Nabha Power Limited
(2X 700 MW Supercritical Rajpura Power Plant)

Best Energy Efficiency Practices in Thermal Utilities

Raju Thomas
AGENDA

Overview

Energy Efficient Design Features

Best Practices on Energy Efficiency

Way forward
Overview V

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Best Practices on Energy Efficiency

Way forward
THE PROJECT

Project Developed by Larsen & Toubro – India’s largest and most reputed infrastructure company under Case-2 of Tariff based Bidding


All major equipment manufactured indigenously through technology tie-up or JV’s

Tie-up with leading manufacturers- Mitsubishi Hitachi Power Systems (MHPS) ,Japan for Boiler Turbine Generator (BTG), Howden-Regenerative Air Pre-heater(RAPH) & Fans, Clyde Bergmann-ESP
Super Critical Technology

Operational Flexibility
- Better Temp Control
- Shorter start up time
- Sliding Pressure Operation

Higher Efficiency
- Less Fuel and emissions
- Less Water Requirement

KEY FEATURES

✓ Total Area ~1200 Acres

✓ Best in class Heat rate
✓ Heat rate (design): 2205 Kcal/Kwh (Net)
✓ Turbine -1849 Kcal/Kwh, Boiler η-88.7%

✓ Availability
✓ 2014-15: 93.15 %,
✓ 2015-16: 91.79 %,
✓ 2016-17: 96.04 % (as on 31-Oct-2016)

✓ Matured and Reliable Technology
✓ Indigenous state of art manufacturing at Hazira with 90% of the equipment manufactured by L&T.

Main Steam Pressure 246 bar

Steam Temp (Superheat/Reheat) 563/593°C

✓ State of Art Automation
✓ Complete Auto Operation
Overview

**Energy Efficient Design Features**

Best Practices on Energy Efficiency

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Key Innovations-Design Beyond Conventions

**Twin Fire Vortex Design**
- No Final SH/RH Outlet temp imbalance
  Controlled by each side SH spray/Gas biasing damper.
- Uniform Heat Flux across the furnace
**Very Stable Combustion: No oil support above 30% load**

**Vertical Wall (Rifled Tube) in Furnace area**
- Simple Structure-Conventional supporting and less no.of field joints
- Less Adhesion of ash
- Low Pressure Drop

**Advanced A-PM Burners**
NOx level compliant to New MOEFCC Guidelines
Advanced Pulveriser Design

Unique Features

- VFD Controlled Rotary Separator
- Better control on Mill fineness
- Improved Comb. Eff.

Low Unburnt Carbon
FA < 1 %
BA < 2%

Variable Pressure Hydraulic loaded roller:

- Pressure cont. as a function of coal flow rate
- Provides Uniform pressure
Overview

Energy Efficient Design Features

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Super-critical technology requires stringent water parameters during unit start-up:

**DO - <10 ppb, Fe - <50 ppb, Silica - <30ppb, Cation Conductivity - < 0.1 µS/cm**

**Action Taken:**
- Implementation of improved [SOP for dissolved oxygen removal (DO)] by increased deaerator pressure & temperature.
- Streamlined steam and water sampling by reducing bends in sampling lines to SWAS panel.

**Benefits:**
- Reduction in MDBFP running hours (4 hours, 40,000 KWhr)
- Improved station availability by 8 hours (Availability Charge: 10 lacs/hour/unit)
- Reduction in Start-up power

**Savings per cold start-up:**
- **APC**: INR 1.1 lacs
- **Plant Availability**: INR 80 lacs
Switch over from HFO to LDO

Action Taken:

• Existing HFO tankage and pumps used for storage and pumping of LDO.
• Atomization of LDO with Steam.
• Consent for use of HFO burners to fire LDO from OEM (Mitsubishi Hitachi Power System)

Benefits:

• Smoother start-up of unit with LDO improves unit start-up time
• Better atomization of oil with steam over compressed air improves combustibility
• Reduction in DM water consumption (Complete isolation of auxiliary steam required for heating of HFO in tank matt coil, suction heaters and tracing lines)
• No choking of suction and discharge filters of pump (LDO is less viscous then HFO)
• GHG emission reduction – 23285 tonnes of CO2/per annum

Savings:

• Isolation of heating steam resulted in coal savings – 15107 tonnes (7.81cr./annum)
• Reduction in DM water – 87120 m³ (INR 21.34 lacs per annum)
Optimization of Turbine Rolling Pressure for Unit Cold Start-up & Coal Firing Optimization

Action Taken:

- **Implementation of modified start-up logic and start-up curve with consent of OEM:**
  - Turbine cold start-up rolling pressure revised from 85 – 60 ksc
- **Mill advance operation prior to synchronization with consent of OEM:**
  - LDO firing in CD & EF elevation
  - Air Pre-heater inlet temp(> 220 deg C), Hot PA header temp. >185 deg C
  - Pre-heating of primary air by charging SCAPH for mill warming (Mill outlet temp. 55 to 60 deg C)
  - Second mill into service after charging of HP & LP heaters (Mill sequence D,E,C,B)

