DESIGN AND FABRICATION OF MINI HEAT TRANSFER TEST RIG FOR NANO FLUID COOLING SYSTEM

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CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

Liquid cooling system is a method of heat removal from components and industrial equipment. As opposed to air cooling, liquid is used as the heat conductor. Liquid cooling is commonly used for cooling automobile internal combustion engines and large industrial facilities such as steam electric power plants, hydroelectric generators, petroleum refineries, and chemical plants. Other uses include cooling the barrels of machine guns, cooling of lubricant oil in pumps; for cooling purposes in heat exchangers; cooling products from tanks or columns, and recently, cooling of various major components inside high-end personal computers. The main mechanism for liquid cooling is convective heat transfer(Reference no.1) As in this project, a mini model of a heat transfer test rig for Nano fluid cooling system that can run a test read to get the thermal efficiency of Nano fluids as a cooling agent was created and produced..

1.1 PROJECT BACKGROUND

This project is focus on designing, fabricating and testing a model to run an experiment in proving the Nano fluids as an efficient cooling agent that can be used in a liquid cooling system, so, a proper preparation need to be done and a few recommendation need to be considered in succeeding this project

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First step in succeeding this project is by designing the main idea and turning it into a simple sketch. Then, the drawing was upgraded and designed using CAD software. The components needed in this project need to be setup and assemble in a short time to avoid the delay in installing the parts. Using the CPU liquid system as an example model, we create a new model that run in a same system but using different main power to run it.

After installing parts completed, the model needs to be run in a few tests to make sure all the parts used is functioning and also to guaranteed this project will succeed. First we need to upgrade and make a test whether this system can be run using the direct current as the main power and then we need to try to run the pump in order to make sure that the pump can pumped out the liquid from the reservoir tank and flow through the whole system.

Lastly, we can make a conclusion whether this project is successful after the test have been completed. If the test run shows positive respond, then we can conclude that this project can be accepted. If the result shows the opposite, then we need to add up a few recommendations that might help in succeeding this project.

1.2 Problem Statement

Liquid cooling system is widely used nowadays. As we may know, the coolant used in this system is usually specialized to get a better result in cooling something such as engine and hot plate. In this case, an experiment need to be done to proof that Nano fluids can be used in this system and shows better results as a coolant compared to the others liquid used. Therefore, a mini heat transfer test rig is needed to analyses the efficiency of Nano fluid in thermal properties performance. So, in order to run this experiment we need a model to run this test.

By using the components in a CPU liquid cooling system, we can build a model that can run a test read for this experiment. The parts used in this system is portable, easy to carry and can be upgrade as the cost is lower compared to the other model such as car liquid cooling system. So, the main idea of this project is to create a system so the experiment to proof that Nano fluids can be an effective coolant in a liquid cooling system can be run.

1.3 Objectives of the project.

The objectives of this project are:-

1) To design and fabricate a mini heat transfer test rig for Nano fluids cooling system.
2) To run a heat transfer analysis.

1.4 Scopes of Project.

1) To design a mini Heat Transfer test rig using CATIA CAD software.
2) To fabricate a mini Heat Transfer test rig using electronics CPU parts..
3) To analyses Nano fluids Heat Transfer using mini Heat Transfer test rig. (Deionized water and Coolant)

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

The specs of each component and apparatus that was related or was used in this project based research and reference done during finishing this project. The function and the application for the component will be explained in this chapter. The information was obtained from journal, article and searching through the internet.

For this project, a model to run a test read for the Nano fluids was designed and fabricated. In this project, CPU (Central Processor Unit) cooling system in the computer was referred and the main idea is trying to create a model that will run exactly the same way as the CPU cooling system. The only different in this project is the power supply used to run this model which is using the direct current as the main source compared to the CPU cooling system which is using the components in the CPU to run the system.

The system that used nowadays is usually sealed and not compatible with the experiment that needs to be run. So, the process to create the same cooling system that will run the same way with the CPU cooling system but using different parts or components was decided. The parts that used in this project will be explained in the next part of this chapter.

