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The effect of vortex generator on the approach value on forced draft type cooling tower

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Abstract. Cooling tower is needed right now in the context of efficiency and energy conventions for cooling circulation. The type of cooling tower used depends on the level of performance. One type of cooling tower used in this study is forced draft. Cooling tower in this study was added by a rectangular winglet generator vortex with the aim to increase the effectiveness of performance by reducing the value of the approach. This is because forced tower cooling draft on its utilization results in performance that is not commensurate with the costs incurred. The results obtained in this study are a comparison of the value of the forced draft cooling tower approach with the addition of a vortex generator and without the addition of a vortex generator. This research was conducted in the workshop and laboratory of Mechanical Engineering, Faculty of Engineering UHAMKA with stages: designing tools, making prototypes, assembling, and testing. Based on the results of the study it was found that the approach value obtained on cooling towers that use 0.86% lower than without a vortex generator.

1. Introduction

Cooling tower is defined as a heat exchanger used as an air conditioner with air as the cooling medium. To produce maximum work, fillers are needed that function to inhibit the rate of air flow so that fluid and air contact will be longer. The increased effectiveness of cooling tower cooling will affect the removal of some of the water into the air due to the evaporation process [1]. However, water loss during evaporation is a better assessment of cooling tower characteristics.

The type of cooling tower used depends on the level of performance produced by the cooling tower. D. Pearlmutter, E. Erell, Y. Etzion, and I.A. Meir, H. Di revealed about the use of preparation in the down-draft cooling tower [2]. The performance of a cooling tower depends on the characteristics of its material, such as fluidized [3], corrugated plastic [4], stone sponges and rubber foam [5], and bamboo wulung [6]. In addition to its content characteristics, cooling tower performance is affected by wind speed [7].

The coolingg tower performance is evaluated to discuss the design value, identify energy waste, and to improve the cooling tower engine so that it has a better impact on the cooling tower [8]. The parameters to measure cooling tower performance are range and approach. The level of approach and cooling range are assessed to identify areas where energy waste is occurring by providing improvements. Although, the range and approach must be controlled, but the approach is a better indicator for cooling tower performance. The lower the temperature of the wet air ball entering, the more effective the cooling tower [9], the cooling tower performance is assessed at the approach and cooling range level to identify areas where energy waste occurs by providing improvements. Although, the range and approach must be controlled, but the approach is a better indicator for cooling tower performance. The lower the temperature of the wet air ball entering, the more effective the cooling tower is. There are several factors that influence the effectiveness of cooling tower performance, namely the amount of water surface that comes in contact with air, and the length of time when contacting water with air, the speed of air through the tower, and the direction of air flow associated with the surface of water contact (parallel, perpendicular or opposite).

Cooling tower performance analysis obtained value range 16,4830C - 18,4240C, approach value 5,0170C - 5,7280C and effectiveness value 76,688% [8]. Researchers do a lot of research to get cooling tower performance. Previous research was only conducted in 2019 to obtain novelty from the cooling tower performance [10], the experimental results show that the effectiveness increases by 22% and 30% for NDWCT and FDWCT fill thickness of 20 cm, respectively. Cooling tower optimization is solved by using a counterflow particle optimization algorithm involving the effectiveness and rate of evaporation of water, while the air flow rate and water as a decision variable [11]. A field test study was carried out on the design of a natural wet cooling tower to investigate quantitatively the distribution of diameter of water droplets in the rain zone for the first time. The results show that it is spread between 0.312 mm and 15 mm, regardless of the cross wind speed [12].

One type of cooling tower that is rarely used in industry is forced draft [13]. This is due to the high costs incurred, while the effectiveness produced is not commensurate. This is a problem that will be examined in this study. To overcome this, this study uses a vortex generator to increase its effectiveness by reducing the value of the approach to the cooling tower.

2. Methodology

This research begins with designing tools, making prototypes, assembling, and testing. The prototype is designed as shown figure 1. The design of the study or experiment is to use a cooling tower with the addition of vortex generators as flow inhibitors and without vortex generators as in Figure 1. The amount of water and air entering the test equipment is of equal value [14], at 1 liter per minute. Water from the basin is pumped through a half inch diameter pvc pipe to the storage area. Then, the water is heated in storage using a heater to a stable temperature, which is 60.1 °C. Furthermore, it is streamed through a flowmeter. Measurement and regulation of release using valves. Water through the flowmeter is released at the top of the tower through a sprinkler to divide the water into small beads. Excess water in storage is thrown back into the water bath. At the same time air from the compressor is channeled through pipes to the bottom of the tower.

