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Research Paper

Effect of Distance Between Expanded Wire Mesh Fillers On Cooling Tower Induced Draft Counterflow

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ABSTRACT: *Industrial development has resulted in the increasing use of industrial machines and one of the problems with these machines is high heat. Therefore, a cooling system is needed, it's a cooling tower. Factors that affect cooling tower performance are contact time and surface area between the phases (water and air). To increase the effect of the above factors, filler is added. The expanded wire mesh filler is used in this research. The purpose of this study was to determine the effect of expanded wire mesh filler on cooling tower performance induced draft counter flow on the effect of variations in initial water temperature and air velocity, and the effect of effectiveness, water-air ratio, cooling capacity, evaporation loss and L / G values. The highest effectiveness value for cooling towers using fillers was 70.61%, while the highest value for cooling towers without using fillers was 49.27%. In this study. The highest cooling capacity value in the cooling tower using filler is 21.61kJ/s while the highest value in the cooling tower without using filler is 15.15 kJ/s.*
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KEYWORDS: *Cooling tower, filler, cooling capacity, expanded wire mesh*

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I. INTRODUCTION

The rapid industrial development resulted in the increasing use of industrial machines [1]. The high intensity of the use of industrial machines causes problems with the machine. One of the problems that arise when the machine is used continuously is that the engine experiences high heat, so a good cooling system is needed to maintain the efficiency and performance of the engine in good condition. The right solution to overcome the above problems is the use of cooling towers.

Cooling tower is a heat exchanger with air and water working fluid. Air serves to lower the temperature of the water entering the cooling tower [2]. This tool uses the principle of heat transfer between water and exhaled cooling air. One of the purposes of using cooling towers in the production process is to cool water so that water can be reused after use in the production process [3]. The quality of cooling towers is generally seen in their performance by comparing between data approach, range, and cooling load [4]. Cooling tower induced draft counterflow is one of the various cooling towers where the working principle is to drain hot water from top to bottom, while the fan sucks air from the bottom to the top of the cooling tower.

Factors affecting the rate of heat transfer from high-temperature water to air are the contact time and surface area of contact between water and air. To increase the influence of the above factors, the filler is added to the cooling tower. The purpose of using filler is to inhibit the flow rate of fluid so that there is longer contact between fluid and air to produce maximum performance [5]. The longer the fluid contact with air, the more it can lower the temperature to the maximum. Damage to the filling material is a major problem in cooling towers. Research by modifying the filling material is expected to produce maximum performance from the cooling tower that has been made before.

Expanded wire mesh in Indonesian Called Expanda Metal is a mesh made of plate incisions in the form of parallelogram holes, processed by a machine that is pulled without welding or casting metal. The raw materials for making expanded wire mesh are galvanized plate, white plate, black plate and aluminum plate. Its advantages are strong, lightweight, weatherproof [6].

Research Hidayat (2014) [7] entitled Heat Load Analysis of Cooling Tower Induced Draft Counterflow with Wulung Bamboo Filler Material. The purpose of this study is to determine the maximum performance of the cooling tower. The variations used are the initial temperature variations in the cooling tower of 40 °C, 50 °C, 60 °C, 70 °C, height 100 cm, 150 cm, and 200 cm.

Research Ramkumar dan Ragupathy (2011) [8] entitled thermal performance of forced draft counter flow wet cooling tower with expanded wire mesh packing. The research examined the performance of cooling towers with the addition of filler in the form of expanded wire mesh. The variations used are the entry temperatures of 40 o C, 47 o C and 52 o C and the filler is positioned zigzag vertical and zigzag horizontal.

Research Sudrajat (2015) [4] examining the analysis of the use of wulung bamboo filler material with variations in fan electric voltage on the performance of cooling tower induced draft counterflow. This research was carried out using a cooling tower which has a height of 320 cm and a tube diameter of 60 cm. The purpose of this study was to find the effectiveness of cooling using initial temperature variations of 40 ^{0} C, 50 ^{0} C, 60 ^{0} C, variations in mains voltage of 0 volts, 110 volts, and 220 volts.

