GAIL (INDIA) LIMITED

GAIL VIJAIPUR,

Distt. GUNA, Madhya Pradesh

SUMMER INTERNSHIP

REPORT ON

COOLING TOWER

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Abstract

The following report describes an overview of the outcomes of work undertaken by me during the industrial Summer training in GAIL (India), Vijaipur.

The overview of the COOLING TOWER plant was studied during this training. All the modules constituting the plant, including the offsite, were visited, and the operation involved was learnt from the plant officials. The placement of equipment and utilities was analysed in terms of feasibility and economics. The usage and working of different types of valves and pump at specific locations were also studied. Training at Fire & Safety department was given instruction, where we were introduced to all Do's and Don'ts.

During this summer training, I was allotted the IOP&S Unit (integrated offsite plant and storage), and in this Unit, there are many small units/plants like RWTP, Cooling tower, ETP, DM Plant, Storage etc. And we had to select one unit for further in-depth study of that unit, and we chose the cooling tower for our summer internship report

Acknowledgement

No work can be completed successfully unless the path of wisdom is illuminated by luminous and excellent guidance. Dozens of persons have aided by devoting their help to preparing this project report.

I would like to express my gratitude to all those who gave me the possibility to complete this project work. I want to thank my institution's Department of Chemical Engineering for allowing me to commence this Summer internship in the first instance.

I am deeply indebted to my guide Ms. Aashi Garg Mam (GPU-OPS), GAIL (India) Ltd, Vijaipur, whose help, stimulating suggestions and encouragement helped me all the time of our Summer internship.

Finally, I am grateful for the joint support from the GAIL Group for the opportunity and assistance they provided me to do my training here.

Introduction

About GAIL

GAIL (India) Limited is India's flagship Natural Gas company, integrating all aspects of the Natural Gas value chain, including Exploration & Production, Processing, Transmission, Distribution and Marketing and its related services. Now it is spearheading the move to a new era of clean fuel industrialisation, creating a quadrilateral of green energy corridors that connect major consumption centres in India with major gas fields, LNG terminals and other cross-border gas sourcing points.

