CHAPTER 1

INTRODUCTION

1.1 Background of The Research

The development of air conditioning systems to reduce room temperature is needed by humans to obtain comfort in the room. Currently, air conditioning systems are increasingly widespread, both in construction, machinery, buildings, and other fields. This is because the needs for air conditioning systems continue to grow according to the efficiency and needs of consumers.

In engineering, especially in industrial engineering, it is very important to learn well about materials because these materials are used for various purposes, one of which is the nature of air flow through a heat exchanger which is intended to cool the air in the room. The results of this decrease in air temperature greatly determine the performance of the room temperature. Then it can be defined that the result of a decrease in air temperature is a material's ability to conduct temperature in the air flow.

The effect of the pressure drop (Δp) of two-phase flow through a 45^o bend has decreased [Awaluddin, 2014]. Used a combination of variations in the air flow rate of the material used. The faster the air flow rate that enters the intake ram-air intake channel, the greater the mass flow rate value obtained [Tony, 2012]

1.2 Formulation of the Problem

In general, the temperature reduction system uses a cooling system such as air conditioning or a fan. But in this case, students try to analyze the decrease in air temperature by using water reservoirs.

1.3 Limitation of the Problem

The problem limitation of this undergraduate assignment is analysis. To avoid irregular discussions and considering the broad of the discussion and accompanied by the limitations of the author's ability and knowledge, in this undergraduate thesis the author limits the problem to only:

1. Analyzing the air temperature reduction system using water reservoirs
2. The research object is analyzed from the model scale.
3. The analysis is limited to a decrease in the temperature of the air inlet and outlet of the system

1.4 The Research Objective

The purpose of the analysis of this air flow rate test equipment is as follows:

1. Analyzing the decrease in air temperature using water reservoirs.
2. Analyze the incoming air flow and the results of the decrease in air temperature with certain materials.
3. Gain efficiency from the temperature reduction system

1.5 The Research Benefits

The research benefits of this air temperature reduction analysis are as follows:

- Understand and know how the system works.
- Knowing the effect of heat exchanger.
- Knowing the results of the heat exchanger.
- Knowing the changes due to each treatment.

1.6 Systematic of Writing

This research is structured with the following systematic writing: The introduction section contains the title page, validation page, introduction, table of contents, list of pictures, and list of attachments. The content of the research report consists of: chapter I introduction contains the background, problem formulation, objectives and benefits, problem limitation, and systematic report writing. Chapter II Literature review, contains an overview of fluids, materials, types of air flow rate test equipment, air flow testing due to heat exchangers. Chapter III Research methodology, is a series of implementations by describing research design, materials and tools used for research, measuring test equipment, flow charts, data collection techniques, data analysis and research sites. Chapter IV Analysis of research results and discussion, contains data on research results, analysis and discussion which are displayed in tables and diagrams. And this research is closed with chapter V Closing contains conclusions and suggestions.

CHAPTER 2

LITERATURE REVIEW

2.1 Basic Properties of Fluids

A fluid is a substance which in a state of equilibrium cannot withstand a shear force or stress. Another fluid definition is a fluid that can flow, which has particles that can move and change its shape without mass separation. Fluid resistance to deformation is very small so that the fluid can easily follow the shape of space. Based on its form, fluids can be divided into two, namely:

1. Gas fluid, is a fluid with loose particles where the attractive force between similar molecules are relatively weak and very light so that it can float freely with uncertain volume.
2. Liquid fluid, is a fluid with dense particles where the attraction between similar molecules is very strong and has a free surface and tends to maintain its volume.

To understand everything about fluid flow, you must first know some of the basic properties of fluids. The basic properties of the fluid are: specific gravity, density, pressure, temperature, viscosity.

2.1.1 Specific Gravity

The specific weight of a fluid, denoted by γ (gamma), is defined as the weight per unit volume. Formulated as follows:

$$\gamma = \frac{W}{\forall} = \frac{mg}{\forall} = \frac{\rho \forall g}{\forall} = \rho g \qquad (2.1)$$

Where;

γ = specific gravity (N/m^3)

ρ = substance density, (kg/m^3)

g = acceleration due to gravity = 9,81 m/s^2

2.1.2 Density

The density of a fluid is defined as the mass per unit volume at a certain temperature and pressure. Density is expressed by ρ (is a lowercase Greek letter pronounced "rho") and formulated as follows:

$$\rho = \frac{mass}{Volume\ unit} = \frac{m}{V} \text{ (Kg/m}^3\text{)}$$

Fluid density varies depending on the type of fluid. For gas fluids, changes in temperature and pressure greatly affect gas density. For liquid fluid, the influence of both is small. If the fluid density is not affected by changes in temperature or pressure, it is called an incompressible fluid.

