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Effectiveness Test of Transient Cross Flow Air Cooler Heat Exchanger

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***Abstract* - The increasing development of technology has an effect on the increasing use of technology. One example of the use of technology that has increased is the use of air conditioning or AC (Air Conditioner). Heat exchanger is a device that allows heat transfer and can also function as a heater or cooler. Heat exchangers are designed as much as possible so that the heat transfer process between fluids can take place efficiently, based on the types of heat exchangers are divided into several types. The purpose of this study is to determine the effect of the effectiveness of the heat exchanger air cooler with cold water temperature that changes over time and to determine the effect of variations in pump and fan flow speed on the performance of the heat exchanger air cooler. The research method was carried out experimentally on the air cooler heat exchanger with variations in water discharge of 5 L/min, 2.5L/min, 0L/min and variations in air velocity of 3.34 m/s, 2.50 m/s, and 1.67 m/s. Based on the effectiveness test carried out and when viewed from the graph and calculation of effectiveness, the best condition for using this air cooler tool is to use the air speed variation of 1.67 m/s or 50% of the maximum speed generated by the fan. It can be noted that this speed can produce a stable effectiveness value.**

Keywords: air cooler; effectiveness; heat exchanger; heat transfer;

I. INTRODUCTION

The increasing development of technology has an effect on the increasing use of technology. One example of the use of technology that has increased is the use of air conditioning technology or AC (Air Conditioner). In general, an air conditioner is a series of machines that have a function as air conditioning where the air can be cooled (Nasution, Nasution and Putra, 2020).

Heat exchanger is a device that allows heat transfer and can also function as a heater or cooler. Heat exchangers are designed as much as possible so that the heat transfer process between fluids can take place efficiently. Heat exchange occurs due to contact, either between fluids that are mixed or fluids that are separated by a partition. Changes in the flow rate in the heat exchanger certainly affect its performance (Fattah and Iskandar, 2020).

Heat exchangers are widely used in everyday life and in the industrial sphere. For example, in everyday life, cooking utensils are often used, all of which are actually heat exchangers. In cars and other means of transportation, there are many cabin air conditioners and radiators, both of which are part of the heat exchanger. In industry there are many heat exchangers such as boilers, super heaters, oil coolers, condensers, and others (Septian, Aziz and Rey, 2021).

In this study will test the air cooler heat exchanger with cold water fluid media by varying the fan speed and varying the flow rate of the water pump. The purpose of this study is to determine the effect of fan variations and pump flow rates on the effectiveness of air cooler heat exchangers and it is hoped that this research will get maximum effectiveness results.

II. RESEARCH OBJECT

2.1 Air Cooler Heat Exchanger

Air cooler is one of the most effective air conditioning tools in cooling the room, very environmentally friendly, and does not take up a lot of space. Air cooler uses water cooling material where the cold vapor produced will be blown through the fan to produce cool air (Rohito, Dantes and Nugraha, 2019). The cooling process that occurs is convection. A picture of the air heater heat exchanger tool can be seen in Figure 1.

Figure 1: Air Cooler Heat Exchanger

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The air cooler heat exchanger tool has several components that have been installed into one part. The following are the components in Table 1.

Table 1: Components of the air cooler

No	Components of the air cooler
1.	Upper water reservoir
2.	Lower water reservoir
3.	Fan
4.	Pump
5.	Aluminium pipe
6.	on / off switch

2.2 Effectiveness Equation (ε)

The heat transfer effectiveness of a heat exchanger is the ratio of the heat transfer rate (Q) to the maximum heat transfer rate value obtained from the calculation (Qmax). The use of effectiveness to determine the quality of a heat exchanger can use the equation (1).

$$\varepsilon = \frac{Q}{Qmax} \qquad (1)$$

Description:

ε = Effectiveness

Q = Heat transfer rate (W)

$Qmax$ = Maximum heat transfer rate (W)

2.2.1 Heat Transfer Rate Equation (Q)

In knowing how much heat transfer in the fluid to be used in equation (1), it can be calculated using equation (2).

$$Q = \dot{m} \times Cp \times \Delta T \qquad (2)$$

Description:

Q = Heat transfer rate (Watt)

C_p = Heat capacity of the fluid (W/kg.K)

ΔT = Difference between fluid temperature and ambient temperature (K)

2.2.2 Maximum Heat Transfer Rate Equation (Qmax)

The maximum heat transfer in the fluid to be used in equation (1) can be calculated using equation (3).

$$Q_{max} = C_{min}\,(T_{hi} - T_{ci}) \qquad (3)$$

Description:

Q_{max} = Maximum heat transfer rate (W)

C_{min} = The smallest value between Ch and Cc values (W/K)

$T_{h,i}$ = Temperature of hot fluid entering the heat exchanger (K)