2.1.1 Water Block

A water block is the water cooling equivalent of a heat sink. It can be used on many different computer components, including the central processing unit (CPU) and Northbridge chipset on the motherboard. It consists of at least two main parts; the "base", which is the area that makes contact with the device being cooled and is usually manufactured from metals with high thermal conductivity such as aluminum or copper and in some cases silver as is found in many newer blocks. The second part, the "top" ensures the water is contained safely inside the water block and has connections that allow hosing to connect it with the water cooling loop. The top can be made of the same metal as the base, transparent Perspex, Delrin, Nylon, or HDPE. Most newer high-end water blocks also contain mid-plates which serve to add jet tubes, nozzles, and other flow altering devices.(Reference no.3)

The base, top, and mid-plate(s) are sealed together to form a "block" with some sort of path for water to flow through as shown in figure 2.1. The ends of the path have inlet/outlet connectors for the tubing that connects it to the rest of the water cooling system. Early designs included spiral, zig-zag pattern or heat sink like fins to allow the largest possible surface area for heat to transfer from the device being cooled to the water. These designs generally were used because the conjecture was that maximum flow was required for high performance. Trial and error and the evolution of water block design have shown that trading flow for turbulence can often improve performance. The Storm series of water blocks is an example of this. Its jet tube mid plate and cupped base design makes it more restrictive to the flow of water than early maze designs but the increased turbulence results in a large increase in performance. Newer designs include "pin" style blocks, "jet cup" blocks, further refined maze designs, micro-fin designs, and variations on these designs. Increasingly restrictive designs have only been possible because of increases in maximum head pressure of commercially viable water pumps.

A water block is better at dissipating heat than an air-cooled heatsink due to water's higher specific heat capacity and thermal conductivity. The water is usually pumped through to a radiator which allows a fan pushing air through it to take the heat created from the device and expel it into the air. A radiator is more efficient than a standard CPU or GPU heatsink/air cooler at removing heat because it has a much larger surface area.

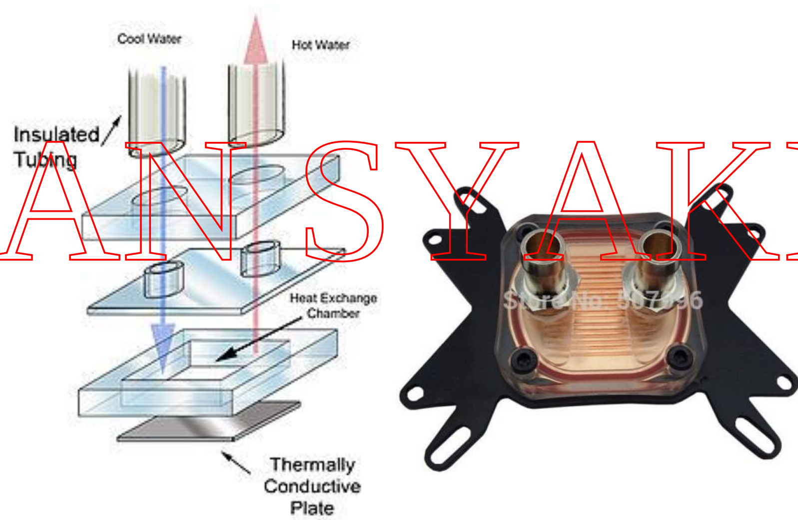

Figure 2.1: Water Block

2.1.2 Shell and Tube Heat exchanger

A normal heat exchanger usually consists of fan and radiator. Shell and tube heat exchangers consist of series of tubes. One set of these tubes contains the fluid that must be either heated or cooled. The second fluid runs over the tubes that are being heated or cooled so that it can either provide the heat or absorb the heat required. A set of tubes is called the tube bundle and can be made up of several types of tubes: plain, longitudinally finned, etc. Shell and tube heat exchangers are typically used for high-pressure applications. Typically, the ends of each tube are connected to plenums (sometimes called water boxes) through holes in tube sheets. The tubes may be straight or bent in the shape of a U, called U-tubes. In this model, the liquid will flow from the tank and move into the radiator before it flows towards the water block. (Reference no.4)

Figure 2.2 (a): Front view of the Heat Exchanger

Figure 2.2 (b): Back view of the Heat Exchanger

2.1.3 Nano fluids

A Nano fluids is a fluid containing nanometer-sized particles, called nanoparticles. These fluids are engineered colloidal suspensions of nanoparticles in a base fluid. The nanoparticles used in Nano fluids are typically made of metals, oxides, carbides, or carbon nanotubes. Common base fluids include water, ethylene glycol and oil.

