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Comparative Analysis of Forced Draft Cooling Tower Using Two Design Methods: A Review

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ABSTRACT
Cooling towers make use of evaporation whereby some of the water is evaporated into a moving air stream and subsequently discharged into the atmosphere which results in cooling of the remainder water. The current research reviews various studies conducted on cooling tower using experimental and numerical techniques. Different design configuration and operating conditions on cooling towers are evaluated by various researchers. Significant findings from researches have shown new and improved design of cooling tower with much better performance as compared to conventional design.

KEYWORDS: *Cooling tower, thermal analysis*

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1. INTRODUCTION

A cooling tower is a type of heat exchanger used to reduce the temperature of a water stream by extracting heat from water and emitting it to the atmosphere. Cooling towers use the evaporation of water to remove process heat and cool the working fluid to near the wet-bulb air temperature. Cooling towers are able to lower the water temperatures more than devices that use only air to reject heat, like the radiator in a car, and are therefore more cost-effective and energy efficient. They are generally used in HVAC application. There are many types of cooling tower available. The forced draft cross flow and counter flow cooling tower are the most common ones used in HVAC application.

2. LITERATURE REVIEW

R. Ramkumar A. Ragupathy[1] has discussed an experimental investigation of the thermal performance of forced draft counter flow wet cooling tower with expanded wire mesh type packing. The packing used in this work is wire mesh with vertical [VOWMP] and horizontal [HOWMP] orientations. The packing is 1.25 m height and having a zigzag form. From the experiments it is concluded that the vertical orientation of the packing enhance the performance of the cooling tower.

XiaoniQi, Yongqi Liu, Zhenyan Liu[2]has described about a descriptive mathematical model of energy and exergy for a shower cooling tower (SCT). The model is used to predict the variation in temperature and exergy along the tower length. The validity of the model for predicting variations in gas and liquid characteristics along the tower length was examined against some operating data measured in a cooling tower company. The results show that the exergy of water decreases as tower height increases. The distribution of the exergy loss is high at the bottom and gradually decreases moving up to the top of the tower. Moreover, 1.50 m/s air velocity results in less exergy destruction. With a decrease in the size of the water droplets, the fluids carrying energy have more opportunities for mass and energy transfers.

Pushpa B. S, VasantVaze, P. T. Nimbalkar[3]has used an evaporative cooling tower is a heat exchanger where transformation of heat takes place from circulating water to the atmosphere. The warm water from the condenser is taken as an inlet water to the cooling tower and it is allowed to flow through the nozzles. As it falls down across baffles or louvers, the water is broken into small droplets. Simultaneously air is drawn in through the air inlet louvers provided at the base of the tower and then this air travels upward through the tower in the opposite direction of water flow. In this process a small portion of water gets evaporated which removes the heat from the remaining water causing it to cool down. This water is collected in a basin and is reused in the cooling water system process. Because of evaporation, some quantity of water is lost and thus to make up the loss, the fresh water is constantly added to the cooling water basin. In a Natural Draft Cooling Tower, warm water is cooled by evaporation process. Here, water gets cooled when a boundary layer is formed between saturated water and saturated air. If the mass flow rate is ideal, then the performance of cooling tower as well as the power plant will be improved. In this study, it is showed that by minimizing the size of water droplet, the performance of Natural Draft Cooling Tower can be enhanced. Study of Sensitivity Analysis is done which shows the dependency of parameters like air temperature, water temperature, relative humidity and rate of heat loss. Further, efficiency is also checked by using power generation data and result found was very good.

Ronak Shah, TruptiRathod[4]has described a detailed methodology for thermal design of cooling tower. The technical data is taken for Mechanical draft cooling tower The design of cooling tower is closely related to tower Characteristic and different types of losses generated in cooling tower. Even though losses are generated in the cooling tower, the cooling is achieved due to heat transfer between air and water. In ideal condition, the heat loss by water must be equal to heat gain by air. But in actual practice it is not possible because of some type of losses. Cooling tower performance increases with increase in air flow rate and characteristic decreases with increase in water to air mass ratio.

Lu, W. Cai[5]has described about a universal engineering model, which can be used to formulate both counter flow and cross flow cooling towers. By using fundamental laws of mass and energy balance, the effectiveness of heat exchange is approximated by a second order polynomial equation. Gauss -Newton and Levenberg-Marquardt methods are then used to determine the coefficients from manufactures data. Compared with the existing models, the new model has two main advantages: (1) As the engineering model is derived from engineering perspective, it involves fewer input variables and has better description of the cooling tower operation; (2) There is no iterative computation required, this feature is very important for online optimization of cooling tower performance. Although the model is simple, the results are very accurate. Application examples are given to compare the proposed model with commonly used models.

B Bhavani Sai, I Swathi, K S L Prasanna, K Srinivasa Rao[6]has described a detailed methodology of a Induced draft cooling tower of counter flow type in which its efficiency, effectiveness, characteristics are calculated. The technical data has been taken from a mechanical draft cooling tower. Cooling towers are heat removal devices used to transfer process waste heat to the atmosphere. Cooling towers make use of evaporation whereby some of the water is evaporated into a moving air stream and subsequently discharged into the atmosphere. As a result, the remainder of the water is cooled down significantly.