Research Pratama (2021) [9] researched the performance analysis of cooling tower induced draft counterflow with asbestos filler material with variations in water entry temperature (T1), air speed and distance between layers. The variations in water inlet temperature (T1) used are 50°C, 60°C, 70°C, air speed 4 m/s, 6 m/s, and 8 m/s, and the distance between layers is 10 cm, 15 cm and 20 cm. Wave asbestos filler material used affects the increase in the effectiveness of the cooling tower.

Based on the description above, a study was conducted that aimed to determine the effect of expanded wire mesh filler material on range , approach, effectiveness, cooling capacity and water losses by evaporation.

II. MATERIALS AND METHODS

The research method used is an experimental method using variations in initial temperature, air speed, and distance between expanded wire mesh as filler cooling towers. Observations are carried out directly to obtain causal data through experiments to obtain empirical data. This research will be carried out in accordance with the work plan that has been prepared. This research was carried out at the Energy Conversion Laboratory, Department of Mechanical Engineering, Faculty of Engineering, Jember University with a room temperature of 27.8 °C and air humidity of around 85%.

The tools and materials used in this study are:

a) One unit cooling tower induced draft counter flow with a height of 250 cm.
b) Expanded wire mesh filler material with a height of 5 cm, 10 cm and 15, can be seen in figure 1.
c) Voltage regulator
d) Water Pump
e) LPG Stoves
f) Temperature and humidity gauges, the laying of temperature and humidity measuring devices can be seen in figure 2

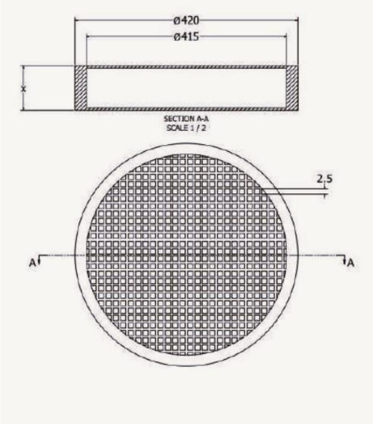
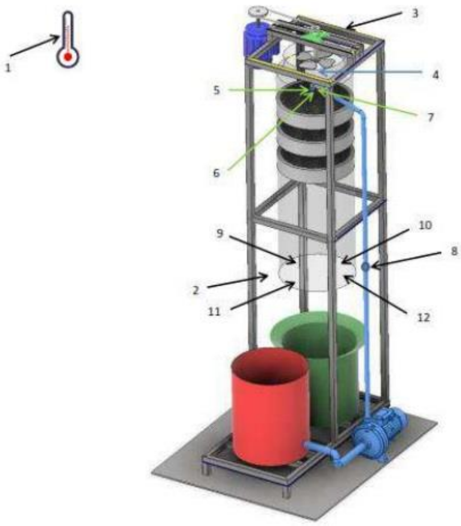


Figure 1. Expanded wire mesh filler



Description of the instrument tool :

No	Equipment
1	Mercury Thermometer
2	Mercury Thermometer
3	Mercury Thermometer
4	Anemometer
5	Thermocouple
6	Thermocouple
7	Thermocouple
8	Flowmeter
9	Thermocouple
10	Thermocouple
11	Thermocouple
12	Thermocouple

III. RESULTS AND ANALYSIS

Range

The graph data from the range calculation of all variations used can be seen in the following figure:

