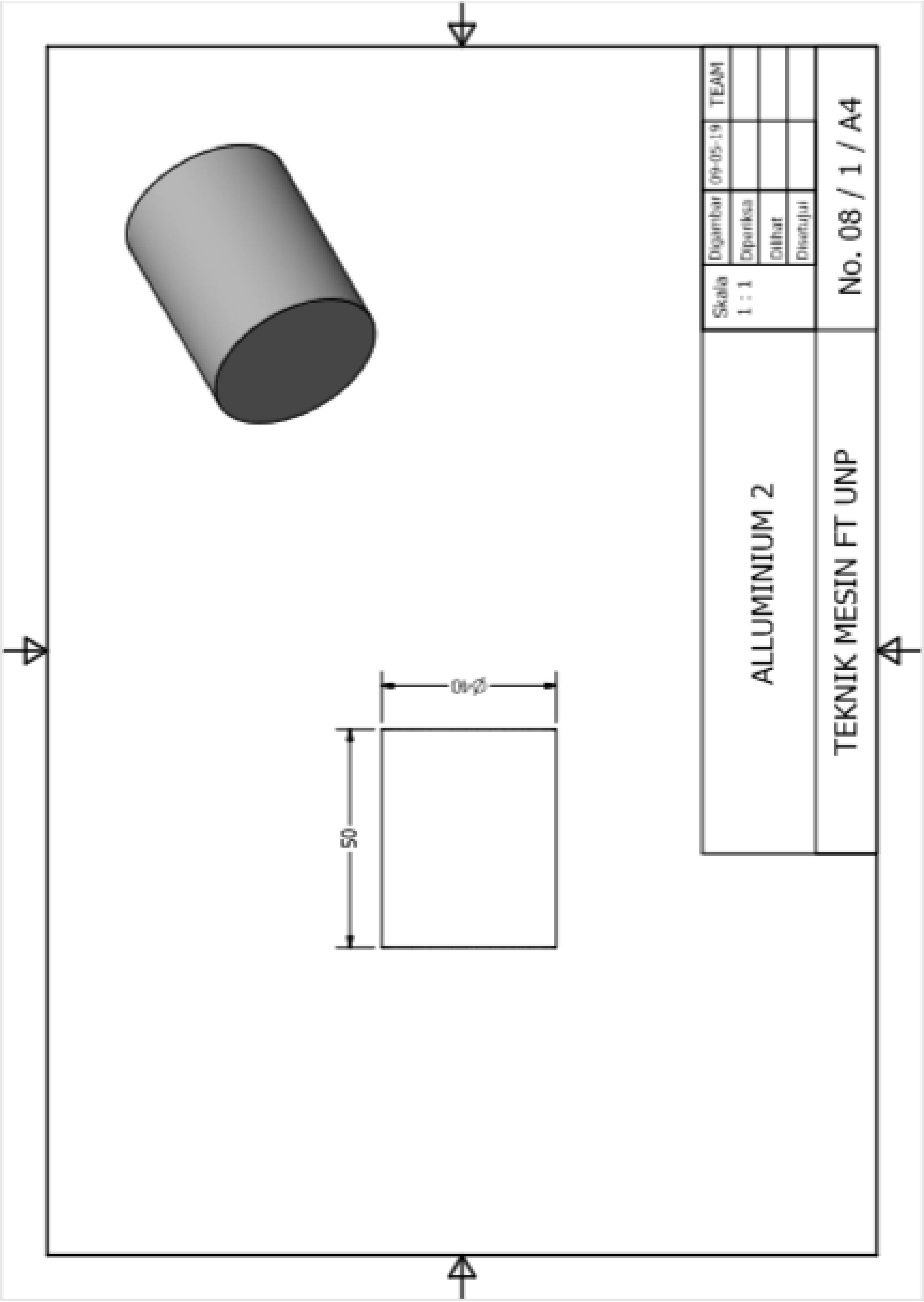
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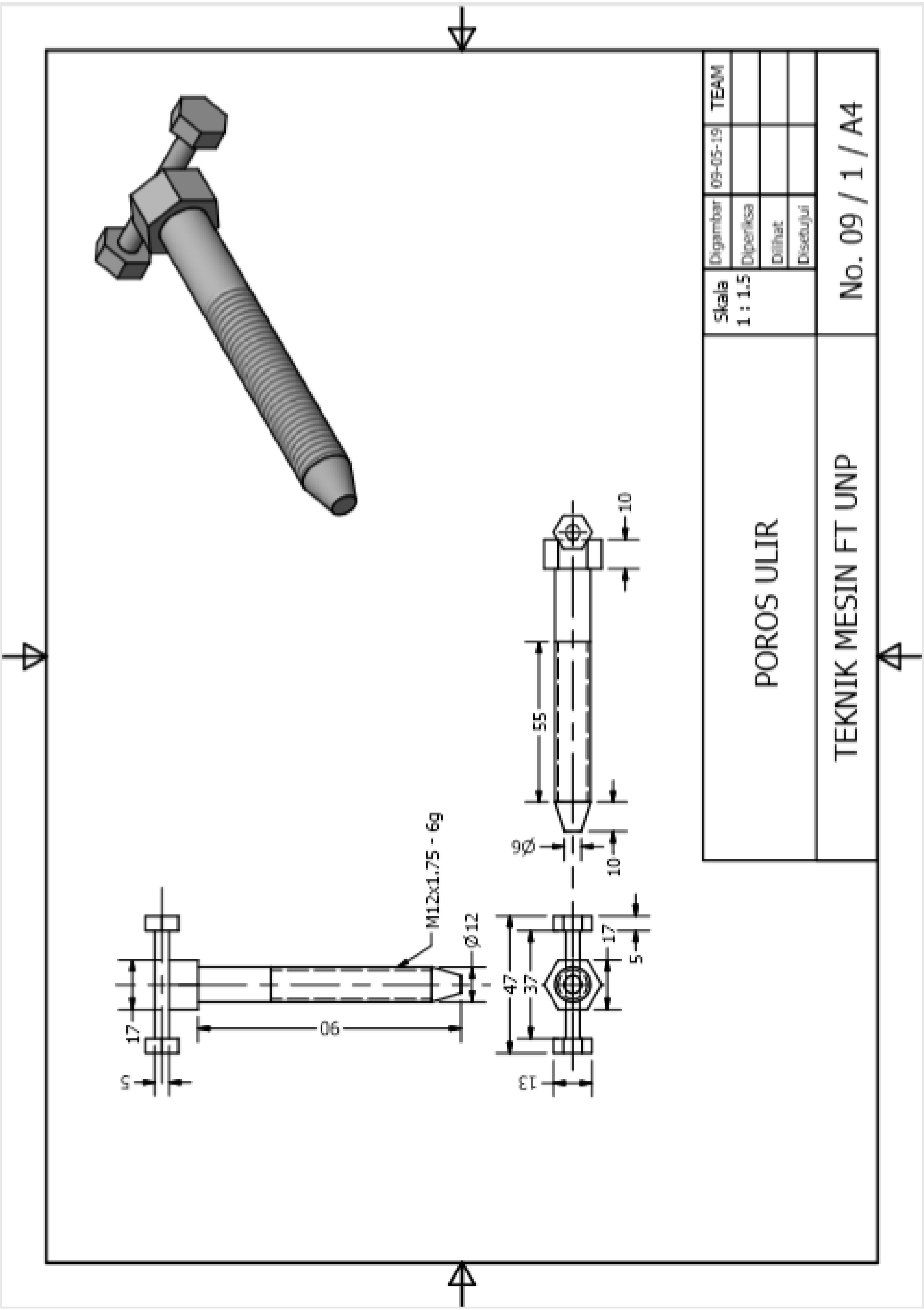
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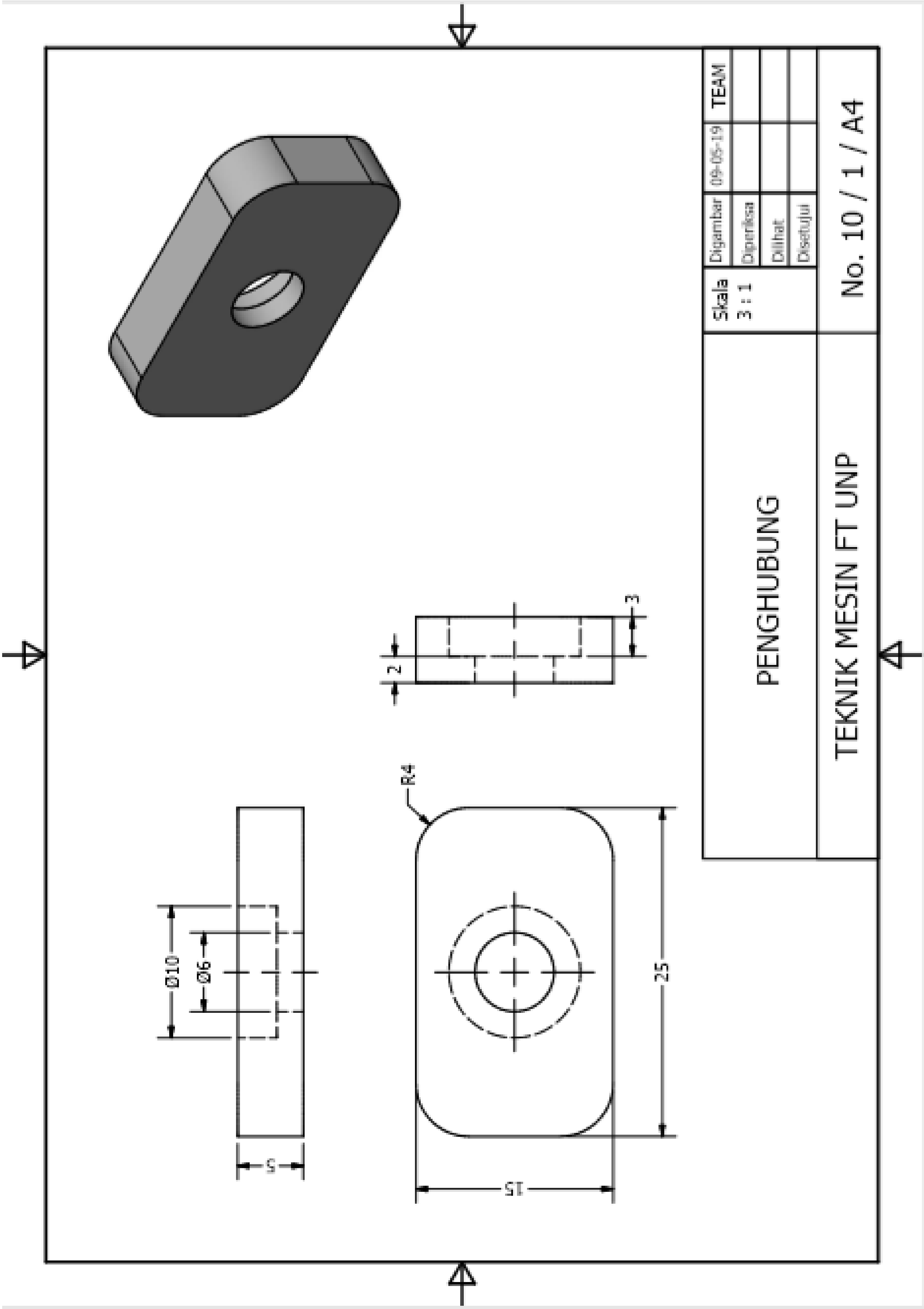
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3
PENGHUBUNG
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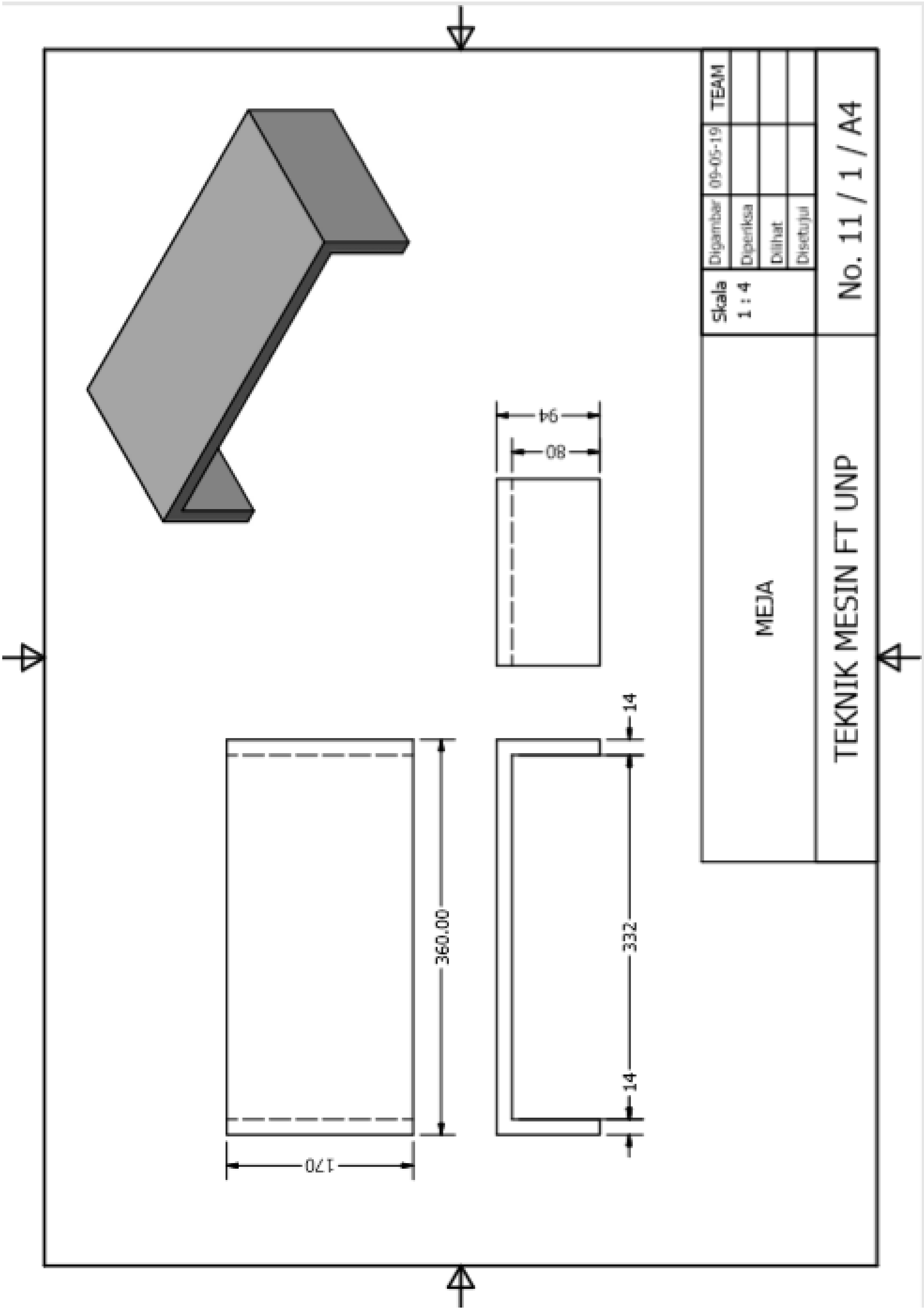
