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A WORK STUDY ON HOW TO INCREASED EFFICIENCY OF PLANT BY COOLING TOWER

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Abstract:

In the present world with the increasing use of plant efficiency many technology are to be taken in industry but all have not recovery problem and not more useful to improve the growth rate of plant where in this paper we study about a cooling tower how to benefits in plant to development. In this paper many factor is to be consider which are to important for installation of cooling tower. Every industry use cooling method to reduced the heat transfer rate with high amount of machinery but now the modern world all the machine parts are reduced and easily working operation performed, So Many selected parameters is to be used in this paper which help to development growth rate and efficiency of industry by the application of cooling tower

Key Words: Components of Cooling Tower, Material Used in Cooling Tower & Cooling Tower Performance.

1. Introduction:

Cooling towers use the principle of evaporative or 'wet bulb' cooling in order to cool water. Cooled water is needed for, for example, air conditioners, manufacturing processes or power generation. A cooling tower is equipment used to reduce the temperature of a water stream by extracting heat from water and emitting it to the atmosphere. Cooling towers make use of evaporation whereby some of the water is evaporated into a moving air stream a subsequently discharged into the atmosphere. As a result, the remainder of the water is cooled down significantly (Figure1). Cooling towers are able to lower the water temperatures more than devices that use only air to reject heat, like the radiator in a car, and are therefore more cost-effective and energy efficient.

Figure: Schematic Diagram of Cooling Tower

1.1 Types of Cooling Tower:

Cooling towers fall into two main categories:- Natural draft and Mechanical draft. Natural draft towers use very large concrete chimneys to introduce air through the media. Due to the large size of these towers, they are generally used for water flow rates above 45,000 m3/hr. These types of towers are used only by utility power stations. Mechanical draft towers utilize large fans to force or suck air through circulated water.

The water falls downward over fill surfaces, which help increase the contact time between the water and the air - this helps maximize heat transfer between the two. Cooling rates of Mechanical draft towers depend upon their fan diameter and speed of operation. Since, the mechanical draft cooling towers are much more widely used.

1. Natural Draft Cooling Tower:

- Counter Flow Natural Draft Cooling Tower.
- Cross flow Natural Draft Cooling Tower

2. Mechanical Draft Cooling Tower:

- Forced Draft Counter Flow Cooling Tower
- Induced Draft Counter Flow Cooling Tower
- Induced Draft Cross Flow Cooling Tower

Natural Draft Cooling Towers:

The natural draft or hyperbolic cooling tower makes use of the difference in temperature between the ambient air and the hotter air inside the tower. As hot air moves upwards through the tower (because hot air rises), fresh cool air is drawn into the tower through an air inlet at the bottom. Due to the layout of the tower, no fan is required and there is almost no circulation of hot air that could affect the performance. Concrete is used for the tower shell with a height of up to 200 m. These cooling towers are mostly only for large heat duties because large concrete structures are expensive.

Counter Flow Natural Draft Cooling Towers:

Air is drawn up through the falling water and the fill is therefore located inside the tower, although design depends on specific site conditions. The counter flow natural draft cooling tower is as shown in the figure.

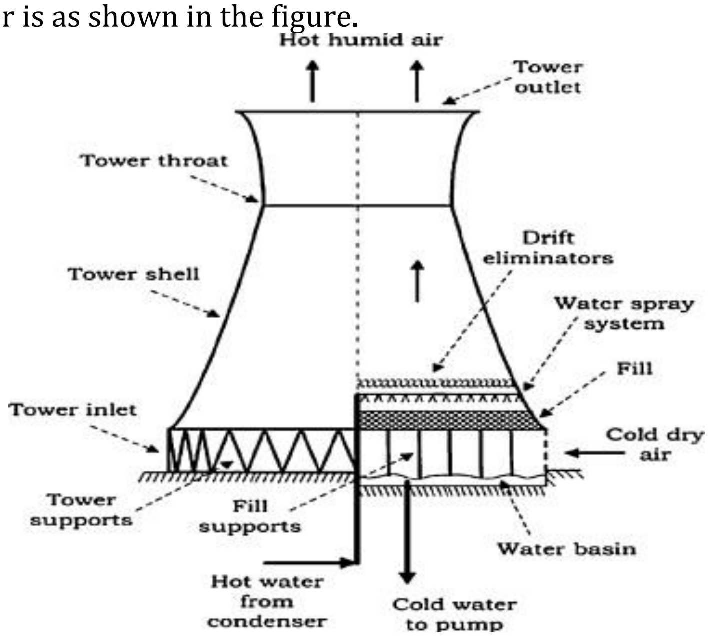

Figure: Counter Flow Natural Draft Cooling Tower.

