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Industrial Problem Diagnosis of Cooling Tower for Performance Upgradation.

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Abstract

Cooling Tower using by Petroleum refinery at Saltwater unit for distillation units application for reduction of temperature at various required stage

Cooling tower performance has been degraded by the time with working running hours has affected the performance of system which required problem identification for diagnosis & performance upgradation by analysis of Operating process parameter & thermal, mechanical electrical efficiency checks for improvement of reliability.

Problem diagnosis of Cooling tower for performance upgradation included following main sectors:

1. *Existing running problem identification & diagnosis – (drift loss/Low approach/low range/less effectiveness, cooling capacity)*
2. *Operating parameter improvement (Temp required/heat loss/water evaporation loss, blowdown loss)*
3. *Overall Vibration parameter reduction and analysis (High vibration/Abnormal sound)*
4. *Machine Reliability performance improvement (Operating parameter/Maintenance improvement/Vibration parameter)*
5. *Energy efficiency index improvement. (Low energy consumption)*

With reference aspect Airfoil Analysis, CAD Model Analysis, CAD Model Deflection & Stress Analysis, cooling tower condition monitoring, Data collection, vibration monitoring system, Material ISO/ASTM Standard analysis, OEM Standard operational methodology, OEM Operating Clearance standard reference, Wind Tunnel Testing, Dynamic balancing, Frequency testing, Design data books, Advance tools for energy index improvement (VFD etc tools), Wind Test Aerodynamic performance of Fan & research papers for problem diagnosis.

As after finding of cooling tower near sea location refinery at Cooling tower Plant unit, major problems identified with Low Operating capacity, High drift, Blowdown & evaporation losses, Low range, approach & temp required outlet.

Thus project significance defines the Overall improvement in Operating parameter, stable working condition, Reliability improvement & performance improvement of cooling tower.

Keywords:

Petroleum refinery sea cooling tower, Problem in Sea Concrete CT, Operating Performance parameter, CT Design tools, CT Drift Losses

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I. INTRODUCTION

A cooling tower is a heat exchanger device that rejects waste heat to the atmosphere by cooling a service water used to a lower temperature for process units of refinery.

Why we require Cooling Tower in Petroleum Refinery:

Water used for cooling purpose in Heat exchanger to get various grades products at normal temp from Process Temp for storage & transportation Purpose, So we Can't throw the hot water out side as it create Thermal Pollution Still if we throw it outside require new fresh water again for process which is costly. So cooling Tower Came in Existence to solve the Purpose.

Cold Water from Cooling tower

- Heat Exchanger by circulating Cooling water pump
- water temp increase in Primary & secondary processing of petroleum product heat Exchanger
- goes at top of cooling tower
- water cool and fall at bottom Basin
- same water going to Reused again.

Principle of Working:
1. Evaporation
2. Forced & Natural Convection
3. Conduction

1.Evaporation of water :

Process of Vaporization that occurs on the surface of a liquid as it changes into the gas phase is known as Evaporation. Lets Consider the eg. of Clothes Iron, Vaporization of water where process heat is removed and cool the working fluid to near the wet-bulb air temperature
The wet-bulb temperature (WBT) is the temperature read by a thermometer covered in water-soaked cloth (wet-bulb thermometer) over which air is passed. (Indicate Moisture Content)
Cooling happened as Hot water exposed to cold air,
very less water evaporate & remaining cools

2.Natural convection is a type of flow occur due to Temp & density Difference in which hot and cold regions forms of either air or water direct contact where heat Transfer Takes place.

3. Forced convection is a mechanism, or type of transport in which fluid motion is generated by an external source (like a pump, fan, suction device, etc.).
Conduction & convection play 1/3 heat transfer in CT as result.

4. Conduction: Heat transfer occurs due to metal & PVC material contact

Types of cooling Towers

1.Natural Draft Cooling Towers
- Fresh cool air is ENTER into the tower from bottom
- Hot air EXIT through tower from top
- No fan required
- Generally are Concrete tower <200 m
- Used for large heat duties

2. Mechanical Draft Cooling Tower
A) Forced Draft CT
Air blown through tower by centrifugal fan at air inlet of CT.
Advantages: suited for high air resistance & fans are relatively quiet large capacity
Disadvantages: recirculation only due to high air-entry and low air-exit velocities (Pressure Difference)

B) Induced Draft CT
Air drawn through tower by centrifugal fan at air exit from CT
Advantage: less water recirculation require than forced draft towers
Disadvantage: fans and motor require with High electric power consumption but less than Forced Draft.