Nano fluids have novel properties that make them potentially useful in many applications in heat transfer, including microelectronics, fuel cells, pharmaceutical processes, and hybrid-powered engines, engine cooling/vehicle thermal management, domestic refrigerator, chiller, heat exchanger in grinding, machining and in boiler flue gas temperature reduction. They exhibit enhanced thermal conductivity and the convective heat transfer coefficient compared to the base fluid. Knowledge of the rheological behavior of Nano fluids is found to be very critical in deciding their suitability for convective heat transfer applications. (Reference no.5)

In analysis such as computational fluid dynamics (CFD), Nano fluids can be assumed to be single phase fluids. However, almost all of new academic papers use two-phase assumption. Classical theory of single phase fluids can be applied, where physical properties of Nano fluid is taken as a function of properties of both constituents and their concentrations. An alternative approach simulates Nano fluids using a two-component model.

The spreading of a Nano fluid droplet is enhanced by the solid-like ordering structure of nanoparticles assembled near the contact line by diffusion, which gives rise to a structural disjoining pressure in the vicinity of the contact line. However, such enhancement is not observed for small droplets with diameter of nanometer scale, because the wetting time scale is much smaller than the diffusion time scale.

So the Nano fluids will be used as the cooling agent in this project and the experiment will prove the efficiency of it as a cooling agent. The fluids will be filled in the reservoir tank and the pump will run the system in flowing the liquid.

2.1.4 Reservoir Tank

Reservoir tank is the place where all liquid used in this project placed. The liquid will be filling into the tank through an accessible hole on the upper part of the tank. This tank is usually made from glass and can withstand high temperature.

Figure 2.3: Reservoir Tank

2.1.5 Water Pump

Water pumps are simple devices. They force coolant through the engine block, hoses and radiator to remove the heat the engine products. It is most commonly driven off the crankshaft pulley or in some cases the pump is gear-driven off the crankshaft. In this project, the pump function is to pump the coolant out of the reservoir tank and run through the whole system. The pump used in this project as shown in figure 2.4 only can withstand 12V of voltage. So, an adapter will be used in order to convert the amount of voltage flowed by the direct current synchronies with the need of the pump.

Figure 2.4: Water Pump

CHAPTER 3

METHODOLOGY

3.0 INTRODUCTION

There will be explanation on methodology used to achieve the project objectives and finish this project. This chapter was done by referring to the information obtained from the literature review. In addition, the procedure of the setup of the model and the test will also be explained in this chapter. Based on the procedure the test was done and the result was recorded.

3.1 PROJECT FLOW

The first step to start a project was by mentioning problem statement, objectives and scope of study. These three things are the most important criteria in a project. They act as a target for this project and the progress was based on this three important things. After these three main components in this report provided, the literature review was conducted.

The next step is designing the project by making an early sketch from the components that will be used in creating this project. After completing the early sketch, then the process of designing the product by using the CATIA V5 software was started. All the dimensions were measured earlier before the process of designing started. Then the preparation was conduct and process starts of collecting all the components needed in this project was startd. In this project, each part was gathered from the different sources. Then, the components were assembled and the installation began. For the installation part, I used the design that already exists. After finish constructing the model, the model was run into a few test to test whether it is following the criteria that have been set earlier. Lastly, data analysis was done to get the project result so that the project report can be done. The project flow just follows the flow that had been drafted earlier as shown in figure 3.1.