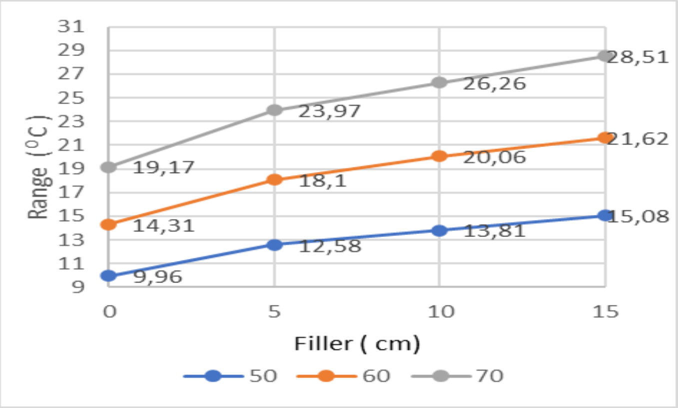


Figure 3. Graph of range calculation with air at 4 m/s

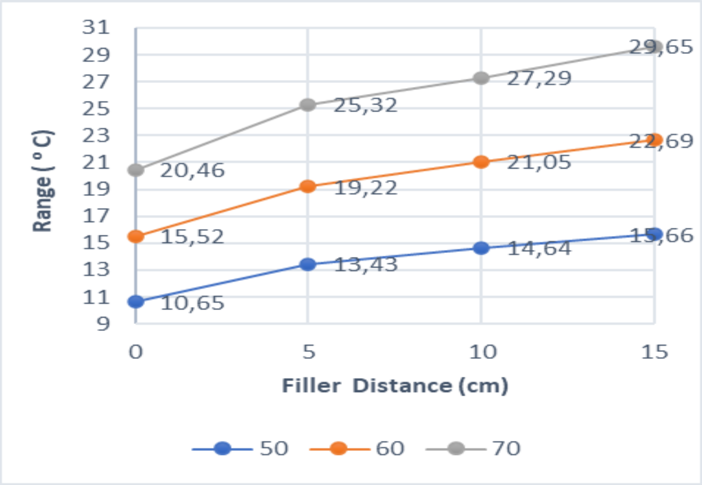


Figure 4. Graph of range calculation with air at 6 m/s

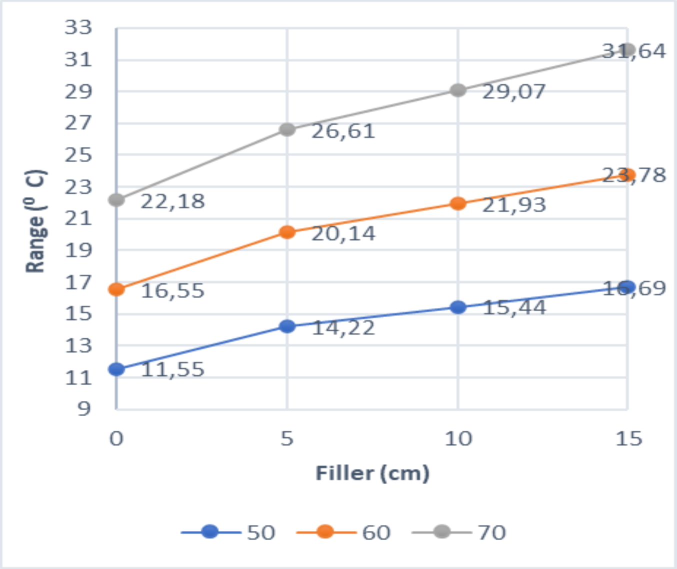


Figure 5. Graph of range calculation with air at 8 m/s

In the figures above, the result is that the increase in the range value (ΔT) is influenced by several things. The use of filler will affect the range value. This study used variations in the distance between layers of filler expanded wire mesh. The greater the distance between the fillers expanded wire mesh results in the speed of water and breaks up the water grains to be smaller, the slower the water falling will make the time of water contact with air greater and the smaller the water grains will make the area of water contact with air larger. The addition of the initial temperature also affects the range value. The greater the initial temperature that enters the cooling tower causes a large temperature difference with the exit temperature of the cooling tower, because theoretically the temperature of the outgoing water will always drop close to the T_{wb} temperature of the surrounding air. Air discharge also has an effect on the cooling process. The greater the air discharge will cause greater heat transfer from water to air so that the water that comes out will be more.

The performance of the cooling tower in the heat exchange between water and air can be observed from the value of the heat transfer rate. [10]. If the value of the heat transfer rate is small indicates a small transfer of energy between the water temperature and the air flow as well. The highest temperature range data obtained was 31.64 °C in variations using fillers with a distance between filler layers of 15 cm, an air speed of 8 m/s and an initial cooling tower temperature of 70 °C. While the lowest temperature range value is 9.96 °C in variations without the use of filler, air speed of 4 m/s and the initial temperature enters the cooling tower of 50 °C. From the data that has been obtained from this study, it can be seen that the additional distance between the filler layers of expanded wire mesh will increase the range value to be larger. This can happen because the surface area of contact between water and air is getting bigger and the time of contact of water with air is getting longer [11] .

