ACHIEVING EXCELLENCIES IN CYCLE CHEMISTRY AT NTPC SIMHADRI

Case studies' on

OPTIMIZATION OF COST AND THROUGHPUT OF CONDENSATE POLISHING SYSTEM, BOILER INSPECTIONS AND ANALYSIS.

P GHOSH (DGM CHEMISTRY)
&
T SESHU(Asst Chemist)
Flow of presentation

- Introduction
- Steps to achieve Excellency in cycle chemistry
- About two case studies
- Results and discussions
- Conclusions
EXELLENCIES IN CYCLE CHEMISTRY?

- To maintain a good health of the boiler in the long run
- Reduces forced outages
- Reduces cycle Make up or blow down
- Improve efficiency

Fulfilling the requirement of PAT
STEPS TOWARDS EXCELLENCE

- Focus on the key steam water parameters
  - e.g. Cond, ACC, chloride level in boiler etc.
- Online and off line data analysis and data ownership
  - Primarily should be chemistry
- Comply with the recommended parameters
- Minimize deviations
- Analyze deviations if any
- Take corrective actions
Improvement mechanism - Approaches

Review and assess the existing activities, processes, and data

Find out Opportunities for improvement

Stabilize

Review and assess and compare the new method

Implement

Innovation
Improvement mechanism- Approaches

1. Review & Assess the existing practices
2. Compare with the design worldwide practices
3. Find out the opportunity/gap in terms of
   - Chemical consumption
   - Process improvement
4. Prepare action plan to reduce gap or adopt to improved process
5. Implement
6. Review & Assess the new practices
Few break troughs

- Change over from AVT(R) chemistry to AVT(O) chemistry first time in NTPC in 2004.
  - *Now It is implemented all over NTPC stations*

- Not using Hydrazine saves chemical about 40-50laks/annum across NTPC

- *Reduction of Iron carry over in feed water to 2ppb from 5-10ppb.*

- *Formation of more protective layer in feed water system*

- *Confidence to accept new changes and to move to higher platform*
Next level of better feed water chemistry is OT (Oxygenated treatment)

Simhadri along with OS/Eng has taken initiative to move in this direction

This change over once proven is also expected to bring lot of tangible and intangible benefits to NTPC
Through this approach—our case Studies on

- **Optimization of Cost and Throughput of Condensate Polishing System**

- **Boiler Inspections and Analysis.**
Today's topics

- Condensate polishing units –
  
  **Benefits are**-
  
  ✓ Filtration or crud removal
  ✓ Removal of dissolved impurities by ion exchange process
  ✓ Reduces blow down thus reducing make up %

**Problems are**-

✓ More chemical cost
✓ No problem in H₂ cycle but Na⁺ and Cl⁻ slippage problem in Ammonia cycle.
Opportunities for improvement

Condensate polishing unit optimization

Maximize Throughput  Minimize cost

Optimization

Benefits  Problems
• Study is based on normal operating conditions without any condenser tube leakages
## Design data analysis

### Anionic load

<table>
<thead>
<tr>
<th></th>
<th>Design</th>
<th>Actual</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ppb</td>
<td>As CaCO3</td>
<td>As CaCO3</td>
</tr>
<tr>
<td>Sio2</td>
<td>30</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>Cl-</td>
<td>10</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>39</td>
<td>2</td>
</tr>
<tr>
<td>CO2</td>
<td></td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Resin Lewatit MP500CL TEC 1.0  
eq/l=50g/l

### Design/actual Cationic load onCPU

<table>
<thead>
<tr>
<th></th>
<th>Design</th>
<th>Actual</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ppb</td>
<td>As CaCO3</td>
<td>As CaCO3</td>
</tr>
<tr>
<td>NH3</td>
<td>500</td>
<td>1470</td>
<td>1470</td>
</tr>
<tr>
<td>Cu</td>
<td>10</td>
<td>7.94</td>
<td>2</td>
</tr>
<tr>
<td>Fe</td>
<td>50</td>
<td>56</td>
<td>2</td>
</tr>
<tr>
<td>Na</td>
<td>10</td>
<td>21.74</td>
<td>43.48</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1555.67</td>
<td>1517.48</td>
</tr>
</tbody>
</table>

Resin Lewatit SP 112H TEC 1.7  
eq/l=85g/l
Condensate polishing system - Opportunity for Improvements

Design throughput 3,46,248 M3

Throughput on Anion load 24,36,364 M3

Throughput on Cation load H-cycle 127424.88 (7.7 days)

Throughput of CPU is restricted by H-Cycle and the cationic load.