$T_{c,i}$ = Temperature of cold fluid entering the heat exchanger (K)

2.3 Data Collection

Data collection begins with recording data manually and in real time for 40 minutes, carried out transiently (the temperature of the water as a cooling medium is allowed to change against time), and the test is given the treatment of variations in fan air speed and variations in water flow rate from the pump. Variations of fan air speed consist of 100% or 3.34 m/s, 75% or 2.50 m/s, and 50% or 1.67 m/s. While the variation of the water flow rate consists of 100% or 5 liters/minute, 50% or 2.5 liters/minute, and 0% or 0 liters (no water flow rate). After finishing taking the data, continue with analyzing the data to calculate the effectiveness value of the tool against the running time. Data collection requires the preparation of a scheme dariperalatan dan bahan yang dapatdilihat pada Table 2 and figure 2.

Table 2: Tools and material

Alat	Bahan
• *Air cooler heat exchanger* • Laptop • Water heater • DHT22 sensor • DS18B20 sensor • Anemometer digital display • Microprocessor • Thermistor • Thermometer • Handphone	• Water • Ice cube

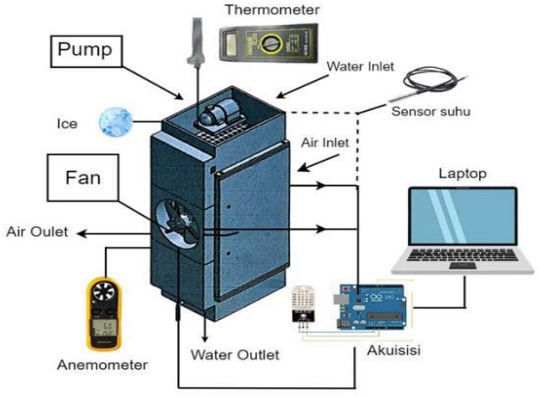

Figure 2: Data Collection Scheme

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III. RESULTS AND DISCUSSION

3.1 Test Data Collection Results

The time of taking the cooler heater test data is during the day starting at 11:00 to 11:40, because according to its function to cool the room, the temperature in the environment around the device must be quite hot, namely during the day. The data obtained comes from sensors that are turned on during the test. as for examples of graphs obtained from data collection as in Figure 3 and Figure 4.

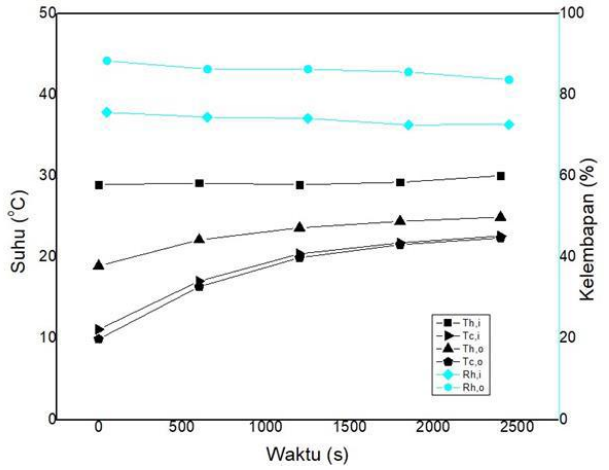

Figure 3: Graph of temperature against time at 5 lt/min flow rate variation, 3.34 m/s air velocity

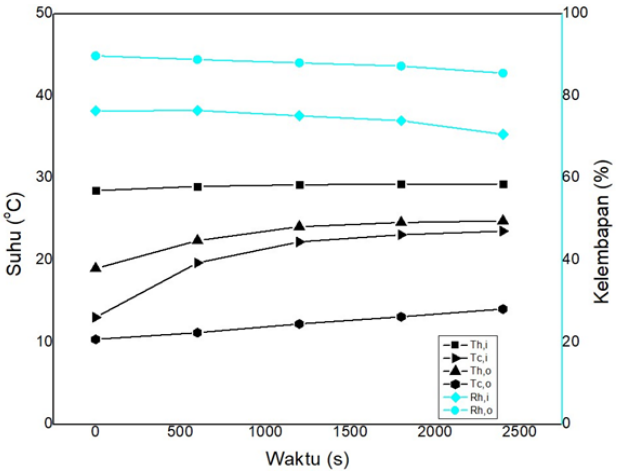

Figure 4: Graph of temperature against time at 0 lt/min flow rate variation, 2.50 m/s air velocity

3.2 Effectiveness (ε)

Based on the results of data collection that has been obtained, then can proceed to the calculation using equation (1). In Figure 5 to Figure 7 is a graph of the results of the calculation of the effectiveness of the air cooler tool obtained from the table of test data collection results in each variation.