2.1.3 Relative Density

Relative density is the ratio between the density of certain fluid to the density of standard fluid, usually water at 4^{o}C (for liquids) and air (for gases). Relative density (specific gravity abbreviated SG) is a pure quantity without dimensions or units, expressed in the following equation:

For gas fluid: $SG_{gas} = \frac{\rho gas}{\rho air} = \frac{\rho gas}{1205\ Kg/m3}$ (2.3)

For liquid fluid: $SG_{liquid} = \frac{\rho liquid}{\rho air} = \frac{\rho gas}{1000\ Kg/m3}$ (2.4)

2.1.4 Pressure

Pressure is defined as the magnitude of the force (F) per unit area of the subjected field (A). If a substance (solid, liquid, and gas) receives a force that acts perpendicular to the surface area of the substance, it can be formulated:

$$P = \frac{F}{A} \tag{2.5}$$

where;

P = pressure (N/m^2)

F = force (N)

A = cross-section area (m^2)

The SI (International Unit) unit for pressure is Pa (Pascal) derived from Newton/m^2. Other pressure units are more commonly used in engineering, such as psi (pounds per square inch), bar, atm, kgf/m2 or in the height of liquids column such as cmHg.

If a point (object) is at a certain depth h below the surface of the liquid as shown in Figure 2.1, then the weight of the object causes the liquid to exert pressure. Pressure affected by this depth of the liquid is called the hydrostatic pressure. This pressure occurs because of the weight of the water which makes the liquid release pressure

Figure 2.1 Pressure at Depth h in Liquid [19]

The force working on the area is F = mg = ρhg, where Ah is the object's volume, ρ is the density of the liquid (assumed constant), and g is the acceleration due to gravity acceleration. Then the hydrostatic pressure Ph is

$$\text{Ph} = \frac{mg}{A} = \frac{\rho\, A\, h\, g}{A} = \rho\ g\ h \qquad (2.6)$$

Understanding hydrostatic pressure by conducting experiments using used cans without lids with holes at different heights, but located in one vertical line, then all holes will emit water. However, each hole emits water at a different distance. The bottom hole is the one that emits the strongest water. So, the force of gravity causes the liquid in the container is always pulled down. The higher the liquid in the container, the greater the pressure of the liquid, so that the greater the pressure of the liquid at the bottom of the container.

Gauge pressure is the difference between the unknown pressure and atmospheric pressure (external air pressure). The pressure value measured by the pressure gauge is the gauge pressure. The actual pressure is called the absolute pressure.

Absolute Pressure = Gauge Presure + Atmospheric Pressure

$$P = Pgauge + Patm \quad (2.7)$$

Pressure gauges and several other types of devices have been invented to measure pressure, among which the simplest is the open tube manometer, as shown in Figure 2.2. The manometer is used to measure pressure tera which consists of a U-shaped tube filled with liquid, generally mercury (mercury) or water.