The Anion still is very much less loaded
Why in ammonia form CPU leaches out Na\(^+\) and Cl\(^-\) is explained below.

### H\(^+\) Form

\[
\text{NH}_4^+ + RH \rightarrow \text{RNH}_4^+ + H^+
\]

\[
\text{Na}^+ + RH \rightarrow \text{R Na}^+ + H^+
\]

\[
K_{H Na} = \frac{[\text{R Na}] [H^+]}{[\text{Na}^+] [RH]}
\]

\[
K_{H NH_4} = \frac{[\text{R NH}_4^+] [H^+]}{[\text{R H}] [\text{NH}_4^+]}
\]

Where \(K_H\) ------- Equilibrium constant
In Ammonia form equation since the value of $[\text{NH}_4^+]$ is very high compared to $[\text{H}^+]$ ion in Hydrogen form, the denominator i.e the value of $[\text{Na}^+]$ increases to maintain the equilibrium.
Anion Resin in Ammonia cycle

\[ \text{ROH} + \text{Cl}^- \rightarrow \text{RCl} + \text{OH}^- \]

\[ K_{\text{OH} \text{Cl}} = \frac{[\text{R Cl}] [\text{OH}^-]}{[\text{R OH}] [\text{Cl}^-]} \]

Where \( K_{\text{OH}} \) ------ Equilibrium constant

Similarly in the case for \( \text{Cl}^- \) in Ammonia operation the value of [OH\(^-\)] increases, so the [Cl\(^-\)] also increases to maintain the equilibrium. The source is the HCl used for the regeneration of the cation resin. So there is restriction in ammonia form operation.
<table>
<thead>
<tr>
<th>Cation resin</th>
<th>H+ form</th>
<th>NH₄⁺ form</th>
<th>Anion Resin</th>
<th>OH⁻ form</th>
<th>OH⁻ form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na⁺</td>
<td>X</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>✓</td>
<td>CL⁻</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

CL⁻ comes from resin cross contamination

Options are Replace CL⁻ with SO₄⁻ ion or convert NH₄⁺ form to H⁺ form
<table>
<thead>
<tr>
<th>Cation resin</th>
<th>H+ form</th>
<th>NH4+ form</th>
<th>Anion resin</th>
<th>OH- form</th>
<th>OH- form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na+</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>CL-</td>
<td></td>
<td>SO4=</td>
<td></td>
</tr>
</tbody>
</table>

Convert NH₄⁺ form to H⁺ form or convert CL⁻ to SO₄= form

Result will be no Na⁺ or CL⁻ slippages
Both trials were conducted by

a) Converting NH4+ form to H+ form of the Cation resin and leaving the Anion resin not regenerated

b) Converting CL- to SO4= by completely regenerating with H2SO4
Condensate I/L

H⁺ form to NH₄⁺
After 7 days opns

No Na⁺ or Cl⁻ slippage

Condensate I/L

NH₄⁺ form to NH₄⁺
+NH₄⁺NH₄⁺
NH₄⁺...Na⁺...
NH₄⁺NH₄⁺N
H₄⁺NH₄⁺NH
4+NH₄⁺Cl⁻

O/L
Na⁺ or Cl⁻ slippage starts
Convert Cation resin to H+ form leaving Anion resin as it is

O/L
No Na+ or Cl- slippage

Condensate I/L

O/L
Net process is - regenerate the Cation Resin with designed quantity of HCL

The Anion resin is only washed and cleaned but not regenerated

The experiment is conducted for one cycle.

