Water Optimization in Thermal Power Plants

Efficient uses and innovative methods
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INTRODUCTION

- Water is key input for thermal power plant.

- For Projects located in main land areas, water is being taken from river, reservoir, lake, canal, barrage etc.

- For coastal plants, water for condenser cooling and wet ash handling system is being taken from sea. For other uses, water is being taken from alternative sources or by using desalination

- Water is required for condenser cooling, removal of heat from other plant auxiliaries, cycle make-up and other consumptive uses.

- Considering large capacity addition programs in 12th Plan, optimization in water consumption is necessary.

With increasing pressure on natural resources like water, optimization of water consumption for thermal power plant is inevitable.
WATER CONSUMPTION IN TPP

- Major water consumption in TPP are:
  - CW Make-up (in case of wet cooling system)
  - Ash Handling System Make-up (in case of wet ash system)
  - Power Cycle Make-up
  - CHP Dust suppression
  - Potable water use
  - Service water use
  - Fire Water

CW Make-up is major consumption in TPP with wet cooling system (closed cycle cooling)
Major water consumption in TPP is (>80%) is cooling water system make-up.
For every kWh of energy generated, 2 kWh waste energy is rejected to ambient environment.

Waste energy is rejected to ambient environment by:

- Wet cooling system
- Dry cooling system

Wet cooling system with water cooled condensers in:

- Closed cycle cooling system
- Once through cooling system.

Dry cooling system through:

- Direct Dry cooling System – LP exhaust steam directly cooled using finned tubes and ambient air.
- Indirect Dry cooling system – LP exhaust steam cooled by water and water in turn cooled by ambient air using finned tubes.
CW MAKE-UP

- Wet cooling system is being generally used because of low capital cost and high cycle efficiency.

- As per MOEF stipulations dated 02.01.1999, plants based on fresh water cannot use once through condenser cooling system keeping in view of the thermal pollution of source body.

- Major water consumption in wet cooling system is evaporation loss.

- Evaporation loss is up to 1.7% in closed cooling system and up to 1% in once through cooling system.

- Dry cooling systems are being used with a view to optimize the plant water consumption.
With Dry Cooling System

- Output reduces by approx. 7%.
- Heat Rate increases by approx 7%.
- Thermal efficiency changes from 38% to 35.5%
- Specific fuel consumption increases by 7%.
- Aux Power consumption:
  - With direct Dry cooling System – 6.8%
  - With Indirect Dry Cooling System- 6.2%
- Plant Cost increase by 10% - 14%.
- Increase in cost of electricity:
  - For load center based plant: INR 0.30 – 0.34 / KWH
  - For Pit Head Based Plant : INR 0.20 – 0.24 / KWH
WET COOLING SYSTEM

COOLING WATER MAKE-UP FOR 2 X 500 MW - 2720 m3/hr
(Wet cooling with closed cycle cooling)

Major Component in CW Make-up is Evaporation Loss, which depends upon heat energy being rejected in Cooling Towers

Evaporation Loss 75%
Blowdown 23%
Drift Loss 2%
Evaporation Loss;

- Major component in CW Make-up.
- Depends on heat energy being rejected and ambient conditions.
- Not much scope is available for reduction except change in cooling system from wet to dry type.
WET COOLING SYSTEM- BLOWDOWN

- Blow-down;
  - Depends on quality of make-up water, chemical treatment scheme adopted and Cycle of Concentration.
  - Blow down can be calculated using the following formula:

\[
BD = \frac{E}{(COC-1)} - D
\]

Where;

- BD = Blowdown
- E = Evaporation Loss
- D = Drift Loss
- COC = Cycle of Concentration

- Blow-down and thus make-up qty decreases as we increase the COC.
WET COOLING SYSTEM- BLOWDOWN

- Blow-down - used for ash water make-up, quenching etc.
- In earlier projects, lower COC with higher blow-down have been used to meet the ash water requirement.
- With dry fly ash handling system, ash water requirement is decreasing.
- All efforts is being made to increase the COC and thus to reduce the blow down from CW system.
- Factors limiting cycle of concentration are:
  - Physical limitation – Due to unavoidable drift, windage and leakage loss (unintentional blow-down).
  - Chemical limitation – As the dissolved solids in cooling water increases, corrosion and scaling tendencies increase.
Higher conductivity due to higher dissolved solids increases the corrosion rate.

Calcium Carbonate - common scale source in CW System.

Calcium Carbonate scaling tendency prediction by Langelier Saturation Index (LSI)

LSI is determined as follows:

$$\text{LSI} = \text{pHa} - \text{pHs}$$

pHs - pH at saturation.

pHa - actual pH of the water.

A positive LSI indicates a tendency for Calcium Carbonate to deposit.
COC needs to be optimized considering quality of make-up water, cost of chemical treatment etc.

