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A Review on Cooling Tower

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ABSTRACT: Cooling towers are heat extraction devices used to provide a constant supply of cold water in industries such as petrochemicals, food processing, dairy, power plants, and nuclear power plants. The heat exchange phenomena in cooling towers are a direct contact phenomenon that involves simultaneous heat and mass transfer. The papers for the numerous methods of Fluidized bed packing that are incorporated for the conventional cooling tower are reviewed in this study. The cooling tower's packing enhances the effective contact surface between air and water, allowing for more efficient heat and mass transfer. The fluidization principle is used in the design of a fluidized bed cooling tower. The upward flow of air fluidizes the bed material employed as packing in the three-phase counter flow fluidized system, and the hot water sprayed down from the top is cooled. The report also goes through the various materials that are used in the fluidization process. As the gas and liquid phases flow through the bed, the weather will cause a bubbling or turbulent effect that gives a larger surface area for heat transfer, resulting in a state of strong contact between them. The major goal of this literature analysis is to look at how different scholars have analyzed the performance of cooling towers with fluidized bed packing, which will lead to additional research. Furthermore, it is discovered from these studies that various investigations are conducted at low water flow rates and also at lower liquid to gas ratios, which leads to the research of cooling tower performance by providing the turbulent bed and experimental conduct at higher flow rates.

KEYWORDS: Cooling tower, Heat exchanger, Improvements, Nuclear Energy, Waste heat.

1. INTRODUCTION

Cooling towers[1] are heat rejection devices that use the cooling of a water stream to transfer waste heat[2] to the atmosphere. Cooling towers are commonly used in power plants to cool the flowing water. The cooling towers have been the subject of a variety of numerical and experimental studies. This section contains a summary of several important works. A research project was undertaken to improve the cooling efficiency [3]of a natural draught dry cooling tower.

The structure was studied using a computational fluid dynamics [4]approach at various wind speeds. The obtained results show that the cooling effectiveness of the natural draught dry cooling tower diminishes with increasing wind velocity due to non-uniform ventilation and the vortex inside the tower for wind speeds greater than 4 m/s. It was discovered that using an enclosure can improve total cooling performance at all wind speeds tested.

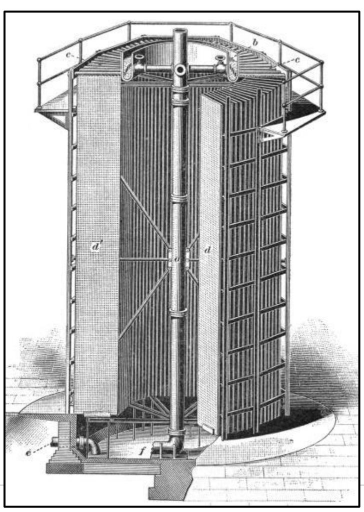
The use of inlet air spray cooling to increase the performance of natural draught dry cooling towers has been suggested. The study analyzed the spray cooling system, which consists of various types of spray nozzles that produce diverse spray patterns characterized by pressure, flow rate, and droplet size distribution, and reviewed both practical and theoretical work on natural draught dry cooling towers. The inlet air pre-cooling enhances cooling tower efficiency and minimizes power generation loss in high ambient temperatures, according to this study.

Cooling towers have been around for a long time, replacing power plants as they moved closer to load centers from the riverbanks. The cooling tower with evaporative cooling technology was designed as a water conservation system, usually to lessen the plants' reliance on "once through" cooling systems, and has since replaced many of them. The cooling tower's creation also increased designers' capacity to deliver efficient cooling in places with limited water supplies. Cooling towers are currently widely used[5] in a variety of sectors. In the case of cooling tower systems, the benefits of optimizing designs have never been more apparent. The benefits of reduced energy and water use are apparent, and tower and component manufacturers have risen to the occasion. New designs and technologies, as well as new materials and manufacturing methods, have resulted in significant improvements in performance and environmental effect. New system control methods and configurations are also yielding major operational benefits. Drift is decreased, fan efficiency is improved, fill and tower effectiveness are improved, and towers are smaller, lighter, and more corrosion resistant than ever. It is possible to make previously noticeable plumes vanish, as well as cut water usage and system energy consumption. Because of advancements in cooling tower engineering and design, towers may now be built on-site faster and for less money than before.