Approach

Graph data from the calculation of all variations used can be seen in the following figure:

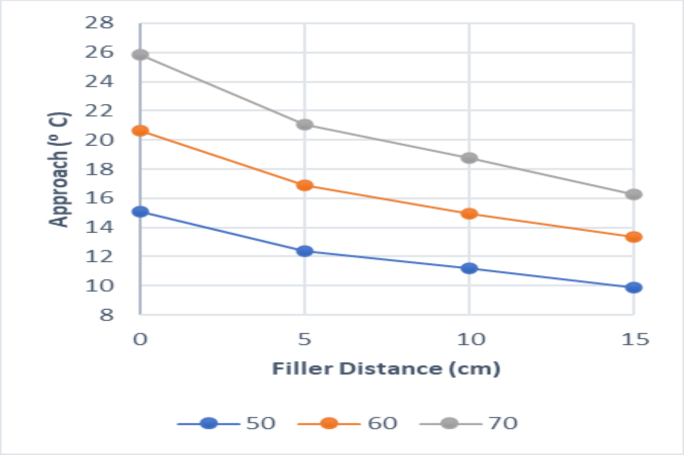


Figure 6. Graph of the results of the calculation approach with air at 4 m/s

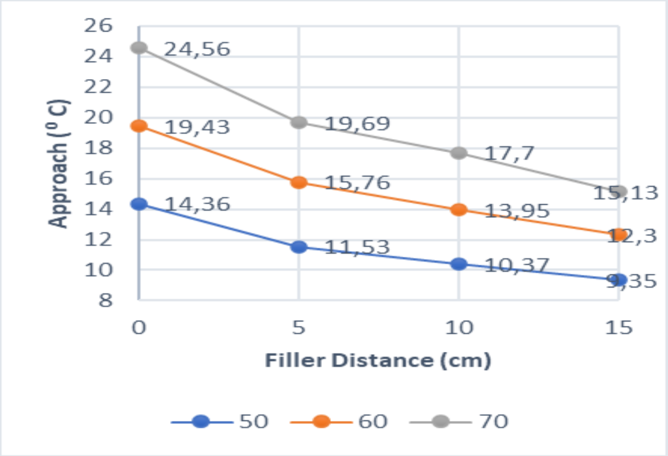


Figure 7. Graph of the results of the calculation approach with air at 6 m/s

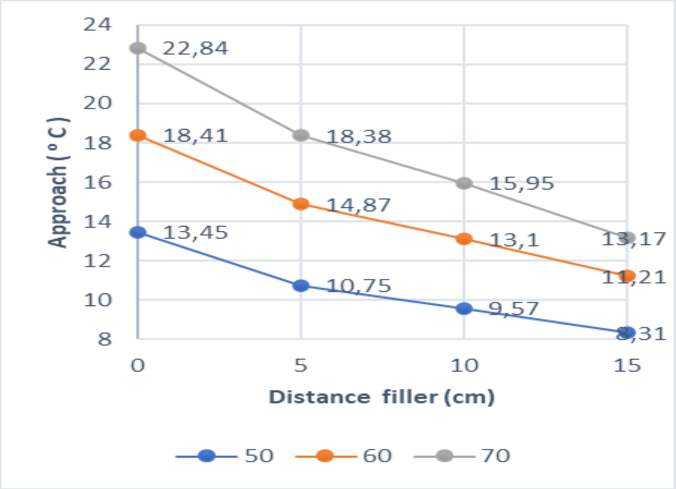


Figure 8. Graph of the calculation results of the approach with air at 8 m/s

In the graphic picture above, it can be understood that the approach value is decreasing. The cause of the decrease in the approach value is the lower temperature of the cooling tower exit water, while the temperature value of the wet ball of the ambient air is relatively fixed. Increased spacing between expanded wire mesh fillers and increased incoming air discharge into the cooling tower also causes a decrease in approach value [7] .

Lower 'approach' values indicate better cooling tower performance. In this study, the lowest approach value without using filler was 13.45 °C at an air speed of 8 m/s and an initial temperature of 50 °C. While the highest approach value is 25.84 °C in air with a speed of 4 m/s and an initial temperature of 70 °C. While the value of the approach using the lowest filler is 8.31 ° C at an air speed of 4 m/s, the distance between the fillers is 15 cm and the initial temperature is 50 ° C. While the highest approach value is 21.02 °C at a fan speed of 4 m/s, distance between fillers of 5 cm and initial temperature of 70 °C.