MAJOR COMPONENTS OF COOLING TOWER
1. Inlet header of COLD water to refinery Plant
2.Return header of HOT water to CT
3.Risers Piping
4.Blow down Piping
5.Cooling tower main pumps
6.Silting chamber piping & Pumps
7.Make up water piping & Pumps
8.Drain arrangement
9. Concrete main Basin
10.Gear box & fan blade assembly
11.Internal fills/ Eliminator etc
12. Concrete Sump & Concrete Pillars.
13. FRP Fan Cylinder,
14. Electric drive Motor,
15. Torque Tube & coupling with supporting structure.

Background
Petroleum refinery Cooling Tower Design 1
CT Type : Induced draft cooling tower
Circulating Pump Pressure: 7 kg/$cm2$
CDU PUMP FLOW: 4120 Cubic Meter per Hr
CDU MAKE UP FLOW: 1560 Cubic Meter per Hr
CDU MAKE UP Pressure: 2.3 kg/$cm2$
Cooling water Design Capacity: 12000 Cubic Meter per Hr
No of Cell : 8 No.(CTF-101 TO 108)
Capacity of each cell: 1500 Cubic Meter per Hr
CDU 4 Silting Pump Pressure: 2 kg/$cm2$
Heat Load: 149.6 MMKCAL/Hr (600 Giga joule)
Avg Wind Velocity: 160 km/Hr
Dosing Facility : Non oxidizing biocide treatment for sea water
Cycle of Concentration: 1.5 design
Make up water: from Cooling water offshore line from Jetty (0.6 kg/$cm2$)

Design Parameters:

Sr No	Parameter	Design data	Unit
	Hot water Temp	45	DegC
	Cold water Temp	34	DegC
	Water flow rate in CT	12000	Cum/Hr
	Cooling Range	11	DegC
	Inlet WBT	31	DegC
	Approach	3	DegC
	Drift loss	0.005% of water flow	%
	Power Motor Consumption	662.48	KW
	Draught Type	Induced	
	Drive Type	Gear- Motor Operated	
	Flow type	Counter Flow	
	Fill type	Film/Splash	
	Drive Type	Belt/Pulley	

Problem Statement : Poor Performance Problems identified as below.

Cooling Tower operating on 50% of Cooling Tower Capacity with due reason as below.
1. Extension of fill in the air inlet zone.
2. Leakage of air through the FRP casing walls in the longitudinal and transverse direction.
3. Reduction of air inlet height due to additional FRP panels in the air inlet height above reference level.
4. Overestimated performance rating of splash grid fill.

Methods of research
Check Points for research methods for problem diagnosis.

A) Technical Aspect
- Drive motor
- Oil line for the gearbox
- Low oil level switch
- Vibration switch
- Mechanical equipment handling system.
- Basin fittings and accessories along with the handling system.

B) Structural & Stability Test
- Staircase and ladders.
- All electrical items like local push button station, earthing, lighting, lightning etc.
- Riser pipe, header pipe along with valves and fitting outside the tower in the hot water circuit.
- RCC structure and all other existing facilities.
- RCC Condition
- Civil RCC external surfaces
- Basement & column stability

- Piping structural supports

C) Design Aspect
- All dimensional check by CMM
- All clearance check by CNC/CMM.
- All Rotary Parts check with QC tools
- Vibration monitoring Tools
- EI check analysis
- Flatness, Perpendicular, straightness, dimensional check.
- Thermal Performance Guarantee Test Run (PGTR)

D) Energy & Power Losses
- Fan power calculation
- Drift loss calculation
- Predicated cold water temperature
- Cross plotting the performance curves.

Pictures after Revamp & development in existing design of Cooling Tower.

Picture 1 - CONCRETE CT WALLS WITH EPOXY COATING /FIBRE SHEETS/ WATER BASIN

Picture 2 - CONCRETE CT WALLS WITH EPOXY COATING /FIBRE SHEETS/ WATER BASIN.