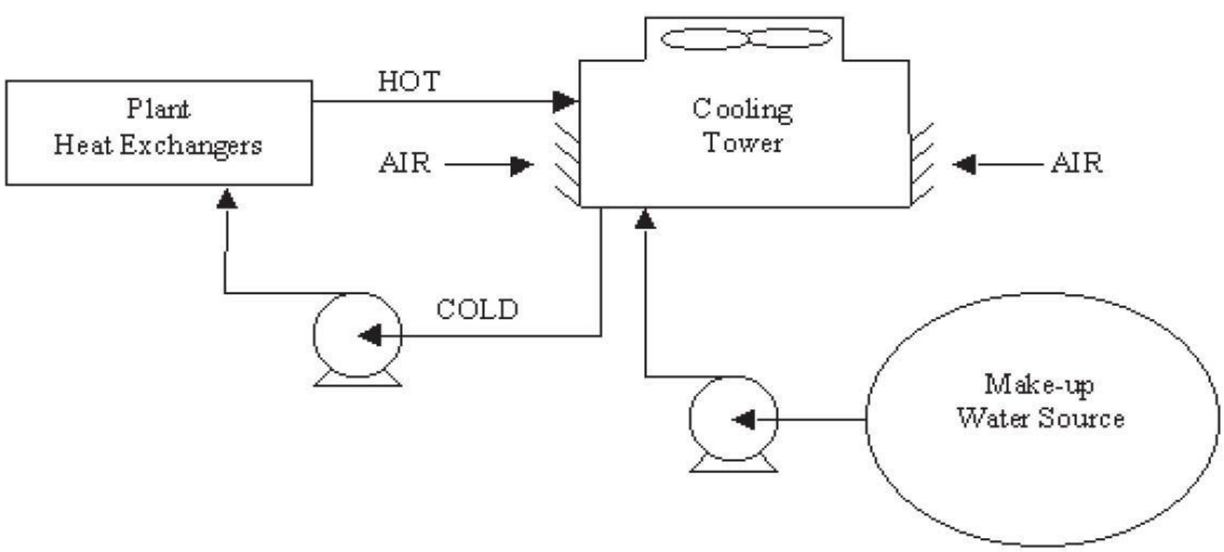
Formation of GAIL

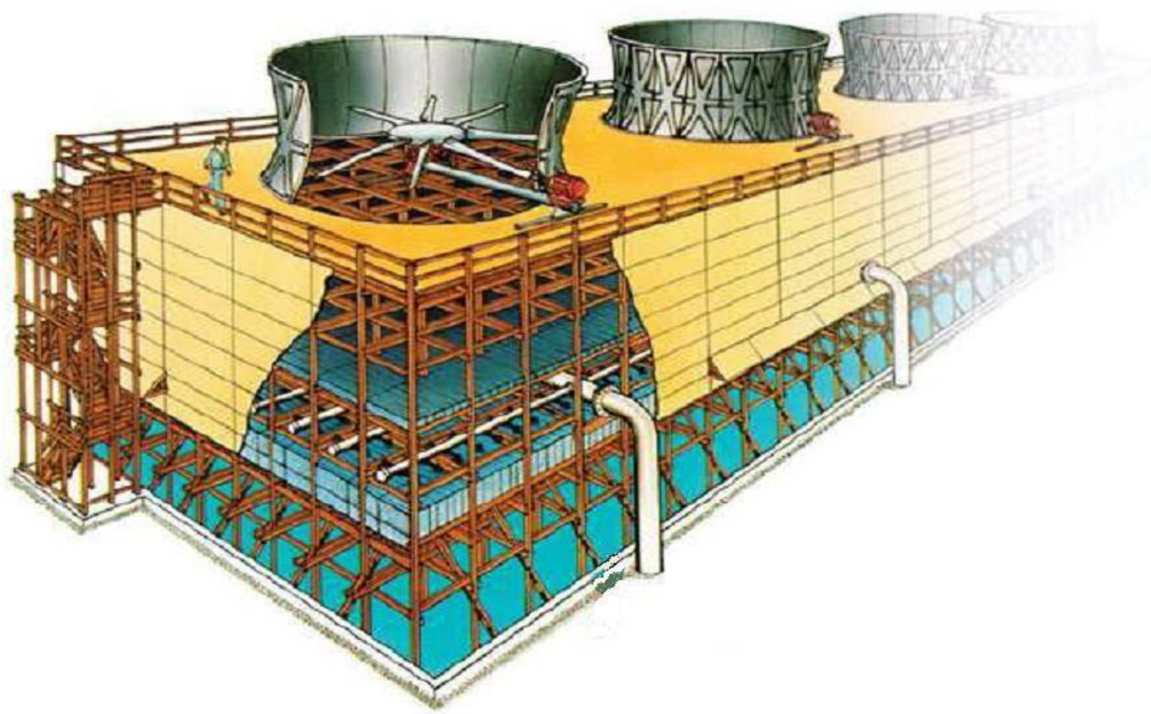
GAIL (India) Ltd was incorporated in August 1984 as a Central Public Sector Undertaking (PSU) under the Ministry of Petroleum & Natural Gas (MOP&NG). The company was initially given the responsibility of construction, operation & maintenance of the Hazira - Vijaypur - Jagdishpur (HVJ) pipeline Project. It was one of the largest cross-country natural gas pipeline projects in the world. Originally this 1800 Km long pipeline was built at a cost of Rs 1700 Crores and it laid the foundation for development of market for natural Gas in India

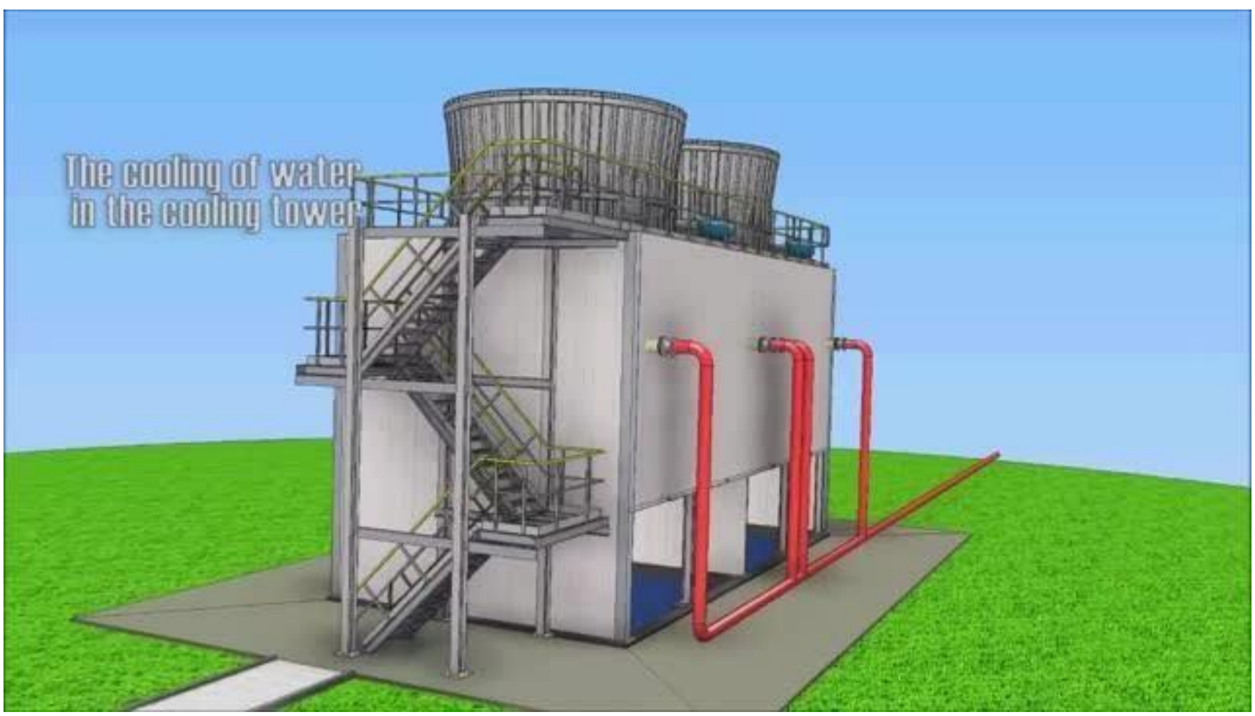
Introduction of cooling tower

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






The cooling of water
in the cooling tower

Theory of Cooling Towers

- Cooling towers fall into two main sub-divisions: natural draft and mechanical draft. Natural draft designs use very large concrete chimneys to introduce air through the media.