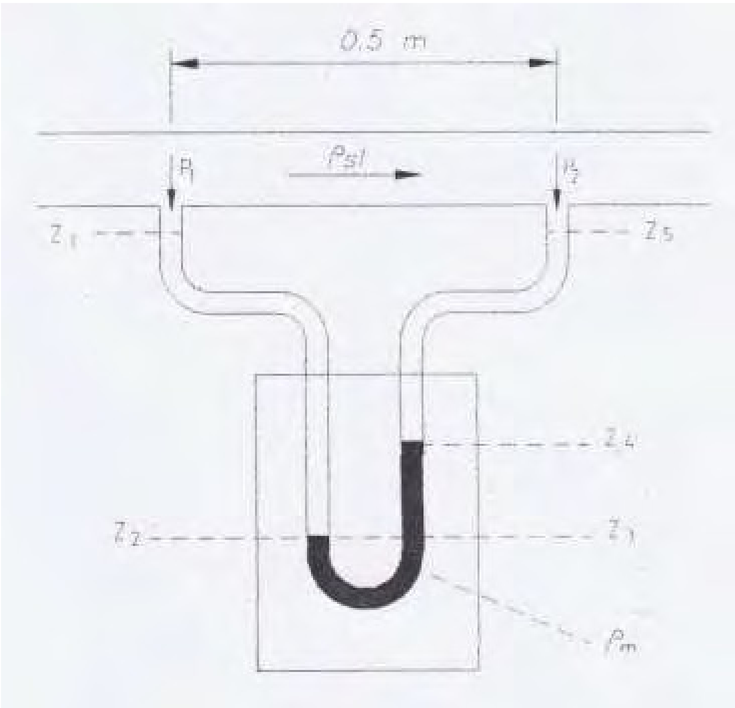


Figure 2.2. Manometer U

$$P_1 + (Z_1 - Z_2)g\rho_m = P_2 + (Z_5 - Z_4)g\rho_{si} + (Z_4 - Z_2)g\rho_{si}$$

$$P_1 - P_2 = (Z_4 - Z_2)g(\rho_m - \rho_{si}) \quad (2.8)$$

2.1.5 Temperature

Temperature is related to the internal energy level of a fluid. Each atom in an object each moves, either in the form of displacement or movement in place in the form of vibration. The higher the energy of the atoms composing the object, the higher the temperature of the object.

The temperature is measured with a thermometer. The four best known types of thermometers are Celsius, Reamur, Fahrenheit and Kelvin. The comparison between one type of thermometer with another thermometer shall follow [8] :

$$C : R : (F-320) = 5 : 4 : 9 \text{ and}$$

$$K = C + 2730 \tag{2.9}$$

2.1.6 Viscosity

Viscosity is defined as the internal resistance to flow, and some experts can also define it as the friction of the fluid. Viscosity is a value measured by the fluid's resistance to deform due to shear stress and tensile stress. In everyday life we can find fluids such as water, jelly, honey, milk, it can also be said that because the shear stress of water is small, so it is easy to fall, the viscosity of water is smaller than honey, because honey has a greater internal shear stress, so that when honey is dripped it is more difficult to fall than water.

The simplest understanding is that the smaller the value of viscosity, the easier a fluid to move. An ideal fluid is a fluid that has no frictional resistance to shear stress, or is usually called an inviscid fluid, while a normal fluid always has a frictional resistance to shear stress, which is called a viscous fluid. Rheology is the science that studies the flow of an object. In it there are also the concepts of viscosity, thermofluid and other relationships

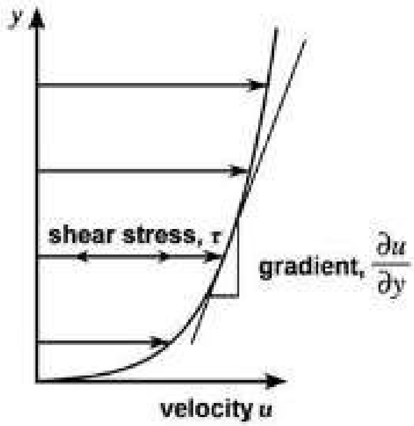


Figure 2.3 Changes in shape due to the application of shear stress [13]

The relationship between shear stress and viscosity and velocity change can be understood in the case of flow between two flat plates as shown in Figure 2.3. Suppose the distance between the plates is y and between the plates there is a fluid with a homogeneous content. Assume that the plate is very wide. With a large area A, the side effect can be considered non-existent. The lower plate is assumed to be fixed and then a force of F is applied to the upper plate. If it turns out that this force causes the material between the two plates to move with a change in velocity u, the force exerted is proportional to the area and the change in velocity.

The applied force is proportional to the area and gradient velocity in fluid:

$$F = \mu A \frac{6u}{6y} \tag{2.10}$$

This equation can be expressed in terms of shear stress $\tau = \frac{F}{A}$, so that

$$\tau = \mu \frac{6u}{6y} \tag{2.11}$$

where;

τ = shear stress (N/m^2)

μ = dynamic viscosity (Pa s)

A = plate cross-sectional area (m^2)

du/dy = velocity gradient (s-1)

The important things that can be concluded are as follows:

a. The shear stress is directly proportional to the change in velocity with the direction perpendicular to the layer.

b. The shear stress is also directly proportional to the viscosity value of a fluid, the greater the viscosity value of the fluid, the greater the shear stress required to flow the fluid.

