Chapter 3.7: Cooling Towers

Part-I: Objective type questions and answers

1.	The type of cooling towers with maximum heat transfer between air to water is ___. a) Natural draft b) Mechanical draft c) Both a & b d) Neither a nor b
2.	Natural draft cooling towers are mainly used in ____. a) Steel industry b) alumina industry c) fertilizer industry d) power stations
3.	In counter flow induced draft cooling towers water and air both enter the top and exist at the top of the cooling tower. State whether True or False?
4.	The range of the cooling tower is determined by the connected heat load – True or False?
5.	Match the following cooling tower parameters a) Range i) Close to wet bulb temperature b) Approach ii) Related to ambient conditions c) Out let water temperature iii) Higher temperature difference Ans. a-iii) b-i) c-ii)
6.	Better indicator for cooling tower performance is ____. a) Wet bulb temperature b) Dry bulb temperature c)Range d) Approach
7.	Cooling tower effectiveness is the ratio of --------- a) Range/(range + approach) b) Approach/(range + approach) c) Range/Approach d) Approach/Range
8.	Cooling tower reduces circulation water temperature close to ---------- a) Dry bulb temperature b) ambient wet bulb temperature (WBT) c) Dew point temperature d) None of the above
9.	The ratio of dissolved solids in circulating water to the dissolved solids in make up water is termed as ____. a) Liquid gas ratio b) cycles of concentration c) cooling tower effectiveness d) None of the above
10.	Which one of the following has maximum effect on cooling tower performance: a) Fill media b) Drift c) Louvers d) Casing
11.	Which one of the following is true to estimate the range of cooling tower? a) Range = Cooling water inlet temperature – Wet bulb temperature b) Range = Cooling water outlet temperature – Wet bulb temperature c) Range = $\frac{Heat\ load\ in\ kcal/h}{Water\ circulation\ in\ lph}$ d) None of the above
12.	A cooling tower is said to be performing well when:

	a) <u>approach is closer to zero</u> b) range is closer to zero c) approach is larger than design d) range is larger than design
13.	Heat release rate to the cooling tower in vapour compression refrigeration system is equal to: a) <u>63 kcal/min/ton</u> b) 500 kcal/min/ton c) 127 kcal/min/ton d) 220 kcal/min/ton
14.	The operating temperature level in the plant or process connected with a cooling tower is determined by: a) Dry bulb temperature b) Wet bulb temperature c) <u>Hot water temperature from the process</u> d) Cold water temperature into the process
15.	Which one of the following fill material is more energy efficient for cooling tower: a) Splash fill b) <u>Film-fill</u> c) Low clog film fill d) None of the above
16.	Which one from the following types of cooling towers consumes less power? a) Cross-flow splash fill cooling tower b) Counter flow splash fill cooling tower c) <u>Counter flow film fill cooling tower</u> d) None of the above
17.	L / G ratio in cooling tower is the ratio of ___. a) Length and girth b) Length and Temperature gradient c) <u>Water flow rate and air mass flow rate</u> d) Air mass flow rate and water flow rate
18.	Normally the guaranteed best approach a cooling tower can achieve is ___. a) 5 ^{o}C b) 12 ^{o}C c) 8 ^{o}C d) <u>2.8 ^{o}C</u>
19.	The temperature selection normally chosen for designing of cooling tower is **___.** a) <u>Average maximum wet bulb for summer months</u> b) Average maximum wet bulb for rainy months c) Average maximum wet bulb for winter months d) Average minimum wet bulb for summer months
20.	Select the statement which is true for a FRP fan. a) It needs low starting torque b) Increases life of gear box c) Easy handling and maintenance d) <u>All the above</u>

<u>Part-II: Short type questions and answers</u>

1.	List out different air flow arrangements of mechanical draft cooling towers? Different air flow arrangements of mechanical draft cooling tower are: a) Counter flow induced draft b) Counter flow forced draft c) Cross flow forced draft
2.	List out different material used for cooling tower fans.