- Mechanical draft cooling towers are much more widely used. These towers utilize large fans to force 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. Heat is transferred from water drops to the surrounding air by the transfer of sensible and latent heat

Cooling Tower Types

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 maximise 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, the focus is on them

Mechanical draft towers

Mechanical draft towers are available in the following airflow arrangements:

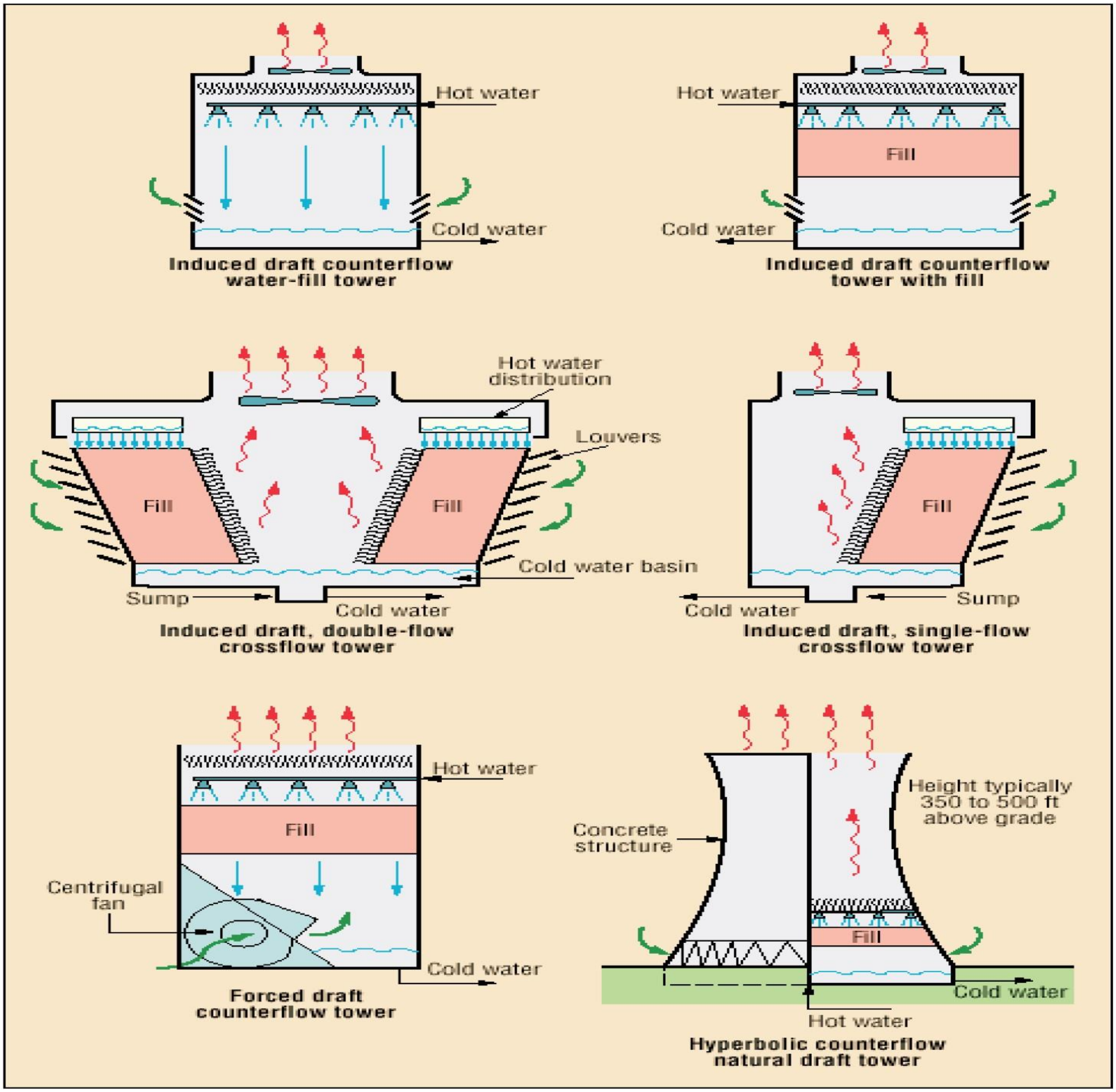
1. Counter flows induced draft.
2. Counter flow forced draft.
3. Cross flow induced draft

