International Journal of Engineering Technology and Applied Science

(ISSN: 2395 3853), Vol. 3 Issue 2 February 2017

Comparative Analysis and Performance of a Counter Flow Natural Cooling Tower In Winter and Summer Season

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ABSTRACT

Cooling towers are heat removal devices used to transfer process waste heat to the atmosphere. Purpose of this project is to increase the performance rate of cooling tower by modifying the design. Thermal performance of cooling of the cooling tower is explained in terms of mass flow rate for convection and evaporation heat transfer along the height of tower. To understand basic operating principles of cooling tower, affecting factors and opportunities to save energy. A general study was made on the design consideration of cooling tower, importance of energy balance and mass balance while designing the cooling tower, influence of Wet bulb temperature in cooling tower performance, applicability of

Psychometric chart in cooling tower design & formulas used for designing the cooling towers and performance calculations.

Keywords: Cooling tower, Wet Bulb Temperature, Cooling tower Performance, Thermal Design, Different types of losses.

1. INTRODUCTION

Cooling towers are a very important part of many chemical plants. The primary task of a cooling tower is to reject heat into the atmosphere. They represent a relatively inexpensive and dependable means of removing low-grade heat from cooling water. The make-up water source is used to replenish water lost to evaporation. Hot water from heat exchangers is sent to the cooling tower. The water exits the cooling tower and is sent back to the exchangers or to other units for further cooling. Typical closed loop cooling tower system is shown in Figure 1.1.

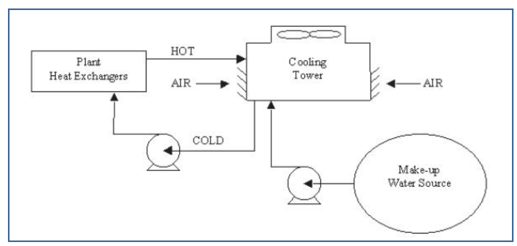

Figure 1 Cooling Water System

Cooling tower is a heat removal device, which removes heat from the hot water stream flowing inside the cooling tower and leaves the heat to the atmosphere. Evaporative type of cooling is done in the cooling tower in that it allows a small portion of the water being cooled to evaporate into a moving air stream to provide efficient cooling to the remaining of that water stream. The heat flows from water to the air stream therefore raise the temperature and relative humidity to 100%, and this air is discharged to the atmosphere. Evaporative heat refusal devices such as cooling towers are usually used to provide significantly lower water temperatures than achievable with air cooled or dry heat rejection devices, such as the radiator in a car, thereby achieving more cost-effective and energy efficient process of systems in need of cooling. Something hot surfaces be rapidly cooled by putting water on it as we have seen it many times, which evaporates, cooling rapidly, such as an overheated car radiator. The cooling potential of a wet surface is much better than adry one.

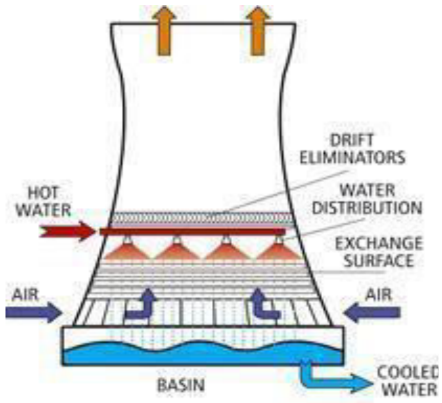

Figure 2. Components of Natural draft cooling tower General applications

2. LITERATURE SURVEY

R. Sattanathan [2015] 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, increase in air-water contact and characteristic decreases with increase in water to air mass ratio. The efficiency of the cooling tower is high in winter season as comparison to summer season. The efficiency of cooling tower in winter season 71.429%. Efficiency of cooling tower in summer season = 61.538% the cooling tower efficiency difference between summer season and winter season is =9.891%.. The losses of the cooling tower are high in winter season as compare to summer season.

