

# Experimental analysis of fluids discharge in cooling tower condenser distillation model

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**Abstract.** The application of traditional cooling distillation devices is carried out naturally where hot steam is left in the condenser tube. The heat transfer occurs depends on outdoor temperatures (20-25 degree C). The heat transfer is also felt to be ineffective because the time needed is quite long (2-3 hours). Based on these problems, we design a heat exchanger by applying cooling tower model to distillation condenser. Tests are carried out by experimental methods on devices designed to obtain the required temperature data. It is expected to obtain an effective heat transfer rate in terms of the amount of cooling fluid flow. Good difference from average heat transfer rate of 153.276 W/m degree C at discharge 2 l/min to an average of 168.758 W/m degree C at discharge 4 l/min. Increased heat transfer rate is 10.1 percent when fluid discharge is added 2 l/min. The increase in heat transfer rate is 13.7 percent when the fluid discharge is added to 4 l/min from the initial discharge of 2 l/min. The test results show that cooling water fluid discharge influences the rate of heat transfer that occurs because the cooling fluid can be more in contact with cooling area.

## 1. Introduction

Heat exchanger is a transfer device or heat exchanger between fluid and other fluids through a separation wall [1]. Based on the direction of fluid flow, this heat exchanger includes the type of Cross Flow (Transverse/perpendicular) [2], then the hot air that will enter the drying chamber will be separated from the smoke produced by the fuel. The hot air is flowed in the arrangement of pipes (tube sheet) and sucked by a blower which is then passed into the drying chamber. Whereas fuel combustion is carried out under the arrangement of pipes so that the hot air with smoke from the combustion results is separated [3]. Heat exchanger is an equipment that is used to exchange energy in the form of fluid water heat which has a different temperature that can occur through direct or indirect contact [4]. The heat exchanger serves to release heat to the surrounding air which is located at the back of the old refrigeration model and is an arrangement of wires and vessels [5].

Heat exchanger is a tool used to move heat can function as a heater or coolant. Heat exchangers are designed as much as possible so that heat transfer between fluids can take place efficiently [6]. Heat exchange occurs because of the back contact between fluids. There is a wall that separates it or both directly mixed [7]. This phenomenon can occur, because the greater the fluid mass flow rate, the greater the convection coefficient value, because the mass flow rate affects the price of dimensionless numbers, namely the Reynolds number (Re) is directly proportional to the mass flow rate. The Re price has a relationship to Nusselts (Nu) numbers. Nusselt numbers are dimensionless numbers that explain the



convection and conduction heat transfer ratios on the fluid surface, where the greater the exergy, the Nu price, the greater the convection value compared to the conditions [8].

Cooling towers are one of the heat exchanger equipment that uses water splash media to reduce temperature by extracting heat from water and emitting it to the atmosphere [9]. It uses evaporation where some of the water is evaporated into the moving air stream and then discharged into the atmosphere. As a result, the remaining water is significantly cooled. It can reduce the temperature of water more than equipment that only uses air to remove heat, such as radiators in cars, and therefore costs more effectively and efficiently. It is a heat exchanger that cools water through the air by spraying which results in a small portion of water evaporating [10].

Distillation is the evaporation of the fraction of the liquid in such a way that the steam which is in equilibrium with the remaining liquid will be separated because of changes in density due to the phase change. The distillation device has important parts, including the condenser tube where it cools, which changes the vapor phase to liquid again. The application of traditional distillation equipment to make alcoholic drinks with coconut tree juice or palm sugar palm juice as raw material is needed to heat the raw material to become steam about 3 to 4 hours to obtain 1 liter of alcoholic beverages at least 16 liters of palm sugar is needed, while the cooling is carried out naturally where hot steam is left in the condenser tube so that the phase of the steam changes back to liquid. This cooling process requires a relatively long time because the heat transfer that occurs depends on the outdoor temperature with a normal temperature of 20 degrees to 25 degrees Celsius. In distillation devices that have been designed previously to change the vapor phase into liquid in the condenser tube using a sell and tube system where there is indirect heat transfer with copper pipe media soaked in running water. The process of heat transfer to change the phase is also felt to be ineffective because the time needed is quite long (2-3 hours).

## 2. Methodology

### 2.1. Design

One application of traditional distillation tools is to make alcoholic beverages with coconut tree juice or palm sugar sap as raw material. To get 1 liter of alcoholic beverages, at least 16 liters of coconut juice are needed, while the ingredients needed to heat the raw material into steam are about 3 to 4 hours. The cooling process is carried out naturally, that is by just leaving it alone, this requires a relatively long time because the heat transfer that occurs depends on the outdoor temperature (Figure 1). Making distillation equipment has also been done in the Mechanical Engineering Department by applying a closed flow cooling system model. Closed flow is meant by circulating cooling water from the condenser to another reservoir and then flowing back to the condenser (Figure 1). This system still requires a long time to change the vapor phase to liquid (2-3 hours) with the result that the condensation is not maximal because there is still steam being wasted through the yield canal.