In the counter flow induced draft design

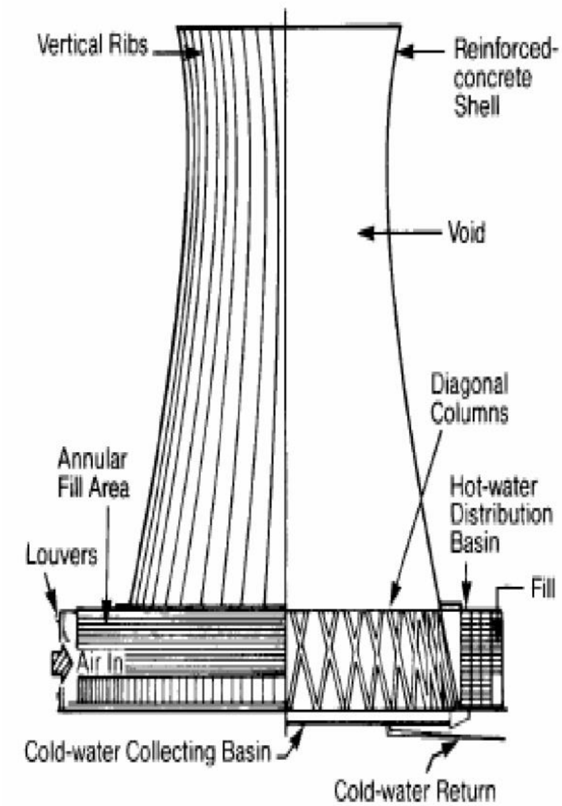
The hot water enters at the top, while the air is introduced at the bottom and exits at the top. Both forced and induced draft fans are used.

In 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.


Hot water
Cold water
Induced draft counterflow water-fill tower
Hot water
Fill
Cold water
Induced draft counterflow tower with fill
Hot water distribution
Louvers
Fill
Fill
Cold water basin
Sump
Cold water
Induced draft, double-flow crossflow tower
Fill
Sump
Cold water
Induced draft, single-flow crossflow tower
Hot water
Fill
Centrifugal fan
Cold water
Forced draft counterflow tower
Height typically 350 to 500 ft above grade
Concrete structure
Fill
Cold water
Hot water
Hyperbolic counterflow natural draft tower