Mechanical Draft Cooling Towers:

Mechanical draft towers have large fans to force or draw air through circulated water. The water falls downwards over fill surfaces, which help increase the contact time between the water and the air - this helps maximize heat transfer between the two. Cooling rates of mechanical draft towers depend upon various parameters such as fan diameter and speed of operation, fills for system resistance etc

Forced Draft Counter Flow Cooling Towers:

In forced draft counter flow design, however, the water at the bottom of the fill is channeled to a perimeter trough that functions as the cold water basin. Propeller fans are mounted beneath the fill to blow the air up through the tower. With this design, the tower is mounted on legs, providing easy access to the fans and their motors.

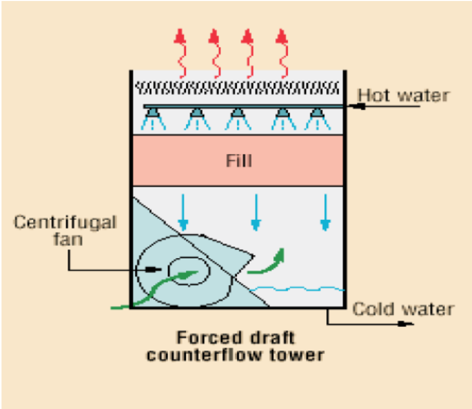

Figure: Forced Draft Counter Flow Cooling Tower

Induced Draft Counter Flow Cooling Towers:

In the counter flow induced draft design, hot water enters at the top, while the air is introduced at the bottom and exits at the top. Both forced and induced draft fans are used. In counterflow towers (Fig. 8), air moves vertically upward through the fill, counter to the downward fall of water. Because of the need for extended intake and discharge plenums; the use of high-pressure spray systems; and the typically higher air pressure losses, some of the smaller counterflow towers are physically higher; require more pump head; and utilize more fan power than their cross flow counterparts. In larger counter flow towers, however, the use of low-pressure, gravity related distribution systems, plus the availability of generous intake areas and plenum spaces for air management, is tending to equalize, or even reverse, this situation. The enclosed nature of a counter flow tower also restricts exposure of the water to direct sunlight, thereby retarding the growth of algae.

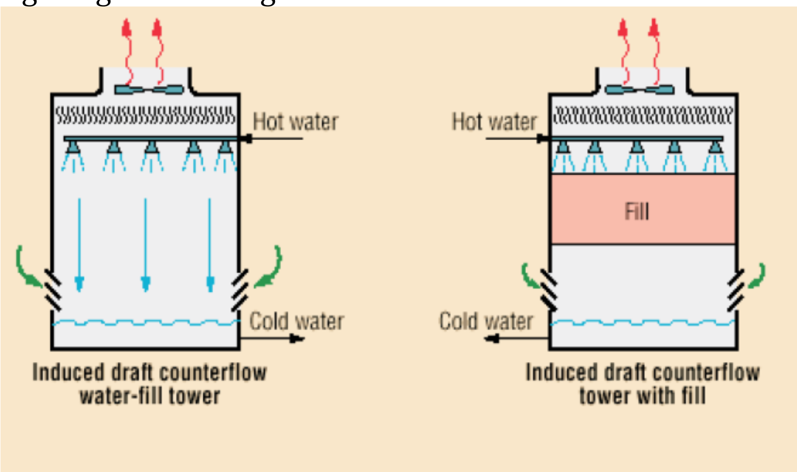

Figure: Induced Draft Counter Flow Cooling Tower

Induced Draft Cross Flow Cooling Towers:

In cross flow induced draft towers, the water enters at the top and passes over the fill. The air, however, is introduced at the side either on one side (single-flow tower) or opposite sides (double-flow tower). An induced draft fan draws the air across the wetted fill and expels it through the top of the structure.