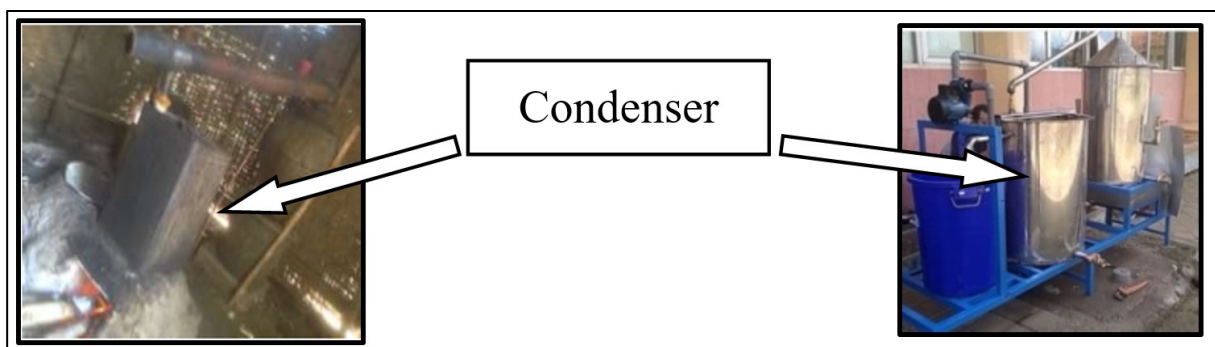
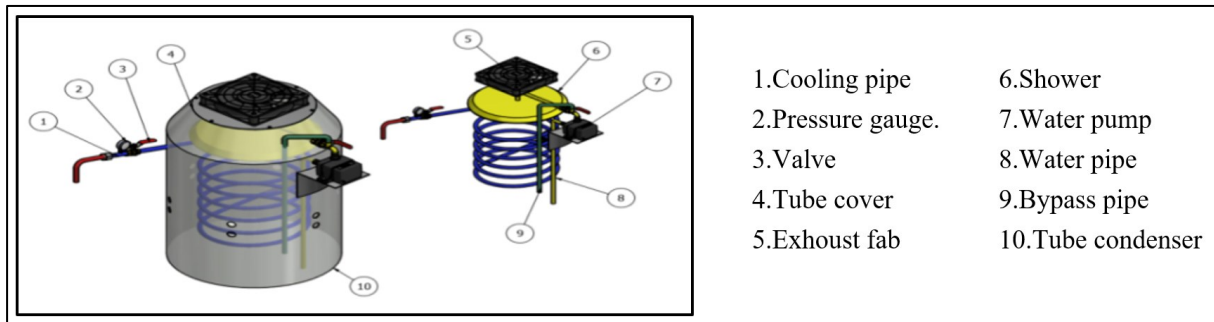


Figure 1. Distillation tool.

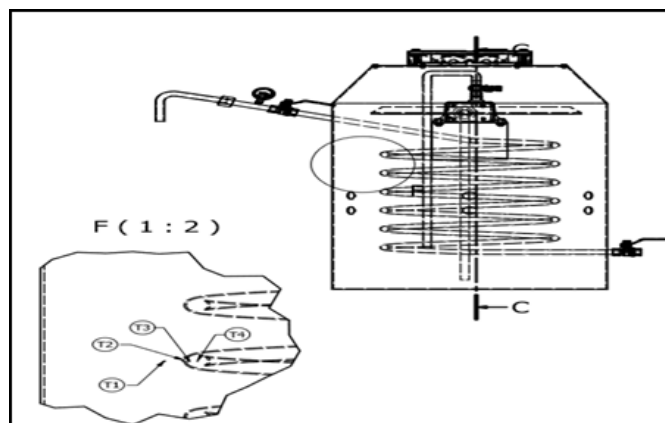
Inspired by the fluid cooling device, the cooling tower, a cooling tower-based condensation tube was created. To determine the efficiency of a cooling tower-based distillation tube, a test was carried out in the form of analysing the effect of cooling water discharge on heat transfer so that it can accelerate phase changes. This test uses relevant theories and real data retrieval and races on fixed variables that have been determined. The following is the design of a cooling tower-based condensation tube device that is designed



**Figure 2.** Condenser design.

## 2.2. Research instrument

The instrument used in the research is thermocouple and stopwatch. Data retrieval in testing uses thermocouple by measuring the temperature in several locations on a condensing tube tool as shown in Figure 3.



**Figure 3.** Location of data retrieval.

Testing is done based on the data that has been taken and the fixed variables such as the time and discharge of water used.