Natural draft cooling tower



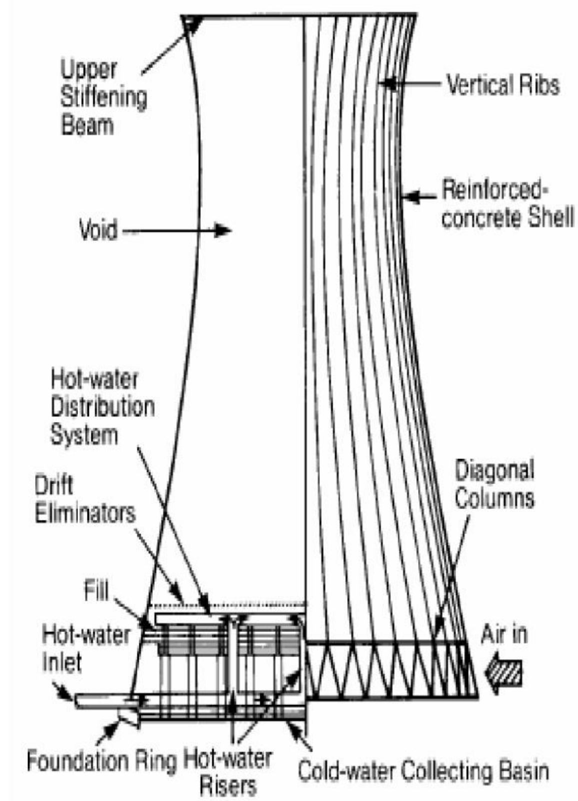


Figure 2. Cross flow natural draft cooling tower

Figure 3. Counter flow natural draft cooling tower

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.**

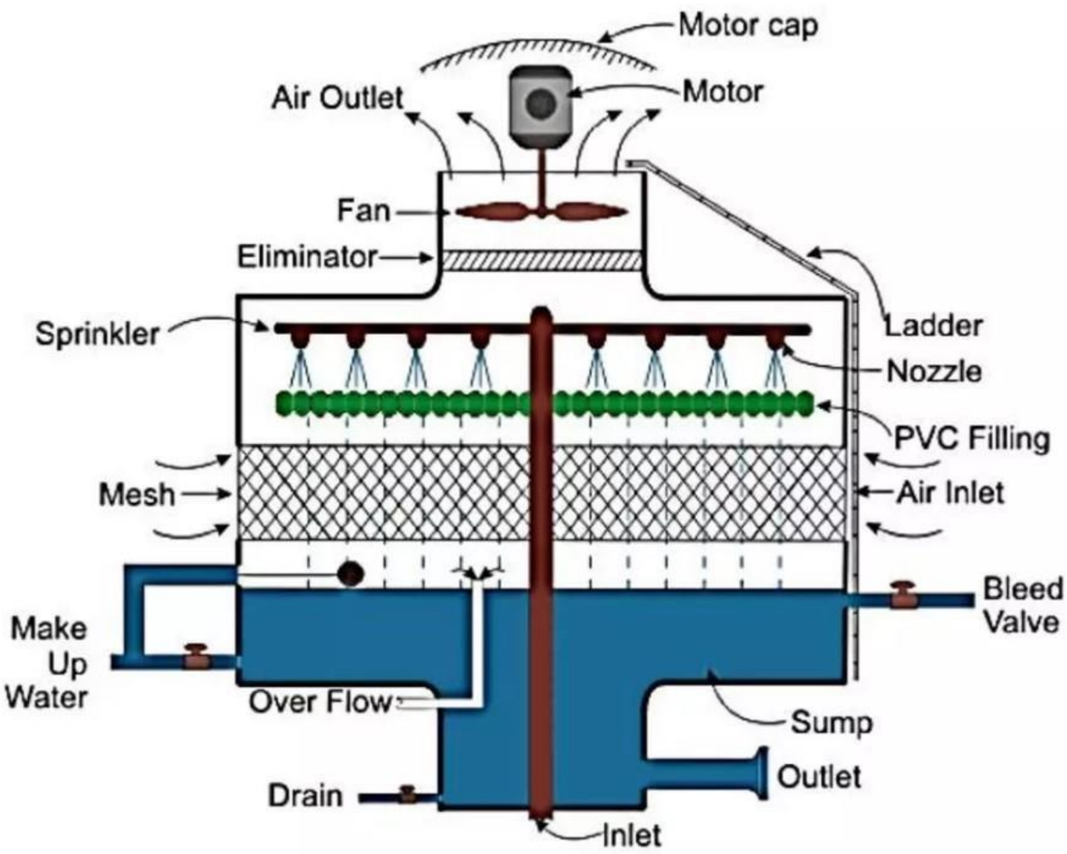


Figure 6. Parts of Cooling Tower

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.

Fill:

Most towers employ fills (made of plastic or wood) to facilitate heat transfer by maximizing water and air contact. Fill can either be splash or film type. With splash fill, water falls 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.

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 basin is beneath the entire fill.

In some 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.

Drift eliminators: These capture water droplets entrapped in the air stream that otherwise would be lost to the atmosphere.

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.

Louvers: Generally, cross-flow towers have inlet louvers. The purpose of louvers is to equalize air flow into the fill and retain the water within the tower. Many counter flow tower designs do not require louvers.

Nozzles: 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.

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.

Cooling tower material

- Wood--- frame, casing, louvers, fill, and cold water basin (or concrete)
- Galvanised steel, various grades of stainless steel, glass fibre and concrete, aluminium and various types of plastics for some components
- Large towers are made of CONCRETE
- Plastics are widely used for FILL, including PVC, polypropylene and other polymers
- Plastics also find wide use in nozzle materials

COOLING TOWER BASICS

- **What are the Basic of Cooling Tower:-**
  - Water flow rate.
  - Approach (difference between outlet water & wet bulb temperature)
  - Range (difference between inlet & outlet temperature).
  - Hot water temperature (HWT).

- Cold water temperature (CWT).
- Wet bulb temperature (WBT).
- Liquid to air ratio (L/G).

- **What factor affecting for CT performance:- **
  Inadequate or excess water flow.
  - Inadequate or excess air flow.
  - Type, quality & spacing of fills.

