

Analysis of the Effect of Range and Approach on the Effectiveness of the Cooler Cooling Tower in a Rubber Compound Factory

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Abstract - Cooling Tower or cooling tower is a tool used to cool the temperature of the water flow, which becomes hot because it is used as a cooling medium for a machine. The effectiveness of cooling in a cooling tower is influenced by the Range and Approach values, where the Range value explains the difference in water temperature entering and leaving the cooling tower, while the Approach explains the difference in water temperature leaving the cooling tower and the ambient wet-bulb temperature. In one Rubber Compound Factory, there is a Cooling Tower which is used to cool the warm water that comes out of the condenser on the machines in the factory. This research aims to assess the effectiveness of cooling tower cooling. The analytical method is used by taking daily monitoring data on the cooling tower. In this research, the average effectiveness value of the cooling tower was 72.10%.

Keywords: Cooling tower, cooling effectiveness, rubber compound factories.

I. INTRODUCTION

Energy-related issues are becoming increasingly prominent to be discussed, apart from energy-saving factors there are also issues related to emissions.

One of the cooling equipment whose performance is of great concern because of its very important role in the industrial world, because it has a big influence on the industrial economy and environmental impact is the cooling tower [1-4].

For example, a thermal power generation unit with a capacity of 350 MW, every 1 °C decrease in the outlet water temperature in the cooling tower can save 1,808 tons of coal fuel per year [5,6], where this has great economic value and also emissions that have quite an impact on the environment.

A cooling tower is a heat exchanger whose function is to cool water by contacting it with air so that it evaporates a small portion of the water [7]. In a cooling tower, heat transfer takes place from water to air. Cooling towers use an

evaporation system where some of the water is evaporated into a moving air stream and then released into the atmosphere, so the remaining water is cooled significantly [8].

A cooling tower is a heat rejection device that transfers waste heat from a process to the atmosphere through cooling water flow. This type of heat rejection is commonly referred to as evaporative cooling. There are 6 basic components of a cooling tower consisting of a frame, fan, filler, inlet pipe, water basin and inlet louvre [9].

The condensate water processing process in the cooling tower is included in the main cooling water system, where the cooling process is by evaporation and heat transfer by convection, where the flow of condensate water entering the cooling tower will be in direct contact with the cooling air (direct contact) so that the cooling air will absorb heat from condensate water so that the water will experience a decrease in temperature. The temperature of the condensate water entering the cooling tower affects the effectiveness of the cooling that occurs in the cooling tower. The greater the condensate water temperature, the effectiveness of the cooling process will decrease [10]. Figure 1 shows the simple concept of a cooling tower system.

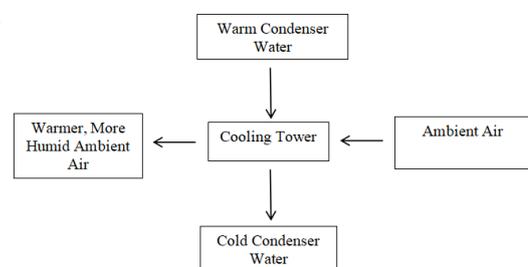


Figure 1: The simple concept of a cooling tower system

Cooling towers are divided into several types according to specifications based on the cooling medium, air flow direction and fan location. Based on the cooling medium, cooling towers are divided into natural and mechanical cooling media, based on the direction of airflow, cooling

towers are divided into a cross flow and counter flow, and based on the location of the cooling tower fan, they are divided into induced draft and forced draft. Meanwhile, the rubber compound factory uses the induced draft cross-flow cooling tower type, as shown in Figure 2 [11].