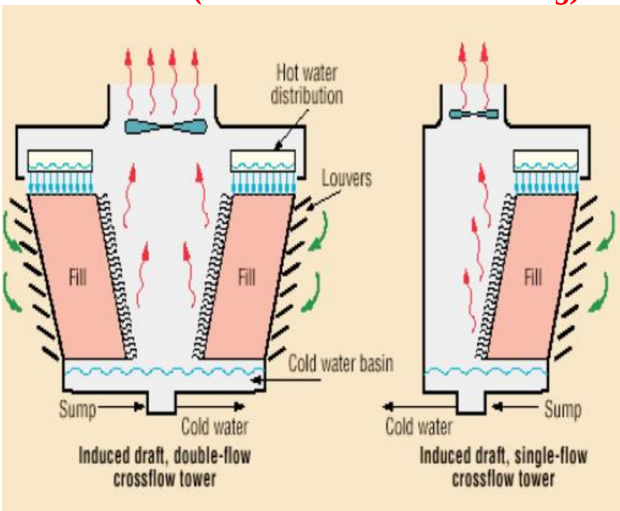

Figure: Induced Draft Cross Flow Cooling Tower

2. Introduction:

In a counter flow design, the air flow is directly opposite to the water flow (see diagram below). Air flow first enters an open area beneath the fill media, and is then drawn up vertically. The water is sprayed through pressurized nozzles near the top of the tower, and then flows downward through the fill, opposite to the air flow.

This cooling tower rotary sprinkler and have honey comb PVC fills that helps in dissipation of heat. The induced draft counter flow cooling towers have square shapes. This enables fair distribution of the airflow. The induced draft square is absolutely silent and is used for their efficiency and high performance.

The square shape of the FRP induced draft cooling towers is compact and silent. These features facilitate low speed of air around the air inlet which in turn fairly distributes the airflow. The FRP induced draft is light weight but very sturdy. It has high efficiency and very low level of noise. The outside of the tower has UV protection as well as corrosion resistant coating that ensures prolonged life of the cooling tower. Because of its scientific design the tower saves water and electricity. The maintenance of the tower is very easy and the structure is durable enough to withstand harsh climatic condition. This tower can be build with various types of fill materials (i.e. film type & splash fill) such as

1. Concrete Lath Bars (These are made of RCC by pre-stress precast).
2. Wooden/PVC Lath bars.
3. PVC Film type fills.
4. PVC Splash Fills of perforated 'V' Bars.

2.1 Components of Cooling Tower:

The basic components of an evaporative tower are:- Frame and casing, fill, cold water basin, drift eliminators, air inlet, louvers, nozzles and fans.

1. **Frame and Casing:** Most towers have structural frames that support the exterior enclosures (casings), motors, fans, and other components. With some smaller designs, such as some glass fiber units, the casing may essentially be the frame.
2. **Fill:** Most towers employ fills (made of plastic or wood) to facilitate heat transfer by maximising water and air contact. Fill can either be splash or film type. With splash fill, waterfalls over successive layers of horizontal splash bars, continuously breaking into smaller droplets, while also wetting the fill surface. Plastic splash fill promotes better heat transfer than the wood splash fill. Film fill

consists of thin, closely spaced plastic surfaces over which the water spreads, forming a thin film in contact with the air. These surfaces may be flat, corrugated, honeycombed, or other patterns. The film type of fill is the more efficient and provides same heat transfer in a smaller volume than the splash fill.

3. **Cold Water Basin:** The cold water basin, located at or near the bottom of the tower, receives the cooled water that flows down through the tower and fill. The basin usually has a sump or low point for the cold water discharge connection. In many tower designs, the cold water basis in beneath the entire fill. In some forced draft counter flow design, however, the water at the bottom of the fill is channelled to a perimeter trough that functions as the cold water basin. Propeller fans are mounted beneath the fill to blow the air up through the tower. With this design, the tower is mounted on legs, providing easy access to the fans and their motors.
4. **Drift Eliminator:** These capture water droplets entrapped in the air stream that otherwise would be lost to the atmosphere.
5. **Air Inlet:** This is the point of entry for the air entering a tower. The inlet may take up an entire Side of a tower–cross flow design– or be located low on the side or the bottom of counter flow designs.
6. **Louvers:** Generally, cross-flow towers have inlet louvers. The purpose of louvers is to equalizeair flow into the fill and retains the water within the tower. Many counter flow tower designs do not require louvers.
7. **Nozzels:** These provide the water sprays to wet the fill. Uniform water distribution at the top of the fill is essential to achieve proper wetting of the entire fill surface. Nozzles can either be fixed in place and have either round or square spray patterns or can be part of a rotating assembly as found in some circular cross-section towers.
8. **Fans:** Both axial (propeller type) and centrifugal fans are used in towers. Generally, propeller fans are used in induced draft towers and both propeller and centrifugal fans are found in forced draft towers. Depending upon their size, propeller fans can either be fixed or variable pitch. A fan having non-automatic adjustable pitch blades permits the same fan to be used over a wide range of kW with the fan adjusted to deliver the desired air flow at the lowest power consumption. Automatic variable pitch blades can vary air flow in response to changing load conditions.