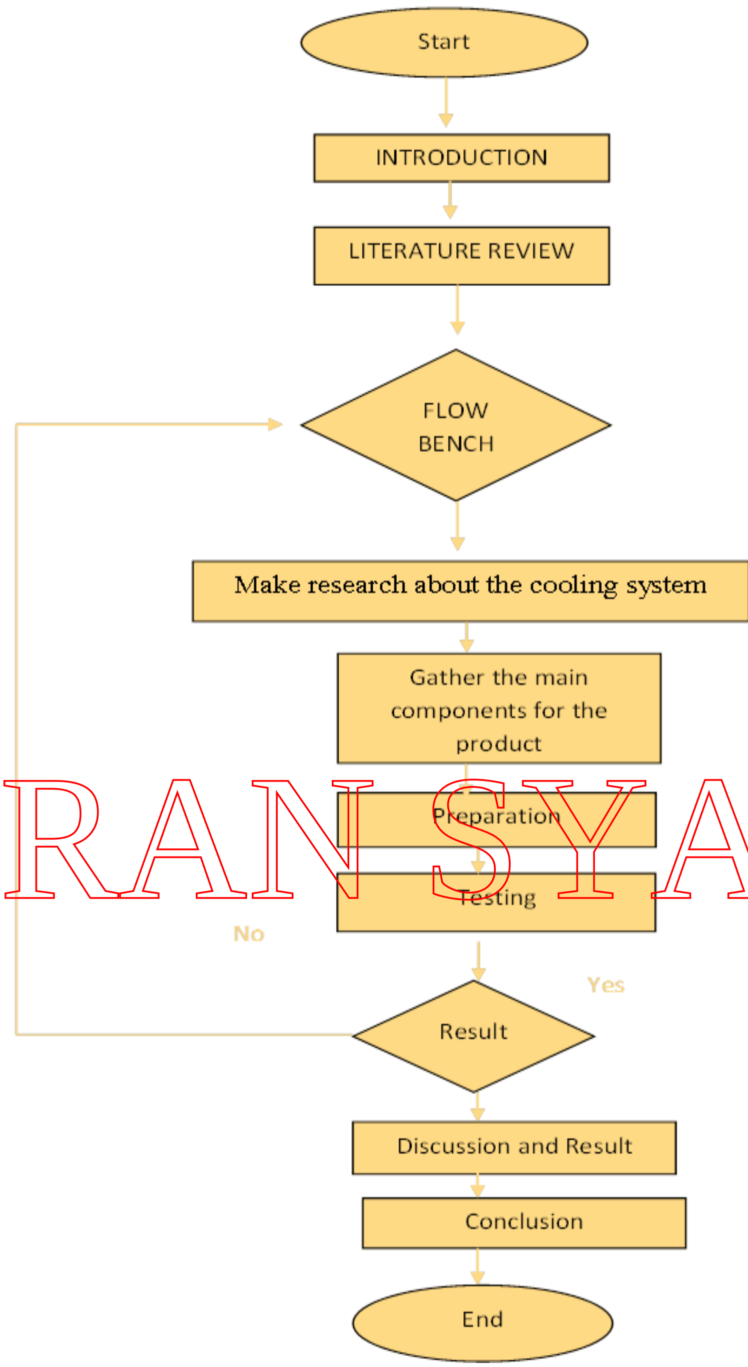

Figure 3.1: Project Flow Chart

3.2 PROJECT PREPARATION

The preparation was started by designing the main sketch or a rough sketch for the product. The rough sketch was designed by only using hands. This design act as an early design before the next step was taken. All the main parts were assembled in this drawing as shown in figure 3.2.