No. 10 / 1 / A4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Disetujui
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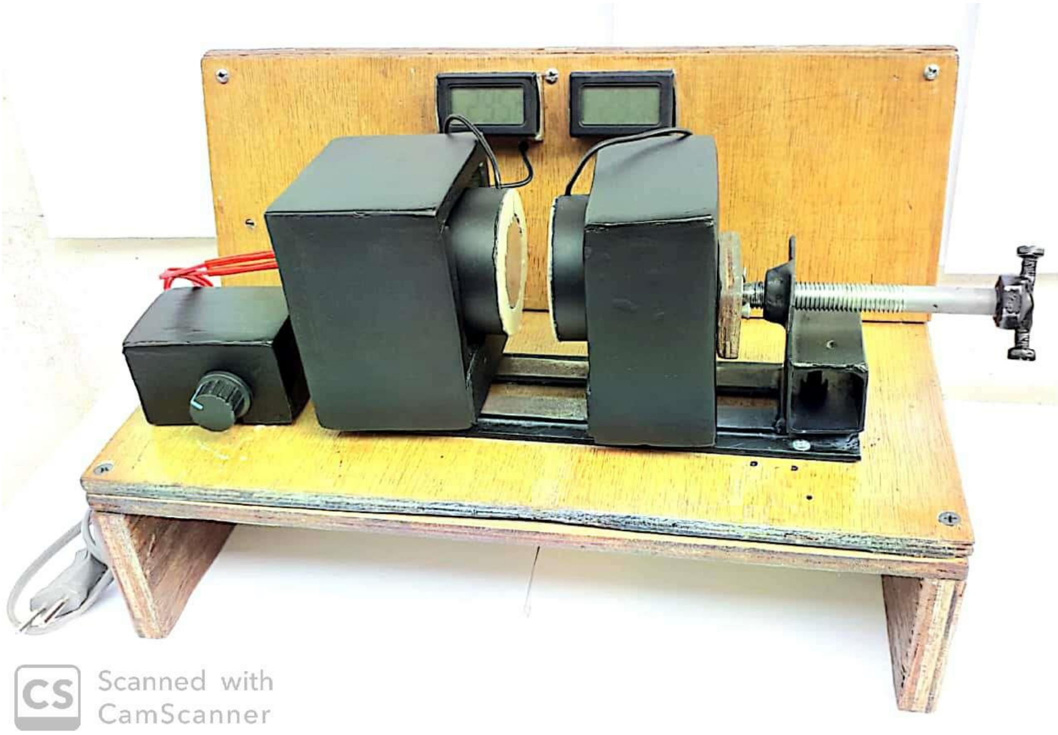
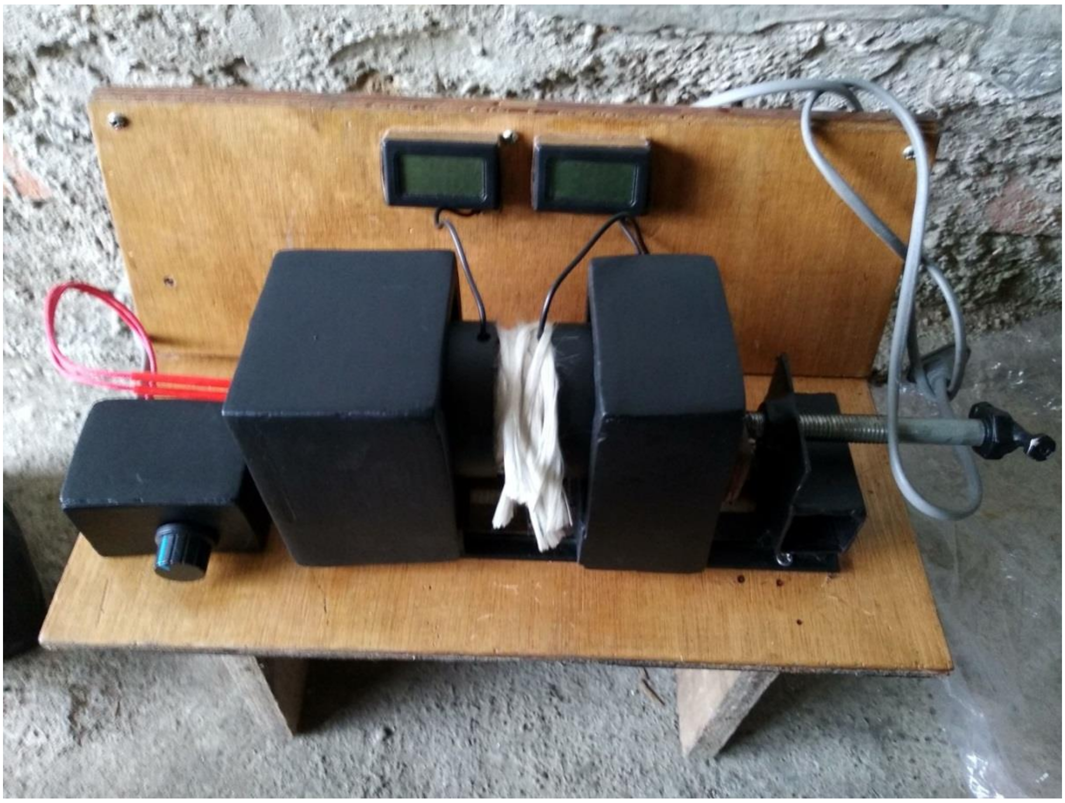
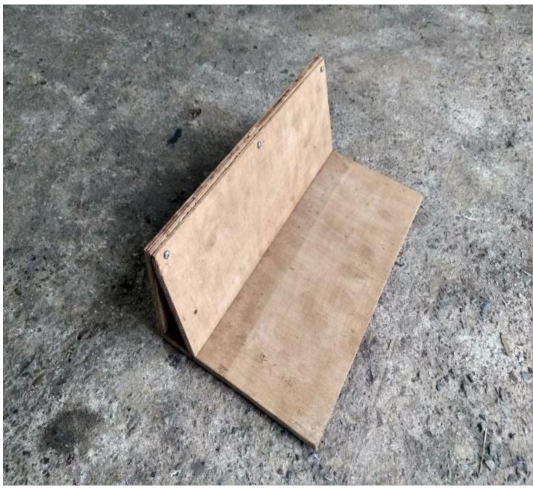
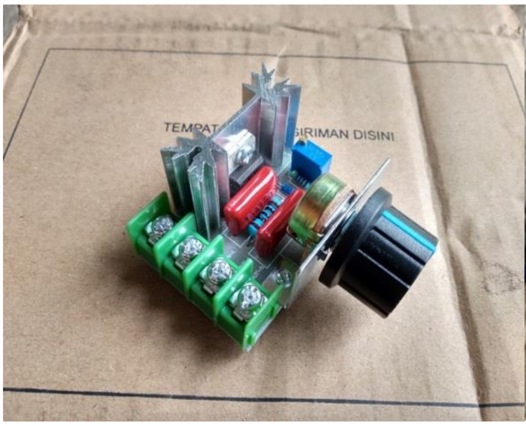