2.2 Cooling Tower Materials:

1. **Wood Type Cooling Tower:** In the early days of cooling tower manufacture, towers were constructed primarily of wood. Wooden components included the frame, casing, louvers, fill, and often the cold water basin. If the basin was not of wood, it likely was of concrete. Today, tower manufacturers fabricate towers and tower components from a variety of materials. Often several materials are used to enhance corrosion resistance, reduce maintenance, and promote reliability and long service life. Galvanized steel, various grades of stainless steel, glass fiber, and concrete are widely used in tower construction as well as aluminum and various types of plastics for some components. Wood towers are still available, but they have glass fiber rather than wood panels (casing) over the wood framework. The inlet air louvers may be glass fiber, the fill may be plastic, and the cold water basin may be steel. Larger towers sometimes are made of concrete. Many towers–casings and basins–are constructed of galvanized steel or, where a corrosive atmosphere is a problem, stainless steel. Sometimes a

galvanized tower has a stainless steel basin. Glass fiber is also widely used for cooling tower casings and basins, giving long life and protection from the harmful effects of many chemicals.

2. **Plastics:** Plastics are widely used for fill, including PVC, polypropylene, and other polymers. Treated wood splash fill is still specified for wood towers, but plastic splash fill is also widely used when water conditions mandate the use of splash fill. Film fill, because it offers greater heat transfer efficiency, is the fill of choice for applications where the circulating water is generally free of debris that could plug the fill passage ways. Plastics also find wide use as nozzle materials. Many nozzles are being made of PVC, ABS, polypropylene, and glass-filled nylon.
3. **Fan Material:** Aluminum, glass fiber, and hot-dipped galvanized steel are commonly used fan materials. Centrifugal fans are often fabricated from galvanized steel. Propeller fans are fabricated from galvanized, aluminum, or moulded glass fiber reinforced plastIn general, the diameter of seal disk is about 20 to 25% to the fan diameter. If the hub is too large for the required performance, the result will be an increase in the velocity pressure due to the smaller net opening, and subsequent waste of power. If the seal disk is too small, the result will be deterioration of the flow near the fan hub, possibly even a reversal of flow in this area.

2.3 Factor Affecting Cooling Tower Fan:

1. Fan Coverage:

For an even air suction from the drift eliminator section and to have a smooth entrance of air into the fan, the fan coverage must not be smaller than 30% of the cross sectional area of cell. Less fan coverage than 30% will returned to a poor intake from the entire drift eliminator section. Therefore, the overall performance of cooling tower will be dramatically reduced. The fan diameter affects the performance of fan primarily because the magnitude of the velocity pressure depends on the fan diameter. The pressure capability of the fan could be changed by changing the number of fan blades, but the fan must be rated to overcome more static pressure, which is a cooling tower system resistance, as having less velocity pressure with keeping a low air velocity through the fan. General speaking, the velocity pressure through the fan should be within 0.14 to 0.25 inch Aq. or the air velocity should be raged within 1600 to 2100 FPM for the optimum rating of fan.

2. Fan Sizing: The major factors in deciding the number of fan blades are as below:-

Blade Strength:

