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EFFECT OF VELOCITY AND TYPE OF COOLING FLUID ON PELTIER HEAT TRANSFER FOR CAR CABIN COOLING APPLICATIONS

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ABSTRACT

This research used the Peltier element as a car cabin cooler. This research aimed to compare the results of the lowest temperature produced by the Peltier element on the hot side. The design of this monitoring tool consists of LM35 as a temperature sensor and an electric velocity sensor to measure the velocity of the cooling fluid. Arduino Uno Microcontroller to control the system before being displayed to the LCD. The type of research used in this research is experimental research. In this study, variations in fluid flow velocity and type of cooling fluid were carried out. The fluid used is a mixture of water and water coolant with a ratio of 50%:50%. The results showed that the circulation of fluid cooling influences the temperature on the hot side of the Peltier. In cooling using water fluid, when the water pump rotates 4.5 liters/second, the temperature on the hot side of the Peltier is 36^{o}C. At the time of rotation of 13 liters/second, the temperature on the hot side of the Peltier is 32^{o}C. The difference between cooling using water fluid, water coolant, or a mixture of water and water coolant greatly affects the temperature produced on the cold side of the Peltier. In cooling using water, the lowest temperature produced reaches 8^{o}C. When cooling using a fluid coolant, the lowest temperature reaches 6^{o}C. While cooling using a mixture of water and coolant, the lowest temperature reaches 3^{o}C. So it can be concluded that cooling using a mixture of water and water coolant is very effective compared to other fluid coolers.

Keywords Peltier Element; Thermoelectric; Cabin Cooling System.
Paper type Research paper

INTRODUCTION

The cooling system to lower the room temperature in the car uses a refrigerant. However, refrigerants are chemicals that can damage the ozone layer if they decompose in the air. Along with developing technology, a cooling system can be designed using the Peltier thermoelectric effect. Thermoelectric Cooling (TEC) is a technology when DC current is supplied to a Peltier element consisting of several pairs of P-type and N-type semiconductor cells, which will cause one side of the Peltier element to cool and the other side to become hot [1]–[6]. Peltier as cooling equipment is clean and safe alternative energy [7]–[11].

The advantage of cooling systems using the Peltier effect is that it does not produce noise. This cooling system does not use a compressor, evaporator, expansion valve, or refrigerant components. Another advantage of this tool is that it can be placed in any position because it is minimalist. In addition, Peltier coolers are very safe because they no longer use chemicals such as refrigerants. Cooling using the Peltier effect has no moving parts, so there is little chance of equipment damage [7]–[9]. This study aims to determine the effect of variations in fluid flow velocity and the use of variations in water fluid, water coolant, and a mixture of water with water coolant on the temperature on the hot side of the Peltier.

METHOD

The study will compare the velocity of the fluid and the cooling fluid as independent variables. Temperatures are observed by measuring the temperature at the heatsink and water block (both sides on the hot and cold sides). The research method used is experimental research, a qualitative research method used to determine the effect of the cooling fluid flow velocity and the cooling fluid on the temperature on the hot side of the Peltier. For data processing, the data is processed into qualitative

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data by taking data through the value of the temperature results on the hot side of the Peltier. Data processing in this study was carried out by converting the data generated from data retrieval in the form of tables into graphic data. After that, the graphic data will be analyzed to determine the effect of the determined independent variables and dependent variables. The data processing process carried out is as follows:

1. Recording every data obtained from the test results
2. Change table data into data presented in graphic form
3. Analyze graphic data related to the relationship between variables.
4. After carrying out the above process, it can be concluded that the relationship between the independent variable and the determined dependent variable.

Research Schedule

The research schedule was designed within eight months from the initial stage to the end. This research begins by identifying the problem by studying literature, formulating the problem, designing the tool, preparing the tools and materials used, and assembling the tool to carry out the data collection process. The data is collected from the influence of flow velocity and fluid type on the hot side of the Peltier. The data taken will be processed into a graph for analysis.

