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Improvement in the Performance of Cooling Tower Of Thermal Power Plant: A Review

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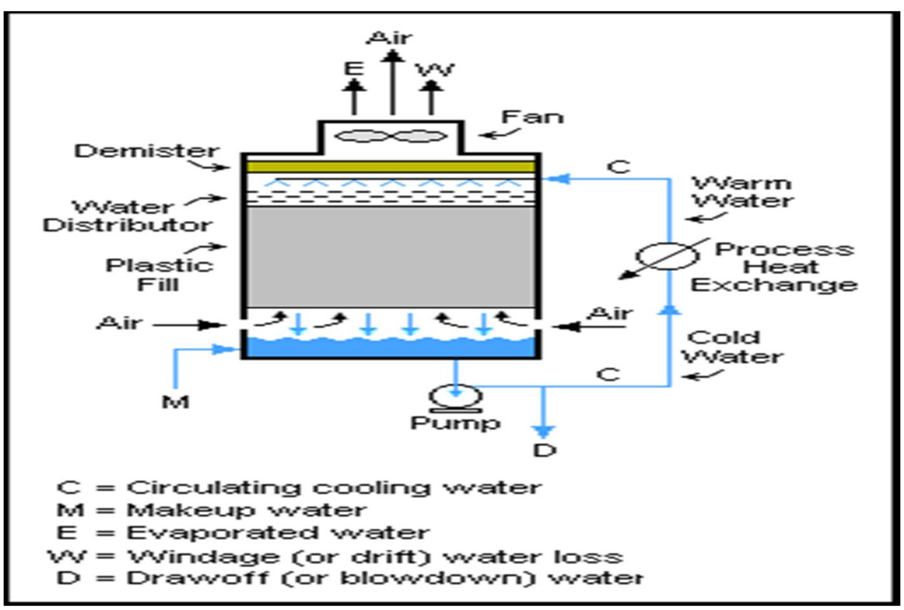
Abstract: Cooling tower is one of the important utility in chemical industries. Normally they are used to dissipate heat from heat sources to heat sink. The cooling of hot effluent and process water is required from reuse and environmental point of view, so when we consider a cooling tower in a point of view of using water due to scale formation and corrosion the performance of cooling tower is reduced. In the present study performance and effectiveness of Cooling Tower (CT) are reported based on the various methodologies available in the literature. The researchers are worked on performance of fill area of CT using various methods such as Mathematical Model, Numerical Analysis, contract for difference (CFD), Engineering Equation Solver (EES) Software and Experimental Analysis. They found that the heat and mass transfer (HMT) of cooling tower (CT) influence by the parameters like water inlet temperature, humidity and air WBT. Water recirculation is also important aspect in the cooling towers. The effectiveness of cooling tower depends on flow rates of air and water and water temperature. Minimization of heat loss is one of the important aspect of studies carried out by various investigators. The interfacial area between air and water is also crucial factor in cooling towers. Three types of packing's used in cooling towers are film, splash and film-grid packing's. The present review is aimed at summarizing studies and research on cooling tower for increasing efficiency and water savings to make it more economical and efficient.

Keyword: cooling tower, efficiency of CT, Evaporation loss, Corrosion inhibitors, pH value controllers.

I. INTRODUCTION OF COOLING TOWERS

Cooling towers are used in a variety of applications; from the 400-foot-tall towers at nuclear power plants to small 4 foot cooling boxes used by neighborhood dry cleaners. The most common use is in large building central cooling systems, but also used for refrigeration, cold storage facilities, dry cleaning, medical equipment, manufacturing and industry. Cooling towers are generally the most efficient means to remove large amounts of heat from air and equipment. Unfortunately, cooling towers use large amounts of water when properly maintained, and can waste greater amounts of water when not maintained properly through wasteful practices, inefficient equipment and leaks. Industrial cooling towers are used to remove surplus heat from water. Cooling towers with open and closed water circuits are available. Both types function as heat exchangers based on the counter flow principle.



Cooling systems transfer heat from one source or medium to another, often using water. In a cooling system with a cooling tower, cool water is pumped away from the cooling tower and is circulated through hot equipment (often chillers used to cool large buildings). The cool water (typically 85F (29.4 C)) absorbs heat from the equipment and becomes warmer. The warmed water (typically 100 F (37.8 C)) then returns back to the cooling tower. In the cooling tower the warmed water is sprayed downward, and air is blown upward with a fan. As the warm water droplets contact the air, some of the water droplets evaporate, and the air absorbs the heat released from this evaporation—thereby lowering the temperature of the remaining water. This cooling effect of the remaining water is called the latent heat of evaporation. During this process, some water is lost to the air from evaporation and some water is lost by the misting effect (called "drift") into the air. The used water from various applications at higher temperature can be cooled and reused.

Various types of cooling towers include Natural draft, induced draft and forced draft cooling towers. In cooling towers, air is passed co-currently or counter currently with water. The heat gained by air is the heat lost by water but in this heat transfer some affective parameter is also considerable like corrosion, scaling, fouling factor, pH value of water is to be used, quality of air, rate of increasing this affective parameter with respect to time. The efficiency of cooling tower depends on air and water flow rates and operating temperatures. Various researchers have carried out studies and investigation on various aspects of cooling tower which influence the effectiveness and working of cooling towers. The current paper reviews this research work on cooling towers.

II. LITERATURE REVIEW

Heat and Mass Transfer (HMT) Analysis in CT

In CT primary requirement is reduced the water outlet temperature it is done by heat and mass transfer of water to the air and dissipated to atmosphere this phenomena study in paper.

