A REVIEW IN DESIGN AND PERFORMANCE ANALYSIS OF COOLING TOWER

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Abstract - *Cooling tower is an important part of power plant. Cooling towers are equipment devices commonly used to dissipate heat from power generation units, water-cooled refrigeration, air conditioning and industrial processes. Numerous factors can affect the operating performances and the design of the indirect air cooling system of power plant. A review mainly focuses on two things. 1. Design and 2.Performance of cooling tower. It provides the base of the selection in cooling tower.*

***Key Words*: exergy, effectiveness, dry-bulb air temperature.**

1. INTRODUCTION

A cooling tower is a heat rejection device that rejects waste heat to the atmosphere through the cooling of a water stream to a lower temperature. Cooling towers may either use the evaporation of water to remove process heat and cool the working fluid to near the wet-bulb air temperature or, in the case of closed circuit dry cooling towers, rely solely on air to cool the working fluid to near the dry-bulb air temperature.

1.1 TYPES OF COOLING TOWER

The classification is based on the type of air induction into the tower: the main types of cooling towers are natural draft and induced draft cooling towers as shown in figure.

1.2 APPLICATIONS OF COOLING TOWER

Common applications include cooling the circulating water used in oil refineries, petrochemical and other chemical plants, thermal power stations and HVAC systems for cooling buildings.

1.3 SIZES OF COOLING TOWER

Cooling towers vary in size from small roof-top units to very large hyperboloid structures (as in the adjacent image) that can be up to 200 metres (660 ft) tall and 100 metres (330 ft) in diameter, or rectangular structures that can be over 40 metres (130 ft) tall and 80 metres (260 ft) long. The hyperboloid cooling towers are often associated with nuclear power plants, although they are also used in some coal-fired plants and to some extent in some large chemical and other industrial plants. Although these large towers are very prominent, the vast majority of cooling towers are much smaller, including many units installed on or near buildings to discharge heat from air conditioning.

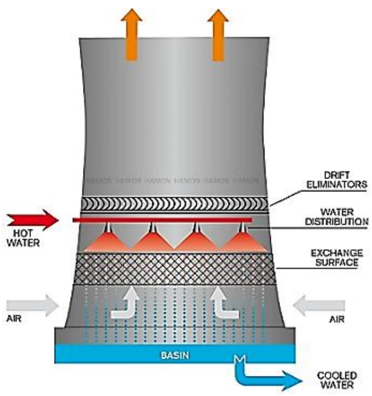

Fig -1: Natural Draft Cooling Tower

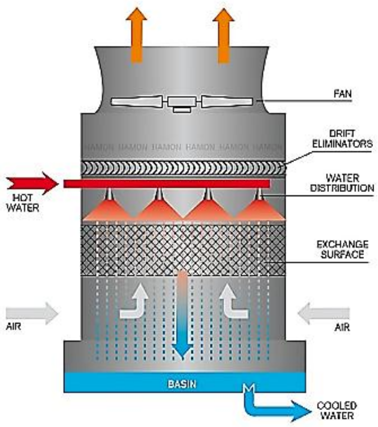

Fig -2: Forced Draft Cooling Tower

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.

3. CONCLUSIONS

For Design of cooling tower Xinming Xi, Lei Yang, Yanan He, Lijun Yang, Xiaoze Du paper give great value on optimization design and safe operation of large-scale indirect air-cooled power plant. For Performance of cooling tower Bhupesh Kumar Yadav, S. L. Sonipaper shows the working principle of cooling tower and a setup is fabricated and various parameters related to cooling tower is calculated i.e. range, approach, effectiveness and evaporation loss.

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