## 3. Methodology

### 3.1. Results of data

Data retrieval is done 10 times with a process time of 150 minutes of distillation reactor heating at a temperature of 100°C. Temperature control is used to keep the temperature in the reactor tube stable so that the steam distillation pressure stabilizes leading to the condenser. The cooling fluid discharge is controlled by a flow meter. Cooling fluid discharge is regulated according to research requirements, namely 2 l/min, 4 l/min and 6 l/min. The results of the distillation process with the media of coconut juice are ignored. The test results data are displayed in Table 1, 2 and 3.

**Table 1.** Fluid Discharge 2 l/min.

NO	TIME (minute)	T1 (°C)	T2 (°C)	T3 (°C)	T4 (°C)	Q tot (W/m°C)
1	15	25.6	25.4	25.0	24.5	3964.026
2	30	55.7	55.7	55.5	24.6	145166.8
3	45	56.6	56.9	56.3	24.8	151851.8
4	60	57.7	58.5	54.3	34.2	96724.03
5	75	67.5	65.5	63.2	36.7	144208
6	90	76.6	70.0	66.0	38.8	210271.3
7	105	64.3	62.0	65.2	37.8	151766.1
8	120	75.7	64.5	66.6	38.9	206556.2
9	135	76.8	67.2	66.8	39.2	211466.5
10	150	77.2	67.5	67.4	39.7	210786.6

**Table 2.** Fluid Discharge 4 l/min.

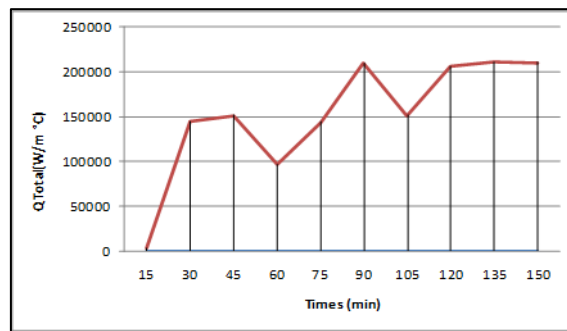
NO	TIME (minute)	T1 (°C)	T2 (°C)	T3 (°C)	T4 (°C)	Q tot (W/m°C)
1	15	25.6	25.4	25.0	24.2	4040.526
2	30	55.8	55.8	52.5	24.4	150538.3
3	45	56.4	56.5	55.3	24.2	155821.6
4	60	56.7	58.5	54.3	30.2	115444
5	75	65.5	65.5	63.2	32.7	161908
6	90	69.6	70.0	66.0	32.8	200281.3
7	105	72.3	79.3	65.2	33.8	108756.6
8	120	75.7	74.7	66.6	33.9	249136.7
9	135	76.8	67.2	66.8	34.2	271016.5
10	150	77.2	67.5	67.4	34.7	270636.6

**Table 3.** Fluid Discharge 6 l/min.

NO	TIME (minute)	T1 (°C)	T2 (°C)	T3 (°C)	T4 (°C)	Q tot (W/m°C)
1	15	25.6	25.4	25.0	24.2	4040.526
2	30	55.2	55.8	52.5	24.4	145534.3
3	45	56.4	56.5	54.2	24.2	156472
4	60	56.8	57.2	54.3	30.2	112459.8
5	75	65.5	65.2	62.1	31.2	176167.6
6	90	68.7	68.5	63.3	31.8	201310.3
7	105	71.2	71.2	65.2	32.6	178866.6
8	120	75.7	74.7	67.2	33.9	249420.9
9	135	76.8	67.2	67.3	34.2	272520.9
10	150	77.2	68.6	67.4	34.5	270009.1

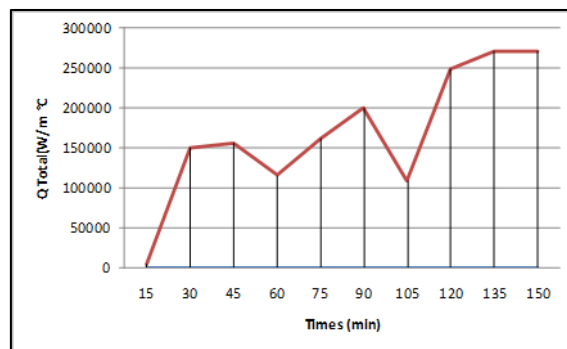
### 3.2. Descriptive analysis

Tables 1, 2 and 3 show significant differences when the fluid discharge is increased. Figure 4 shows a good increase in heat transfer rate when fluid discharge is set at 2 liters/minute. There was a decrease in the value of  $Q$  at minutes 60 and 105 because the stove fire in the reactor went out in the 45<sup>th</sup> minute so that the temperature was maintained at 100°C. Control will give the stove command to light when the temperature in the tube drops to 99°C. The wait time is long (15 minutes) until the temperature control gives a signal to turn on the stove fire. This also happened in the 105<sup>th</sup> minute when the stove went out in the 90<sup>th</sup> minute. This will affect the temperature change in the condenser where the thermocouple is installed. The temperature change certainly affects the decrease in the heat transfer rate.