The ratio between dynamic viscosity and density is called kinematic viscosity, namely:

$$V = \frac{\mu}{\rho} \qquad (12.2)$$

Density, kinematic viscosity and dynamic viscosity of a fluid are strongly influenced by temperature. The physical properties of water and various other liquids on the effect of temperature variations are given in Table A1 in the appendix.

2.2 Fluid Flow in Pipes

Moving fluids can be classified into several categories. Weather the flow is steady or unsteady, whether the fluid is compressible or incompressible, whether the fluid is viscous or non-viscous, or whether the fluid flow is laminar or turbulent. If the fluid is steady, the velocity of the fluid particles at any point is constant with respect to time. Fluids in various parts can flow at different rates or velocities, but fluid at one location always flows at a constant rate or velocity.

An incompressible fluid is a fluid that cannot be compressed. Most fluids can be said to be incompressible. You can easily say that a gas fluid is a compressible fluid, because it can be compressed. A viscous fluid is a fluid that does not flow with easy, like honey and asphalt. Meanwhile, non-viscous fluids are fluids that flow easily, such as water.

2.2.1 Laminar and Turbulent Flow in Pipes

Fluid flow can be divided into laminar flow and turbulent flow, depending on the type of flow line generated by the fluid particles. If the flow of all fluid particles moving along a line parallel to the direction of flow (or parallel to the pipe diameter, if the fluid flows through the pipe), such a fluid is said to be laminar. Laminar fluids are sometimes referred to as viscous fluids or streamlined fluids. The word laminar comes from the Latin “lamina”, which means a thin layer or plate. Thus, laminar flow means flow in layers. The fluid layers will overlap each other without crossing as shown in Figure 2.5 (top).

If the motion of the fluid particles is no longer parallel, they begin to cross over each other, so that form a vortex in the fluid, this type of flow is called turbulent flow, as shown in Figure 2.5 (bottom).

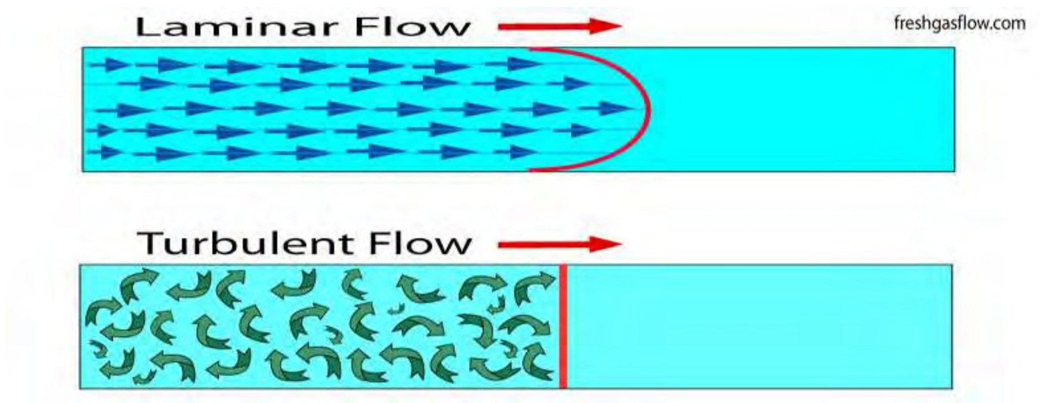


Figure 2.5 Laminar flow (top) and turbulent flow (bottom) [16]

The characteristics of the internal flow structure (in the pipe) are very dependent on the average flow velocity in the pipe, density, viscosity and pipe diameter. The flow of fluid (liquid or gas) in a pipe may be laminar or turbulent flow. The difference between laminar and turbulent flow was experimentally first described by Osborne Reynolds in 1883. The experiment was carried out by injecting a colored liquid into water stream flowing in the glass tube. If the fluid moves at a sufficiently low velocity, the colored liquid will flow in the system in a straight line that does not mix with the water stream, as shown in Figure 2.6(a).