T.Jagadeesh, et. al, [2013] had studied that the performance of the natural draft cooling tower was dominated by wind speed, ambient air temperatures and moisture in the atmospheric conditions. They stated in their paper that when the humidity was high in atmosphere, large quantity of water was required for cooling condensate and when moisture was low in atmosphere, small quantity of water was required for cooling condensate. The rate of relative humidity in the atmosphere varies from place to place and time of year. The various losses in the cooling tower such as float losses, evaporation losses and blow down losses could be calculated. The upholding of cooling tower in the form of removal of scale or corrosion had played important role in the performance of the tower.

Randhire Mayur A. [2014], showed that a natural draft cooling tower could be improved by optimizing the heat transfer along the cooling tower packing using a suitable water distribution across the plane area of the cooling tower. They described that in natural draft cooling towers, a method of counter flow heat transfer, where water was cooled by air. Between the water and the air, a boundary layer was recognized, which was considered to be saturated air at the same temperature as the water.

B Bhavani Sai, et. al, [2013] in their paper presented detailed methodology of a Induced draft cooling tower of counter flow type in which its efficiency, effectiveness, characteristics were calculated. The industrial data had been taken from a mechanical draft cooling tower. Cooling towers were heat removal devices used to transfer process waste heat to the atmosphere. Cooling towers made use of evaporation whereby some of the water was evaporated into a moving air stream and subsequently discharged into the atmosphere. As a result, the rest of the water was cooled down significantly.

3. BASIC THEORY OF COOLING TOWER

3.1 Main components of cooling tower: -

Frame - The structure of a cooling tower must accommodate long duration dead loads imposed by the weight of the tower components, circulating water, snow and ice, and any buildu p of internal fouling; plus short term loads caused by wind, maintenance and, in some areas, seismic activity. It must maintain its integrity throughout a variety of external atmospheric conditions, and despite a constant internal rainstorm. Wide-ranging temperatures must be accepted, as well as the corrosive effects of high humidity and constant oxygenation.

Casing - A cooling tower casing acts to contain water within the tower, provide an air plenum for the fan, and transmit wind loads to the tower framework. It must have diaphragm strength, be watertight and corrosion resistant, and have fire retardant qualities. It must also resist weathering, and should present a pleasing appearance.

Make-Up - Water added to the circulating water system, to overcome the losses held in cooling tower.

Mechanical Draft - Air movement is done by the externally applied devices like fans. **Module** - A preassembled portion or section of a cooling tower cell. On larger factory-assembled towers two or more shipped modules may require joining to make a cell.

Natural Draft - Air drawn inside the cooling tower by means of natural current or we can say by density differential.

Packing - This portion constitutes primary heat transfer surface of cooling tower.

Partition - A wall which subdivides the interior of the cooling tower and it also separates the other cells.

3.2 Cooling tower performance

Important parameters

(i) Range = Cooling tower water inlet temperature - Cooling tower water outlet temperature.

(ii) Approach = Cooling tower outlet cold water temperature - Ambient wet bulb temperature.

(iii) Cooling tower effectiveness: -

Cooling tower effectiveness = Range / Ideal range.

(iv) Ideal Range = (Range + Approach).

(v) Cooling capacity (Q) = m x c x (T_1-T_2) in kCal/hr or TR,

3.3 Factors Affecting Cooling Tower Performance Capacity

The atmosphere from which a cooling tower draws its supply of air incorporates infinitely v a r i a b l e psychrometric properties, and the tower reacts thermally or physically to each of those properties. The tower accelerates that air; passes it througha maze of structure and fill; heats it; expands it; saturates it with moisture; scrubs it; compresses it; and responds to all of the thermal and aerodynamic effects that such treatment can produce.

Finally, the cooling tower returns that “used up” stream of air to the nearby atmosphere, with the fervent intention that atmospheric winds will not find a way to reintroduce it back into the tower. Meanwhile, the water droplets produced by the tower’s distribution system are competing with the air for the same space and, through natural affinity, are attempting to coalesce into a common flowing stream having minimum surface area to expose to the air.