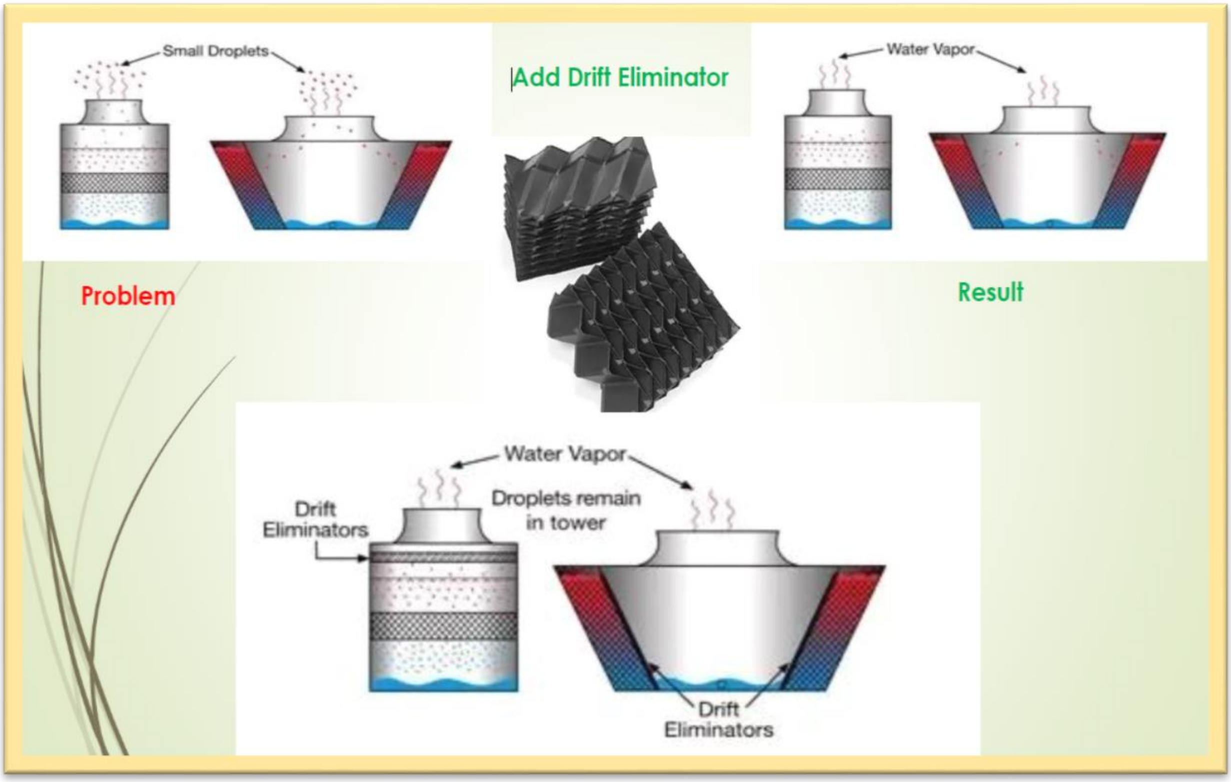
Hot water Distribution System: Pipe , Nozzle, Saddle support

Water distributed over fill media and cools down through evaporation
•Fill media impacts
-Efficiently designed fill media reduces pumping costs
-Fill media influences heat exchange: surface area, duration of contact, turbulence
-Which reduce Fan Motor work & pump motor work.
Grid Fills Installation: Grid size: 706*956 mm

Picture 3 : FILLS STRUCTURE & SS WIRE/SPACER PIPES/SPIDERS

Sr No	**Description**	**Material**
1	Grid Fills	PP Polypropylene material
2	Spider	PP
3	SpiderPipe 200mm length	PVC Polyvinyl chloride
4	Wire Lock	SS 316
5	SSWire 2.5 mm dia	SS316
6	Hook5 mm dia	SS316

Picture 4 : DISTRUBUTION PIPES (left photo) ON WHICH DRIFT ELEMINATOR MOUNTED(Right photo)