There is a limit of blade strength in bearing the torque or horsepower. In case of Hudson Products Corp. the maximum and Trouble Free BHP/Blade by the fan diameter is as a general rule, do not select the fans near to the limit of BHP/Blade specified like above. The high BHP/Blade will cause a fatigue in a short period due to the high blade air loading, and will make a trouble for the vibration noise. Author's experience is the less number of fan blades causes the severe vibration (called Throat Flutter) in the fan stack, unless a special attention in making the fan stack is paid. Any fan that is effectively moving air at the tips of the blades will develop a reduced pressure area (or suction) on the fan throat at the tip of the blade. This suction tends to draw the throat toward the tip of each blade, which means that a four blade fan would tend to draw the throat into something approaching a square while a six blade fan would draw it into something resembling a hexagon, etc. Since the fan is rotating, the effect on the throat is that of continually drawing it into a rotating polygon. The resulting throat flutter is frequently mistaken for fan unbalance. A substantial throat will be sufficiently rigid that flutter will not exist. A weak or flexible throat, particularly when used with a fan of a low number of blades, will be greatly affected by this type of vibration. Throat flutter is easily detected due to the fact that it is invariably of a frequency of the fan RPM times the number of blades on the fan. If in doubt that throat flutter is the cause of vibration, reduce the angle of the blades until the fan is doing little or no work. If the vibration ceases under this condition, it is certain that throat flutter is present when the blades are loaded. Throat flutter will cause no damage to the fan so long as the throat does not disintegrate and fall into the fan blades. It may be eliminated by stiffening or bracing the throat.

3. Material Construction of Tower Structure and Fan Stack: Common practice in deciding the number of fan blades is to maintain the level of vibration below 80 micron at the gear reducer. A general guideline with Hudson's fans is as below.

2.4 Cycles of Concentration:

Cycles of concentration represents the accumulation of dissolved minerals in the recalculating cooling water. Draw-off (or blow down) is used principally to control the buildup of these minerals. The chemistry of the make-up water including the amount of dissolved minerals can vary widely. Make-up waters low in dissolved minerals such as those from surface water supplies (lakes, rivers etc.) tend to be aggressive to metals (corrosive). Make-up waters from ground water supplies (wells) are usually higher in minerals and tend to be scaling (deposit minerals). Increasing the amount of minerals present in the water by cycling can make water less aggressive to piping however excessive levels of minerals can cause scaling problems.

As the cycles of concentration increase, the water may not be able to hold the minerals in solution. When the solubility of these minerals has been exceeded they can precipitate out as mineral solids and cause fouling and heat exchange problems in the cooling tower or the heat exchangers. The temperatures of the recirculating water, piping and heat exchange surfaces determine if and where minerals will precipitate from the recirculating water. Often a professional water treatment consultant will evaluate the make-up water and the operating conditions of the cooling tower and recommend an appropriate range for the cycles of concentration. The use of water treatment chemicals, pretreatment such as water softening, pH adjustment, and other techniques can affect the acceptable range of cycles of concentration. Concentration cycles in the majority of cooling towers usually range from 3 to 7. In the United States, many water supplies are well waters and have significant levels of dissolved solids. On the other hand, one of the largest water supplies, for New York City, has a surface rainwater source quite low in minerals; thus cooling towers in that city are often allowed to concentrate to 7 or more cycles of concentration.

2.5 Water Treatment:

Besides treating the circulating cooling water in large industrial cooling tower systems to minimize scaling and fouling, the water should be filtered and also be dosed with biocides and algaecides to prevent growths that could interfere with the continuous flow of the water. Under certain conditions, a biofilm of micro-organisms such as bacteria, fungi and algae can grow very rapidly in the cooling water and can reduce the heat transfer efficiency of the cooling water. Biofilm can be reduced or prevented by using chlorine or other chemicals. Other technologies to control algae and biofilm include.

Plused Technology: Applies high frequency electrical pulses to break open biosolid cell membranes.

Ultrasonic Algae and Biofilm Control: Controls algae by emitting ultrasonic frequencies which can rupture different cell organelles such as the vacuole's tonoplast, cell wall or membrane and the gas vesicles of blue-green algae. Specific ultrasonic vibrations around a submerged surface can inhibit bacteria from settling and thus forming a biofilm.

Chlorine Dioxide Generation Systems: Chlorine dioxide is effective in the control of microbiological growths in industrial cooling waters under conditions unfavorable to chlorine. It is particularly effective in systems having a high pH, ammonia-nitrogen contamination, persistent slime problems, or where the microbial contamination is aggravated by contamination with vegetable or mineral oils, phenols or other high chlorine-demand producing compounds.

3 Distribution Systems and Performance of Cooling Tower:

3. Air Water Distribution System Design:

A cooling tower is an air and water management device, which consists of fan stacks, fans, drift eliminators, fill and water/air distribution systems. For the fans and fan stacks were previously discussed. So, the explanation shall be focused to the air/water distribution systems.