This value is obtained due to the use of fillers which results in the splitting of water grains to be smaller and causes a longer contact time of water and air in the cooling tower. approach experienced an overall decrease when compared to cooling towers without the use of fillers. The air discharge also affects the approach value. The greater the air discharge that enters the cooling tower will cause more heat and water vapor to be wasted into the air, causing a decrease in the approach value. The value is obtained due to the use of filler material which results in the splitting of water grains to be smaller and causes the longer contact time of water and air in the cooling tower. approach experienced an overall decrease when compared to cooling towers without the use of fillers. The air discharge also affects the approach value. The greater the air discharge that enters the cooling tower will cause.

Cooling Capacity

Graphic data from the calculation of cooling capacity from all variations used can be seen in the following figure:

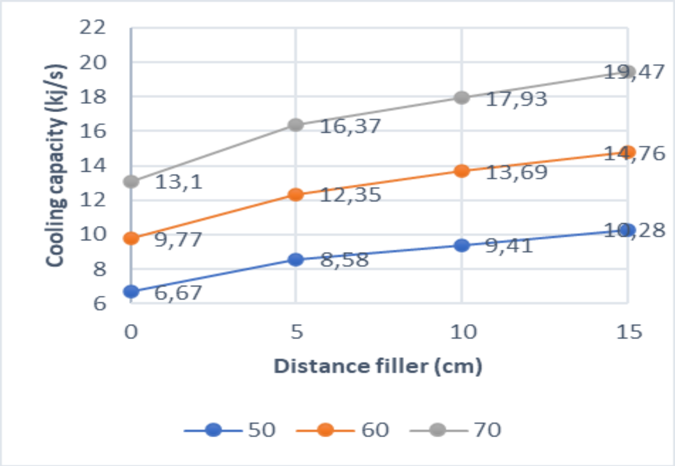


Figure 9. Graph of the results of the calculation of cooling capacity with air at 4 m/s

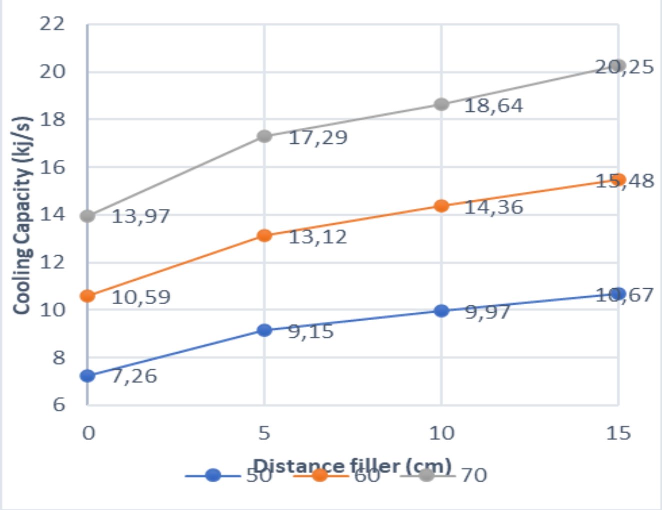


Figure 10. Graph of the results of the calculation of cooling capacity with air at 6 m/s

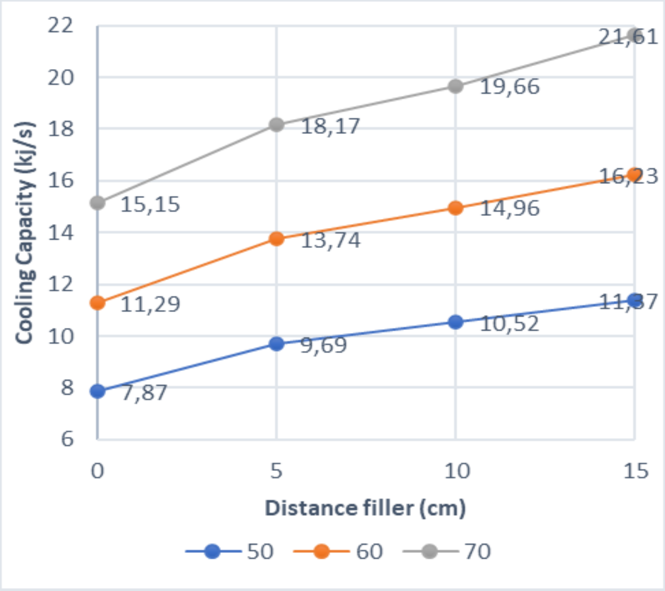


Figure 11 Graph of the results of the calculation of cooling capacity with air at 8 m/s

In the figure 9 to figure 11 above, it is shown that the overall cooling capacity is increasing according to the variations used. This influence has a conformity experienced with changes in range. The ability of the cooling tower to dissipate heat into the environment is also influenced by the temperature of the incoming water and the speed of the air entering the cooling tower.

