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Review - Optimization to determine the effectiveness of cooling tower model using CFD

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***Abstract**: The cooling towers are used in remove waste heat from condenser in to the atmosphere using mechanical method or natural methods. The cooling tower has its application in cooling of power plants, petroleum refineries and natural gas plants. The current research investigates the previous research conducted on design and improvement of cooling tower using experimental and numerical methods. The research also reviews various types of cooling towers and their usage.*

***Key Words:** Cooling tower, thermal analysis*

1. INTRODUCTION

Cooling tower role is of cooling the circulating water for repeated use (as shown in Figure 1). With the development of industry, the demand for the cooling tower is on the increase. Especially in the chemical industry, refrigeration, air conditioning, textile, power plant, and water-shortage area, cooling towers have been widely used in the circulating water supply systems [1]. Fast and accurate calculation of the heat and mass transfer process in the cooling tower is the basis and theoretical guidance for its optimization control.

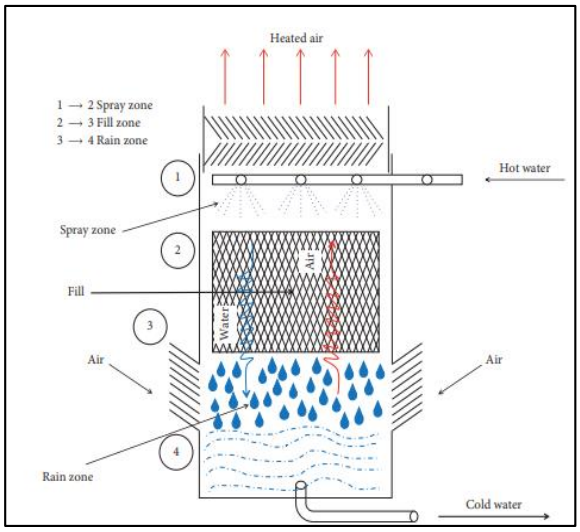

Figure 1: Schematic of a counter flow wet cooling tower [1]

2. LITERATURE REVIEW

Merkel [2] introduced the concept of enthalpy in his paper, and he unified the heat and mass transfer into enthalpy and proposed the enthalpy difference model. At present, most scholars are using the Merkel enthalpy difference model to calculate the performance of cooling towers.

Baker and Shryock [3] analyzed the performance curve and the packing characteristic curve of the cooling tower, established the working point of the cooling tower, and applied this method to calculate the cross-flow cooling tower.

Fisenko et al. [4] established the four-variable model. Compared with the Merkel enthalpy model, the four-variable model considered the evaporative loss of water. So the accuracy was improved, but it also increased the solving difficulty.

Whiller [5] elaborated another method to derive the formula for the characteristic parameters, but this method is not very useful for engineering design.

Dowdy et al [6] evaluated heat and mass transfer coefficient by conducting experiments with the help of various types of cellulose pads thickness.

Sodha et al [7] analyzed the cooling tower's thermal performance which is fitted in the building in terms of discomfort index for dry and warm climates.

Singh, Tulsidasni, Swhney and Sodha [8] in series of 6 papers reported their work on optimization of coefficient of performance (COP), cooling potential, thermal performance in building, recirculation effect on cooled room and design evolution has been investigated in IEC (Indirect Evaporative Cooling) system.

Sutherland [9] abandons the hypothesis of Merkel and makes a rigorous derivation of the heat and mass transfer process in the cooling tower. The calculation results show that the outlet temperature is reduced by 5%-15%, compared with the Merkel enthalpy model. Based on the theory of heat and mass transfer and the concept of heat exchanger,

Jaber and Webb [10] put forward the number of heat transfer unit (ε-NTU) model, which provides another method for the calculation of the cooling tower. It is worth noting that the model, like the Merkel enthalpy model, ignores the effect of water evaporation.

Gan [11, 12] put forward several mathematical models. These models take into account the mass, momentum, and energy transfer simultaneously. These models are based on the Merkel theory and its modified form, and they can analyse the thermal processes of different cooling towers. They also carried out numerical simulation analysis of closed cooling towers and obtained an earlier relatively mature simulation experience.

Ronak Shah, Trupti Rathore [13] had done thermal design of industrial cooling tower and determined the complete performance parameters with given inlet and outlet conditions and considering several possible losses. they investigated that cooling tower performance increases with increasing air flow rate and cooling tower characteristic decreases with increase in water to air mass ratio.

Plasencia et al [14] developed a new model which is based on transfer of heat and mass for IEC; few simplifications were incorporated to make this model as user friendly used for analysis of energy as well as adaption of system.

Camargo et al [15] presented an operational concept for both type of cooling systems and generated equations for mass and heat transfer between warm air and wetted media. Above researches and mathematical models has been limited up to the conditioning of air coming out of the coolers, and to increase the saturation efficiency or effectiveness of cooler; however, the use of cooled water stored in tank was not at all explored. This gap of not using the coolness of cooler water has been identified as a research gap and thus becomes the main objective of the present work.

Pushpa B. S, Vasant Vaze, P. T. Nimbalkar [16] have evaluated performance of cooling tower in thermal power plant by varying water inlet temperature, air inlet temperature and mass flow rate of water. They found that efficiency of cooling tower increases by increasing water inlet temp, air inlet temperature and decreases by increasing mass flow rate.

S. Parimala Murugaveni, P. Mohamed Shameer[17] in their research have analyzed a forced draft cooling tower by varying air inlet parameters and by varying air inlet angles in horizontal and vertical direction and both. The cooling tower model has been prepared in solid works 2013 and it has been meshed using icem cfd 14.5 software and meshed models have been analyzed using fluent software. On the basis of temperature contours obtained, they found that outlet temperature of water increases as the air inlet angle increases which will lead to decrease in effectiveness.

Manoj Kumar Chopra, Rahul Kumar[18] in their research carried out the cfd analysis on a counter flow cooling tower reference model. the model has been prepared in Creo and meshed and analyzed through Ansys 12.1. The analysis is carried out by simultaneous varying of three parameter inlet water flow rate, inlet air rate and fills porosity and applied taguchi method to carry out the optimization. They investigated that cooling tower gives best performance at lower mass flow rate of water, high mass flow rate of air and fill porosity of 50%.

3. CONCLUSION

Various researchers are conducted in improving efficiency of cooling tower. The performance of cooling towers is evaluated on the basis of operating parameters like mass flow rate, air inlet temperature, water inlet temperature. The effect of geometric design parameters i.e. air inlet angle was also investigated which shows significant effect on performance of cooling tower. The CFD is a viable tool that can be used in investigation of cooling tower which can save time and cost.

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