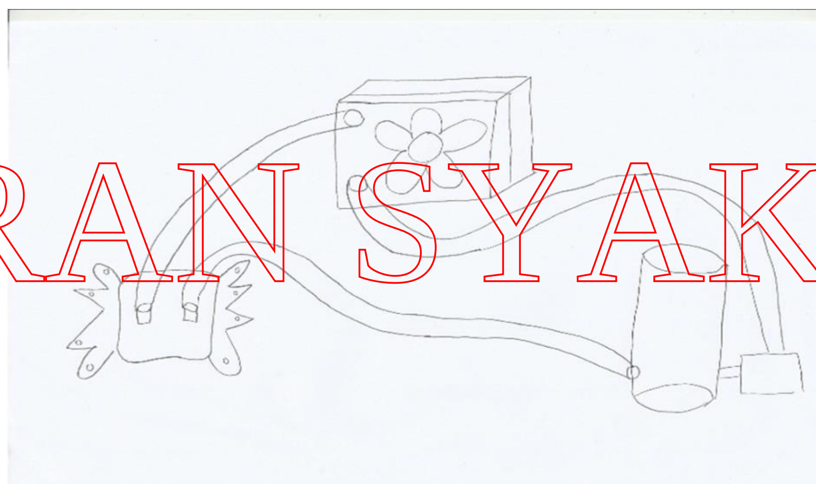

Figure 3.2: Conceptual Design

Then the process of designing this project using CAD software was conducted. In this project, the CATIA V5 software was chosen in making the actual design of this project. All the dimensions were measured earlier before so the designed process can be done. The complete design was as shown in figure 3.3.