In this condition, the fluid still flows in a laminar way. Thus, in principle, if the fluid flows low enough as in this experimental condition, then there is a flow line. When the fluid velocity is increased, a critical velocity will be achieved. Fluid reaching a critical velocity can be indicated by the formation of a color liquid wave. This means that the flow line is no longer straight, but starts to wavy and then the flow line disappears, because the colored liquid begins to spread uniformly in all directions of the water fluid, as illustrated in Figure 2.6 (b).

When the fluid begins to move randomly (erratically) in the form of cross-currents and vortex, indicates that the water flow is no longer laminar. The fluid flow line is no longer straight and parallel in this condition, as shown in Figure 2.6 (b).

Figure 2.6 Reynolds experiment on laminar flow (a) and turbulent flow (b)17]

According to Reynolds, to distinguish whether the flow is turbulent or laminar, it may use a dimensionless number called the Reynolds number. The following equation calculates this number:

$$Re = \frac{\rho V D}{\mu} = \frac{VD}{v} \qquad (2.13)$$

where;

Re = Reynolds number (dimensionless)

V = average speed (ft/s atau m/s) *D* = pipe diameter (ft or m)

v = μ/ρ kinematic viscosity (m^2/s)on

Re < 2300, laminar flow

Re > 4000, turbulent flow

Re = 2300-4000 there is a transition

Laminar Flow

The laminar flow velocity profile in the pipe is analyzed by considering the fluid element at time t as shown in Figure 2.7. This is a circular cylinder of fluid of length l and radius r centered on the horizontal pipe axis with diameter D. The flow is assumed to be fully developed and steady. Each portion of the fluid only flows along traces parallel to the pipe wall at a constant velocity even though the neighboring particles have slightly different velocities. Speed varies from one trace-line to the next and this is combined with the fluid's viscosity, thereby producing a shear stress.

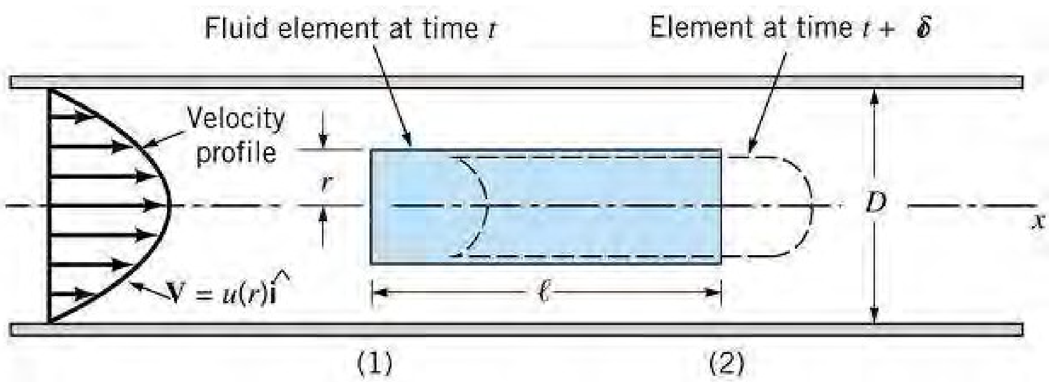


Figure 2.7 Movement of a fluid element in a cylindrical pipe [9]

2.3. Sensors/Transducer

A sensor is a device that can detect the presence of a natural phenomenon and measure it in a physical quantity and convert it into a signal that an observer or a particular device can read. So many physical quantities that can be observed from the many natural phenomena that exist in this world, then there are so many sensors created and invented by humans, each specific for the type of quantity and object are measured. Therefore, sensor technology continues to evolve over time. New sensors are constantly being studied and developed to meet human needs and curiosity, and create a universal measurement standard. This research will discuss various kinds and developments in sensor technology, specifically on sensors used to measure wind speed.

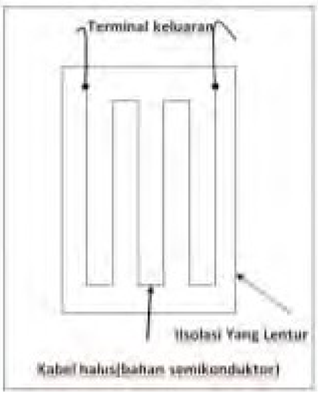


Figure 2.8. Strain Gauge Basic Construction

Strain gauge is one of the most widely used transducers to detect and measure forces, torsion loads and strains. The basic unit of this apparatus (figure 2.8) consists of a resistive strip bonded to a base of flexible insulating material. This blade is attached to the mechanical part/object whose strain is to be measured.