Benefits:

- Reduction in unit start-up time
- Reduction in fuel oil consumption (1488 KL)
- Reduction in OPEX (Oil support termination at 235 MW as compared to 275 MW previously)
- Reduction in GHG emission (688 tonnes of CO₂/per annum)

Savings:

- Reduction in OPEX by **INR 6.22 crore**

*Start-up oil in KL per start*
Energy Conservation Measures in Ash Handling Plant

Action Taken:

- Duct hopper to buffer hopper line re-routed resulting in reduced line length from 69 to 29 m
- Hopper fluidizing line rerouting done to provide improve fluidizing air to ash in ESP hoppers.
- Additional air receiver provided to bag filters for effective purging.
- Additional insulation and wrap around heaters provided in ESP hoppers.

Benefits:

- Poking of hoppers reduced to **Zero**
- All hoppers evacuation possible **Three** times a day
- System idle time of **Seven** hours/day achieved
- Housekeeping levels improved
- Specific Power consumption reduced from **24.8 KWH/T - 15.08 KWH/T**

AHP Specific Power Consumption
Source: NPL operations record; AHP energy meters

![Graph showing specific power consumption reduction over time](image)
Energy Conservation measures in Coal Handling Plant

Action Taken:
- By-passing of Vibrating Grizzly Feeder (VGF) and Crushers for imported coal.
- Use of one nos. of crushers and vibrating grizzly feeder for washed Indian coal against earlier philosophy of two nos. of crushers and VGFs.

Benefits:
- Reduction in over-crushing and fine generation in imported coal.
- Crusher Loading improved from 1100 TPH to 1500 TPH (design-1600 TPH)
- Aux. power savings by stopping of one VGF (37 KW), Crusher (372 KW) and other auxiliary (15 KW).

Savings:
- Power Consumption reduced by $4125.71 \text{ KWhr/day}$
- Cost Saving – INR 37 lakhs per annum
Energy Conservation measures in Clarified Water Pump House

Action Taken:

• Water requirement for quenching in boiler flash tank was less (CV opening 5-6%)
• Margin available in Service water pump was explored
• Boiler flash tank quenching water was provided from plant Service Water Pump instead of Boiler Blow Down (BBD) Pump by providing an interconnection between both the headers.

Benefits:

• APC improvement by stoppage of 150 KW BBD pump in daily operation.

Savings:

• Power Saving per year - 696960 KWhr
• Cost Saving – INR 18.81 lakhs per annum
Coal Yard Management

Compact stacking of received coal in stock yard, water sprinkling on condition basis

Wind shield barrier erection on three sides to avoid direct air impact on inclined portion

Regular GCV monitoring of stock piles for commercial decision to minimise heat loss

Zero outage due to CHP downtime
Environmental Perspective

Zero Liquid discharge
- RO plant for effluent recycling
- Reject used for bottom ash slurry preparation
- Functional ash water recovery system
  \[ DM \text{ Water } M/u < 0.5\% \]

100% Dry Fly Ash Utilisation since 1st year
- Endowed with cement grinding units in vicinity
- Supporting SSI’s nearby
- Bottom ash utilised for back filling.

100 % Washed Coal used
- Only washed coal transported from mine end

Online display for general public
Screen 600 M(L) × 15 M(H) around stock piles stockyard
Overview

Key Design Interventions

Best Practices on Energy Efficiency

Way forward
## Way-forward

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<tr>
<th>Green Power</th>
<th>Installation of 200 KW roof-top solar for lighting of office spaces</th>
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<td>Enhancing natural lighting in TG hall</td>
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<tr>
<th>Process and Certification</th>
<th>ISO 50001 certification</th>
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<td>NABL accreditation for coal testing laboratory</td>
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<td>Exploring the feasibility of VFD (CEP, CCW, ACW and other HT/LT equipments)</td>
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<td>Strategic methodology under experimentation for reduction in coal yard GCV losses to &lt;100 kcal/kg</td>
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<tr>
<td></td>
<td>Exploring the feasibility for reduction in MS pressure at full load to minimize the throttling pressure</td>
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</tbody>
</table>
In modified process and sampling arrangement, feed water brought to saturated condition in early stage by elevated operational parameters inside deaerator (pressure-9.6ksc and temperature-185 Deg.C).

