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Experimental Study on the Effect of Numbers of Waves in Vane Type Drift Eliminator on the Collection Efficiency, Pressure Drop and the Wet Cooling Tower Performance

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ABSTRACT: In this paper, the effect of using three drift eliminators with a different number of waves in a constant total length on compensation water flow rate and cooling efficiency of cooling tower and collection efficiency and air pressure drop of drift eliminator is investigated. These drift eliminators were made of galvanized iron in three models: type A with one wave, type B with two waves, and type C with three waves. The main purpose of this study is to investigate the effect of using drift eliminators on the performance of the cooling tower. Accordingly, experiments were performed on the laboratory cooling tower under constant environmental conditions in terms of temperature and humidity, and parameters including air mass flow rate, water mass flow rate, and inlet water temperature to the tower were assumed as constant. The results of this study show that the use of these types of drift eliminators can increase the cooling efficiency of the cooling tower by 18.5% and reduce the compensatory water flow rate of the cooling tower by 20%. On the other hand, the use of these drift eliminators increases the air pressure drop by 70% per wave and the collection efficiency of the drift eliminator by 48%.

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1- Introduction

Cooling towers are devices commonly used to discharge heat from power plants, refrigeration and water-cooling systems, and industrial processes. In this device, water must be sprayed by a diffuser system into a set of heat exchangers (packing) through which air passes. As a result, a number of water droplets join the air stream and depending on the speed of the air, may be carried out of the tower.

The amount of droplets coming out of the cooling tower is important for several reasons. The main reasons are the increase in water consumption and the move of chemicals and microorganisms to the atmosphere, including a collection of bacteria known as Legionella.

The use of wane type drift eliminators reduces the droplets coming out of the tower. In addition, the use of drift eliminators has a positive effect on the thermal performance of the tower and can increase it. Also, the presence of drift eliminators reduces the air pressure through the tower in the air flow path. This effect can be harmful in both natural and forced convection towers.

2- Methodology

In this paper, a laboratory cooling tower device is used for experiments. As shown in Fig. 1, the cooling tower consists of several parts including tray, packing section, water distribution system, drift eliminator section, airflow fan, compensation water tank, circulating water pump, and measuring sensors.

To perform the experiments, we consider conditions and hypotheses to simplify the problem. These terms and conditions are:

• The temperature and humidity of the environment are in a certain range and are assumed to be constant.

• According to the equation of continuity and stability of

Fig. 1. The real shape of the laboratory cooling tower

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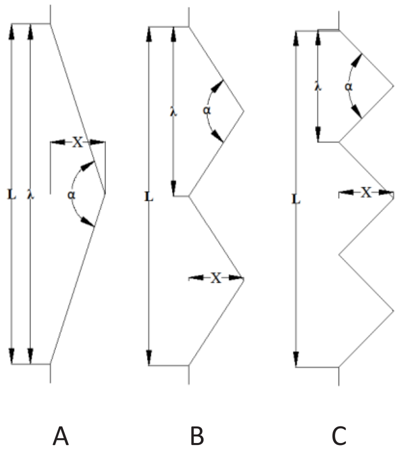

Fig. 2. The schematic shape of drift eliminators

airflow in the tower, the air mass flow rate along its path from the inlet to the outlet of the tower is assumed to be constant.

• The water flow rate was kept constant by a flowmeter equipped with a control valve during each of the experiments.

• The temperature of the water entering the tower is kept constant by two electric heaters.

• In the experiment of all three drift eliminators, one type of packing in terms of material and number has been used.

3- Drift Eliminator

The drift eliminators used in the tower, as seen in Fig. 2, were made in three geometries named A, B, and C with four fixed parameters common to all of them. These fixed parameters along with wave length and wave angle are shown in Table 1. These drift eliminators are made of galvanized iron.

4- Equations

Some equations have been used to obtain the parameters needed in this paper. By having the absolute humidity of the air at the inlet and outlet of the tower and using the airflow rate, the evaporation flow rate can be obtained and as a result, the drifts flow rate can be reached. Also, by having the wet ambient temperature and the temperature difference between inlet and outlet water, the cooling efficiency of the tower can be reached.

$$\dot{m}_{evaporation} = \dot{m}_a(\omega_2 - \omega_1) \quad (1)$$

$$\dot{m}_{drift} = \dot{m}_{makeup} - \dot{m}_{evaporation} \quad (2)$$

$$C.E = \frac{T_{water,inlet} - T_{water,outlet}}{T_{water,inlet} - T_{wetbulb}} \times 100 \quad (3)$$

Table 1. Geometric characteristic of drift eliminators

Type	n	L (mm)	X (mm)	λ (mm)	α (degree)
A	1	90	15	90	143
B	2	90	15	45	113
C	3	90	15	30	90

The collection efficiency shows the amount of droplets coming out of the drift eliminator in the cooling tower, and the higher this parameter, the lower the water consumption.

$$\eta = \frac{\dot{m}_{drift,inlet} - \dot{m}_{drift,outlet}}{\dot{m}_{drift,inlet}} \times 100 \quad (4)$$

5- Results and Discussion

As it can be seen in Table 2, raising the number of waves in the drift eliminator increases the droplet collection efficiency, which the largest amount of it is equal to 48% in drift eliminator type C. In contrast, the compensatory water flow rate decreases due to the increase in the number of waves. It is significant that as the number of waves increases, the compensatory water flow rate decreases with a sharper slope, and this shows the effect of using more waves in the drift eliminator because as the number of waves increases, the drift eliminator’s ability to collect droplets with smaller diameters increases because larger droplets in the first wave and smaller droplets in the next waves separate.

In addition, the more waves we have in the drift eliminator, the more cooling efficiency of the tower will be obtained. So by using drift eliminator type C, it is about 18.5% higher than when there is no drift eliminator. In fact, the exiting droplets are trapped when passing through the drift eliminator and then return to the tower, so that they are in contact with the air during this period and the drift eliminator acts as packing and to some extent, reduces the temperature of the water leaving the tower.

On the other hand, As the number of waves in the drift eliminator increases, the pressure drop increases too. According to increasing the number of waves from 1 to 2, the amount of pressure drop rises 72% and from 2 to 3 It increases 76%, which can have a significant impact on the power consumption of the cooling tower fan.

6- Conclusion

In this study, the effect of using drift eliminators in the cooling tower has been investigated experimentally. To do

Table 2. Values of four parameters in different types of drift eliminators

Parameter	Without drift eliminator	Type *A*	Type *B*	Type *C*
Collection efficiency (%)	0	2.14	33.43	47.73
Compensatory water flow rate (kg/s)	6.7×10^{-4}	6.6×10^{-4}	6.2×10^{-4}	5.4×10^{-4}
Cooling efficiency (%)	49.2	59.5	63.2	67.7
Pressure drop (kPa)	0	0.0058	0.01	0.0176

this, changes were made in terms of geometry in the number of waves at a fixed length, and the types of drift eliminators were compared to each other and the state without drift eliminator. Finally, we achieved the following results:

• The use of a drift eliminator in the cooling tower reduces the compensatory water flow rate and increases the collection efficiency.

• Drift eliminator increases the cooling efficiency of the tower, which can be attributed to the fact that the drift eliminator also acts as a packing

• Drift eliminator increases the air pressure drop in the tower, which can be attributed to the vortex areas of the flow, which is formed after each bend.

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