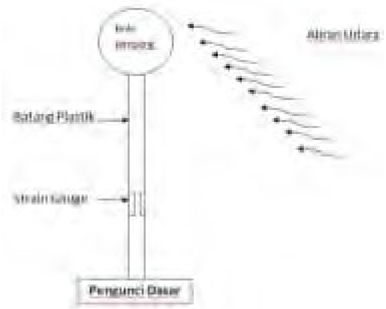


Figure 2.9. Strain Gauge with Retaining Rod And Pimppong Ball

Due to the presence of fluid (wind) with a certain speed, then :

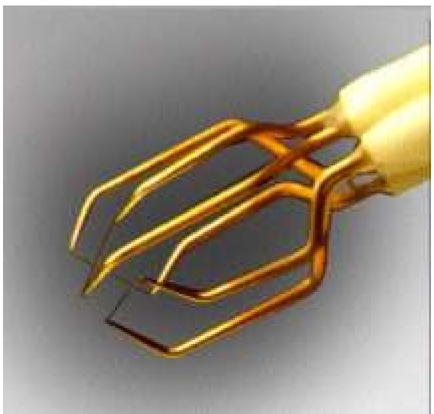
$$F_D = C_D \rho A V^2 \qquad (2.14)$$

Where ρ is the density of the fluid (wind) , V is the velocity of the fluid (wind) at the measured point, A is the area passed through by fluid(wind), and C_D is the overall drag coefficient . C_D is a dimensional factor whose magnitude depends on the physical plane of the object and relative to the fluid flow(wind), obtained from the strain:

$$\varepsilon = [3C_D \rho A V^2 (L-x)]/(Ea^2 b) \qquad (2.15)$$

where L is the **length of the rod**, x is the point where the strain gauge is attached, E is Young's modulus, a and b are **geometric planes**.

Hot Wire as a wind speed sensor works based on the heat received by the



probe which is affected by wind speed (figure 2.10). When the wind speed increases, the air temperature will decrease, causing a change in the temperature received by the hot wire.

Figure 2.10. Probe Hot Wire

Anemometer Cup (figure 2.11) as a wind speed gauge, by means of a cup that is installed in such a way that it rotates the shaft when the cups are pressured by the wind which can then run a dynamo to produce an electrical signal.

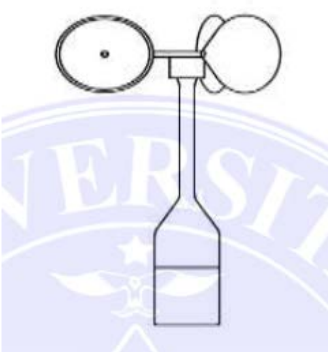


Figure 2.11. The Basic Form of the Cup Anemometer System

CHAPTER III

RESEARCH METHODS

3.1. Place and time

This research was carried out from the date of approval of the proposal by the study program manager until it was declared complete, which planned to last for about 8 weeks. The place of research is in the production laboratory of the Meda Area University and the timing of the research is as shown in the table 3.1.

Table 3.1 Research implementation schedule

No	Activity	Time (Week)							
		I	II	III	IV	V	VI	VII	VIII
1.	Literature search, proposal writing								
2.	Submission of proposals								
3.	Procurement of tools and materials								
4.	Preparation and installation of tools								
5.	Test tools and measurements								
6.	Data processing and analysis								
7.	Conclusion and preparation of the report								
8.	Undergraduate assembly								

3.2 Materials and Tools

3.2.1 Material

Figure 3.1 *Exhouse Fan* size 50x50x15 mm

First, the material is selected according to the needs used in this study. Procurement of materials that have been planned according to the material of the air temperature reduction system by utilizing water reservoirs.

a. Exhouse Fan: used to draw / suck air from outside that has passed through the finned pipe contained in the reservoir water tank.

Figure 3.2 copper pipe

b. Aluminum Pipe: Aluminum pipe is used to circulate air.

c. Iron plate: used for water storage containers

Figure 3.3 Iron plate

d. Box Streofom: used as a model room

Figure 3.4 Box Streofom

3.2.2 Tools

a. Calipers

A measuring device or what we often know as a caliper serves to measure the length, width, thickness and depth of the test object that we are examining .