Xinming Xi, Lei Yang, Yanan He, Lijun Yang, Xiaoze Du[7] they had developed physico-mathematical model to describe the thermo-flow characteristics of air cooling tower for indirect air cooling system. Based on the model, a comprehensive analysis on optimization of air cooling tower is conducted for 600MW indirect air-cooled power generating unit. By using the software VC++, the indirect air-cooled tower optimization program is developed. With the help of optimization of tower structure, a tower with better structure is used to conduct thermal analysis of the influences of ambient temperature, wind speed, and saturated exhaust flow rate on back pressure of turbine.

Ding Feng, Xing Ke-jia, Li Shi-Bei, Bai Jun-hong[8] they has described Sensitiveness of cooling tower based on the atmospheric dispersion model from VDI3784 guidelines in German, the sensitivity analysis of plume rising height from Cooling Tower is calculated by using six factors and five levels of orthogonal test method. The results showed that: the main factors affecting the plume rising height is the atmospheric stability, with the average plume rising height of 469 meters; followed by wind speed, the average range of 447 meters; while the least effect of the flue gas and flue gas flow rate of liquid water content on significant uplift, the average range of 186 meters and 178 meters.

Y.A. Li and M.Z. Yu, F.W. Shang, P. Xie[9]has describes the counter flow closed circuit cooling towers developed by the authors. The new cooling towers have many desirable features, including pure water, low noise, safety, energy effective and so on. The mathematical models of the counter flow closed circuit cooling towers are established in terms of mass and heat balance. An analytical solution of the counter flow closed circuit cooling towers is carried out. Performance curve of the cooling towers is drawn and it is mainly calculated that the outlet temperature of cooling water varies with the spray water flow rate. Results of the theoretical calculation are found to be close to the experimental data.

Bhupesh Kumar Yadav, S. L. Soni[10] has discussed about Cooling tower is used to reduce the temperature of hot water stream. It is mainly used in air conditioning plants, chemical plants etc. Evaporation loss and effectiveness are two important performance parameters of cooling tower. Effectiveness of the cooling tower model comes out to be 52.94%. Practical evaporation loss is calculated i.e. 9.25 kg/hr. Validation of practical values is done using empirical relations. For calculating theoretical evaporation loss various empirical relations i.e. Modified Apjohn equation, Modified Ferrel equation and Carrier equation are provided. By reviewing literature it is came to know that results provided by carrier equation is most satisfactory. So analytical calculation is done using carrier equation and thus theoretical evaporation loss is calculated as 5.45 kg/hr which comes nearer to practical value.

Neetesh singh raghuvanshi, dr. aloksingh [11] (2014) Cooling tower closing maintenance is extremely complicated and time intense. This drawback is happens once correct sequencing procedure isn't employed in closing maintenance. Closing maintenance of cooling system is happens once the part of cooling system aren't activity their functions properly causes the performance of cooling system reduces. Once we use the correct sequence of closing maintenance activity then we are able to cut back the quality in maintenance activity and reach the less time with minimum labor. Once these maintenance activities square measure unplanned then it will increase the overhauling value of a cooling system in terms of labor value and time consumption.

Xiaoxiao Li, Hal Gurgenci, Zhiqiang Guan, Yubiao Sun[12] The heat rejection rate of natural draft dry cooling system, furthermore because the in operation performance of an influence plant, will be full of varied close factors. The cold flow is unfavourable air turbulence at the highest of the cooling system and includes an important negative impact on the performance of natural draft cooling towers. Within the gift analysis, results square measure given for a 20m high natural draft dry cooling system experimental system tested at totally different close conditions.

Xiaoxiao Li, Hal Gurgenci, Zhiqiang Guan, Yubiao Sun[13] Crosswind could be an important concern for natural draft dry cooling towers. The priority is a lot of serious for shorter towers. Therefore, the current of air influence could be an important threat to the utilization of natural draft dry cooling towers in concentrating star thermal power plants, that square measure typically engineered at sizes smaller than typical fossil-fired plants and use comparatively shorter towers.

ZhengZou, Hengxiang Gong[14] Solar increased natural draft dry cooling system (SENDDCT) could be a new heat rejection device victimization alternative energy to reinforce its cooling performance. In a trial to seek out the best structural arrangement of SENDDCT, this paper conducts three-dimensional CFD simulations to match cooling performances of varied style choices. The simulations start by investigation whether or not the look possibility with lower-height heat exchangers at collector entrance has higher cooling performance than that with partial blockage at an equivalent location.

Guanhong Zhang, Suoying He, Zhiyu Zhang[15] Evaporative pre-cooling with wetted-medium can improve heat exchange of natural draft dry cooling towers (NDDCTs) in hot days (usually in summer). However, the media introduce further pressure drop that reduces the air flow of a NDDCT, and as a result, impairs the tower performance. Students studied the impact of state change pre-cooling on performance of cooling system through experiments or simulations by taking into thought the advantage of state change pre-cooling and additionally the disadvantage of further pressure loss.

3. CONCLUSION

The cooling tower design has significant effect on its cooling characteristics. The numerical and experimental studies have shown that Induced draft cooling tower has higher performance as compared to natural draft cooling tower. The two different design configurations i.e. horizontal and vertical are studied experimentally and its shown that vertical orientation of the packing enhance the performance of the cooling tower.

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