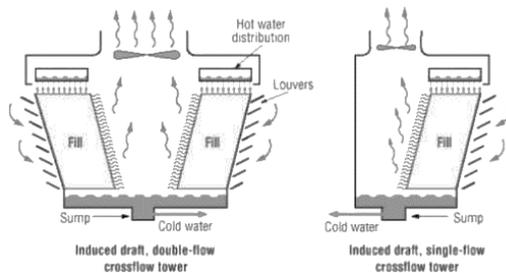


Figure 2: Draft cross-flow cooling tower

One way to determine the performance of a cooling tower can be seen from its effectiveness value. The greater the cooling effectiveness value of the cooling tower, the better the performance. Cooling effectiveness can be found by paying attention to two important things, namely the approach value and the range value. The range is the difference or distance between the temperature of the incoming water and the temperature of the water leaving the cooling tower, so a high Range value means that the cooling tower has been able to reduce the water temperature effectively and its performance is good. Meanwhile, the approach is the difference in the temperature of the cold water leaving the cooling tower and the wet-bulb temperature ambient, the lower the approach the better the cooling tower performance [12]. Hence the research will focus more on the parameters of cooling tower cooling effectiveness which are influenced by range and approach.

II. METHODOLOGY

The rubber compound factory has one cooling tower that operates for cooling warm water condensate after leaving the heat exchanger. This cooling tower has not had its performance analyzed for a long time.



Figure 3: Cooling tower rubber compound factory

It is hoped that the results of this effectiveness analysis can help provide data on the current operating performance conditions of the cooling tower in terms of cooling effectiveness and also see the influence of range and approach. Figure 3 shows the cooling tower rubber compound factory.

2.1 Data

Research data is needed to carry out an analysis of cooling effectiveness values in cooling towers in the rubber compound factory sourced from the cooling tower log sheet rubber compound factory from May 25, 2022 - May 26, 2022.

2.2 Data analysis method

The working principle of this cooling tower is to pump hot water from the condenser to the cooling tower through a piping system which at the end has many nozzles for the spraying stage. The hot water that comes out of the nozzle (spray) directly makes contact with the surrounding air which moves forcibly due to the influence of the fan and is temporarily retained because the water is inhibited by the drift eliminator installed on the cooling tower. Then the water which has experienced a decrease in temperature is collected in a pool and then pumped back to the condenser which is inside the cooler. In the cooling tower, a make-up water valve is also installed which is connected to the nearest water source to increase the water capacity if there is a shortage of water during the evaporation process [13]. Figure 4 explains the concept of range and approach to the cooling tower.

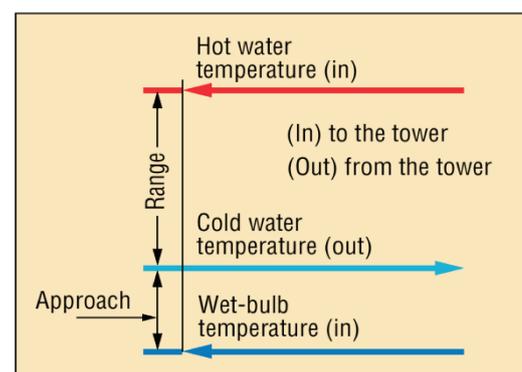


Figure 4: Range and approach to the cooling tower [13]

These measured parameters are then used to determine the performance of the cooling tower in the following ways.

1. Range

The range is the $T_{in} - T_{out}$ value. The Range is calculated using the following Equation 1:

$$\text{Range} = (T_{in}) - (T_{out}) \quad (1)$$

2. Approach

The approach is the T_{out} air value - T_{wb} . The approach is calculated using the following Equation 2:

$$\text{Approach} = (T_{out}) - (T_{wb}) \tag{2}$$

3. Effectiveness

Effectiveness is a comparison between the range and the ideal range (in percentage), namely the difference between the cooling water inlet temperature and the wet-bulb temperature. The higher this ratio, the higher the effectiveness of the cooling tower. Effectiveness can be calculated using the following Equation 3:

$$\xi = \frac{\text{Range}}{\text{Approach} + \text{Approach}} \times 100 \% \tag{3}$$

III. RESULTS AND DISCUSSION

In general, a cooling tower can be categorized as an evaporative cooler which is used to cool water or other working media to a temperature close to the wet-bulb temperature of the surrounding air. The main use of a cooling tower is to remove heat absorbed due to circulating water from cooling systems used in power plants, petroleum refineries, petrochemical plants, natural gas processing plants, food factories, semiconductor factories, and other industrial facilities.