2. DISCUSSION

2.1 History of Cooling Tower:

The development of the steam engine[6] was the first stage in the development of cooling towers, which began in the 19th century with the usage of condensers in power generation systems. The steam coming out of the turbines or cylinders was condensed using condensers. Cooling ponds were employed in some regions with available large acreage, whereas cooling towers were used in large cities with limited land. Early towers were built on top of buildings or as free-standing constructions. In 1901, an American engineer developed a unique design based on a rectangular or circular shell that looked like a chimney stack but was much larger laterally. Water from the condenser is pushed to the top of the tower and then trickles down over wooden slats or woven wire screens, which fill the space within the tower. The Dutch engineers Gerard Kuypers and Frederik van Iterson initially invented a hyperboloid cooling tower in 1918, and it was built at Heerlen the following year 1920 (Figure 1).



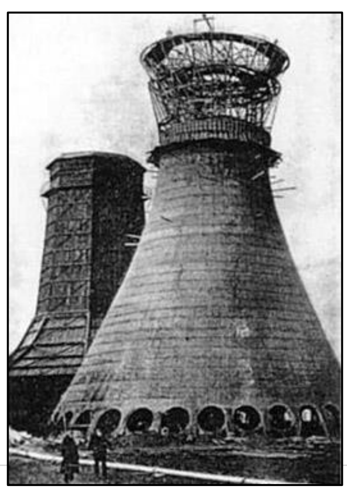


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Figure 1: Barnard's fanless self-cooling tower (1902) relied on natural draft and open sides; water to be cooled is sprayed down from top onto the vertical wire-mesh mats (left) first hyperboloid cooling tower build in 1918 (right)

2.2 Types of Cooling Tower

The mainly two types of cooling towers are:

- Natural draft cooling tower
- Mechanical draft cooling tower

2.2.1 Natural draft cooling tower:

Towers*[7]* are usually used for large power plants and industries with infinite cooling water flow. The tower operates by hot air in the tower rising removing waste heat and then releasing it into the atmosphere. These towers are tall and have a hyperbolic shape to induce proper air flow as shown in figure 2.

Heat transfer is totally achieved in this form of cooling tower by natural convection via air flowing inside the cooling tower, and warm, moist air naturally rises due to the density differential with the outside air, resulting in an air flow through the cooling tower as shown in Figure 2.