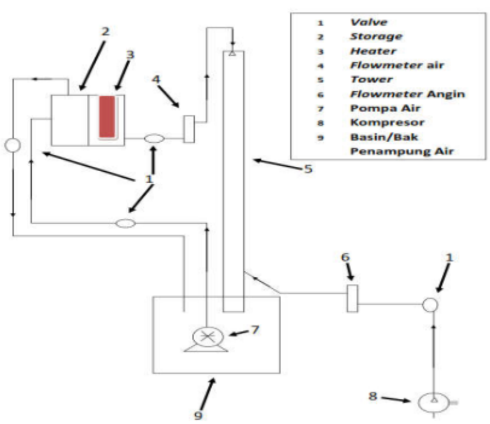

Figure 1. Cooling tower schematic diagram

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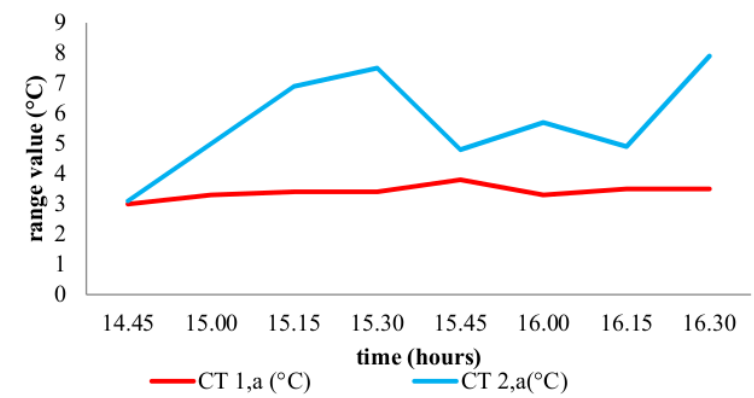
The test equipment is based on the Ramkumar and Raguphaty test model [15]. The thickness of the acrylic used is 5 mm with a height of 195 cm. The size of the tower from 30 cm × 30 cm to 3 cm × 3 cm. This is because the cross-sectional area of the Ramkumar and Raguphaty 900 cm ^{2} simulation devices is divided by the number of filler holes of 56 which are assumed to have other holes of equal value. The type of vortex generator used in this study is a rectangular winglet made of aluminum with a size of 1 cm × 5 cm. The number of vortex generators used was 3 pairs with a slope of 15 ° and a distance of 35 cm in each pair. Data collection was carried out for 2 hours for 6 days. Before data collection, a leak test is performed. Leakage tests are carried out to observe the connection of the pipe with the compressor and the connection of the inlet water with the pump. Furthermore, observing data includes the cooling capacity (Q), the temperature of the inlet air ($T_{in\ air}$) and outlet ($T_{out\ air}$), the temperature of the inlet water ($T_{in\ water}$) and outlet ($T_{out\ air}$), and the temperature of the wet ball (T_{wb}). Data collection was carried out for 2 hours with a distance of observation every 15 minutes. The results of the observation data will be processed to get the approach value. Then, the approach values using the vortex generator on the cooling tower and without the vortex generator will be compared

3. Results and Discussion

Based on the test results obtained that the reynold number on cooling tower with vortex is $1{,}1887 \times 10^{-11}$ for air and 143.505.9 for water. While the reynold number in cooling towers without vortex generators is $3{,}566 \times 10^{-11}$ for air and $2{,}090 \times 10^{-9}$ in water. That is, cooling tower with vortex generator can bring up vortex. This is due to vortex occurring at reynold numbers more than 50 (Ciptoadi, 2011).



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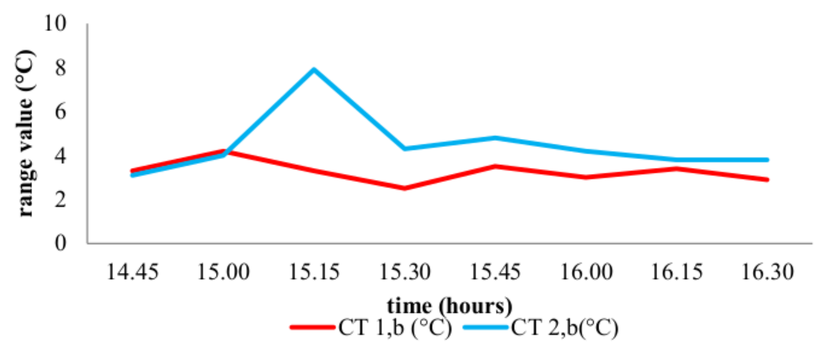

(b)

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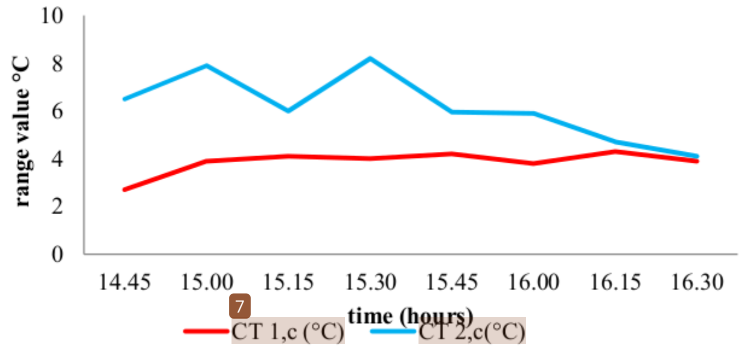
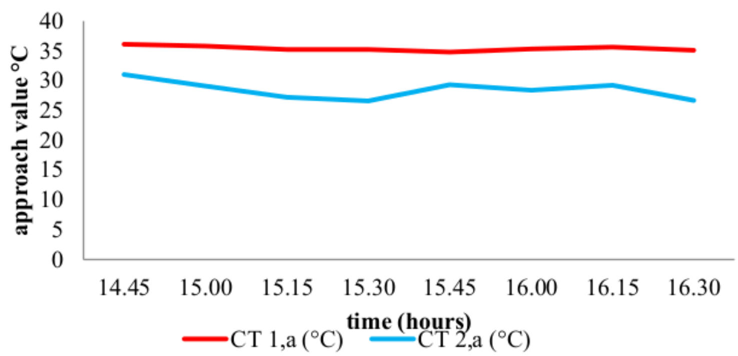