Design and material determination

The design of the equipment can be seen in Figure 1. The water block and heatsink are installed on the hot and cold sides using paste and a propagation medium for the hot and cold sides. The heatsink on the cold side is smaller than on the hot side. Peltier releases the absorption on the hot side, is removed by the water block, and then pumped to the radiator and back to the water block for a more optimal cooling process on the hot side of the Peltier. The use of a fan or fan to blow cold air from heat transfer.

This monitoring tool aims to monitor the fluid flow velocity and temperature resulting from the tool design. The components used in Figure 2 are as follows:

1. Arduino Uno R3 functions as a microcontroller to capture sensor data.
2. The SD Card module functions to store data that Arduino Uno has managed.
3. The LM35 Temperature Sensor functions to detect the temperature on the hot side of the Peltier.
4. DS 3231 RTC module serves to determine the time at the time of research.
5. Water Flow Sensor serves to capture the value of the fluid flow velocity.
6. LCD 16x2 displays data in real time, which can facilitate regular checking.
7. The breadboard serves as a connecting terminal between sensors, and the microcontroller

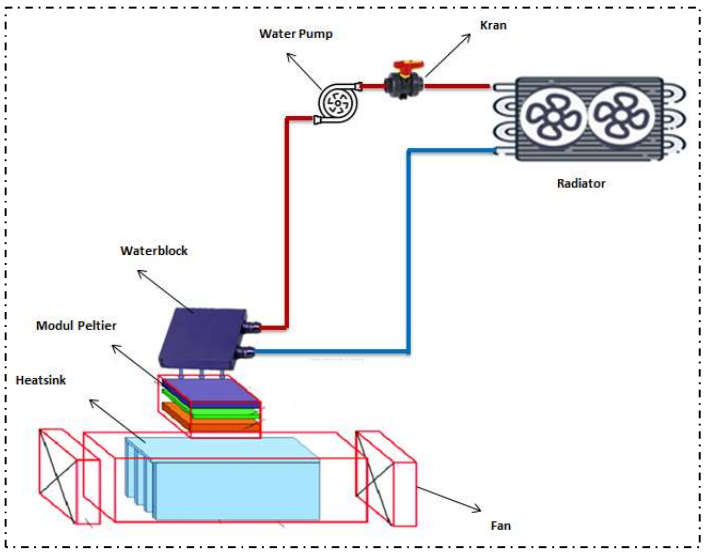

Figure 1. Equipment Setting Design

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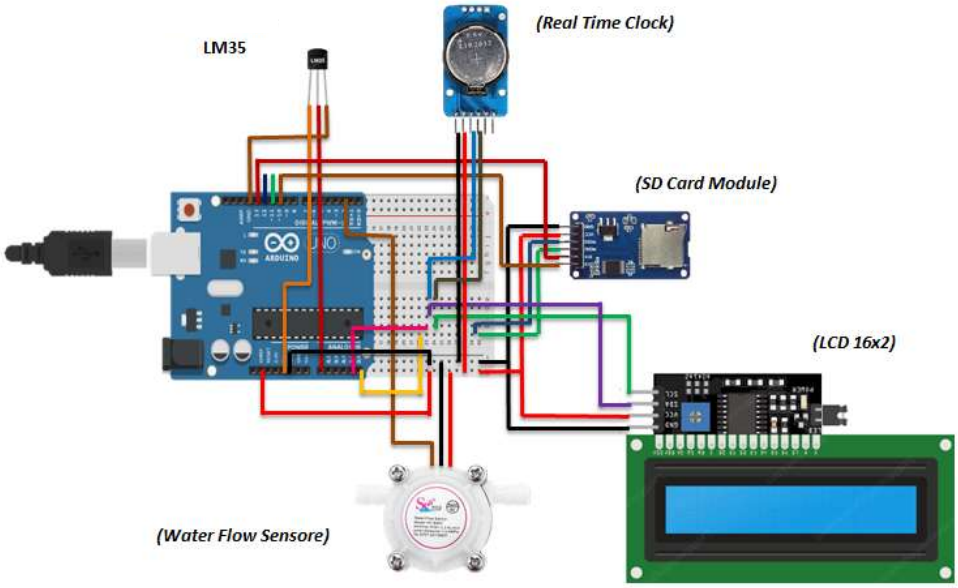

Figure 2. Monitoring Tool Design

RESULTS DAN DISCUSSION

Figure 3 shows the monitoring tool for fluid flow velocity and temperature on the hot side of the Peltier. The Arduino Uno acts as a microcontroller for sensors such as water flow sensors, LM35 temperature sensors, and others. For data collection, this monitoring tool works by reading the fluid flow velocity and temperature on the hot side of the Peltier. In collecting this data, the researchers varied the flow velocity and the type of fluid used. Each variation will be collected data five times in 1-5 minutes.