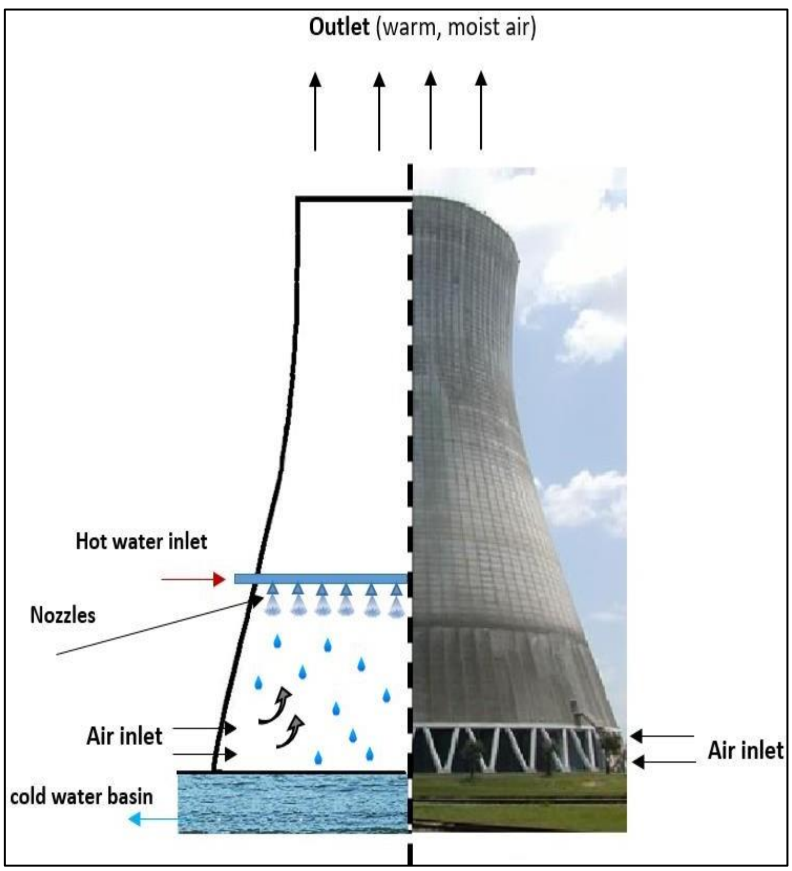

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Figure 2: Natural draft cooling tower

2.2.2 Mechanical Draft Cooling Tower:

The cooling tower*[8]* is known as a mechanical draught cooling tower when air is circulated by a fan or blower. The atmospheric natural draught cooling tower is comparable to the mechanical draught cooling tower. The air is forced into them by the fans.

There are two types' mechanical draught cooling towers

- Forced draught and
- Induced draught cooling towers.

Induced draught: in this design, air is drawn through the cooling tower by a motorized fan mounted on top of the discharge. In this type of draught, axial fans are frequently used (Figure 3).

Forced draught: A blower-type fan is installed at the cooling tower's intake to force air into the cooling tower, resulting in high entering and low departing air velocities. Forced draughts typically take more energy than induced draughts, which is a downside of this sort of draught. This approach employs centrifugal and axial fans (Figure 4).