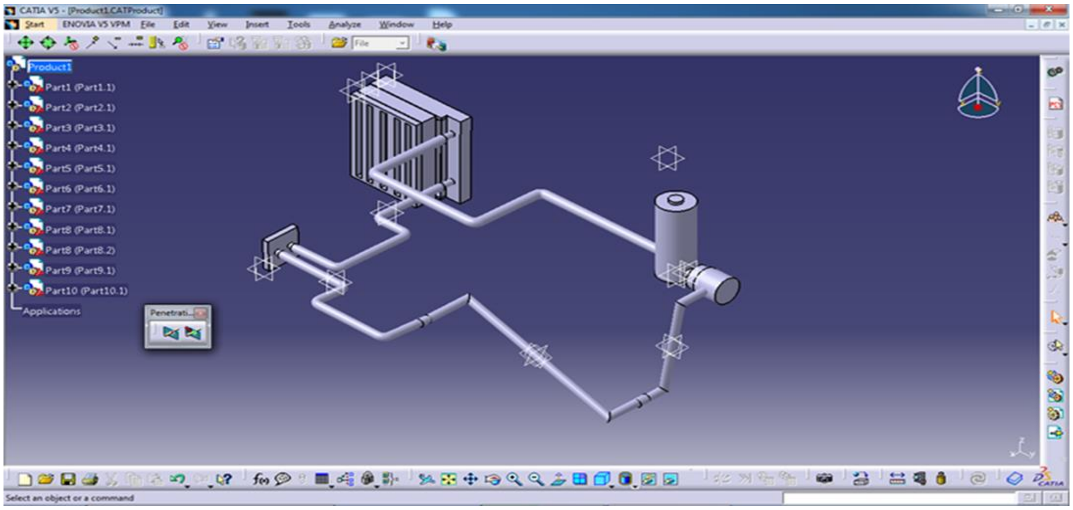

Figure 3.3(a): Complete Design using CATIA V5 software

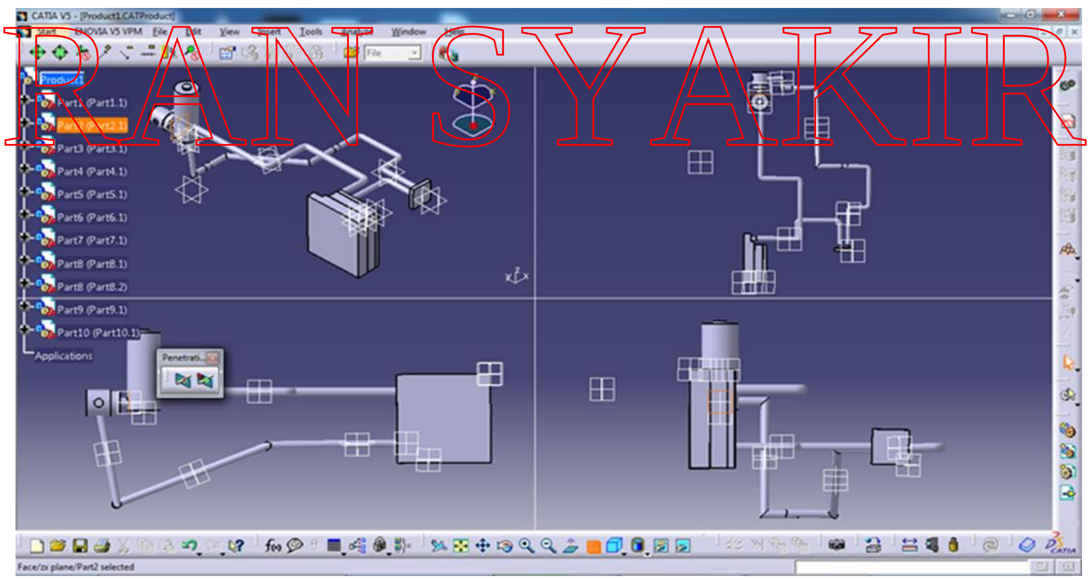

Figure 3.3(b): Orthographic Design

The parts or components used in this model were sold separately. First thing first is assembling all the parts that need to be used in building this project. The parts that need to be used in succeeding this project as mentioned in the literature review are water block, heat exchanger, liquid pump, reservoir tank and tubes. After all the parts completely assembled, then I start to create a design for this project by referring the old model that uses the same concept but different way in operating.

3.3 INSTALLATION

All the components needed in making this project has been assembled together. then the setup begin. First, cut the tube into four parts as shown in figure 3.4 and make sure the length is same so that the flow of the liquid is smooth and equal. Actually only three tubes are use in this model and as a safety precaution, the fourth one will act as a spare if any leakage happen during this process run. Then, all the tubes were connected to each part.

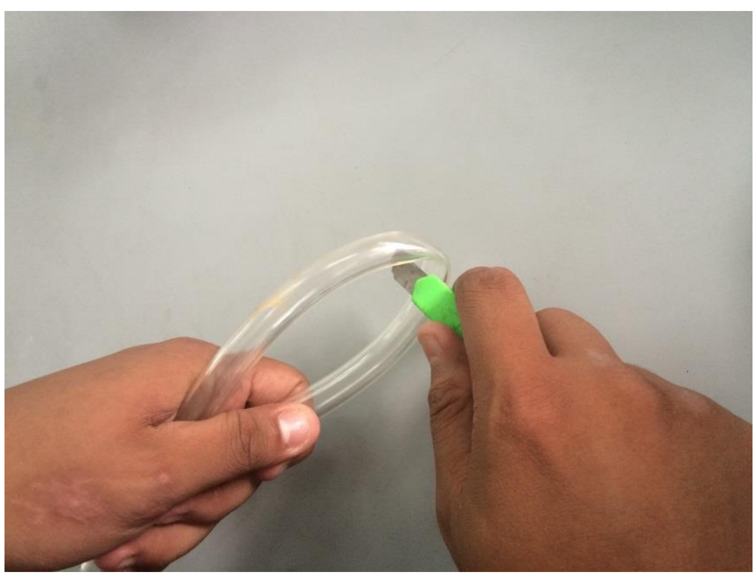

Figure 3.4: Tube were cut into 4 parts

The most involved (and time-consuming) step is the first: setting up the waterblock, the mechanism that uses flowing liquid to chill down the CPU. The good news is that the process is simple. It consists of three pieces, all vaguely shaped like a capital "H" and containing screw holes, a metal clip, a cushion to protect the motherboard, and an insulator to go between them. As in this project, the model will run using the direct current(DC) and not through the CPU. Connect the tube to the water block using the tube holder. Use the tube clip to tighten the tube as shown in figure 3.5 below as a way to avoid any leakage occur.

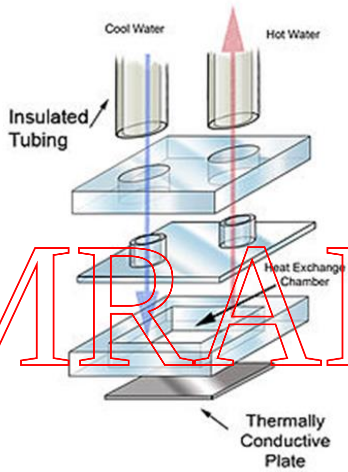

Figure 3.5 (a)

Figure 3.5 (b):The clip was used to tighten the tube.

Then connect the tube from the water block to the reservoir tank as shown in figure 3.6. Make sure the tube in a fix position so the flow of the liquid will smooth and not clog.