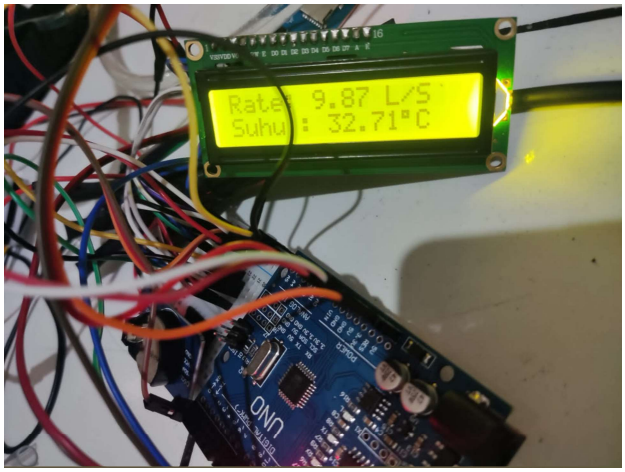

Figure 3. Monitoring Tool

Cooling using Water Fluid

In Figure 4, it can be analyzed that when using water fluid with a water flow rate of 4.5 liters/second, it can absorb heat on the hot side of the Peltier by 42^0C – 36^0C, and on the cold side, the Peltier produces a temperature of 12^0C - 11^0C. When the water flow velocity is increased to 7.73^0C, the temperature on the hot side of the Peltier is 37^0C – 33^0C. While on the cold side, the Peltier produces

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a temperature of 37^0C – 33^0C. When the water flow rate increases to 13 liters/second, the temperature on the hot side of the Peltier decreases by 35^0C – 32^0C, and on the cold side, the Peltier can produce a temperature of 9^0C – 8^0C. So with this, the velocity of the water can affect the heat transfer experienced by Peltier. The greater the velocity of water, the lower the temperature generated by the Peltier.