Heat and mass transfer has been analyzed by Lemouari et al. [1] observed, two regimes during air/water contact inside the tower, a Pellicular Regime (PR) and Bubble and Dispersion Regime (BDR) in this investigated that BDR to be more efficient than PR as it enables to achieve more Evaporation rate and higher HMT coefficient using experimental method.

Muangnoi et al. [2] identify HMT properties of water and air and calculate Energy based on mathematical model to result shows that Energy supplied by water in larger than absorbed by air because of producing entropy by system.

According to second law, Energy analysis, thermodynamic ambient temperature and humidity influence the performance of counter flow cooling tower founded by Muangnoi et al. [3]. A numerical analysis of closed wet cooling tower has been performed by Jiang et al. [4]. They concluded that plate fin heat exchanger HMT coefficient and cooling Efficiency is a function of flow rate of air, process water temperature, spray water and process water. The results derived from numerical method are validated with experimental data. Qi et al. [5] have derived HMT characteristics of Shower Cooling Tower (SCT) without any assumptions without assumption but many authors have taken assumptions in literature to reduce complexity and computational time.

The optimization of heat transfer rate and CT packing through proper water distribution of plane area has been done by Smrekar et al. [6] to improve the efficiency of NDCT. They found that it is possible by reduction of entropy generation and minimizing the exergy destruction. Kloppers et al. [7] have derived HMT equation for CT. Various governing equations are derived from different methods such as poppe method, merkel method and effectivess-NTU method and results compared together and also given its suitable application for different CT. Asvapoositkul et al. [8] predicted cooling tower performance by specification of mass evaporation rate equation and also Evaluate acceptance test for new tower and monitor change in tower performance.

Fisenko et al. [9] have calculated HMT between water droplet and damp air, design parameter and ambient condition influence on efficiency of CT and describe boundary value problem of a system by ordinary differential equation using mathematical model.

Facao et al. [10] has Developed correlation between mass transfer coefficient and spray heat transfer coefficient and also evaluates error in CT efficiency.

Heating ventilation and air conditioning system have been optimized by Lu et al. [11] with genetic algorithm where constraints is mechanical limitation, component interaction, outdoor environment and indoor cooling load and minimizing total operating cost of energy consuming device and obtain result compared with conventional operation data.

Yaqub et al. [12] observed that thermal performance influenced by varying air, water temperature, and driving potential for convection and Evaporation Heat Transfer (HT) along height of tower.

Experiments On Cooling Tower

Lu and Cai presented a universal engineering model for cooling towers [13].

It was applicable for both counter flow and cross-flow cooling towers. They used fundamental laws of mass and energy balance to approximate the effectiveness of heat exchange by a second order polynomial equation. The two major advantages of this model compared to old one were, less variables, better description of the cooling tower operation and no need of alternate computations. Qi et.al.[14]

Provided a descriptive mathematical model of energy and exchrgy for a shower cooling tower (SCT). They used this model to predict the variation in temperature and energy along the tower length. They validated the method by experimental data. According to their studies, the energy of water is not completely absorbed by air and a notable portion of the energy is always destroyed. With increase in droplet diameter, the energy destruction increased. A review on closed cooling tower was carried out by Qian et.al.[15].

According to the studies, domestic closed cooling tower is restricted to material performance and design and manufacturing level. According to them there is space for improvement in closed cooling towers with respect to energy and efficiency. This is not matured and there is huge scope for improvement and hence research. Shah and Rathod carried out studies on thermal design of cooling tower [16].

According to them, the design of cooling tower is affected by tower characteristics and different types of losses generated in cooling tower. Ideally heat loss by water is heat gained by air. So these two amounts must be equal. With air flow rate, cooling tower performance increases. Randhire studied the natural draft cooling towers for performance improvement [17].

Their research indicated that the performance of a natural draft 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. [18] According to them, downtime and associated losses can be prevented by proper operation and maintenance. Proper water treatment is important for the maximum efficiency. Proper use of operating manual and optimum shutdown policies are key to the economical operation. They were able to save 12.93% labour cost which was associated with shutdown maintenance activity. In cooling tower maintenance, they saved 34.28% time which is associated with shutdown maintenance activity. Ramkumar and Ragupathy presented an experimental investigation of the thermal performance of forced draft counter flow wet cooling tower with expanded wire mesh type packing [19].

A theoretical analysis of the cooling system of a 110 MW coal-fired power plant located in Central Serbia was presented by them. They carried out research in order to show the theoretical analysis of the tower heat and mass balance, taking into account the sensible and latent heat exchanged during the processes which occur inside these towers. According to them these cooling towers have 5 percent less efficiency than once through cooling towers. According to these studies, cold end operating conditions are important for a steam power plant. Abbas carried out studies on cooling towers by using different packing’s [20].

III. CONCLUSION

Poor cooling water treatment and control increases facility costs via destruction of expensive equipment’s, damage to the facility, cost of water and sewerage, and increased energy used and cost. Selection of cooling water management program, techniques and supplier based on some knowledge of chemistry and control needed will increase the probability of obtaining reliable equipment cooling with maximum heat transfer efficiency at the lowest total cost. Thus facilities that devote sufficient time and resources to the vital area will be rewarded by lowered cost and more reliable operation.

Knowledge of the field also enable the buyer to separate counter fit products from valid technologies and guard against the problems that can result from use of such something for nothing products.

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