Attachment 2. Research Documentation








TEMPAT
DISINI








Attachment 3. Supervision Sheet

KEMENTERIAN RISET, TEKNOLOGI DAN PENDIDIKAN TINGGI
UNIVERSITAS NEGERI PADANG
FAKULTAS TEKNIK
JURUSAN TEKNIK MESIN

Alamat: Jl. Prof. Dr. Hamka, Kampus UNP Air Tawar, Padang 25131
Telp. (0751) 7055644, 445118 Fax (0751) 7055644, 7055628
website: www.ft.unp.ac.id e-mail: info@ft.unp.ac.id

LEMBARAN KONSULTASI
SKRIPSI/PROYEK AKHIR*)

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NIM/TM : 15067071/2015
Prog. Studi : Pendidikan Teknik Mesin
Pembimbing : Dr. Ir. Arwizet K,S.T.,M.T.
Judul : Pembuatan dan Pengujian Alat Uji Konduktivitas Termal Bahan

No	Hari/Tanggal	Uraian Konsultasi	T. Tangan Pembimbing
1.	26 Maret 2019	Perbaikan Judul dan Penambahan	
2.	10 April 209	Perbaikan pada Bab I dan penambahan referensi Latar Belakang.	
3	18 April 2019	Perbaikan pada rumusan masalah di Bab I	
4.	26 April 2019	Perbaikan Bab II dan penambahan Materi tentang konduktivitas dan perpindahan panas	
5.	13 Mei 2019	Perbaikan pada Bab II dan pengubahan Materi tentang teori pembuatan	
6.	14. Mei 2019	Penambahan lampiran gambar alat yang akan dibuat.	

No	Hari/Tanggal	Uraian Konsultasi	Paraf Pembimbing
7.	15 Mei 2019	Acc Seminar.	
8.	23 Juli 2019	Perbaikan Pendahuluan dan BAB III	
9.	31 Juli 2019	Perbaikan Pada BAB IV dan penambahan teori percobaan.	
10.	2 Agustus 2019	Perbaikan Jurnal	
11.	7 Agustus 2019	ACC Kompre	