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Effect of Varying Number of Filler Mesh Arrangements in Induced Draft Cooling Tower on Cooling Capacity and Effectiveness

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ABSTRACT

The use of filler in lowering the temperature of the air condenser can affect the performance improvement of a cooling tower. This study aims to determine the effect of many filler arrangements on the cooling capacity and effectiveness of cooling water. The research was carried out by building an induced draft cooling tower by varying the amount of infill arrangement. Based on the research results, it was found that there were significant differences in the capacity and effectiveness of the cooling tower from the 5 number of filler variations. Cooling towers that use 5 filler variations have the best cooling capacity and effectiveness, namely 622.45 kJ/s and 22%.

Keywords: Cooling tower, filler, performance, effectivity

1. Introduction

A cooling tower is a heat exchange device which has a working principle by utilizing the air around the environment to reduce the temperature of hot water. The water cooling process aims to reuse water as a cooling medium [1]. Cooling towers as a cooling system have the advantage that the cooling process takes place by direct contact between hot water and environmental air. From this process, heat will move maximally into the environmental air, where the principle applies that the higher the capacity of the air flowing into the cooling tower, the greater the capacity of the cooling process [2]. There are various methods to increase the effectiveness of cooling tower performance, namely by modifying the material or filler arrangement in the cooling water. The filler in cooling water has the function of holding back the flow of water so that the resulting contact time with environmental air is longer and indirectly becomes a medium so that the contact area of water with air becomes wider [3]. The arrangement of the filler in the cooling tower affects the flow of water and air as well as contact time. The closer the arrangement distance, the contact time will increase, but this results in a greater pressure drop [4]. This research was conducted to determine the effect of varying the number of mesh arrangements on the cooling capacity and effectiveness of the cooling tower

2. Methodology of Research

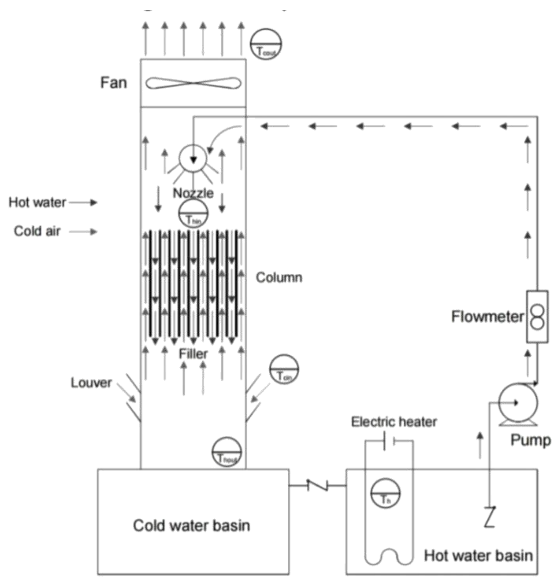
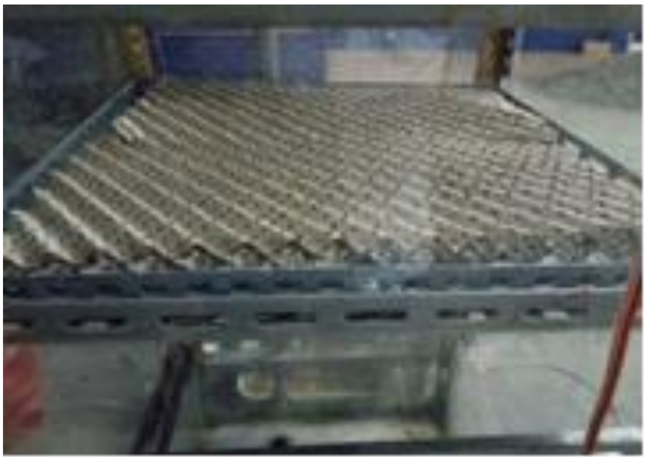


Figure 1. Schematic of cooling tower arrangement testing equipment [5]

This research uses experimental methods in its application [5]. The testing process was carried out using tools in the form of a cooling tower replica with laboratory scale dimensions of 120 x 40 x 40 cm. The cooling water installation scheme is shown in Figure 1. The cooling water prototype is modified by varying the number of filler arrangements, namely, 1, 2, 3, 4 and 5 fillers as shown in Figure 2. The water flow is conditioned with the tap fully opened. From these variables, differences in cooling capacity and effectiveness will be known.