The highest filler-free cooling capacity value was 15.15 kJ/s at an initial temperature of 70 ^{o} C with an airspeed of 8 m/s while the lowest cooling capacity value was 6.79 kJ/s at an initial temperature of 50 ^{o}C and an airspeed of 8 m/s. The highest fill cooling capacity value was 21.61 kJ/s at an initial temperature of 70 ^{o} C, the distance between fillers was 15 cm and the airspeed was 8 m/s, while the lowest cooling capacity value was 8.58 kJ/s at an initial temperature of 50 ^{o} C, the distance between fillers was 5 cm and airspeed was 4 m/s. This research shows that the additional distance between fillers will increase the value of cooling capacity, as well as the air discharge that enters the cooling tower. The greater the air discharge entering the cooling tower will cause an increase in the value of cooling capacity.

Water losses by Evaporation

Evaporation of water every 10,000,000 kcal of heat discharged reaches 1.8 m^3 theoretically [12] . The graph data of the range calculation results of all variations used can be seen in the following figure The graph data of the range calculation results of all variations used can be seen in the following figure:

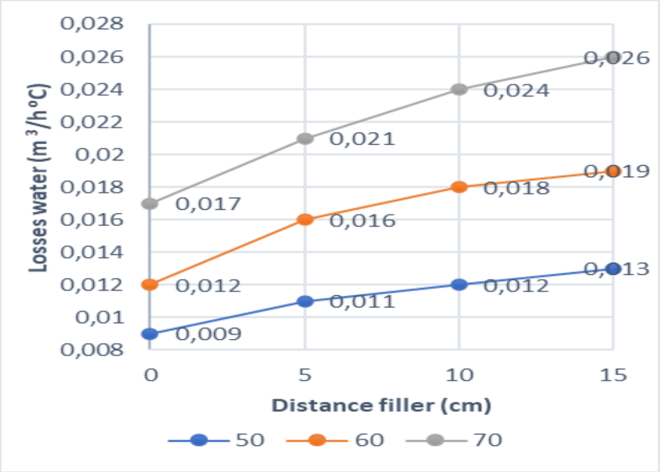


Figure 12. Graph of the results of the calculation of evaporation loss with air at 4 m/s

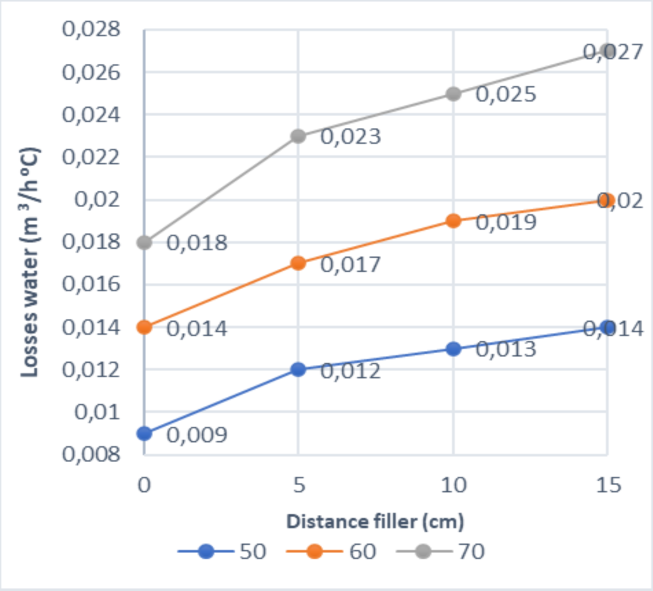


Figure 13. Graph of the results of the calculation of evaporation loss with air at 6 m/s