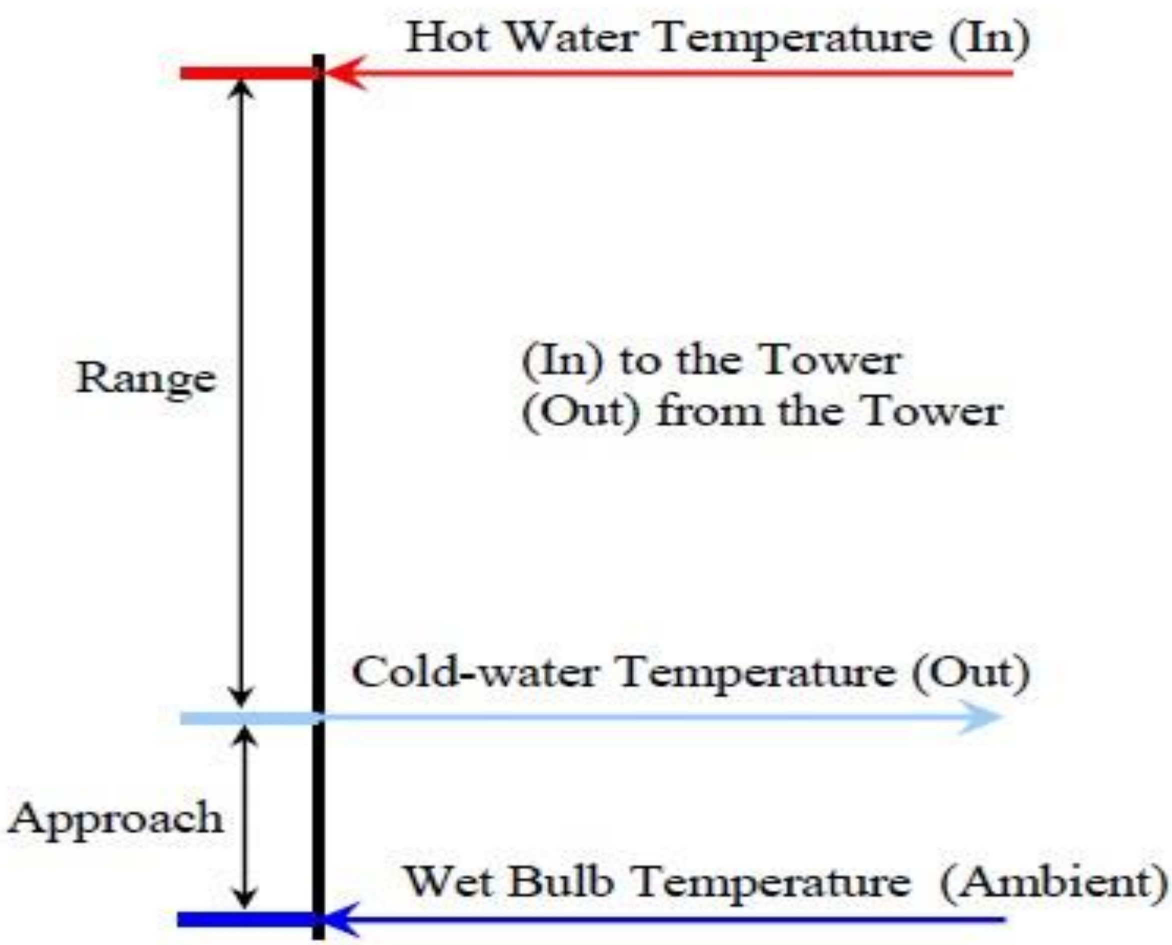


Figure 7. Range and approach of cooling towers

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

Range (see above Figure).

This is the difference between the cooling tower water inlet and outlet temperature. A high CT Range means that the cooling tower has been able to reduce the water temperature effectively, and is thus performing well. The formula is:

CT Range (C)= [CW inlet temp (°C) - CW outlet temp (°C)]

Approach (see Figure).

This is the difference between the cooling tower outlet cold- water temperature and ambient wet bulb temperature. The lower the approach the better the cooling tower performance. Although, both range and approach should be monitored, the Approach' is a better indicator of cooling tower performance.

CT Approach (°C) = [CW outlet temp (°C) - Wet bulb temp (°C)]

Effectiveness. This is the ratio between the range and the ideal range (in percentage), i.c. difference between cooling water inlet temperature and ambient wet bulb temperature, or in other words it is equals to Range / (Range + Approach). The higher this ratio, the higher the cooling tower effectiveness.

CT Effectiveness (%) - 100 x (CW temp - CW out temp) / (CW in temp - WB temp)

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. An empirical relation used often is:

*Evaporation Loss (m3/hr) = 0.00085 x 1.8 x circulation rate (m3/hr) x (T1-T2)

T1-T2 = Temp. difference between inlet and outlet water.
*Source: Perry's Chemical Engineers Handbook (Page: 12-17)

Cooling capacity. This is the heat rejected in kCal/hr or TR, given as product of mass flow rate of water, specific heat and temperature difference.

Cycles of concentration (C.O.C). This is the ratio of dissolved solids in circulating water to the dissolved solids in make up water.

Blow down losses depend upon cycles of concentration and the evaporation losses and is given by relation:

Blow Down = Evaporation Loss / (C.O.C. – 1)

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.

Thermodynamics also dictate that the heat removed from the water must be equal to the heat absorbed by the surrounding air:

$$L(T_1 - T_2) = G(h_2 - h_1)$$

$$\frac{L}{G} = \frac{h_2 - h_1}{T_1 - T_2}$$

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 vapor mixture at exhaust wet-bulb temperature (same units as above) h1 = enthalpy of air-water vapor mixture at inlet wet-bulb temperature (same units as above)

Dry-bulb temperature

• Dry bulb temperature is the temperature that is usually thought of as air temperature, and it is the true thermodynamic temperature. It is the temperature measured by a regular thermometer exposed to the airstream

Wet-bulb temperature

• Wet bulb temperature is the lowest temperature that can be reached by the evaporation of water only. It is the temperature one feels when one's skin is wet and is exposed to moving air. Unlike dry bulb temperature, wet bulb temperature is an indication of the amount of moisture in the air. **Wet-bulb temperature** can have several technical meanings

Factors Affecting Cooling Tower Performance

Capacity utilization

- Amount of water circulated

Range

- Determined by the process it is serving
- Determined by heat load and water circulation rate
- Thus Range: f (Heat load & water circulation rate)
- Wet Bulb temperature: design range is specified at certain WBT
- The closer the approach to the WBT, the more expensive the cooling tower due to increased size.

Wet Bulb Temperature

- WBT of air entering the cooling tower determines operating temperature levels throughout the plant, process or system.

- Recirculation raises the effective WBT of the air entering the tower with corresponding increase in cold water temperature.

Approach and Flow

- Approach is dependent on WBT of air entering the cooling tower.
- Water circulation rate is directly proportional to the heat load

Range, Flow and Heat Load

- Range is a direct function of the quantity of water circulated and the heat load.
- Increasing the range as a result of added heat requires an increase in tower size.
- If the hot water temp is constant and the range is specified with a lower cold water temp, then the tower size required for such applications would increase considerably.