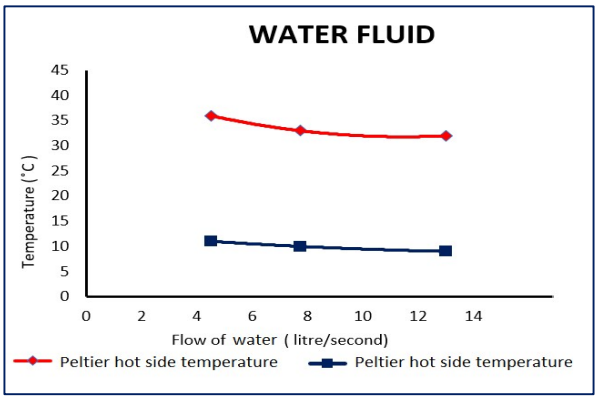

Figure 4. Graph of data collection using water fluid

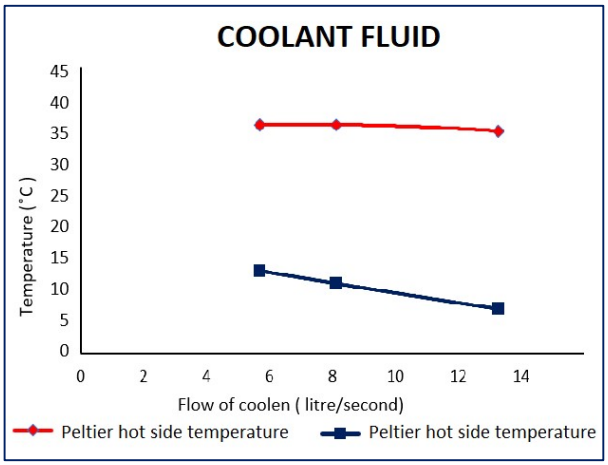

Figure 5. Graph of data collection using coolant fluid

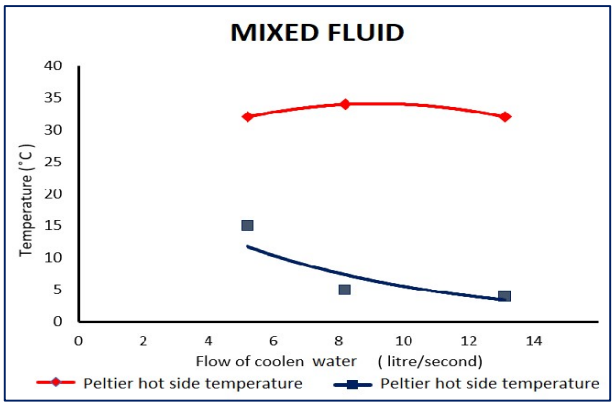

Figure 6. Graph of data collection using mixed fluid

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Cooling Using Fluid Coolant

In Figure 4, it can be seen that the heat generated by Peltier decreased when using coolant fluid. When the fluid flow velocity is 5.7 liters/second, the temperature on the hot side of the Peltier is 39^0C – 36^0C; on the cold side, the Peltier produces a temperature of 37^0C – 36^0C. When the fluid velocity is increased by 8.13 liters/second, the temperature on the hot side of the Peltier is 37^0C – 36^0C; on the cold side of the Peltier, it is 11^0C – 9^0C. Meanwhile, when the water flows at a maximum velocity of 13.27 liters/second, the temperature on the hot side is 36^0C – 35^0C; on the cold side, Peltier produces a temperature of 7^0C – 6^0C.

Cooling Using a mixture of water and coolant (50% - 50%)

In Figure 6, the data collection uses a mixture of water and coolant fluids (50% - 50%). Mixing this fluid can affect the temperature decrease, which is more optimal than when using water and coolant fluids. This conclusion can be seen when the fluid flow velocity reaches 13.1 liters/second, and the temperature on the hot side of the Peltier is 32^0C – 31^0C. In comparison, the temperature on the cold side of Peltier can reach the lowest temperature of 3^0C.

Air Conditioners generally use a compressor working system by utilizing the difference in temperature of freon gas. As we know, chemical substances such as freon gas can break the ozone layer on the earth's surface. If there is a continuous erosion of the ozone layer, then the destructive impact will be the increasing temperature of the air on earth, which triggers global warming. Using a Peltier thermoelectric cooler module, it will become an environmentally friendly cooling device. This Peltier module has two elements: the hot element side and the cold element side. With this function, a cooling device is made, namely cabin cooling using a Peltier with solar electrical energy.

The benefits obtained from this research are as follows:

1. It can be helpful for future research by developing tools that have been made
2. Understand the design and assembly of the Air cooler cooling system using the Peltier module
3. It can be used as teaching materials/learning media related to research.

CONCLUSION

Based on the data from the research, it can be concluded that several important things about temperature changes on the hot side of Peltier with variations in fluid flow velocity and cooling fluid are as follows. The circulation of fluid cooling greatly affects the temperature on the hot side of the Peltier. For example, in cooling using water fluid, when the water pump spins at 4.5 liters/second, the temperature on the hot side of the Peltier is 36^oC. Meanwhile, at 13 liters/second rotation, the temperature is 32^oC. These changes are not much different, but this change proves that the rotation of the water pump can affect the temperature on the hot side of the Peltier. The difference between cooling using water fluid, coolant, and a mixture of water and coolant greatly affects the temperature produced on the cold side of the Peltier. In cooling using water, the lowest temperature produced reaches 8^0C. In cooling using a fluid coolant, the lowest temperature reaches 6^0C. In cooling using a mixture of water and coolant, the lowest temperature reaches 3^0C. So it can be concluded that cooling using a mixture of water and coolant is very effective compared to other fluid coolers.

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