Water Distribution:

The distribution of water to the top of counter flow fill is a key aspect of assured performance. It is a function of nozzle design, nozzle installation pattern, nozzle distance, and the structural cleanliness of the spray chamber. The impact of water distribution on performance is a combination of uniformity of water distribution, air-side pressure drop through the spray chamber, and heat transfer occurring in the spray zone. The challenge for a spray system designer is to accomplish an optimum balance of design parameters with practical considerations such as resistance to silt build-up, and the ability to pass objects from trash to Amertap balls. To provide the primary function of precise water distribution, the nozzle must be designed with other considerations in mind:-

1. The location of counter flow nozzles and the potential for poor quality circulating water demands that the nozzle system be designed to minimize fouling.
2. The nozzle must be capable of providing uniform distribution over a wide range of flows, without significant loss in nozzle performance.
3. The nozzle must be capable of efficient operation while consuming a minimum of expensive pump energy.

Air Flow Distribution System:

Cooling tower performance is also related to the amount of air moving through the tower and coming into direct contact with the water. In counter flow towers the air movement is vertically upward through the fill, counter to the downward fall of the water. This configuration, along with the finer water droplet size available from pressurized spray nozzles, allows counter flow towers to make more efficient use of available air. However, the resistance to upward air travels against the falling water results in higher static pressure loss and greater fan horsepower than a cross flow system. Cross flow towers have a fill configuration through which air flows horizontally across the downward flow of the water. Cross flow towers utilize essentially the full tower height for inlet louvers, reducing air inlet velocity and minimizing recirculation and drift loss. The air inlet louvers in counter flow towers are restricted to the tower base, increasing inlet velocities and susceptibility to airborne trash and other debris.

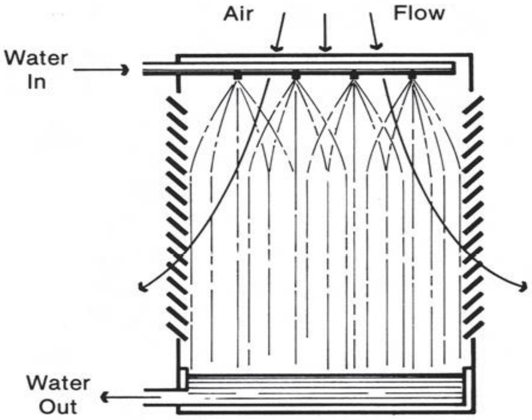

Figure: Air Water Distribution Design of Cooling Tower

3.1 Cooling Tower Performance:

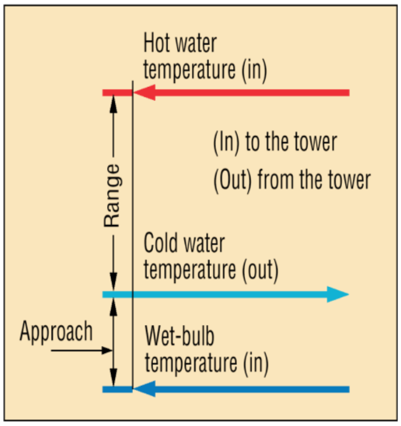

Figure: Diagram of Cooling Tower Performance

The important parameters, from the point of determining the performance of cooling towers, are:-

1. "Range" is the difference between the cooling tower water inlet and outlet temperature.
2. "Approach" is the difference between the cooling tower outlet cold water temperature and ambient wet bulb temperature. Although, both range and approach should be monitored, the 'Approach' is a better indicator of cooling tower performance.
3. 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).
4. Cooling capacity is the heat rejected in kCal/hr or TR, given as product of mass flow rate of water, specific heat and temperature difference.
5. Evaporation loss is the water quantity evaporated for cooling duty and, theoretically, for every 10, 00,000 kCal heat rejected, evaporation quantity works out to 1.8 m3.
6. Liquid/Gas (L/G) ratio, of a cooling tower is the ratio between the water and the air mass flow rates. Against design values, seasonal variations require adjustment and tuning of water and air flow rates to get the best cooling tower effectiveness through measures like water box loading changes, blade angle adjustments. Thermo dynamics also dictate that the heat removed from the water must be equal to the heat absorbed by the surrounding air.

Where:-

L/G = liquid to gas mass flow ratio (kg/kg)
T1 = hot water temperature (°C)
T2 = cold water temperature (°C)
h2 = enthalpy of air-water vapour mixture at exhaust wet-bulb temperature (same units as above).
h1 = enthalpy of air-water vapour mixture at inlet wet-bulb temperature (same units as above).