Figure 3.6: Reservoir tank was connected to the water block

The tank then will be connect to the water pump as shown in figure 3.7. Use the rubber ‘O’ ring to tighten and avoid leakage from occur.

Figure 3.7: The tank was connected to the water pump

Use another tube and connect the reservoir tank with the heat exchanger as shown in figure 3.8. Just like the earlier, use the clip to tighten the tube and repeat the procedure by connecting the radiator to the water block using another tube.

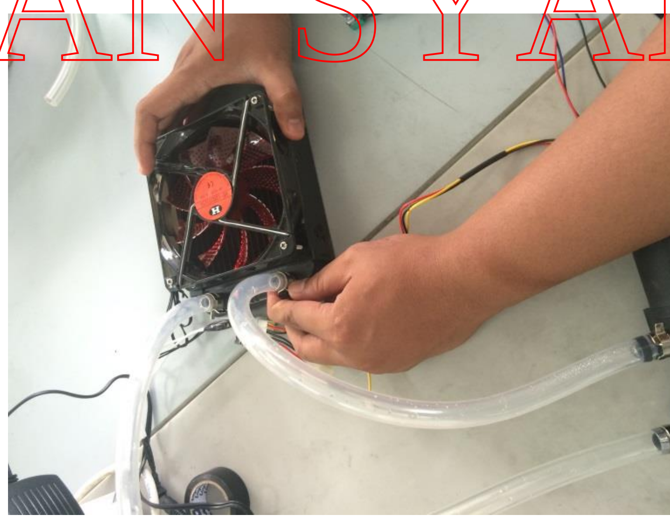

Figure 3.8: The tube was connected to the heat exchanger

Each parts now are connected to each other and now it is time to run the system. In this project, the power supply used is by using th direct current(DC). The main idea in this project is by upgrading or reinnovating the system to run using direct current compared to the CPU cooling system which using motherboard as the power source . The minor problem in this project is the water pump used only can support 12V of voltage while the direct current that flow from the socket supply 240V of voltage. So, the adapter that can convert 240V of voltage flow from the socket into 12V of voltage was used so that the pump can operate and will not blow. The adapter then connected to the pump using a simple wiring process as shown in figure 3.9 and then the switch is turn on

Figure 3.9 (a)

Figure 3.9 (b)

Before turning the switch on, the liquid or the cooling agent is filled into th reservoir tank as shown in figure below. Then the switch is turn on. Make a neat observation and observe if there is any leakage on the tubes. The flow of the liquid also need to be observe to make sure the liquid flow smoothly.

Figure 3.10: The liquid is filled into the reservoir tank

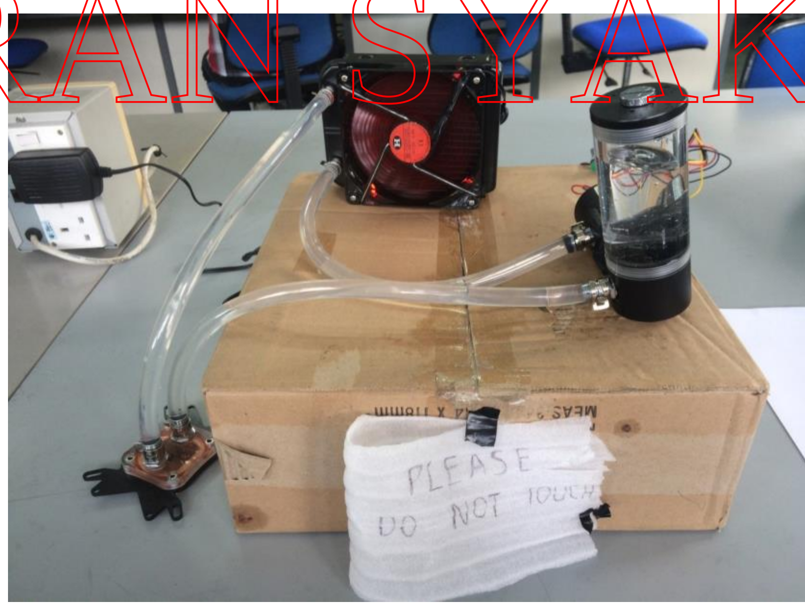

Figure 3.11: Full Installation of Product

CHAPTER 4

RESULTS AND DISCUSSIONS

4.0 INTRODUCTION

In this chapter, the results of the different types of test are obtained and are explained. There are figures and tables provided show the results that already obtained. At the end of this chapter, the result will be explained based on their specifications, advantages and disadvantages. The discussion is explained at every test with the proof and achievement stated.