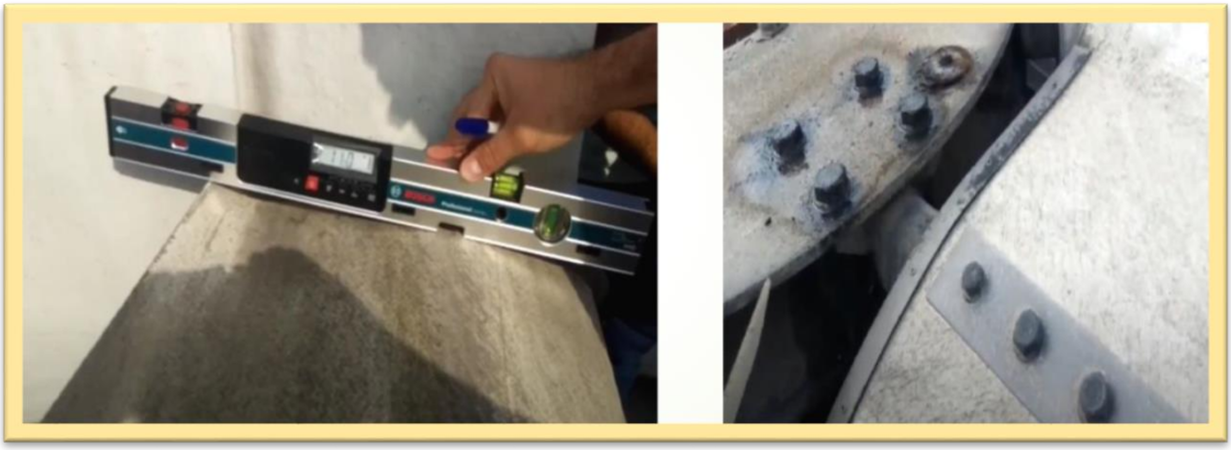
Picture 5 : Fill Design - Reduce drift loss from 0.02% to only 0.003–0.001%

Picture 6 : **Gear Box with 4 no Blades of Induced Fan Assembly**

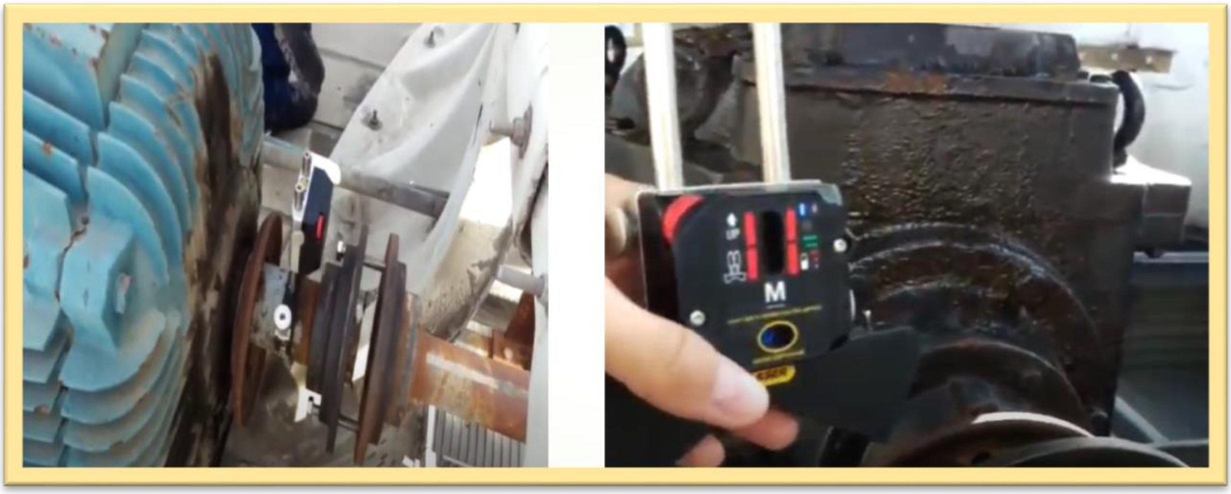
Factors Consider while design of Fan Blade assembly:
1.Height of fan from bottom : Approx20 m
2. Speed or RPM : How fast blade Spin at specific Speed
3. Blade Shape and Size: depend of volume where air flow required
Large size & width –Motor I/P power Increase –Fan blade Maint cost Increase-Not able to produce required Air Flow
4. Airflow: Amount of air your fan moves each minute impacts the level of performance.
5. Pitch Angle & motor Power is co-related.
Motor power always consider for Pitch angle is not then your fan will have to work much harder to move less air, resulting in less temp decrease in CT and a motor that burns out faster & frequently.