4. RESULT AND ANALYSIS

Table 1 Specifications Of Natural Draft Counter Flow Cooling Tower

Tower height	113 meters
Air inlet height	8.6m
Fill depth	1.8m
Tower basin diameter	100.808 m
Fill base diameter	90m
Tower top diameter	53.000 m
Spray zone height	0.8m

Table 2 Data from Psychrometric Chart And Steam Table

Enthalpy of air at in let temperature(Ha1)	77 kJ / kg	78.5 kJ / kg
Enthalpy of air at in	117 kJ / kg	125 kJ /

let temperature(Ha2)		kg
Specific humidity of air at inlet temperature(W1)	0.0203 kg / kg of air	0.0208 kg/ kg of air
Specific humidity of air at outlet temperature(W2)	0.0365 kg / kg of air	0.039 kg / kg of air
Specific volume of air at inlet temperature(VS1)		0.908 m³ / kg
Specific volume of air at outlet temperature(VS2)	0.927 m³ / kg	0.930 m³ / kg
Enthalpy of water at inlet temperature(Hw1)	167.57 kJ / kg	180.10 kJ / kg
Enthalpy of water at inlet temperature(Hw1)	125.79 kJ / kg	138.33 kJ / kg

Table 3 comparison of parameter between winter time and summer time.

Parameter	Winter	Summer
Range	10^0C	10^0C
Approach	2^0C	4.94˚C

Efficiency of cooling tower	71.43%	66.93%
Heat loss by water	1342593.152 MJ / hr	2645415.536 MJ / hr
Mass of air	415256.8927 Kg / hr	406401.86 kg / hr
Drift losses	1282.9 Kg / hr	1263.9 Kg / hr
Evaporation losses	490723.249 kg / hr	966910.122 kg / hr
Blow down losses	163574.416 kg/ hr	322303.37 Kg / hr

Table 4 Efficiency with respect to air inlet temperature in winter season.

Temperature	% of Efficiency
25	89.47
27	84.2
30	81.25
33	76.9
35	71.43

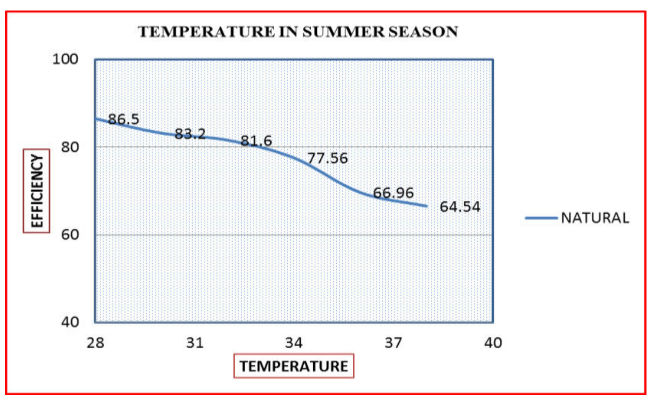

Figure 3 efficiency of summer season

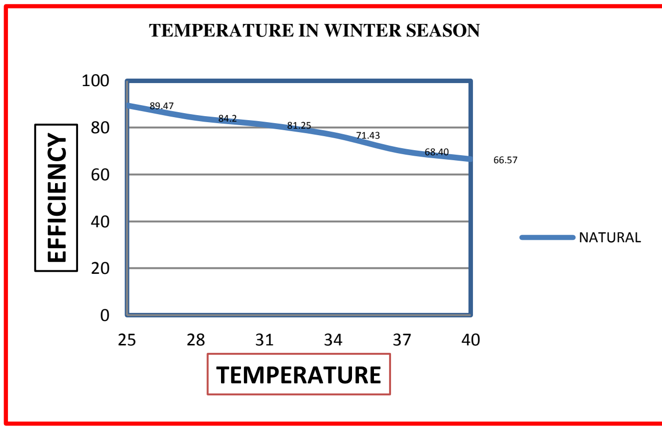

Figure 4 efficiency of winter season

6. CONCLUSION

The efficiency of the cooling tower is high in winter season as comparison to summer season. The efficiency of cooling tower in winter season71.43% .Efficiency of cooling tower in summer season =66.93% the cooling tower efficiency difference between summer season and winter season is =4.5% the cooling tower is closely related to different types of losses generated in cooling tower. The losses of the cooling tower are high in winter season as compare to summer season. We can conclude that by increasing the efficiency of cooling tower is built in non coastal areas (Humidity is low) we can increase the cooling tower efficiency.

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, increase in air-water contact and characteristic decreases with increase in water to air mass ratio.

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