4.1 RUNNING THE SYSTEM

For this model, the components used are usually run by using CPU as the power source but for this project we need to upgrade the system and try to operate it and find a way to make it run by using the direct current as the power supply. The figure blow will show the simple wiring that has been made in order to run this system by using the direct current from the socket.

Figure 4.2: The simple wiring process in order to converting the power supply used

Figure 4.3: The model run smoothly

After the wiring process complete, the test was run to make sure the system run as expected. The test was successful as the system run smoothly. So, we can conclude that there is no problem in converting the power supply used by this project.

4.2 WATER PUMP TEST

After the system was run according to the plan, we need to make sure the water pump functioning. If the pump does not functioning, then this project will be a failure as the pump is on of the main components in running this project. The figure below shows the result after the switch on the water pump was adjusted.

Figure 4.4 The switch on the pump was adjusted

Based on the figure above, we can see that the amount of liquid in the reservoir tank is reducing. That is mean the pump is functioning as the water is pumped out from the tank into the tube. So, the water pump is completely functioning and this project can be run successfully.

4.3 HEAT TRANSFER ANALYSIS

The analysis was conducted to test and proof that this test rig model functioning and can perform the entire characteristic that had been described earlier. A digital thermometer or thermostat was placed under the water block where the thermal efficiency was measured.

The test rig then was run to determine the heat transfer analysis. The experiment was done for about 10 minutes and the reading was taken very two minutes. The results of the experiment were shown in the table below. The initial temperature was taken before the experiment was held on which is 25.3^{o}C.

Time , (minutes)	Temperature ,(^{o}C)
2	25.0
4	24.2
6	23.8
8	23.6
10	23.4

Table 4.1: Heat transfer analysis results

As can be seen in the table 4.1, we can see that the temperature was slowly reduced. The test rig can be assumed succeed as it follows the specification which is the test rig must succeed in lowering the temperature of the water block. So, we can conclude that the heat transfer.

4.3 DISCUSSION

Based on the results that have been explained above, we can conclude that this project has reached and completed the goals that have been set earlier. So the main idea to create a model that can run a test read to proof Nano fluids as an efficient coolant is succeeded.

The main factors that make all the test is succeed without any failure are the components used, the structure reinforcement, and the details of the idea in making this project runs well.

The functionality is important to make sure that this model can be used for a long term and capable to give the advantages to the users to use it. All the operations of the main component likes heat exchanger and water pump is already succeed. Hence, it can be concluded that this model is able to perform the intended functions successfully and without having any failure.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

As a conclusion, the model for the test read to get the thermal efficiency of the Nano fluids was completely succeed and follow all the enquiries need. All the process follow the flow chart that have been set earlier and the time taken to construct the model follow the due dates given. The apparatus and components need were setup completely and the process installing all the parts were done in the lab for safety requirement to avoid something unwanted happen. The main idea in creating a liquid system has been achieved as this project run and follows the system referred which is CPU liquid cooling system. The experiment then will be constructed to prove whether Nano fluids will perform better as a cooling agent compared to the available liquid. The main objective in producing a model to run the experiment has been achieved successfully.

5.2 RECOMMENDATION

During the procedure in making this model, I found and observed a few weaknesses that can be improve to gain a better result. If these recommendations can be considered then the percentage in gaining a better result will be higher.

The first recommendation that can be considered is by using a bigger heat exchanger by means using a bigger cooling fan and radiator in enhancing a better result by then, the process of cooling the coolant will be more efficient.

Next, we can apply a device that can measure and read the temperature direct to the water block or hot plat so that the result will be more accurate. So, the device will show the actual readings without any error occur and the amount of heat loss will be lower during the temperature taken.

Lastly, the time taken to run this project should be longer to produce a better model. The due dates should be extended so that the product will look neater and can be improvise perfectly.

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