Approach and Wet Bulb Temperature

- Design WBT is determined by the geographical location.
- Usually the WBT selected should not exceed 5% of the time in that area.
- Higher WBT, smaller the tower required to give a specified approach to the wet bulb at a constant range and flow rate

Fill Media Effects

- Function: Heat exchange between air and water is influenced by surface area of heat exchange, time of heat exchange and turbulence in water effecting thoroughness of intermixing.
- Due to fewer requirements of air and pumping head, there is a tremendous saving in power with the intervention of film fill.
- Recently, low clog film fills with higher flute sizes have been developed to handle high turbid waters. (sea water)

Cooling Water Treatment

- For controlling suspended solids, algae growth, etc.
- Improving treatment methods, increases C.O.C, thereby reduces make up water requirements.
- For large Cooling towers (especially power plants), water treatment is the key area for energy conservation.

Drift loss

- Should be less than 0.02% of the circulation rate
- With technological development, incorporation of efficient designs of drift eliminators enables to specify to as low as 0.003 to 0.001%.

Cooling Tower fans

Purpose: To move a specified quantity of air through the system, overcoming the system resistance, which is defined as the pressure loss.

Work done by the fan: air flow x pressure loss

Fan efficiency:

- Dependent on profile of the blade like tip clearance, obstacles to air flow and inlet shape etc.
- Metallic fans doesn’t have the ideal aerodynamic profile characteristics
- Hence FRP fans finds use for such application, where power consumption is as low as 80 to 85% compared to metallic ones.
- Due to light weight, FRP blades require low starting torque, resulting in low kW of the motors
- Light weight increases the life of the gear box, motor and bearings and allows for easy handling and maintenance

Performance Assessment of Cooling towers

Typical measurements and Observations

- **Inlet and outlet water temp.**
- **DBT and WBT**
- **Heat loads of process**
- **TDS of cooling tower**
- **Blowdown**
- **Make up water requirements**
- **C.O.C at site conditions**

Energy saving opportunities

- Replace splash bars with self extinguishing PVC cellular film fill
- Install new nozzles to obtain a more uniform water pattern
- Optimise blow down rate as per COC limit
- Installing FRP blades in place of metallic blades
- Incorporation of thermostatic controls for fan operation
- Consider COC improvement measures for water savings
- Evaluate the efficiency of CT pumps on a periodic basis

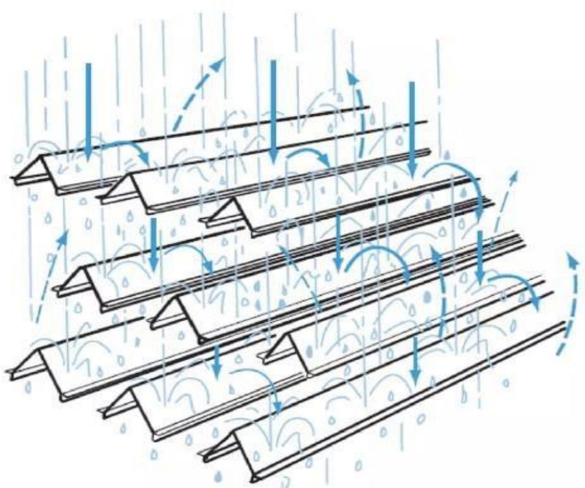
Splash-type fill

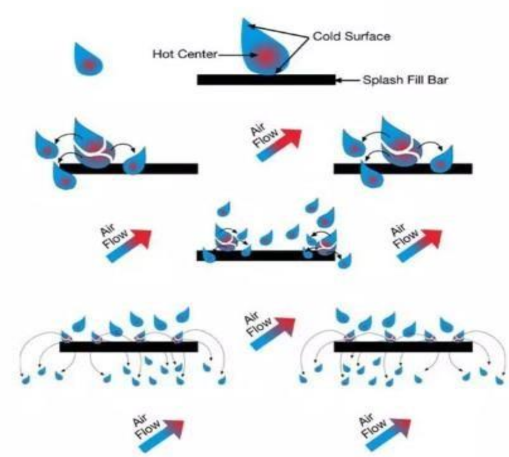
Maximizes contact area and time by forcing the water to cascade through successive elevations of splash bars arranged in staggered rows.