Table 1: Cooling Tower Logsheet

No.	Execution time		T (water)		Wet-bulb (°C)
	Date	Time	T _{in} (°C)	T _{out} (°C)	
1.	05/25/2022	07.00	29.7	27.3	26.0
2.	05/25/2022	08.00	29.5	27.0	25.9
3.	05/25/2022	09.00	29.7	27.3	26.2
4.	05/25/2022	10.00	29.5	27.2	26.1
5.	05/25/2022	11.00	30.3	28.5	27.5
6.	05/25/2022	12.00	29.7	27.2	26.3
7.	05/25/2022	13.00	30.1	28.1	27.0
8.	05/25/2022	14.00	29.8	27.3	26.5
9.	05/25/2022	15.00	29.8	27.5	26.8
10.	05/25/2022	16.00	29.7	27.6	26.9
11.	05/26/2022	07.00	29.3	26.9	25.7
12.	05/26/2022	08.00	29.7	27.3	26.5
13.	05/26/2022	09.00	30.2	28.1	27.0
14.	05/26/2022	10.00	29.5	27.2	26.5

15.	05/26/2022	11.00	29.3	27.0	26.3
16.	05/26/2022	12.00	29.7	27.5	26.9
17.	05/26/2022	13.00	29.5	27.7	26.9
18.	05/26/2022	14.00	28.5	26.4	25.8
19.	05/26/2022	15.00	28.2	26.1	25.5
20.	05/26/2022	16.00	28.1	26.0	25.4

To get the cooling effectiveness value, you must first get the range and approach values for a cooling tower. By using the data in Table 1, with Equations 1 and Equations 2, we can get that on 05/25/2022 at 10.00 WIB, the range and approach values are 2.3 °C and 1.1 °C. After getting the range and approach values, using Equation 3 above, we can get an effectiveness value of 67.64%.The effectiveness value resulting from the calculation process using Equation 3 is shown in Table 2.

Table 2: Calculation Results of Range, Approach, and Cooling Effectiveness

No	Execution time		Range (°C)	Approach (°C)	Effective ness (%)
	Date	Time			
1	05/25/2022	07.00	2,4	1.3	64.86%
2	05/25/2022	08.00	2.5	1.1	69.44%
3	05/25/2022	09.00	2,4	1.1	68.57%
4	05/25/2022	10.00	2,3	1.1	67.65%
5	05/25/2022	11.00	1.8	1.0	64.29%
6	05/25/2022	12.00	2.5	0.9	73.53%
7	05/25/2022	13.00	2.0	1.1	64.52%
8	05/25/2022	14.00	2.5	0.8	75.76%
9	05/25/2022	15.00	2,3	0.7	76.67%
10	05/25/2022	16.00	2.1	0.7	75.00%
11	05/26/2022	07.00	2,4	1,2	66.67%
12	05/26/2022	08.00	2,4	0.8	75.00%
13	05/26/2022	09.00	2.1	1.1	65.63%
14	05/26/2022	10.00	2,3	0.7	76.67%
15	05/26/2022	11.00	2,3	0.7	76.67%
16	05/26/2022	12.00	2,2	0.6	78.57%
17	05/26/2022	13.00	1.8	0.8	69.23%

18	05/26/2022	14.00	2.1	0.6	77.78%
19	05/26/2022	15.00	2.1	0.6	77.78%
20	05/26/2022	16.00	2.1	0.6	77.78%

3.1 Comparison of inlet, outlet and wet-bulb temperatures against time

From the data in Table 1, it can be seen that the inlet, outlet and wet-bulb temperatures are indeed related, it can be seen from the time and date that the maximum and minimum temperatures of each temperature are the same. This can be seen from the working principle of the cooling tower, where the hot water from the inlet will be cooled by the air in the environment which is influenced by the wet bulb, and then the hot water which undergoes an evaporation process will cause the temperature to decrease. The inlet, outlet and wet-bulb temperatures have a directly proportional relationship. The correlation of these three temperatures is shown in Figure 5 and Figure 6.