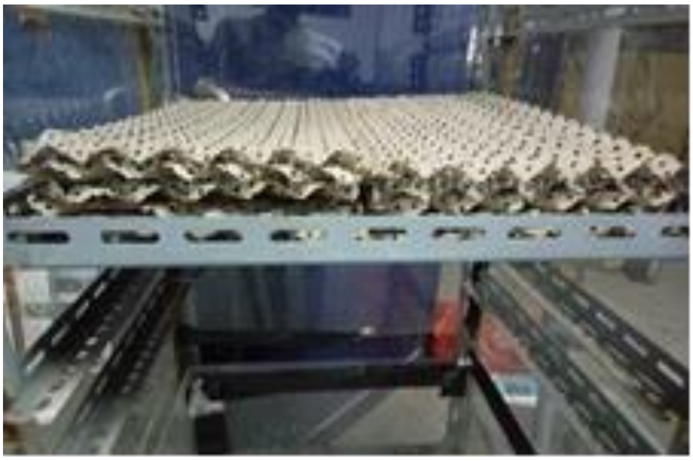
(a)



(b)

(c)

(d)



(e)

Figure 2. Composition of cooling water filler (a) arrangement of 1 filler, (b) arrangement of 2 fillers, (c) arrangement of 3 fillers, (d) arrangement of 4 fillers, and (e) arrangement of 5 fillers

The dependent variables in this research are cooling effectiveness, cooling air flow speed, cooled water speed and cooling tower cooling power. The data collection method was carried out by flowing hot water with a temperature of 40°C with the tap fully open, then the temperature of the resulting water passed through the filler was measured 3 times. From the average value of the outlet water temperature, we next calculate the cooling capacity. Before measuring the capacity and effectiveness, first the water discharge is measured using a flowmeter to determine the water flow mass using equation 1.

$$m = \rho \cdot V \tag{1}$$

where:

m	=	water flow mass (kg/s)
ρ	=	density of water (kg/L)
V	=	water discharge (L/s)

The cooling capacity is calculated using equation 2, where ΔT is the temperature difference between the inlet and outlet water fluids with the inlet hot water temperature is 40°C.

$$Q = m \cdot Cp \cdot \Delta T \tag{2}$$

where:

Q	=	cooling capacity (kJ/s)
m	=	water flow mass (kg/s)
Cp	=	heat capacity (J/kg.°C)
ΔT	=	Temperature difference (°C)

3. Result and Discussion

The tests in this study were carried out sequentially starting with the filler arrangement variable totaling 1. Initially, measurements were made on the water discharge using a flowmeter with the tap fully open and a water discharge of 0.05 L/s was obtained. From the experimental results of variations in filler arrangements, it shows that the more filler arrangements there are, the cooling capacity will increase [6] as shown in Figure 3. The cooling capacity is determined using equation 2. From the calculation results, the data obtained for the lowest cooling capacity is for filler arrangement number 1, which is 238.92 kJ/s. Meanwhile, the highest cooling capacity in the filler arrangement is 5, which is 622.45 kJ/s. This result is in line with the results of research conducted by previous researchers, where the number of filler arrangements can influence the cooling capacity [7]. Generally, the more filler arrangements will increase the cooling capacity of a cooling tower[1], [8]. Of course, this will also affect the cooling tower performance [9].

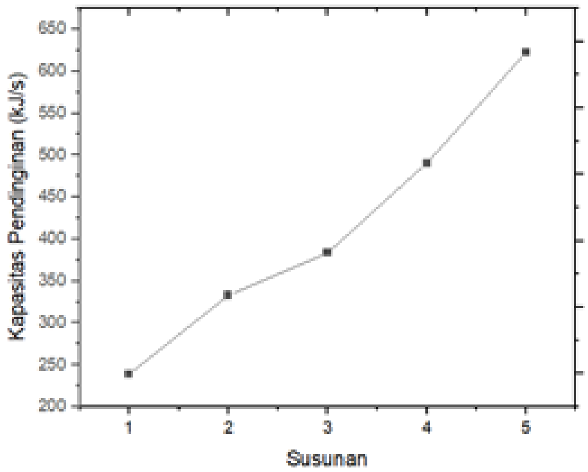


Figure 3. Graph of the effect of many fillers arrangements on cooling capacity

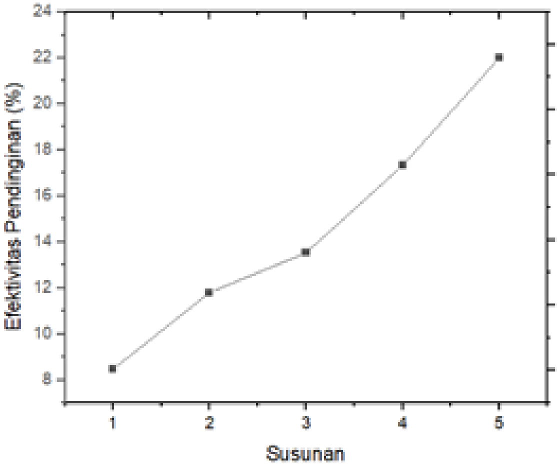


Figure 4. Graph of the Effect of Multiple Filler Arrangements on Cooling Effectiveness