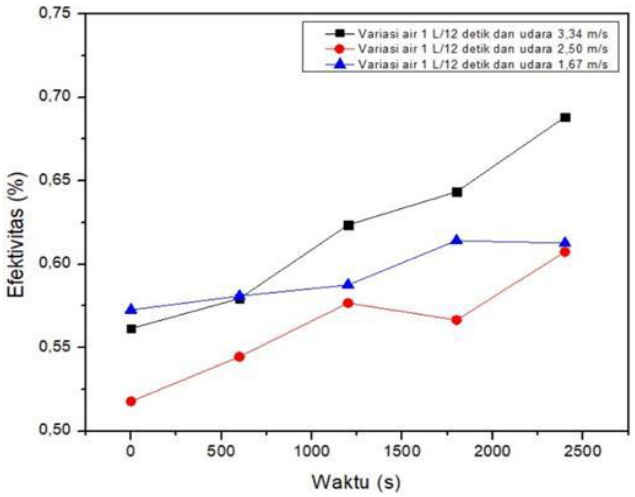

Figure 5: Graph of effectiveness (ε) against time at a water discharge variation of 5 liters/minute

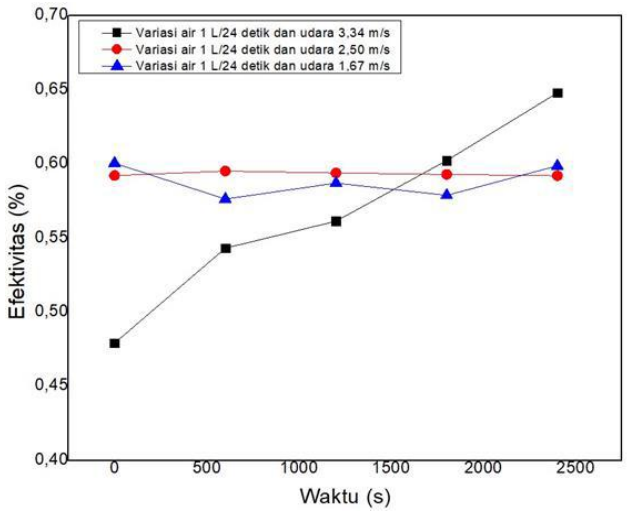

Figure 6: Graph of effectiveness (ε) against time at a water discharge variation of 2,5 liter/minute

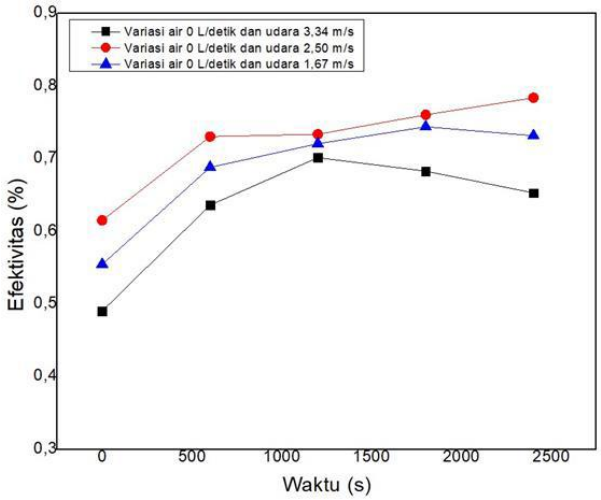

Figure 7: Graph of effectiveness (ε) against time at a water discharge variation of 0 liter/minute

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The graph above is the result of the effectiveness calculation of each test variation carried out. Based on the graph obtained, the variation with an air velocity of 3.34 m / s at a pump discharge of 100% and 50% produces a high effectiveness value at the end of the minute, but at the initial minute or t = 0 has a low effectiveness value.

At an air velocity of 2.50 m/s it can be seen that at that air velocity with all variations of pump flow discharge of 100% to 50% produces an unstable graph, but at 0% pump discharge variation produces the greatest effectiveness in the last minute.

Meanwhile, when viewed at an air velocity of 1.67 m/s in all variations of pump flow discharge in the test tends to have the most stable effectiveness value between air velocities of 3.34 m/s and air velocities of 2.50 m/s.

IV. CONCLUSION

Based on the results of testing and analysis on the transient air cooler tool, the following are the results:

1. The application of air coolers of various variations carried out produces the effect of different variations. Where the smaller the air speed and flow rate on the pump, the greater the effectiveness value obtained. However, if the pump flow discharge is turned off, it produces a small effectiveness value.
2. Based on the effectiveness test carried out and when viewed from the graph and calculation of effectiveness, the best condition for using this air cooler tool is to use a variation of air speed of 1.67 m / s or 50% of the maximum speed generated by the fan. It can be noted that this speed can produce a stable effectiveness value.

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