Film-type fill

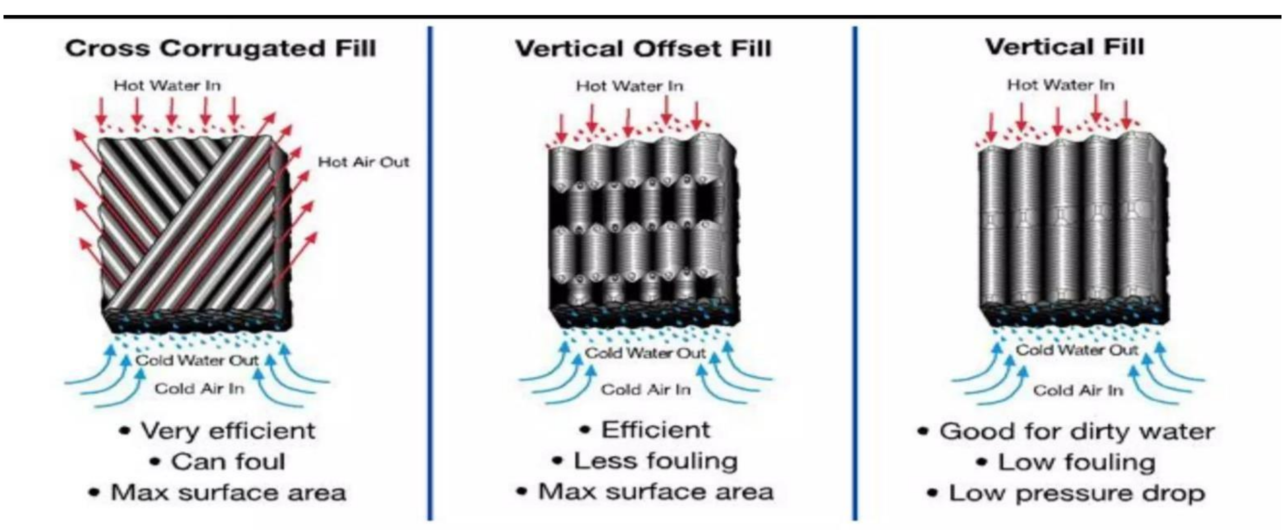
Achieves the same effect by causing the water to flow in a thin layer over closely spaced sheets, principally polyvinyl chloride (PVC), that are arranged vertically.

Splash type fill





Film type fill



Chemical Dosing and Their Functions

1. Corrosion Inhibitors:

   Purpose: Prevent the degradation of metal surfaces caused by corrosive agents.

   Common Chemicals: Phosphonates, zinc salts, molybdates, and organic inhibitors.

   In the GAIL plant, we use Phosphate (Ortho, Meta, Organo) as an anti-corrosive agent.

   Mechanism: These chemicals form a protective film on metal surfaces, reducing the rate of corrosion.

2. Scale Inhibitors:

   Purpose: Prevent the formation of scale deposits from dissolved minerals in the water.

   Common Chemicals: Polyphosphates, organophosphonates, and acrylates.

   Mechanism: They interfere with the crystallization process of minerals, keeping them in a soluble state and preventing deposition on surfaces.

3. Microbial growth controllers:

Biocides:

Purpose: Control the growth of microorganisms such as bacteria, algae, and fungi.

Common Chemicals: Chlorine, bromine, isothiazolinones, and glutaraldehyde.

Chlorine dioxide (ClO_2) is an effective biocide widely used in cooling towers to control microbial growth. It offers several advantages over traditional biocides such as chlorine and bromine, including better performance in controlling biofilms and a reduced tendency to form harmful byproducts. This report discusses the properties, mechanisms, benefits, and application strategies of ClO_2 as a biocide in cooling towers.

Mechanism: Biocides kill or inhibit the growth of microorganisms that can form biofilms and cause biofouling.

Biodispersants:

Purpose**:** chemicals specifically formulated to break up and disperse biofilms and other organic deposits, ensuring they can be effectively removed from the system.

Non-Oxidizing Biodispersants:

Quaternary Ammonium Compounds (Quats):

Properties: Effective at low concentrations, stable over a wide pH range.

Function: Penetrate and disrupt biofilms, making microorganisms more susceptible to biocides.

Example: Dodecylbenzenesulfonic acid (DDBSA).

Polymeric Dispersants:

Properties: Long-chain polymers that can encapsulate and disperse organic deposits.

Function: Increase the solubility of organic matter, preventing it from adhering to surfaces.

Example: Polyacrylic acid.

4. pH Adjusters:

Purpose: Maintain the water at an optimal pH level to enhance the effectiveness of other chemicals.

Common Chemicals: Sulfuric acid, hydrochloric acid, sodium hydroxide.

Mechanism: pH adjusters neutralize acids or bases in the water, maintaining a stable and optimal pH level.

Conclusion:

Effective management of cooling towers is essential for the efficient and reliable operation of gas plants. By incorporating appropriate chemical treatments, including corrosion inhibitors, scale inhibitors, biocides, and biodispersants, operators can maintain clean and efficient cooling systems. These chemicals play vital roles in preventing corrosion, scaling, and microbial growth, which are the primary causes of reduced performance and increased maintenance costs.

Chlorine dioxide (ClO_2) stands out as an effective biocide due to its broad-spectrum efficacy, reduced byproduct formation, and operational efficiency across various pH levels. Meanwhile, biodispersants enhance biocide performance by breaking up biofilms and dispersing organic deposits, ensuring cleaner heat exchange surfaces and better overall system performance.

Implementing a comprehensive chemical dosing strategy, tailored to the specific needs and conditions of the cooling tower system, is crucial. Continuous monitoring and real-time adjustments of chemical concentrations help maintain optimal water quality and system performance. Additionally, following proper safety and handling procedures ensures the safe use of these chemicals, protecting both personnel and the environment.

In conclusion, a well-maintained cooling tower, supported by effective chemical treatment programs, leads to improved operational efficiency, extended equipment life, reduced operational costs, and compliance with environmental standards. By prioritizing the proper management of cooling tower chemistry, gas plants can achieve reliable and sustainable operations.