4. Efficient System Operation:

1. Cooling Water Treatment:

Cooling water treatment is mandatory for any cooling tower whether with splash fill or with film type fill for controlling suspended solids, algae growth, etc. With increasing costs of water, efforts to increase Cycles of Concentration (COC), by Cooling Water Treatment would help to reduce make up water requirements significantly. In large industries, power plants, COC improvement is often considered as a key area for water conservation.

2. Drift Loss in the Cooling Tower:

It is very difficult to ignore drift problem in cooling towers. Now-a-days most of the end user specification calls for 0.02% drift loss. With technological development and processing of PVC, manufacturers have brought large change in the drift eliminator shapes and the possibility of making efficient designs of drift eliminators that enable end user to specify the drift loss requirement to as low as 0.003 –0.001%.

3. Cooling Tower Fans:

The purpose of a cooling tower fan is to move a specified quantity of air through the system, overcoming the system resistance which is defined as the pressure loss. The product of air flow and the pressure loss is air power developed/work done by the fan; this may be also termed as fan output and input kW depends on fan efficiency. The fan efficiency in turn is greatly dependent on the profile of the blade. An aerodynamic profile with optimum twist, taper and higher coefficient of lift to coefficient of drop ratio can provide the fan total efficiency as high as 85–92 %. However, this efficiency is drastically affected by the factors such as tip clearance, obstacles to airflow and inlet shape, etc. As the metallic fans are manufactured by adopting either extrusion or casting process it is always difficult to generate the ideal aerodynamic profiles. The FRP blades are normally hand moulded which facilitates the generation of optimum aerodynamic profile to meet specific duty condition more efficiently. Cases reported where replacement of metallic or Glass fibre reinforced plastic fan blades have been replaced by efficient hollow FRP blades, with resultant fan energy savings of the order of 20–30% and with simple payback period of 6 to 7 months. Also, due to lightweight, FRP fans need low starting torque resulting in use of lower HP motors. The lightweight of the fans also increases the life of the gear box, motor and bearings and allows for easy handling and maintenance.

4.1 Performance Assessment of Cooling Tower:

In operational performance assessment, the typical measurements and observations involved are:-

1. Cooling tower design data and curves to be referred to as the basis.
2. Intake air WBT and DBT at each cell at ground level using a whirling pyschrometer.
3. Exhaust air WBT and DBT at each cell using a whirling psychrometer.
4. CW inlet temperature at risers or top of tower, using accurate mercury in glass or a digital thermometer.

5. CW outlet temperature at full bottom, using accurate mercury in glass or a digital thermometer.

4.2. Energy Saving Opportunities in Cooling Towers:

1. Follow manufacturer's recommended clearances around cooling towers and relocate or modify structures that interfere with the air intake or exhaust.
2. Optimise cooling tower fan blade angle on a seasonal and/or load basis.
3. Correct excessive and/or uneven fan blade tip clearance and poor fan Balance.
4. On old counter-flow cooling towers, replace old spray type nozzles with new square spray ABS practically non-clogging nozzles.
5. Replace splash bars with self-extinguishing PVC cellular film fill.
6. Install new nozzles to obtain a more uniform water pattern.
7. Balance flow to cooling tower hot water basins.
8. Optimise blow down flow rate, as per COC limit.
9. Replace slat type drift eliminators with low pressure drop, self extinguishing and PVC cellular units.
10. Restrict flows through large loads to design values.
11. Optimise process CW flow requirements, to save on pumping energy, cooling load, evaporation losses (directly proportional to circulation rate) and blow down losses.

5. Conclusion:

This article demonstrates rather pointedly that cooling tower performance and operation are not so straightforward as they many times are thought to be. These misconceptions and inadequate knowledge of cooling tower design can cost you money in all phases of dealing with cooling towers. Purchase of a new tower will cost more in the long run if plant operations do not run efficiently due to an ill-designed cooling tower. Tower operation, in terms of energy cost, will be more expensive if utilization of fan power is misunderstood. Upgrading an existing tower may turn out to be futile because tower performance was viewed in terms of range. It is necessary to have a working knowledge of the performance of cooling towers, without misconception, in order to purchase and operate them to the best advantage for maximum production at minimum cost.

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