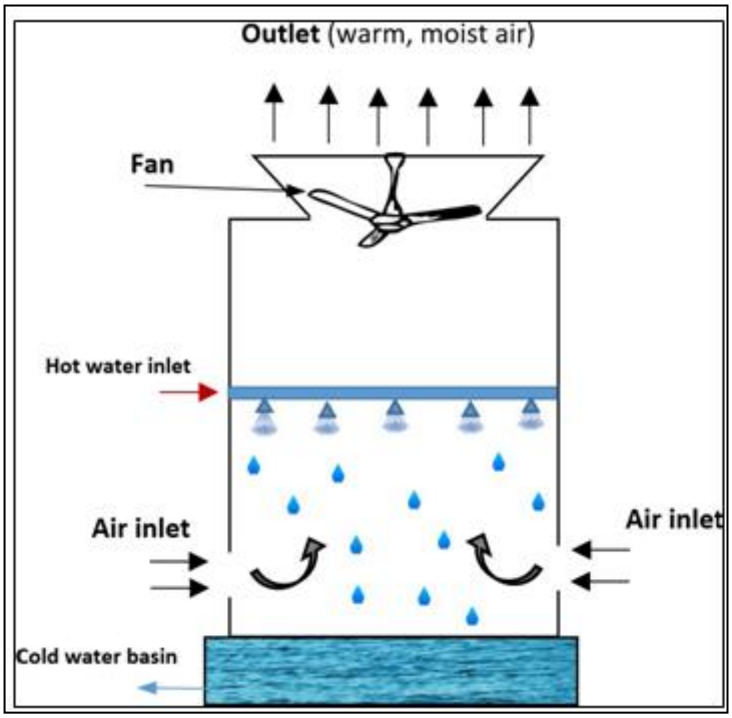

Figure 3: Forced draught

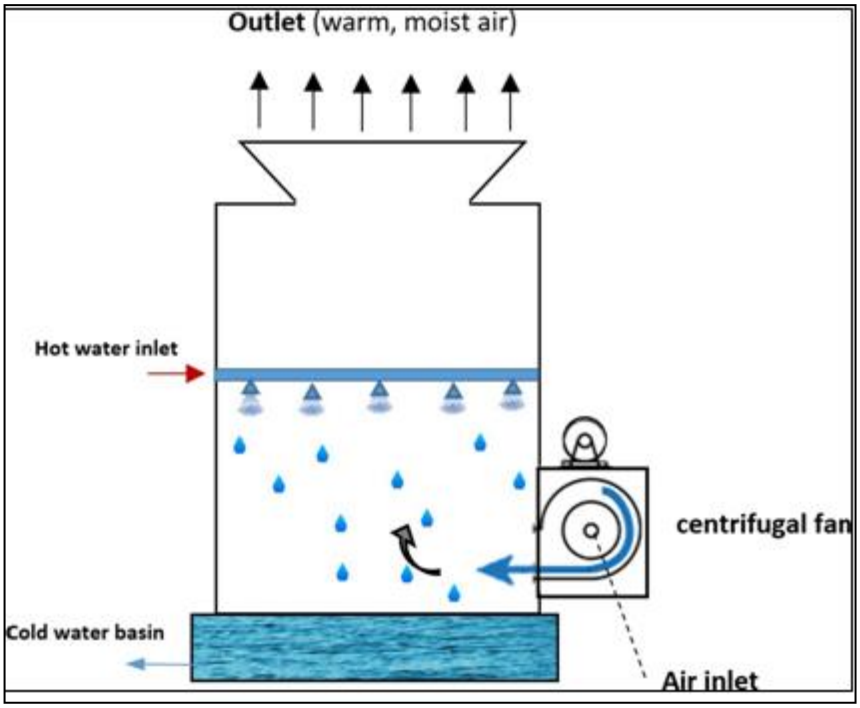

Figure: 4 Induced draughts

2.3 Components of Cooling Tower:

- Cooling Tower.
- Heat Exchanger.
- Reciprocating pump

2.4 Maintenance of Cooling Tower:

The maintenance of cooling towers is exceedingly difficult and time-consuming. This issue arises when the proper sequencing technique is not followed when doing closing maintenance. Closing maintenance of a cooling system occurs when a component of the cooling system ceases to function properly, causing the cooling system's performance to suffer. When we adopt the correct sequence for closing maintenance activities, we can reduce the quality of the work and complete it in less time with less manpower. When these maintenance efforts are unplanned, the overhauling value of a cooling system increases in terms of labor cost and time waste.

2.5 Size of Cooling Towers:

The size of the cooling towers is determined by the needed cooling performance and is either built on-site (in the case of large towers) or at a factory (small towers). The size of the towers varies from modest roof-top types to very big hyperboloid towers that can reach heights of more than 200 metres and have a diameter of more than 100 metres, or rectangular cases that are more than 40 metres tall and 80 metres long. In order to improve the effectiveness of cooling towers, the Niederaussem Power Plant in Germany created one of the world's tallest natural draught

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cooling towers, which is also the world's largest shell construction.

2.6 Improvement in Cooling Tower:

Cooling tower can be improved by optimizing the heat transfer along the cooling tower packing. For this purpose, suitable water distribution across the plane area of the cooling tower is required. Air and water contact is important for improving the performance. It can be observed that the proper distribution to ensure the homogeneity of the heat transfer and a reduction of entropy generation is critical for the cooling tower.

2.7. How Does Fluidized Bed Cooling Tower Works

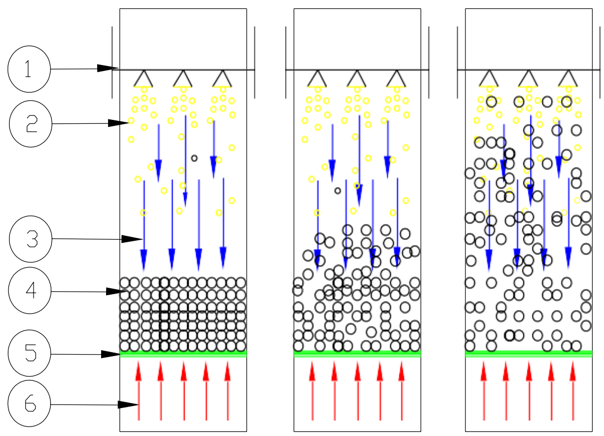

Figure 5: phenomenon of cooling tower

Fluidization is the process of making solid particles behave like a fluid by contacting them with a gas, a liquid, or both. The development of three-phase fluidized bed cooling towers is based on this theory. Low density fluidizing solid particles lie on top of one another on a mesh or retaining grid at the bottom of the cooling tower main body column at low air flow rates, as shown in Figure 5. The fluidized bed is considered to be in a static or fixed condition in this state. Fluidization occurs as the air velocity rises, the low-density bed materials form bubbles, and vigorous mixing of the bed materials with the air produces a turbulent action similar to that of a boiling fluid, as seen in Fig 5. This is the state of flux. The fluidized bed particles from the column will eventually be entrained into the upward moving air as the air velocity rises. As the solid particles become mobile, they lose contact and close closeness to one another, as shown in Fig 5. The pneumatic or hydraulic transport state is this.