In earlier projects, COC of 1.6 to 3 have been used.

Nowadays COC of 4 to 6 is being used based on make-up water quality and other considerations.
Increasing COC more than 6 does not give much benefits on CW Make-up
AHP MAKE-UP

- Traditionally Fly Ash and Bottom Ash disposed to ash pond in wet slurry form.
- Various measures adopted to reduce the water consumption for AHP includes:
  - Using optimum ash water ratio (25% - 30% ash by weight in slurry)
  - Dry Fly Ash Handling System
  - Ash Water Recovery (typically 70%-80% recovery from ash pond)
  - HCSD System for Fly Ash (typically more than 60% solid by weight).
- As per MOEF notification, 100% Fly Ash utilization by fourth year.

Under above conditions, water requirement for AHP can be met from CW Blow-down.
POWER CYCLE MAKE-UP

- DM Plant make-up - around 4% of the total plant water requirement.
- Power cycle make-up is required to compensate the losses due to boiler blow-down and other losses.
- With the use of Condensate Polishing units, better metallurgy of feed cycle and boiler components, make-up is less than 2%.

Cycle make-up in plant is generally less than 1.5% of Main steam flow.
OTHER REQUIREMENTS

- CHP Dust Suppression – From CW Blow-down
- Service / Potable Water – After Pre-treatment
- Gardening – Treated Sewage / Waste Water.
- Waste Stream generated during process like clarifier sludge, filter backwash-Being treated and re-cycled back to system.
- CT Blow-down and DM Plant / CPU regeneration waste:
  - These waste water have high TDS.
  - Can be used for Ash Handling System OR
  - Can be treated using RO System and re-cycled back.

All efforts are being made during design and operation of plant to minimise the make-up water requirement for the plant.
GLOBAL TRENDS

- Water Consumption for power generation will double by 2035.
- Coal Powered electricity driving the greatest demand for water.
- Coal Power Producer can optimise the water consumption by deploying dry cooling system.
- Cost of dry cooling system is higher than wet cooling system.
- Also the efficiency of dry cooling system is lower than wet cooling system.
- Other ways to reduce the water consumption is use of renewable energy.

Development of highly efficient and low cost dry cooling system is key driver for optimisation of water consumption for TPP.
# TATA POWER EXPERIENCE

## 4000 MW MUNDRA UMPP

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<tr>
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<th>CAPACITY</th>
<th>5 X 800 MW</th>
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<tbody>
<tr>
<td>1</td>
<td><strong>CAPACITY</strong></td>
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<tr>
<td>2</td>
<td>SOURCE OF WATER</td>
<td>SEA WATER</td>
</tr>
<tr>
<td>2</td>
<td>TYPE OF COOLING SYSTEM</td>
<td>ONCE THROUGH COOLING SYSTEM</td>
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<tr>
<td>3</td>
<td>CW PUMP CAPACITY</td>
<td>2 X 63000 m³/hr per unit</td>
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<tr>
<td>4</td>
<td>AHP MAKE-UP</td>
<td>FROM CW SYSTEM &amp; FROM GUARD POND</td>
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<tr>
<td>5</td>
<td>MAKE-UP TO PT PLANT</td>
<td>2400 m³/hr for the Plant</td>
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<tr>
<td>6</td>
<td>TREATED EFFLUENT</td>
<td>150 m³/hr</td>
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TREATED EFFLUENT IS BEING USED FOR AHP MAKE-UP & GARDENING
TATA POWER EXPERIENCE

4000 MW MUNDRA UMPP

SEA WATER → CLARIFIER → PSF/DMF → Ist Pass RO

DM WATER ← MB ← IInd Pass RO ← Ist Pass RO PERMEATE

POTABLE WATER ← ACF ← BORON EXCHANGER ← SERVICE / FIRE WATER
**TATA POWER EXPERIENCE**

**2 X 525 MW MAITHON**

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<th>CAPACITY</th>
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<td>2</td>
<td>SOURCE OF WATER</td>
<td>MAITHON DAM RESERVOIR</td>
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<td>TYPE OF COOLING SYSTEM</td>
<td>CLOSED COOLING SYSTEM</td>
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<tr>
<td>3</td>
<td>CW &amp; ACW FLOW</td>
<td>64000 m³/hr per unit</td>
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<td>4</td>
<td>AHP MAKE-UP</td>
<td>FROM CW BLOWDOWN &amp; FROM GUARD POND</td>
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<tr>
<td>5</td>
<td>MAKE-UP TO THE PLANT</td>
<td>BEING OPTIMIZED.</td>
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<tr>
<td>6</td>
<td>TREATED EFFLUENT</td>
<td>BEING USED FOR GARDENING &amp; AHP MAKE-UP</td>
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Optimization of water consumption is being done to meet the requirement of expansion project within allocated water.
Thank You