**Figure 4.** Fluid discharge 2 l/min.

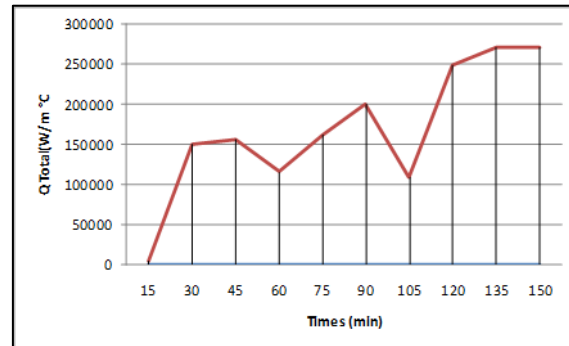
Figure 5 shows an increase in the heat transfer rate which starts to increase when the fluid discharge is set at 4 liters/minute. There was a decrease in the value of  $Q$  at minutes 60 and 105 because the stove fire in the reactor went out in the 45<sup>th</sup> minute so that the temperature was maintained at 100° C. Control will give the stove command to light when the temperature in the tube drops to 99° C. The wait time is long (15 minutes) until the temperature control gives a signal to turn on the stove fire. This also happened in the 105<sup>th</sup> minute when the stove went out in the 90<sup>th</sup> minute. This will affect the temperature change in the condenser where the thermocouple is installed. The temperature change certainly affects the decrease in the heat transfer rate.



**Figure 5.** Fluid discharge 4 l/min.

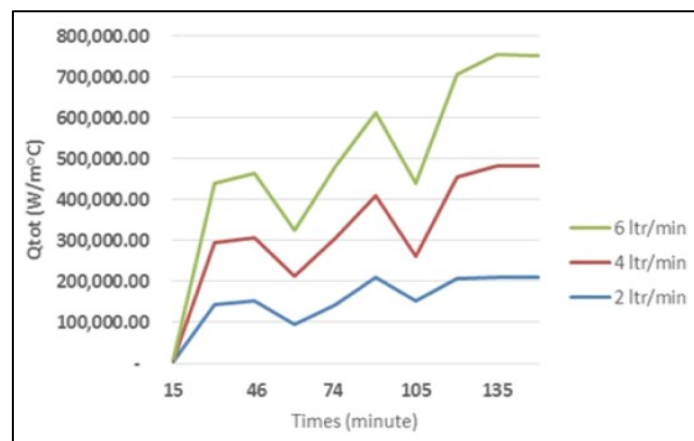
Figure 6 shows an increase in the heat transfer rate which is greatly increased when the fluid discharge is set at 6 liters / minute as a result of the cooling fluid being more in contact with the area of cooling in the copper condenser pipe. The high direct  $Q$  value reaches 145.534 W/m°C. There was a decrease in the value of  $Q$  at minutes 60 and 105 because the stove fire in the reactor went out in the 45<sup>th</sup> minute so that the temperature was maintained at 100°C. Control will give the stove command to light when the temperature in the tube drops to 99°C. The wait time is long (15 minutes) until the temperature control gives a signal to turn on the stove fire. This also happened in the 105<sup>th</sup> minute when

the stove went out in the 90<sup>th</sup> minute. This will affect the temperature change in the condenser where the thermocouple is installed. The temperature change certainly affects the decrease in the heat transfer rate.



**Figure 6.** Fluid discharge 6 l/min.

Significant changes when cooling fluid discharge is increased. Difference from the average heat transfer rate of 153.276 W/m°C at discharge 2 l/min to an average of 168.758 W/m°C at discharge 6 l/min. Increased heat transfer rate is 10.1% when fluid discharge is added 2 l/min from 2 l/min become to 4 l/min. The increase in heat transfer rate is 13.7% when the fluid discharge is added to 4 l/min from the initial discharge of 2 l/min become to 6 l/min.



**Figure 7.** Difference of heat transfer.

#### 4. Conclusions

The results of the study the effect of cooling water fluid discharge on the condenser distillation of cooling tower models are increasing the total heat transfer rate ( $Q_{tot}$ ) by 10.1% from fluid discharge 2 l/m to 4 l/m and increasing by 13.7% when the discharge is increased to 6 l/m and the discharge of cooling water influences the rate of heat transfer that occurs because the cooling fluid can be more in contact with the cooling area.

#### 5. References

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