3. LITERATURE REVIEW

K. N. Seetharamu and K. V. S. Varier,[9] carried out Experimental investigations to find out the effect of various configurations of the packing material on the performance of a Fluidized Bed Cooling Tower (FBCT). From the experiments it is observed that the shape of the packing material does have a definite effect on the performance of FBCT and the spherical shape is not the best shape

N. Sisupalan and K. N. Seetharamu, IIT Madras,[10] carried out Experimental investigation on a counter flow three-phase fluidized bed cooling tower (FBCT) with different static bed heights.

The efficient static bed height for the present tower is found to be between 1I cm and 13 cm. The pressure drop observed is in the order of 0.6 mm of water column per cm of static bed height within the range of parameter investigated.

Ram GopalSeth.1112 Yardley Rd., CherryHill. N. J.08034 conducted the experiments on dry cooling tower andconcluded A forced draft dry cooling tower is disclosedwhere in the medium to be cooled passes through the heat exchanger tubes embedded within a bed of inert particles composed of smaller particles composed of smaller particles surrounding and embedded in much larger particles. The forced draft through the cooling tower fluidizes the smaller particles but not the larger particles which stabilizes the fluidization of smaller particles and enhances the fluidizationand heat exchange effect thereof.

Hamid Reza Goshayeshi,John MissendenSouth Bank University, London.[11] This paper presents a mathematical model and a computer simulation program for the numerical prediction of the performance of a fluidized bed cooling tower. The mathematical model is based on the heat and mass transfer equations. This model is used to predict the thermal behavior of a fluidized bed cooling tower with experimental data. In this paper experiments have been performed to measure the thermal performance of a fluidized bed cooling.

A Grandov, A Doroshenko, I Yatskar [12]In this paper the authors have given the grounds for using cooling towers with fluidized beds in contaminated water and air. The results of experimental research into the hydrodynamic and heat and mass exchange processes have been listed in the wide range of water and air velocities with bed elements of different densities. The authors make recommendations for the working regimes and designs of small ventilating cooling towers. The influence of flow non-uniformity on cooling efficiency has been studied in the columns of great productivity (the scale-up effect). The methods and algorithmof engineering calculation for cooling towers with fluidized beds have been worked out. These methods take into account the scale-up effect and a more accurate balance of the column resistance and ventilator head flow. The authors also give the technical characteristics of some designed and manufacturedcolumns with productivity from 2.8 to 27.61 s^{-1} (from 10 to 100 m^3 h^{-1}) of cooled water.

4. CONCLUSION

Cooling tower studies have been conducted on many elements of cooling towers in order to optimise their performance. Natural draught cooling towers can benefit from proper water distribution across the planar area of the cooling tower. One of the concerns is the degradation of the filler material. A good shutdown strategy can help you save time and money. Vertical packing orientation improves performance, and intake conditions of water flow rate, air, and inlet water temperature are all critical elements in cooling tower operations. It can be inferred that adequate cooling tower packing, shut-down strategy and water distribution are critical for cooling tower optimization. It is critical to identify and optimise such elements in order for cooling towers to operate efficiently. Using literature references, the main characteristics of several types of cooling towers were evaluated to demonstrate variances in structure, use, and cooling principles. Cooling towers are a critical component of power plants such as nuclear power plants, as well as petroleum refineries, petrochemical factories, and food processing plants, according to the discussion. Natural draught and mechanical draught cooling towers were contrasted in terms of their operation. In addition, the study looked at both dry and wet cooling towers. Finally, fluent software was used to simulate a sample cooling tower using a CFD programme, and the simulation's major contours were determined.

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