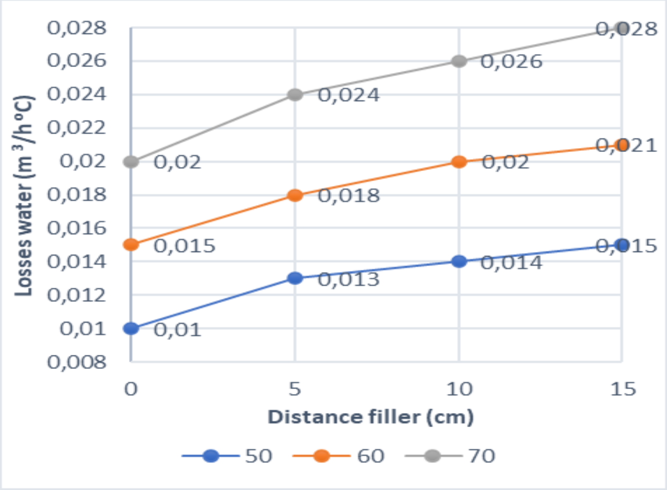


Figure 14. Graph of the results of the calculation of evaporation loss with air at 8 m/s

In the figure 12, figure 13 and figure 14, a graph of the evaporation rate of water that has increased in each variation used. Evaporation will become faster as the air speed increases into the cooling tower. High air speed will cause pressure drops in the cooling tower [4] .

The highest evaporation loss value using filler was 0.0285 m^3/h °C at an airspeed of 8 m/s, the distance between filler layers was 15 cm and the initial temperature was 70 ºC, while the lowest evaporation loss value was 0.0113 m^3/h °C at an airspeed of 4 m/s, the distance between filler layers was 5 cm and the initial temperature was 50 ºC. The highest evaporation loss without using filler was 0.02 m^3/h °C at an airspeed of 8 m/s and an initial temperature of 70 ºC, while the lowest evaporation loss was 0.008 m^3/h °C at a fan speed of 4 m/s and an initial temperature of 50 ºC. From this study, it can be seen that the greater the air discharge that enters the cooling tower and the greater the layer distance between fillers, causing the evaporation loss value to be greater.

Effectiveness of Cooling Towers

The effectiveness of cooling towers can be obtained from the comparison of ideal range and range values in the form of percentages. The higher the ideal range and range comparison value causes the higher the effectiveness of the cooling tower [15]. Graphic data from the calculation of the effectiveness of all variations used can be seen in the following figure:

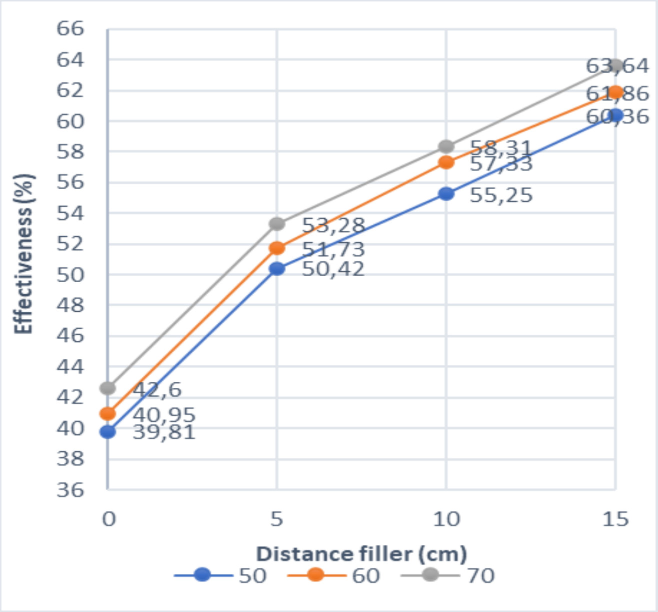


Figure 15. Graph of the results of the calculation of effectiveness with air at 4 m/s