	Different material used for cooling tower fans: 1. Aluminium blades (metallic) 2. Glass reinforced plastic (GRP) 3. Fibre reinforced plastic (FRP)
3.	What are the components of the cooling tower? The basic components of an evaporative cooling tower are: Frame and casing, fill, cold water basin, drift eliminators, air inlet, louvers, nozzles and fans.
4.	Estimate the cooling tower capacity (TR) with the following parameters Water flow rate through CT = 120 m^3/h SP. Heat of water = 1 k.Cal/kg °C Inlet water temperature = 37 °C Outlet water temperature = 32 °C Ambient WBT = 29 °C Cooling tower capacity (TR) = (flow rate x density x sp.heat x diff. temp)/3024 = 120 x 1000 x 1 x (37-32)/3024 = 198.4 TR
5.	Specify the CT manufacturer design approach value. Generally a 2.8 °C approach to the design wet bulb is the coldest water temperature that cooling tower manufactures will guarantee.
6.	How a continuously monitored ambient DBT and RH data can be utilised for the cooling tower design? From the monitored DBT (°C) and RH%, wet bulb temperature (WBT) can be arrived using psychometric chart and same is used for designing cooling tower. In the design of CT wet bulb temperature selected is not exceeded over 5 percent of the time in that area.
7.	How size of cooling tower and wet bulb temperature are related? Wet bulb temperature is a factor in cooling tower selection. The higher the wet bulb temperature, the smaller the cooling tower required to give a specified approach to the wet bulb at a constant range and flow rate.
8.	List the features of FRP fans in cooling tower. FRP blades are normally hand moulded. These blades are aerodynamic in profile to meet specific duty conditions more efficiently. Due to light weight FRP fans need low starting torque resulting in use of lower HP motors.
9.	Under what circumstances, do the cooling tower motors are excessively loaded? Reasons for excessive electrical load on CT fan motors are: 1. Voltage reduction 2. Incorrect angle of axial fan blades 3. Loose belts on centrifugal fans 4. Over loading owing to excessive air flow-fill has minimum water loading per m^3 of tower 5. Low ambient air temperature

10.	Plant has installed 100 TR refrigeration system of compression type. It has planned to utilize waste heat in absorption chiller to meet 100 TR cooling load. What is the size of cooling tower required? For the given refrigeration capacity (100 TR), absorption type chillers require double the capacity cooling tower in comparison to compression type chiller.
11.	What will be the effect of cooling water temperature on A/C compressor operation? Effect of cooling tower outlet water temperature on A/C compressors, 1 °C cooling water temperature rise may increase A/C compressor power consumption (kW) by 2.7%.
12.	What is meant by "Range and Approach" of a cooling tower? i) "Range" is the difference between the cooling tower water inlet and outlet temperature. ii) "Approach" is the difference between the cooling tower outlet cold water temperature and ambient wet bulb temperature. Though both parameters should be monitored, the 'Approach' is a better indicator of cooling tower performance.
13.	List the factors affecting cooling tower performance? i) Capacity and range ii) Heat load iii) wet bulb temperature iv) Approach and water flow v) Filling media
14.	What do you meant by effectiveness of a cooling tower? Cooling tower effectiveness in percentage is the ratio of range, to the ideal range, i.e., difference between cooling water inlet temperature and ambient wet bulb temperature or in other words it is = Range / (Range + Approach).
15.	How do you calculate evaporation loss in cooling tower? Evaporation loss is the water quantity evaporated for cooling duty. An empirical relation used often is: CMH evaporation loss $= \dfrac{Circulation\ Rate\,(CMH)\ x\,Temp.\,difference\,in\,°C}{675}$
16.	What are the advantages of FRP blades over the conventional blades for cooling tower fans? • Due to optimum aerodynamic profile, energy savings of the order to 20 – 30 % can be achieved • Due to light weight, low starting torque is required, hence requiring smaller capacity motor • Also due to light weight the life of gearbox, motor and bearing is increased and allows handling and maintenance
17.	How to calculate blowdown quantity required in cooling towers? Blow Down = Evaporation Loss / (C.O.C. – 1) C.O.C = Cycle of concentration
18.	What will be the effect of cooling water temperature in heat rate in thermal power plants? Effect of cooling tower outlet water temperature on thermal power plant: 1 °C temperature drop in cooling water will lead to heat rate saving of 5 kcal/kWh in thermal power plant.
19.	List the types of fill media generally used in cooling towers? Fill media is of two types:

	1. Splash fill media 2. Film fill media
20.	In case of cooling towers, which type of fill media are more 'energy efficient'? Fills made of PVC, polypropylene, and other polymers are more energy efficient.