Fans designed such way it must overcome system resistance & pressure loss.
•Fan efficiency depends on blade profile
-Material of blade
-GRP-Glass Reinforced Plastic used in CT
-FRP-Fiber Reinforced Plastic used in CT
-Aluminium metallic blade
-Use blades with aerodynamic profile (85-92% fan efficiency)

Pitch Angle for Fan Blade Assembly
Blade pitch refers to the angle of the blades as they move through the air.
Fan blades with a relatively flat pitch—between 9 and 12 degrees—do not require a very large motor to reach a high speed.
Increasing speed with making more Flat blade : fan will move less air and may wobble or make noise due to being overworked.
A steeper blade pitch, such as 14 to 15 degrees, will require a more powerful motor to achieve the same speed.
Increasing Blade Pitch fan with the steeper blade pitch : Blade may wear out much faster if the motor isn't powerful for longer periods of time.
After design found angle should be maintain 9.7Deg Pitch Angle Measurement for better CMH/Cell



Picture 7 : Pitch Angle Measurement for fan blade



Picture 8 : Alignment of GB & Motor

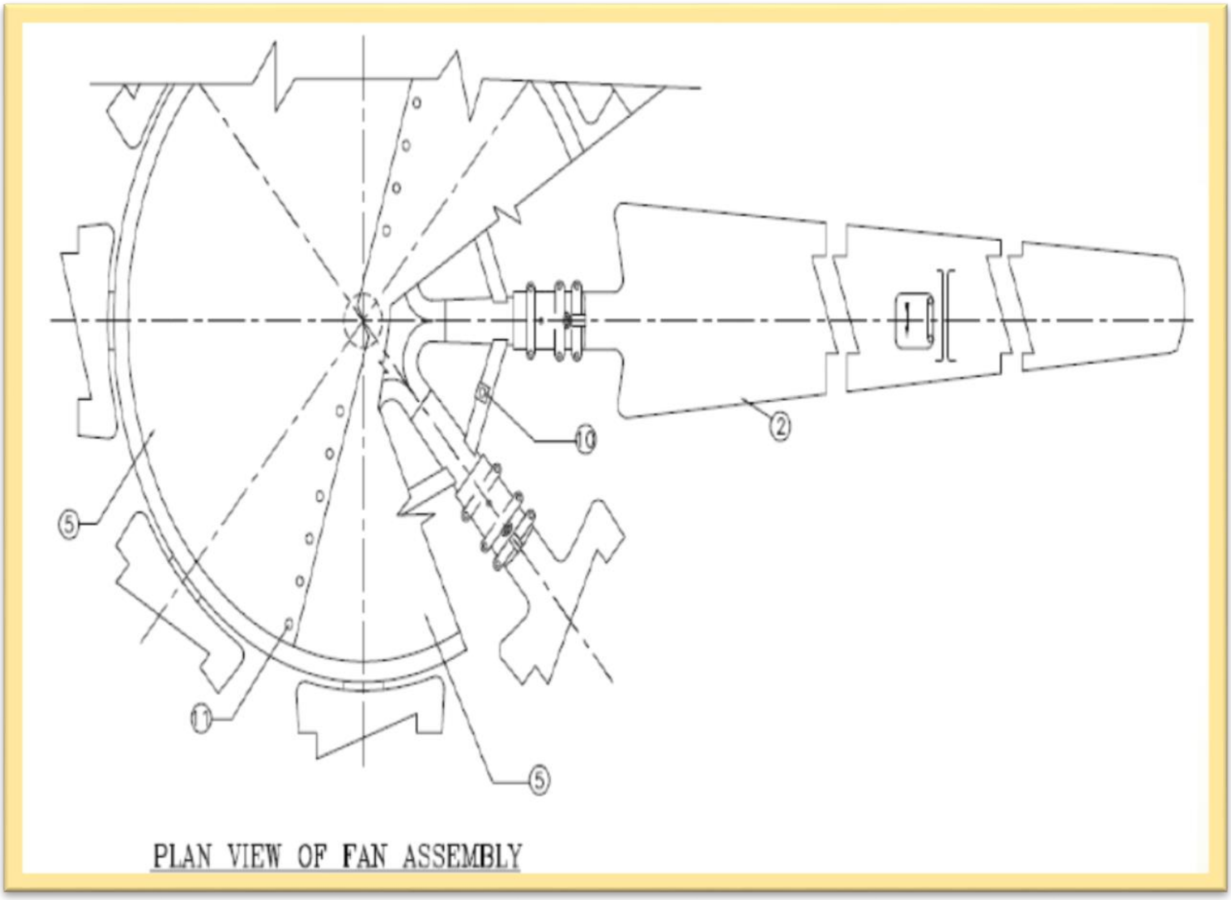
Daily Maintenance Activities
1.Gear Box Oil checking
2.Motor Noise Condition
3.Gear Box / Motor Vibration –Observation & Visual
4.Checklist Schedule & operational activity
5.Fan Blade Checking & operational cleaning activity
6.Strainer checking & operational Cleaning activity
7.Structural condition
8.Deck Cleaning & operational activity
9.Piping Valve related problems

