NTPC O&M Conference 2013

Performance and Optimization of Water Utilisation Increase of Existing Power Plants

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Introduction

Water is a vital Resource

- Water is a vital commodity for the population and being utilised substantially high quantity possible in the Power Sector as it is one of the largest consumers

- **Performance increase** and options to **reduce water consumption** in existing power plants will be introduced
Agenda

1st topic  
Integrated Performance Improvement

2nd topic  
Water Utilisation Increase
Example Power Station “Arnot”

- Arnot is a coal fired power plant that was originally rated 6 x 350MWe owned by ESKOM
- Located in South Africa in the Mpumalanga Province

ESKOM Needs:

- Modernisation and life extension for all 6 units
- Capacity increase
  - From 350 MWe → 400MWe
- Minimal outage time and Cost
**ECO|RAM™**: analysis methodology covering Plant design, operation & maintenance

- **ECO|RAM™** draws from both Customer and ALSTOM experience to ensure as many improvement ideas as possible are considered.
- Strength of the methodology: ability to quickly assess and select realistic ideas to be investigated further
- Comprehensive analysis and ranking provides a shortlist of Viable Potentials for the Customer to consider for investment
- The co-operative approach of **ECO|RAM™** also ensures that the plant owner is aware of the direction of the investigation from start to finish.

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**A systems-level approach covering the Total Plant Optimization**
Arnot Assessment

ESKOM GOALS

- Determine maximum plant capacity increase achievable with:
  - No Turbine Modifications
  - Minor Turbine Modifications
  - Major Turbine Modifications
- Determine required technical measures for each stage

Assessment Workflow

Customer/Operator
- Operation
- Maintenance
- Reliability / Availability

Site Discussion

ECO|RAM™ Questionnaire combining technical and economic drivers

ALSTOM Power
- Technology
- Service
- International Experience

Cost Analysis
- Cost of Electricity
  - Variable
  - Fixed
  - Primary
  - Secondary
  - Operation

Final Report

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Arnot Implementation

• Implementation

Assessment
Arnot Boiler Scope

- Complete replacement of firing components
- New Secondary & Offset Air Nozzles with Low NOx design features
- Regenerative Airheater Upgrade
Arnot Boiler Scope

- Superheater & Reheater Material Upgrade
- High Performance Classifier
- Steam Drum Internals
Arnot Turbine Scope

• HP cylinder
  – Inner Casing
  – Bladed Rotor

• IP Cylinder
  – Inner Casing
  – Bladed Rotor
  – Inlet & Extraction Connections
Arnot Plant Retrofit Results

- Steam-water cycle optimisation maximising
- Unit performance guarantees
- Short time scales with quick MWe to the grid system
- Extending plant lifetime by 20 years in an economically and environmentally viable manner (NOx reduction)
- Minimal outage time and cost

*weighted nominal turbine generator output 406-408MW

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Before</th>
<th>After</th>
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<tbody>
<tr>
<td>Power Output</td>
<td>350 MW</td>
<td>408 MW*</td>
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</table>
Agenda

1st topic  Integrated Performance Improvement

2nd topic  Water Utilisation Increase
Water Utilisation Increase

Water consumption in an evaporative cooled power plant

- **70-90%** evaporative and blow down losses
- Blow down water is a continuous extraction from the cooling water to maintain the concentration of TDS (Total Dissolved Solids)
Main Water Consumer

Reduce the evaporative losses of existing wet cooling system

- Evaporative losses are nearly linear dependent on the thermal load on the cooling water

- Options:
  - 100% dry cooling
  - Power output reduction
  - Hybrid cooling

3.45 m³/MWh

Cooling tower evaporative and blow down losses
100% Dry Cooling

- Fully dry cooled power plants are common and proven technology
- Large scale air cooled condenser units like Matimba (6 x 665MWe) in South Africa
- **100% dry cooling conversion is in most cases not viable as a retrofit measure**
Hybrid Cooling

Hybrid Cooling for existing power plants

- Hybrid Cooling with Air Cooled Condenser (ACC)
  - Steam extraction with pressure offset to main condenser
  - Modified inner and outer casing of the LP turbine(s) for large steam extractions
  - New LP rotor with state of the art blading
  - Small space requirements for an ACC (high condensation temperature)

Condensation Pressure: 0.03-0.1 bara

Condensation Pressure: 0.35-0.75 bara
Hybrid Cooling Concept

New LP turbine with Hybrid Cooling Interface and state of the art steam path

Hybrid Cooling Interface with steam ducts

Control Valve

Air Cooled Condenser p=0,35 - 0,7 mbar

Existing surface condenser with reduced backpressure due to reduced heat load
Sankey Diagram of the simple Rankine Cycle

Steam power plant with 210 MWe power output

- Chemical Energy In Fuel
- Thermal Energy in Flue Gas
- Thermal Energy in Cooling Water
- Electrical Energy
- To Grid 210MWe
- To Condenser 250 MWth
- To Stack – 88MWth

3% to Auxiliary Power
NOTE: Aux Power = ~7% of Electric Power

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Sankey Diagram of the simple Rankine Cycle

Option: Load Reduction

Chemical Energy in Fuel

Electrical Energy

Thermal Energy in Cooling Water

Thermal Energy Flue Gas

To Stack – 62MWth

To Grid
147MWe

3% to Auxiliary Power
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Sankey Diagram of the simple Rankine Cycle

Option: 30% Hybrid Cooling Share

Electrical Energy

Chemical Energy
In Fuel

Thermal Energy
in Cooling Water

Hybrid Cooling*

Thermal Energy Flue Gas

To Condenser
175 MWth

To Grid
204 MWe

To Stack – 88 MWth

*Assuming 30% Hybrid Cooling Share

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Impact of Hybrid Cooling

Original

Hybrid Cooling
Assuming 30% Hybrid Cooling share

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Benefits of Hybrid Cooling

- Hybrid Cooling is a Retrofit Solution for existing power plants
- 20-45% reduced water consumption possible
- Flexible heat sink
- Improved availability
- Low efficiency loss
  - Off loading the existing condenser leads to improved LP turbine exhaust pressure
- Applicable for mechanical or natural draft recirculation cooling systems and once through cooled power plants
Summary

• Combining Plant Assessments and Plant Retrofit, is an effective measure for successful and cost effective performance increase and lifetime extension

• Hybrid Cooling is a Retrofit option for existing steam power plants to reduce water consumption and maintain power output
Thank You All