Every alternate cycle the same can be repeated

Throughput was found to be normal throughput

Net saving is saving of caustic soda i.e about 2.0MT/regenerations
<table>
<thead>
<tr>
<th>S.No</th>
<th>Chemical</th>
<th>Cost/M T</th>
<th>Design Regn. Quantity(MT)</th>
<th>Design Throughput M3</th>
<th>Cost Rs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HCl (30%)</td>
<td>4950</td>
<td>4.73</td>
<td></td>
<td>23415</td>
</tr>
<tr>
<td>2</td>
<td>NaOH (48%)</td>
<td>11700</td>
<td>2.18</td>
<td>346000</td>
<td>25506</td>
</tr>
</tbody>
</table>

Specific chemical cost (Design) = chemical cost/Through put
= 48821/360000
= 0.136Rs/M3

Present AV actual throughput = 280000M3
Present actual Sp chemical cost = 0.174Rs/M3

Sp chemical cost after optimization = 4950/280000
=0.0176Rs/M3
Net savings per annum

\[
= (.174 -.0176) \times 9 \times 4 \times 280000
\]

\[
= Rs16,000,000\text{lakhs}/\text{Annum for four units}
\]
Figure 2 silica normal value <10

CPU - SIO2 VESSEL O/L

SIO2 (PPB)

Figure 3 chloride normal value 50-150ppb
Figure 4 normal value silica <100ppb

CBD - Reactive Silica (PPB)
Results of trial run in U II with cation resin H₂SO₄ regeneration only
Quantity of H₂SO₄ used was about 0.7 MT 98% AR grade H₂SO₄

Acid Strength was maintained to about 3-4%

Injection was done through the existing ejector system

No separate modification was carried out.
CPU throughput optimization-case study

Complete regeneration with H₂SO₄ one lot
Convert Cation resin to H+ form with H2SO4

No Na+ or Cl- slippage

O/L

Condensate I/L

O/L
Vessel O/L ACC
Cost benefit analysis

- Direct Saving of 2MT of NaOH for each alternate regeneration. In monetary term this amounts to about $2 \times 20000 \times 10 \times 4 = \textbf{Rs 160000lakhs}$ for a station like us of 4X500MW. Other benefits of DM water saving man power saving will also be there.
- Other benefit is to run the CPU only in H+ cycle.
- Combining these two is the throughput and cost optimization.
- With complete H2SO4 regeneration of cation unit resin, the chloride problem and CBD opening expected to be minimized.
• Station chemistry has conducting continuous experiments as explained above

• How to ensure things are in right directions?
Methodology of boiler internal surfaces *inspections and analysis*

a tool for the measurement of effectiveness of cycle chemistry vis a vis health of the boiler
Boiler Overhauling period is the best time when this activity is followed.

This is the time when boiler drum, bottom ring header, turbine blades, condenser, heaters, deaerator everything is opened for inspection.

Systematically we carry out the inspection as follows

- **Record the activities of inspection in OH activity charts**,
- **Carry out physical and chemical inspection**,
- **Analysis and interpretation of the data collected**.
- **Low magnetic electromagnetic technique for corrosion mapping of boiler tubes. A typical life assessment case study carried out in U II during overhaul.**
• Physical inspections of the internal surfaces e.g. boiler drum, bottom ring headers, condenser, D/A HP heaters, Turbine blades

• Chemical analysis of the deposit samples where ever applicable

• Corrosion mapping during overhaul in UII during OH
The Corrosion mapping study in the scanned areas such as tubes in High heat flux, ‘S’ panel and Goose neck regions of water wall tubes indicates no change in the LFET waveform signals amplitude and no ID metal loss due to corrosion.

The scanning of below ‘S’ panel bend straight tubes indicates slight non uniform of waveform signal output but there is no increase in the amplitude of signals and it is free from ID metal loss due to corrosion.
U-2 BOILER WATER WALL DEPOSIT -2009

Deposit quantity (mg/cm²)

<table>
<thead>
<tr>
<th>Corner</th>
<th>Cold Side</th>
<th>Hot Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corner 1</td>
<td>15.4</td>
<td>16.8</td>
</tr>
<tr>
<td>Corner 2</td>
<td>16.8</td>
<td>17.2</td>
</tr>
<tr>
<td>Corner 3</td>
<td>14.8</td>
<td>16.5</td>
</tr>
<tr>
<td>Corner 4</td>
<td>13.8</td>
<td>15.2</td>
</tr>
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</table>
Deposit analysis carried out by site chemistry lab
Unit-II During OH in Dec 2011

U-2 WATER WALL DEPOSIT -2011

<table>
<thead>
<tr>
<th>Corner</th>
<th>Cold Side</th>
<th>Hot Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corner 1</td>
<td>15.8</td>
<td>17.55</td>
</tr>
<tr>
<td>Corner 2</td>
<td>17.01</td>
<td>17.96</td>
</tr>
<tr>
<td>Corner 3</td>
<td>15.02</td>
<td>16.92</td>
</tr>
<tr>
<td>Corner 4</td>
<td>14.19</td>
<td>15.82</td>
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</table>
Deposit analysis comparison NETRA and site chemistry