Material of Construction

Blade : GRP-Glass Reinforced Plastic
Blade length: 168 Inch
Adv of material:
- less Torque require
- increase life of GB/
- Easy Handling & Maint
- Low Power Consumption
Balancing Weight: SS316
HUB Cover : GRP

FAN HUB: ASTM-27 : Carbon steel castings with
Epoxy coal Tar Painted
Fan Hub dia: 60 Inch
Hub cover bolts kit: SS 316
Best Suited for capacity of CT Design 1 - Total Fan Assembly Weight 965 KG Approx

Motor Failure generally occur due to:
1.Voltage Reduction
2.Incorrect Angle of Fan Blade
3.Excess load of airflow & moisture
4.Ambient Temp of Air
5.Etc…



Picture 9: Plan View of Fan Assembly.

Daily Operation Activities :
Regular Blow down: used for removal of concentration of impurity content in water
Makeup of water: line used for adding water loss due to Evp+ leak + Blow down water removed.
Reading –Fan motor Amps/flow/temp/Water level in basin/Pressure/Pump & fan avaibility
Stop Procedure -Initial reading-Shut Fan-Close inlet line of valve.
Start Procedure –Valve open then fan start –Reading again

Regular Checkup from Operation side to avoid Failure:
1.Foam level on water basin-Visual observation –occur due to leak of products from exchanger
2.Pump & motor/GB/Fan: noise / vib/ overheating/ lubrication etc
3.Screen work as filter –Clean regularly
4.water falling : Nozzle may be blocked or clogged if water falling vary on fills.
5.Structural Check: Check wooden structure/Hood condition etc

Contaminants in water check:
1.Suspended Solids: solid particle trap in CW which carried by flowing air inside CT & carry with make up water iesludge & mud decreases CT efficiency , chemicals-calcium & magnesium caused scaled build up inside exchanger can reduce heat transfer avoid by strainer provision at many entry location
2.Dissolved Solids: water evaporate while heat transfer so Impurity concentrationin water increase & untreated make up water done by blow down or drain water from system & scale preventing chemicals added called Scale Inhibitors form protective layer on metal surface & other chemicalsadded to maintain PH
High PH: water is alkaline : increase scale formation add sulphuricacid to reduce PH
Low PH: corrosion rate increase add alkaline to increase PH
3. Dissolved Gases: Hydrogen Sulphide, carbon do-oxide,Oxygen
Increase rate of corrosion & reduce PH of water
4. Micro-Organisms: Algae & bacteria : reduce heat transfer & release gas like oxygen promote corrosion & add chlorine to reduce this.

Performance Parameter:
1. Range
2. Approach
3. Effectiveness
4. Cooling capacity
5. Evaporation loss
6. Cycles of concentration
7. Blow down losses
8. Liquid / Gas ratio

Factors Affecting Efficiency of CT
1.Selection of Cooling Tower (Design)
2.Fills Selection
3.Water Distribution
4.Fan & Motor

Selection Criteria for Efficient CT
1.Capacity
2.Heat dissipation (kCal/hour)
3.Circulated flow rate (m3/hr)
4.Water Quality

Results After Design & Modification :

1. Range - 10 DegC
2. Approach - 6 DegC
3. Effectiveness – 0.625
4. Cooling capacity – 12000 cum/hr
5. Evaporation loss – 0.0138 %
6. Cycles of concentration - 1.5
7. WBT – 26 DegC

II. CONCLUSION :

We will successfully incorporate experimental data analysis, maintenance trouble shotting, reliability & energy improvement etc with Overall performance parameter improvement for better improvement & performance of cooling tower including Power consumption of cooling tower, Drift losses, heat load

We have achieved Improvement of range & Approach with increment in cooling tower effectiveness. Due to moist air atmospheric sea location of petroleum refinery, evaporation losses not found inline with design requirement correspondingly achieved WBT & COC of cooling tower.

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