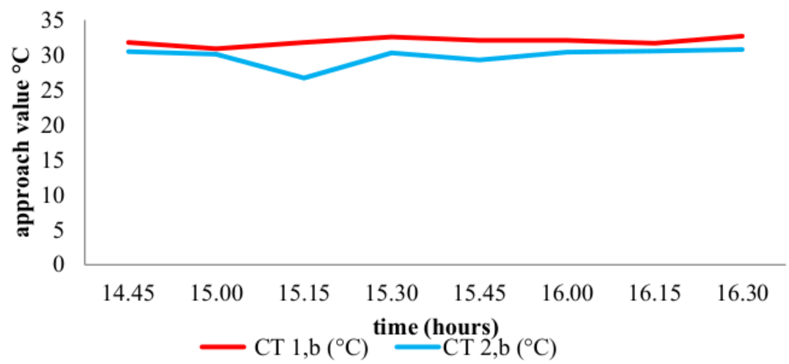
(c)

Figure 2. Comparison of range value (a) range value the first day (b) range value the second day (c) range value the third day

The figure 2 (a), (b), (c) shows that the vortex added to the cooling tower (blue line) has an average range greater than the range of the cooling tower without the vortex generator (red line). The largest range of cooling towers with vortex generators is 8.2 °C while the cooling towers without vortex generators have a range of 4.3 °C. This is because cooling towers with vortex generators lower the temperature more than cooling towers without vortex generators. High Range values indicate cooling tower can reduce temperature efficiently with good performance [14]. Therefore, the vortex generator added to the forced draft type cooling tower can increase the temperature decrease in the cooling tower.



(a)



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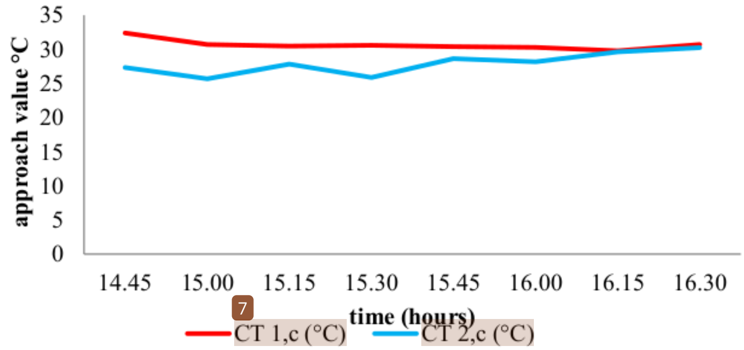

(c)

Figure 3. The Comparison Approach Value (a) approach value the first day (b) approach value the second day (c) approach value the third day

Figure 3 (a), (b), (c) shows the average cooling tower approach with vortex generator has a smaller approach than cooling tower without vortex generator. The smallest approach to cooling tower with vortex generator is 25.7 °C, while the smallest approach to cooling tower without vortex generator is 29.8 °C. That is, the approach with the vortex generator is lower than the approach without the vortex generator. Therefore, the performance of cooling towers with vortex generators is closer to the ambient temperature according to the main functions of cooling tower. Cooling tower with vortex generator is better than cooling tower without vortex generator because the lower the approach value, the better the cooling tower performance [15]. So it can be said that the application of the vortex generator is able to reduce the value of the approach to the forced draft type of cooling tower.

Cooling tower performance is assessed at the approach and cooling range level to identify areas where energy waste is occurring by providing suggestions for improvement. Although, the range and approach must be controlled, but the approach is a better indicator for cooling tower performance. The lower the temperature of the wet air ball entering, the more effective the cooling tower is. [8], the cooling tower performance is assessed at the approach and cooling range levels to identify areas where energy waste occurs by providing improvements. Although, the range and approach must be controlled, but the approach is a better indicator for cooling tower performance. The lower the temperature of the wet air ball entering, the more effective the cooling tower is.

4. Conclusion

The smallest approach to cooling tower with vortex generator is 25.7 °C, while the smallest approach 2 cooling tower without vortex generator is 29.8 °C. The application of vortex generators is able to reduce the approach value in forced draft type cooling towers because cool2g towers with vortex generators are better than cooling towers without vortex generators because the lower the approach value, the better the cooling tower performance

Acknowledgments

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