Based on Figure 4, it can be seen that the more fillers there are in the cooling water, the cooling effectiveness will increase [10]. The highest effectiveness was 22% in an arrangement of 5 fillers. The lowest effectiveness had a filler composition of 1 piece, which is 8.47%.

4. Conclusion

The research data obtained shows that the number of filler arrangements in the cooling water affects the cooling capacity and effectiveness. The more filler arrangements, the more cooling capacity will increase. The highest capacity is 622.45 kJ/s in an arrangement of 5 fillers and the lowest capacity is 238.92 kJ/s in an arrangement of 1 filler. This also applies to cooling effectiveness, the more filler the cooling effectiveness increases. The highest effectiveness is 22% with a filler composition of 5 pieces. Suggestions for further research are to vary the tap openings by considering the amount of filler in the cooling water.

References

[1] J. Ruiz, P. Navarro, M. Hernández, M. Lucas, and A. S. Kaiser, “Thermal performance and emissions analysis of a new cooling tower prototype,” *Appl. Therm. Eng.*, vol. 206, p. 118065, 2022, doi: 10.1016/j.applthermaleng.2022.118065.

[2] N. Karimi Bakhtiyar, R. Javadpour, S. Zeinali Heris, and M. Mohammadpourfard, “Improving the thermal characteristics of a cooling tower by replacing the operating fluid with functionalized and non-functionalized aqueous MWCNT nanofluids,” *Case Stud. Therm. Eng.*, vol. 39, no. June, p. 1DUMMY, 2022, doi: 10.1016/j.csite.2022.102422.

[3] Z. Cui, Q. Du, J. Gao, and R. Bie, “Optimum design of a deep cooling tower for waste heat and water recovery from humid flue gas,” *Case Stud. Therm. Eng.*, vol. 49, no. March, p. 103317, 2023, doi: 10.1016/j.csite.2023.103317.

[4] G. Asgari, M. Khazaei, A. Seidmohammad, M. Mansoorizadeh, and S. Talebi, “Reclamation of treated municipal wastewater in cooling towers of thermal power plants: Determination of the wastewater quality index,” *Water Resour. Ind.*, vol. 29, p. 100207, 2023, doi: 10.1016/j.wri.2023.100207.

[5] Arikunto, “Metodelogi Penelitian, Suatu Pengantar Pendidikan,” in *Rineka Cipta, Jakarta*, 2019, p. 21.

[6] M. Xu *et al.*, “Investigation on heat exchanger arrangement in solar enhanced natural draft dry cooling towers under various crosswind conditions,” *Case Stud. Therm. Eng.*, vol. 28, no. September, 2021, doi: 10.1016/j.csite.2021.101505.

[7] J. M. Serrano, P. Navarro, J. Ruiz, P. Palenzuela, M. Lucas, and L. Roca, “Wet cooling tower performance prediction in CSP plants: a comparison between artificial neural networks and Poppe’s model,” *Energy*, p. 131844, 2024, doi: 10.1016/j.energy.2024.131844.

[8] P. Navarro, J. Ruiz, A. S. Kaiser, and M. Lucas, “Effect of fill length and distribution on the thermal performance of an inverted cooling tower,” *Appl. Therm. Eng.*, vol. 231, no. May, p. 120876, 2023, doi: 10.1016/j.applthermaleng.2023.120876.

[9] W. Wang, L. Li, M. Gao, M. Zhang, Q. Xu, and J. Wang, “Water-saving performance study of water conservation and plume abatement device in wet mechanical draft cooling towers,” *Case Stud. Therm. Eng.*, vol. 56, no. October 2023, p. 104188, 2024, doi: 10.1016/j.csite.2024.104188.

[10] J. Miao *et al.*, “Comparison on cooling performance of pre-cooled natural draft dry cooling towers using nozzles spray and wet medium,” *Case Stud. Therm. Eng.*, vol. 27, no. May, p. 101274, 2021, doi: 10.1016/j.csite.2021.101274.