I. LP/HP Condenser hot well fill upto the normal level.
II. Start one CEP to take water into deaerator.
III. Maintain water level inside deaerator upto the start-up water level (520-530mm).
IV. Start condensate system clean up through GSC R/C valve.
V. Charge turbine gland steam.
VI. Line up deaerator bottom steam pegging line.
VII. Closed the D/A condensate I/L valve.
VIII. Start vacuum pull up and simultaneously open the D/A start up and continues vent (Fully open).
IX. After achieving vacuum 0.6 in HP/LP condensers then start D/A pegging at constant water volume. (Fig -1)
X. The rate of increasing the D/A water temperature (Approx. 2 Deg. C/Min).
XI. After completion of D/A heating upto 185 Deg. C. start increasing the water level inside the D/A gradually up to the normal water level (2400mm) as per below mentioned curve. (Fig -2)
XII. During rising the water level inside the D/A, precaution are taken for the D/A temperature and pressure should be steady.
XIII. When water level reach in D/A upto normal water level then the MDBFP/TDBFP was started for water circulation through feed water circuit.
### HFO to LDO Switch over

- Auxiliary Steam supplied to HFO tank, heaters, line heating, strainers as per design document
- Auxiliary Steam supplied to HFO tank, heaters, line heating, strainers (kg/hr) 11000
- Steam cut off per annum (kg) 8712000

**As the steam is left open ended so make-up water is required in the system to match the requirements**

- Enthalpy of Make-up water @25 deg C , 0.1 Ksc in Kcal/kg 25.1
- Enthalpy of Auxiliary Steam @350 deg C , 14 Ksc in Kcal/kg 752.163
- Net enthalpy gain in water to superheated steam in kcal/kg 727.063
- With switchover from HFO to LDO this superheated steam is cut-off and hence energy saved (kcal) 63341728560

**Weighted avg GCV of coal in FY 15-16** 4193

**Total coal saved by isolation of LT header (T)** 15107

**Average price of coal in FY 15-16 (Rs/T)** 5170

**Total Saving for FY 15-16 (Rs in Cr.)** 7.81

**GHG Calculation**

- Total carbon content in coal @42% by weight (average weight for FY 15-16) 6344.75
- Total CO2 emission (Considering 1 gm of Carbon yields 3.66 gms of CO2 by stoichiometric equation) 23285.22
## Reduction In Oil Consumption

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Oil consumption after unit-2 commissioning (from July-14 to March-15)</td>
<td>0.659</td>
<td>ml/KWhr</td>
</tr>
<tr>
<td>Specific Oil consumption of FY 2015-16</td>
<td>0.466</td>
<td>ml/KWhr</td>
</tr>
<tr>
<td>Total Generation of FY 2015-16 (MU)</td>
<td>7703.309</td>
<td>MU</td>
</tr>
<tr>
<td>Total oil consumption in FY 15-16</td>
<td>3589.742</td>
<td>KL</td>
</tr>
<tr>
<td>Total oil consumption in FY 14-15 with same generation of FY 15-16</td>
<td>5078.021</td>
<td>KL</td>
</tr>
<tr>
<td>So total oil savings</td>
<td>1488.279</td>
<td>KL</td>
</tr>
<tr>
<td>Cost of LDO in FY 15-16</td>
<td>41793.5</td>
<td>Rs</td>
</tr>
<tr>
<td>Total savings</td>
<td>6,22,00,401</td>
<td>Rs</td>
</tr>
</tbody>
</table>
## Reduction in CHP Power Consumption

<table>
<thead>
<tr>
<th></th>
<th>Power consumption (KW)</th>
<th>Loading (TPH)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Double Crusher Operation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CR-1 (Crusher)</td>
<td>365.30</td>
<td>750</td>
</tr>
<tr>
<td>CR-2 (Crusher)</td>
<td>365.30</td>
<td>750</td>
</tr>
<tr>
<td><strong>Single Crusher Operation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crusher</td>
<td>370.03</td>
<td>1500</td>
</tr>
<tr>
<td>Savings</td>
<td>360.57</td>
<td></td>
</tr>
<tr>
<td>Average time for stream in service (Hrs/day)</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Power consumption reduced by stopping one VGF (KW)</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>Other Aux. consumption savings with stopping of one VGF &amp; Crusher</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td><strong>Total Power Saving per day (KWHr)</strong></td>
<td>4125.71</td>
<td></td>
</tr>
<tr>
<td><strong>Total Power Saving per annum (lacs)</strong></td>
<td>36.76</td>
<td></td>
</tr>
</tbody>
</table>
### Reduction in BBD Power Consumption

<table>
<thead>
<tr>
<th></th>
<th>Voltage (V) /Current (A)</th>
<th>Power Consumption (KWhr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESP/BBD/APH PUMP</td>
<td>415/140</td>
<td>2160</td>
</tr>
<tr>
<td>Service Water Pump</td>
<td>415/73</td>
<td>1128</td>
</tr>
</tbody>
</table>

**After the modification**

<table>
<thead>
<tr>
<th></th>
<th>Voltage (V) /Current (A)</th>
<th>Power Consumption (KWhr)</th>
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<tr>
<td>Service Water Pump</td>
<td>415/76</td>
<td>1176</td>
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**Power savings after the modification**

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Total Power Savings per day (KWh)</td>
<td>2112</td>
</tr>
<tr>
<td>Total energy saving per annum (KWh)</td>
<td>696960</td>
</tr>
<tr>
<td>Considering 330 days of operation</td>
<td></td>
</tr>
<tr>
<td>Cost savings per annum (INR) @ 2.7 Rs/unit</td>
<td>18.81 lacs</td>
</tr>
</tbody>
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Hydraulic Oil function is function of coal flow rate