Figure 3.5 Caliper measuring tool

b. Tachometer

Tool for measuring the speed of rotation of the dryer tube

Figure 3.6 Tachometer

d. Ruler

Used to measure the length of the dryer cylinder

e. Temperature sensor

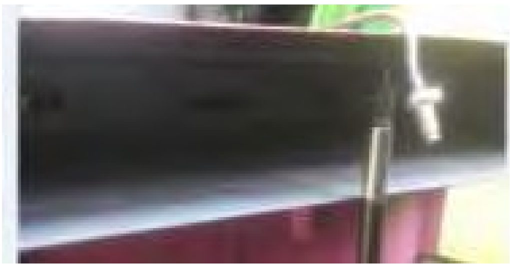


Figure 3.7 Termocouple

Using type K thermocouple as much as 2 pieces.

f. Hygrometer

To measure the humidity in the room

Figure 3.8 Eltech brand hygrometer

g. Hot wire

To know the magnitude of air volume

Figure 3.9 Krisbow Brand Hotwire Anemometer

h. Aluminum pipe cutterm

Aluminum pipe cutter is used to cut Aluminum pipe so that the cutting surface is neater.

Figure 3.10 Aluminum pipe cutter

3.3 Set Up Test Equipment

In this study, a complete set of rice dryers is required, such picture below:

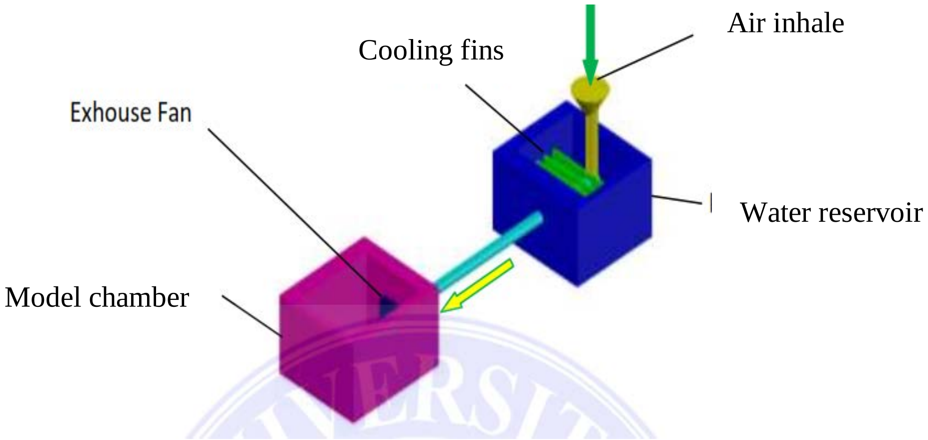


Figure 3.11 System set up

This system works by flowing air through pipes attached to the cooling fins, which will be immersed in water in the water reservoir for coolling down the air flowing in the pipes where the exhouse fan sucks in the air in the room model.

3.4. Data Collection Method

3.4.1 Observation Method

The data collection method used in this analysis is the observation method, which is carried out by observing changes in symptoms that occur in the object of research.

3.4.2 Measuring method of temperature and in -out air velocity

3.5 Research Variables

The main variables used in this research or analysis are the temperature and velocity of the incoming air as well as the ambient and system temperature.

