

Performance of Cooling Tower in a Thermal Power Plant

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Abstract— The performance of a cooling tower is critical in evaluation of its efficiency. The ability to cool the hot coolant fluid leaving from the condensate system in a thermal power plant mostly sea water, where the power plant is situated near sea, depends upon the performance of the cooling tower and also includes several key factors such as the design conditions, operating conditions, external factors. Most power plant sectors using large water-using systems which consumes a large amount of water and consume huge amount of power. Hence research on the cooling water system focus mainly on energy-saving aspects and recirculation of water. Hyperbolic shaped cooling towers are extensively used in thermal power plants for acting as a heat exchanger. The heat is transferred from the hot water to the ambient air that flows counter flow direction inside the tower. The mass flow rate of air depends upon a variety of internal and external factors depending upon the type of cooling tower.

Keywords— Cooling Tower, Efficiency, Approach, Range, Drift Loss, Wet Bulb Temperature

I. INTRODUCTION

The thermal power plants reject enormous quantity of heat during the process of power generation. If this heat is not properly handled, it affects the efficiency of the power plant.

The cooling towers are thermodynamic systems which use the principle of evaporative cooling and handle this enormous heat generated in a balanced manner thus ensuring the safe temperature parameters for maximum power generation.

The cooling towers are designed heat rejection systems which remove heat by the process of evaporation. Considering the constraints of water resources, making use of the limited water sources is a major topic to be explored and includes water recycling and waste water treatment [1].

The majority of power plant sector uses water for cooling by once-through or briefly called as wet type cooling towers [2]. Upon the rapid development of the thermal power plant sectors, and consequently with the shortage of water resources, water pollution have increasingly become the main bottlenecks for the sustainable development of economy.

II. WORKING PRINCIPLE OF COOLING TOWER

The cooling tower works by the principle of evaporative cooling. The coolant after exchanging the heat from the steam-vapor mixture and comes out from the condenser at a raised temperature. The coolant is normally sea water where the power plant is near sea.

This hot water is pumped to the top of the cooling tower which passes through nozzles that spray into fine droplets. The fine droplets travel along the height of the tower and reach the basin fixed at the ground level. The ambient air is let in to the lower portion of the tower circumferentially either naturally or forced manner.

The heat exchange within air and hot water is done by evaporative cooling, as shown in Figure No.1. As the hot water meets the atmospheric air entering, a small portion of the hot water evaporates.

The absorption of latent heat during phase change lowers the temperature and the hot water is cooled significantly. The cooled water in the form of drops gets collected in the basin at the bottom of the tower. The collected water is pumped back to the condenser for further heat absorption and this cycle continues.

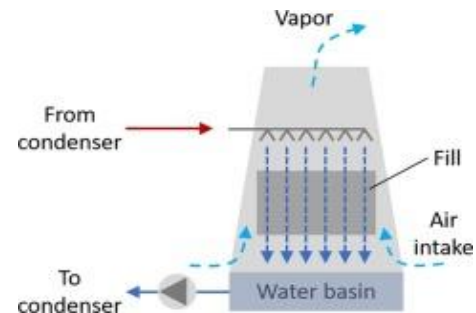


Figure No.1. Principle of working of a cooling tower

III. PERFORMANCE OF COOLING TOWER

Merkel's theory is one of the methods for computing the performance of cooling towers [3]. The total heat transfer occurring at any juncture in the cooling tower is directly proportional to the difference between the total heat of air in saturated conditions to the temperature of air at same conditions.

The Range and Approach are the two main factors in driving the performance of cooling tower which is depicted in Figure No.2. below.

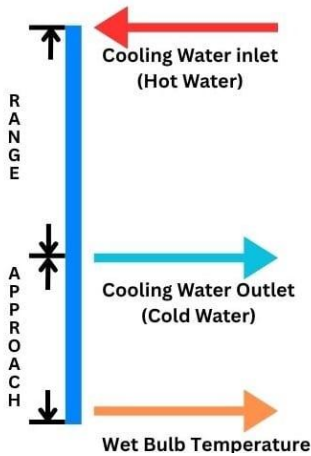


Figure No.2. Range and Approach in cooling tower

A. Approach:

The temperature difference between the cooled water leaving the cooling tower and the atmospheric air is defined as the Approach. The ambient air temperature noted will be at the Wet Bulb Temperature. If the approach temperature is close to zero, the cooling tower is more efficient since evaporative cooling is effectively executed.

B. Range:

The temperature difference between the hot water entering the cooling tower T_{hw} and the cold water leaving the cooling tower T_{cw} is denoted by Range. It is calculated by the formula as below:

$$Range = T_{hw} - T_{cw} \quad \text{Eqn (1)}$$

C. Drift Loss:

Some amount of water is lost as the droplets of water along the travel are carried away by the air flow. Reduction in water consumption is possible if this loss is low. Drift eliminators are kept on their way to capture the water droplets.

Water savings can be done in performing dynamic simulations of cooling towers to optimize their modes of operation in air-cooled wet cooling towers [4].

The working conditions of closed cooling tower have a significant influence on the performance of the cooling tower which is directly related to wet-bulb temperature of the atmospheric air [5].

D. Cooling Capacity:

Cooling Capacity is the total heat energy rejected from the cooling tower and is calculated as follows:

$$Cooling\ Capacity = \dot{m} \times C_p \times \Delta T \quad \text{Eqn (2)}$$

Where $\dot{m}$ is the mass flow rate of water in kg/s, C_p is the specific heat capacity of water in kJ/KgK and ΔT is the temperature difference calculated using equation (1).

E. Blow down Loss:

Water is blown down at regular intervals to discharge the dissolved solids which get accumulated during the evaporative cooling process.

F. Cooling Tower Efficiency

The cooling Tower Efficiency is a quantity to know the effectiveness of the cooling tower with reference to the ideal condition of cooling down to the wet bulb temperature.

$$Efficiency = \frac{Range}{Range + Approach} \times 100 \quad \text{Eqn (3)}$$

IV. CONCLUSION

The cooling tower completes the heat rejection phase on the thermodynamic cycle of the thermal power plant. The condenser temperature is one of the main factors in reducing the turbine efficiency. The condensate in the condenser if not effectively cooled raises the back pressure which decreases turbine efficiency and at a prolonged running of the system, leads to failure of the equipment. The recirculation of the cooling water conserves gallons of water usage considerably.

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