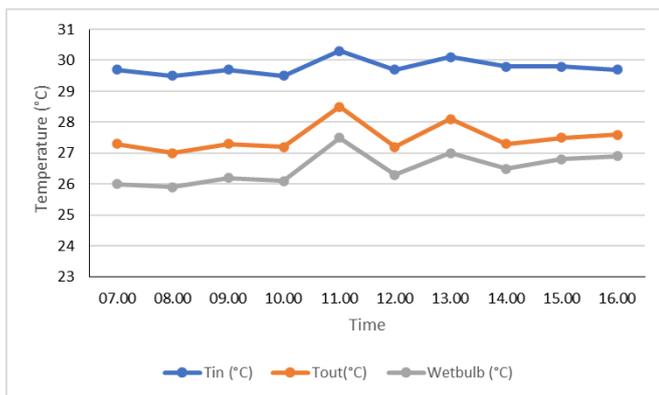


Figure 5: Comparison graph of temperature against time on June 25 2022

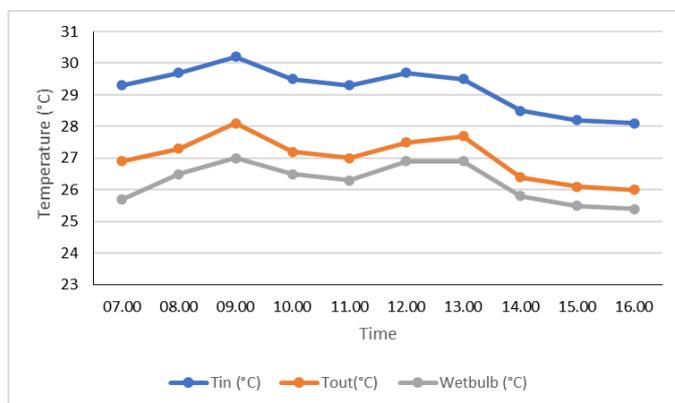


Figure 6: Comparison graph of temperature against time on June 26 2022

3.2 Comparison of Range and Approach Against Time

A high range value indicates that the cooling tower is able to reduce water temperature effectively and has good

performance. Meanwhile, for approach, the lower the Approach value, the better the cooling tower performance. The best range value obtained by the cooling tower was a temperature difference of 2.5°C which occurred on May 25, 2022, at 08.00 WIB and 12.00 WIB. The best approach values obtained by the cooling tower occurred on May 26, 2022, at 12.00, 14.00, 15.00 and 16.00 WIB with a temperature difference of 0.6°C. The range and approach values that are not directly proportional can be seen in Figure 7 and Figure 8.

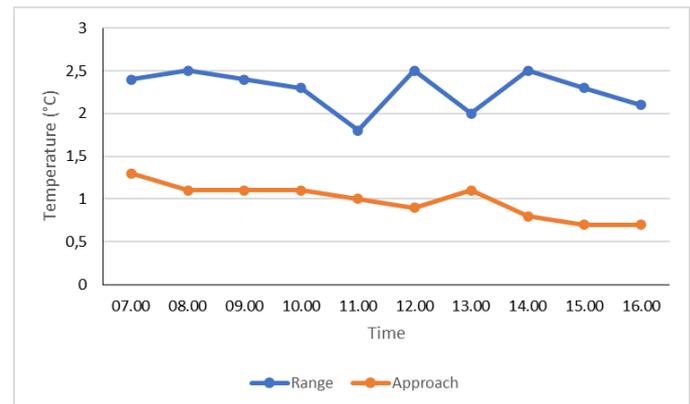


Figure 7: Comparison graph of range and approach values against time on June 25 2022

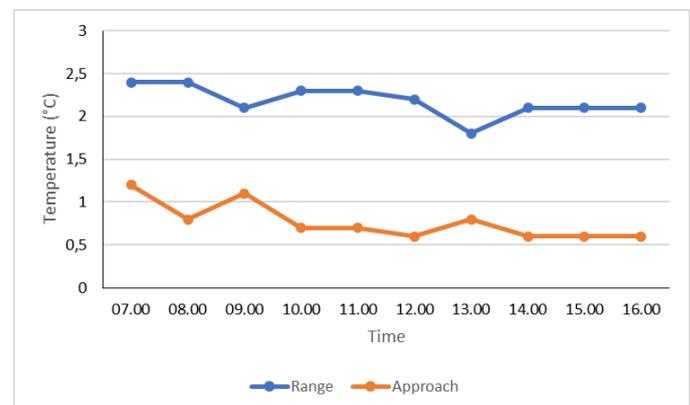


Figure 8: Comparison graph of range and approach values against time on June 26 2022