3.6. Implementation Flowchart

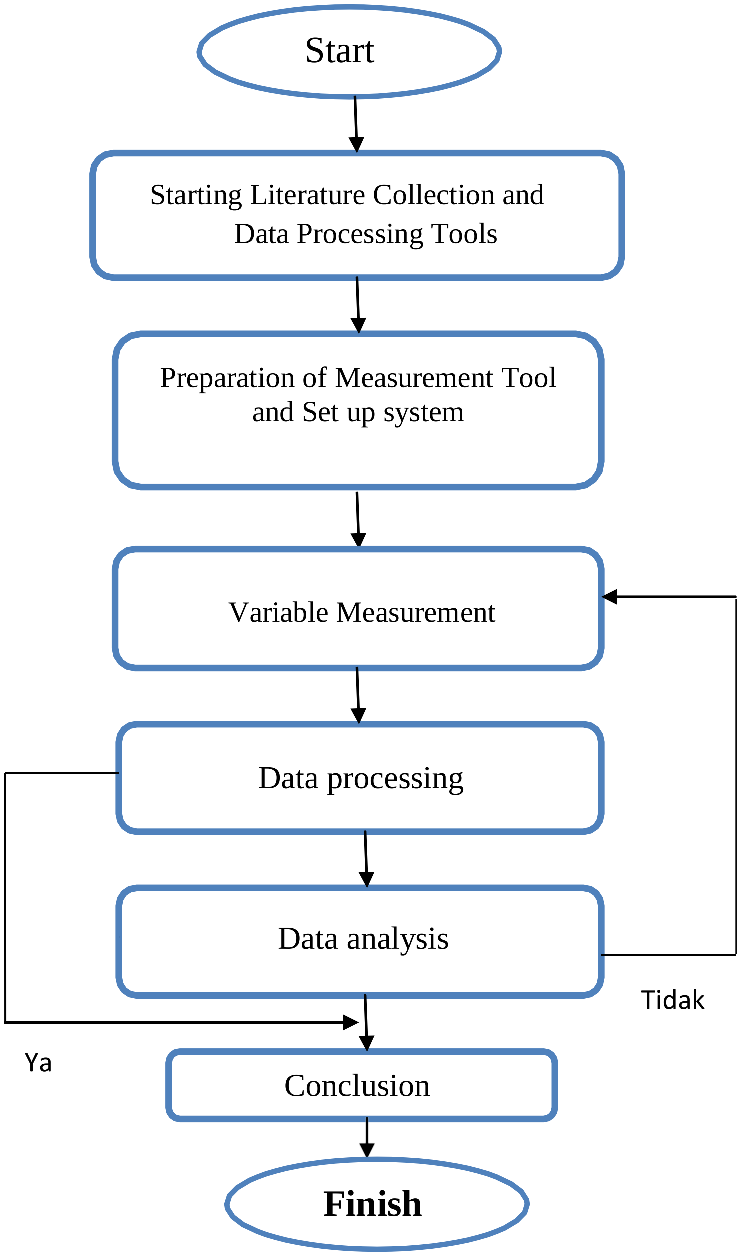


Figure 3.12 Research flow chart

CHAPTER V

CLOSING

4.1 Conclusion

By utilizing a water reservoir, the air conditioning system can obtain a decrease in temperature per unit of time or a certain time interval. The cooling rate of the room using water with a speed of 2 LPM is 34.572 J/s and if using water with a speed of 3 LPM the cooling rate of the model room is greater (84.076 J/s) or faster when compared to without using a faster water flow rate. The power required is 25.9061 Watt for 5 minutes (300 seconds) and the average energy consumption required during system operation is 139.893 Joules (5400 seconds)

4.2 Suggestions

From the results of the research that has been done several things must be considered, including:

1. It is necessary to study other methods to increase the number of pipes used
2. The design and dimensions of the tool need to be designed in order to be tighter in bending the pipe
3. It needs to be better developed for applications in the field

PROOFREADING

1.	humans in order to obtain	:	humans to obtain
2.	the use of air conditioning systems is	:	**air conditioning systems are**
3.	continues to grow in accordance with	:	continue **to grow according**
4.	as the ability of a material	:	**is a material's ability**
5.	displayed in the form of tables and diagrams	:	displayed in tables and diagrams
6.	definition of fluid	:	fluid definition
7.	volume of the object	:	object's volume
8.	tube that filled with liquid	:	tube filled with liquid
9.	resistance of the fluid	:	fluid's resistance
10.	If the fluid is moving	:	If the fluid moves
11.	In this condition, the fluid	:	The fluid
12.	The behavior when the fluid	:	When the fluid
13.	This number is calculated by the following equation	:	The following equation calculates this number
14.	viscosity of the fluid	:	fluid's viscosity,
15.	can be read by an observer or a particular device	:	an observer or a particular device can read
16.	manager of the study program	:	study program manager
17.	The way of this system works is	:	This system works
18.	the air is sucked in by the exhouse fan	:	the exhouse fan sucks in the air
19.	where this method	:	which
20.	a decrease in temperature can be obtained by the air conditioning system	:	the air conditioning system can obtain a decrease in temperature
21.	there are several things that must	:	several things must
22.		:	
23.		:	