Part-III: Long type questions and answers

1.	Explain the terms with respect to cooling tower performance: a) Wet bulb temperature Wet Bulb Temperature is an important factor in performance of evaporative water cooling equipment. It is a controlling factor from the aspect of minimum cold water temperature to which water can be cooled by the evaporative method. Thus, the wet bulb temperature of the air entering the cooling tower determines operating temperature levels throughout the plant, process, or system. Theoretically, a cooling tower will cool water to the entering wet bulb when operating without a heat load. However, a thermal potential is required to reject heat, so it is not possible to cool water to the entering air wet bulb temperature when a heat load is applied. The approach obtained is a function of thermal conditions and tower capability. b) Capacity and Range Any cooling tower, regardless of its size, will dissipate all the kCals sent to it. Unlike a pump which will only move a certain quantity of water against a definite head, a cooling tower will continue to dissipate kCals to the atmosphere as long as they are added to the circulating water, the cooling tower will dissipate the heat coming to the tower. Specifying cooling towers in terms of water flow rate, CMH circulated is also erroneous. Other factors must be stated along with CMH. For example, a cooling tower sized to cool 4540 CMH through a 13.9^{o}C range might be larger than a cooling tower to cool 4540 CMH through 19.5^{o}C range. Range is determined not by the cooling tower but by the heat exchanger it is serving. The range at the exchanger is determined entirely by he heat load and the water circulation rate through the exchanger and on to the cooling water. **Here, Range ^{o}C = Heat Load in kCals/hour / Water Circulation Rate in LPH** It is obvious that the range is not a function of the flow cooling tower but is a function of the cooling tower but is a function of the heat load and the flow circulated through the system.
2.	From the given cooling tower parameters, evaluate the following: i) Make up water requirement per day ii) Evaporation loss iii) Blow down loss Cooling water temperature : 1260 m^3/h Outlet water temperature : 32 °C Drift losses : 0.1 % No. of concentrating cycles : 3 Estimation of cooling tower losses: a) Drift loss : 0.1% b) Evaporation loss : Range (temp. difference, °C) x 100/675 : $\frac{(37-32)}{675} x100 = 0.74\%$

	c) Blow down loss	: Evaporation loss/(No. of concentrating cycle-1) : $\left(\frac{0.74}{3-1}\right) = 0.37\%$
	Total make up water requirement	: 0.1 + 0.74 + 0.37 = 1.21%
	Cooling water circulation rate	: 1260 m^3/h
	Make up water requirement	: 1260 x 0.0121 = 15.2 m^3/h :364.8 m^3/day

3. What is the effect of change in heat load on cooling tower performance? Explain.

The heat load imposed on a cooling tower is determined by the process being served. The degree of cooling required is controlled by the desired operating temperature level of the process. In most cases, a low operating temperature is desirable to increase process efficiency or to improve the quality or quantity of the product. In some applications (e.g. internal combustion engines), however, high operating temperatures are desirable. The size and cost of the cooling tower is proportional to the heat load. If heat load calculations are low undersized equipment will be purchased. If the calculated load is high, oversize and more costly, equipment will result.

Process heat loads may vary considerably and are dependent upon and peculiar to the process involved. Determination of accurate process heat loads can become very complex but proper consideration can produce satisfactory results. On the other hand, air conditioning and refrigeration head loads can be determined with greater accuracy.

Dependable information has been developed for the heat rejection requirements of various types of power equipment. A sample list is as follows:

*	Air Compressor with two-stage intercooler and after cooler	- 862 kcal/kW/hr
*	Refrigeration, Compression	- 63 kcal/min/ton
*	Refrigeration, Absorption	- 127 kcal/min/ton
*	Steam Turbine Condenser	- 555 kcal/kg of steam
*	Diesel Engine, Four-Cycle, Supercharged	- 880 kcal/kW/hr

4. Write about the importance of wet bulb temperature in cooling towers?

Wet bulb temperature is an important factor in performance of evaporative water cooling equipment. It is a controlling factor from the aspect of minimum cold water temperature to which water can be cooled by the evaporative method. The wet bulb temperature of the air entering the cooling water determines operating temperature levels throughout the plant, process or system.

Initial selection of towers w.r.t design wet bulb temperature must be made on the basis of conditions existing at the lower side. The temperature selected is generally close to the average maximum wet bulb for the summer months.

5. Why air conditioning and refrigeration heat loads have to determine with greater accuracy in case of cooling towers?

Air conditioning and refrigeration equipment are sensitive comparative to other cooling loads. It is vitally important to have the cold water temperature low enough to exchange heat or to condense vapours at the optimum temperature level. A 1 °C cooling water temperature increase may increase A/C compressor power consumption (kW) by 2.75. To achieve the lower power consumption of A/C compressors ensure that inlet cooling water temperature to be the lowest as possible. It is better to isolate cooling towers of high heat loads like furnaces, air compressors, DG sets from refrigeration cooling towers to maintain lowest possible cooling water temperature.