3.3 Comparison of Cooling Effectiveness Against Time

In Figure 9 it can be seen that the lowest cooling effectiveness value occurred on May 25 2022 at 11.00 WIB with a cooling effectiveness of 64.29% and it can also be seen in Figure 7 that on May 25 2022 at 12.00 WIB there was a minimum distance between range and approach. From Figure 10 it can be seen that the highest cooling effectiveness value that occurred in the cooling tower occurred on 26 May 2022 at 12.00 WIB with cooling effectiveness reaching 78.57% and it can also be seen from Figure 8 that on 26 May 2022 at 12.00 the maximum distance between the ranges occurred and

approaches. From the data, the average cooling effectiveness value was 72.10%, which can be said to be quite good.

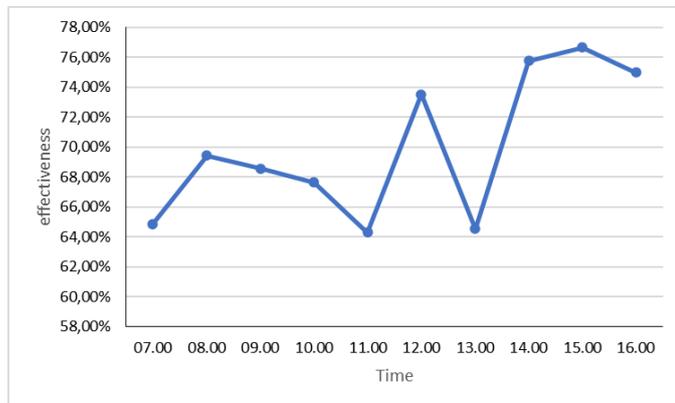


Figure 9: Comparison graph of cooling tower effectiveness over time on June 25 2022

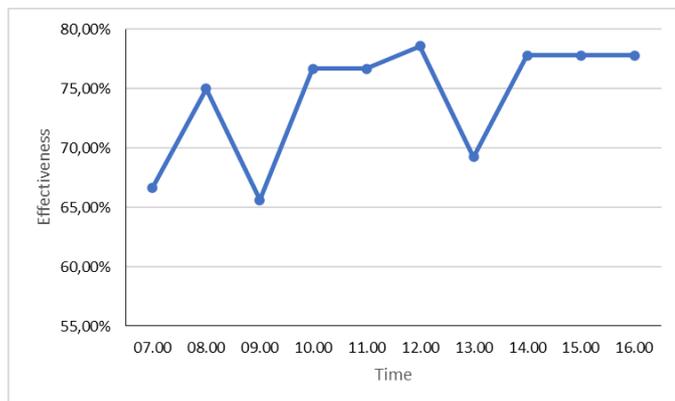


Figure 10: Comparison graph of cooling tower effectiveness over time on June 26, 2022

IV. CONCLUSION

Cooling effectiveness is a comparison between Range and ideal Range, where from the definition of Range and Approach it can be seen that the value of cooling effectiveness is directly proportional to Range and inversely proportional to Approach. From the data available on the cooling tower at the rubber compound factory studied, it was found that the highest cooling effectiveness value occurred on May 26 2022 at 12.00 WIB with cooling effectiveness reaching 78.57%. Meanwhile, the lowest cooling effectiveness value occurred on May 25 2022 at 11.00 WIB with cooling effectiveness worth 64.29%. From the data, the average cooling effectiveness value was 72.10%.

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Citation of this Article:

Norman Iskandar, Afrio Yandra Arvabugi, Sulardjaka, “Analysis of the Effect of Range and Approach on the Effectiveness of the Cooler Cooling Tower in a Rubber Compound Factory” Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 7, Issue 11, pp 411-416, November 2023. Article DOI <https://doi.org/10.47001/IRJIET/2023.711055>