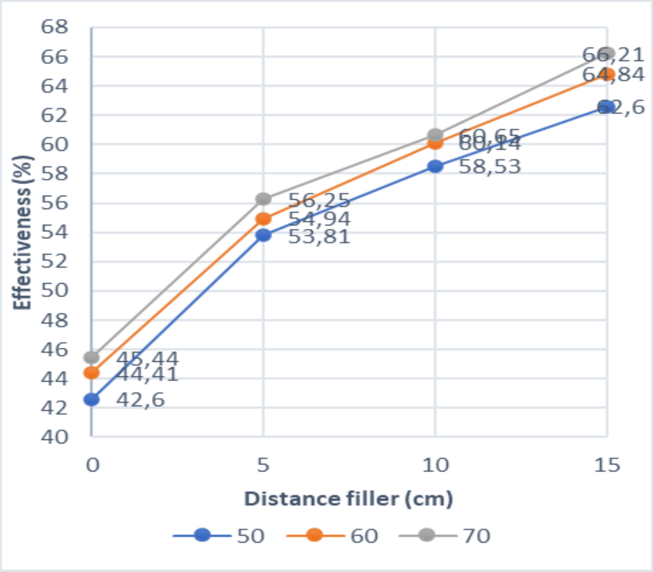


Figure 16. Graph of the results of the calculation of effectiveness with air at 6 m/s

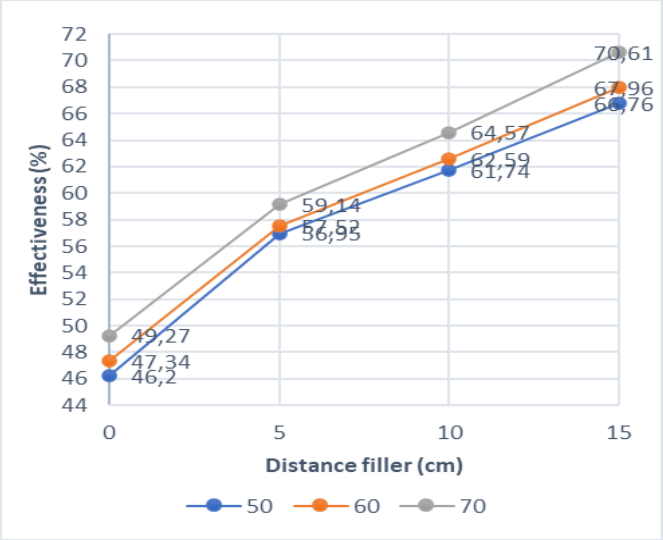


Figure 17. Graph of the results of the calculation of effectiveness with air at 8 m/s

The ambient temperature greatly affects the increase and decrease in the effectiveness of cooling towers [16]. The effectiveness graph in figures 15, to figure 17 above can be seen that the effectiveness increases with each variation used. The variation in the initial temperature of the water with the addition of the air speed will affect the range value increasing with the initial temperature value (T_1) and the wet ball temperature (T_{wb}) being set the same, then the value of the effectiveness will also increase. Meanwhile, the decrease in the effectiveness of the cooling tower occurs if the range value is low while the wet ball temperature value increases. Meanwhile, the effectiveness of the cooling tower decreases if the range value is low but there is an increase in wet ball temperature (T_{wb}). The operating temperature of the cooling tower system is affected by the wet ball temperature (T_{wb}). This is what makes the wet ball temperature (T_{wb}) an important factor in determining the performance of the cooling tower[17]. The lower the wet ball temperature value (T_{wb}) causes the cooling tower performance to be more effective [16].

From the chart above, it can be seen that the effectiveness of cooling towers using the highest filler is 70.61% at an airspeed of 8 m / s, the distance between filler layers is 15 cm and the initial temperature is 70 °C, while the lowest effectiveness is 50.42 % at an airspeed of 4 m / s, the distance between filler layers is 5 cm and the initial temperature is 50 °C. The effectiveness of cooling towers without using filler was highest at 49.27% at an airspeed of 8 m/s and an initial temperature of 70 °C, while the lowest effectiveness was 39.81% at an airspeed of 4 m/s and an initial temperature of 50 °C overall the effectiveness of cooling towers is high when using fillers compared to without using fillers. Increasing the distance between filler layers will make the effectiveness greater.

IV. CONCLUSION

From the results of research and calculation of cooling towers using experimental methods, using variations in the distance between filler expanded wire mesh 5 cm, 10 cm and 15 cm, temperature variations of 50 °C, 60 °C, 70 °C, and speed variations of 4 m /s, 6 m /s, 8 m /s. The test results found that the higher the distance between the expanded wire mesh fillers, the more cooling tower performance will increase. This is evidenced by the increase in the range value, evaporation loss, cooling capacity and effectiveness, and the decreasing approach value.

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