<table>
<thead>
<tr>
<th>Boiler</th>
<th>NETRA</th>
<th>Site Chem</th>
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<tbody>
<tr>
<td>BPC-1H</td>
<td>18.5</td>
<td>15.8</td>
</tr>
<tr>
<td>BPC-1C</td>
<td>12.2</td>
<td>17.55</td>
</tr>
<tr>
<td>BPC-2H</td>
<td>22.1</td>
<td>17.01</td>
</tr>
<tr>
<td>BPC-2C</td>
<td>12.8</td>
<td>17.96</td>
</tr>
<tr>
<td>BPC-3H</td>
<td>21</td>
<td>15.02</td>
</tr>
<tr>
<td>BPC-3C</td>
<td>15.2</td>
<td>16.92</td>
</tr>
<tr>
<td>BPC-4H</td>
<td>20.9</td>
<td>14.19</td>
</tr>
<tr>
<td>BPC-4C</td>
<td>14.6</td>
<td>15.82</td>
</tr>
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</table>
Deposit analysis carried out by NETRA Unit-II During OH in Dec 2011

<table>
<thead>
<tr>
<th>Corner</th>
<th>Tube side</th>
<th>Sample no</th>
<th>Deposit quantity (mg/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BPC-1H</td>
<td>C - 2419</td>
<td>18.5</td>
</tr>
<tr>
<td>2</td>
<td>BPC-1C</td>
<td>C - 2420</td>
<td>12.2</td>
</tr>
<tr>
<td>3</td>
<td>BPC-2H</td>
<td>C - 2421</td>
<td>22.1</td>
</tr>
<tr>
<td>4</td>
<td>BPC-2C</td>
<td>C - 2422</td>
<td>12.8</td>
</tr>
<tr>
<td>5</td>
<td>BPC-3H</td>
<td>C - 2423</td>
<td>21.0</td>
</tr>
<tr>
<td>6</td>
<td>BPC-3C</td>
<td>C - 2424</td>
<td>15.2</td>
</tr>
<tr>
<td>7</td>
<td>BPC-4H</td>
<td>C - 2425</td>
<td>20.9</td>
</tr>
<tr>
<td>8</td>
<td>BPC-4C</td>
<td>C - 2426</td>
<td>14.6</td>
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</table>
UNIT-2 WATER WALL DEPOSIT TREND: 2007 TO 2011

<table>
<thead>
<tr>
<th></th>
<th>CORNER 1</th>
<th>CORNER 2</th>
<th>CORNER 3</th>
<th>CORNER 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>COLD SIDE 2007</td>
<td>8.5</td>
<td>11.7</td>
<td>10.9</td>
<td>9.4</td>
</tr>
<tr>
<td>HOT SIDE 2007</td>
<td>14.9</td>
<td>11.8</td>
<td>12.9</td>
<td>12.6</td>
</tr>
<tr>
<td>COLD SIDE 2009</td>
<td>15.4</td>
<td>16.8</td>
<td>14.8</td>
<td>13.8</td>
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<tr>
<td>HOT SIDE 2009</td>
<td>16.8</td>
<td>17.2</td>
<td>16.5</td>
<td>15.2</td>
</tr>
<tr>
<td>COLD SIDE 2011</td>
<td>15.8</td>
<td>17.01</td>
<td>15.02</td>
<td>14.19</td>
</tr>
<tr>
<td>HOT SIDE 2011</td>
<td>17.55</td>
<td>17.96</td>
<td>16.92</td>
<td>15.92</td>
</tr>
</tbody>
</table>
Turbine blade inspection and sample
Corrosion mapping of U II in overhaul

Low magnetic electromagnetic technique for corrosion mapping of boiler tubes through CPRI
Boiler drum internal

Blr drum

Bottom ring header
HP heater
Boiler tube deposit analysis
Conclusion

- There is scope for the optimization of condensate polishing system throughput.

- The data collected in boiler inspections helps in a) taking preventive action, b) interpretation of past historical and routine events, c) confidence in taking further improvement action plans.
THANK YOU