“Severe corrosion on rotor blades of back pressure type Steam Turbine due to unique reason”. What Went Wrong?

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Presenter/Author bios

Arun Kumar (Author)
Arun Kumar is working with HPCL- Mittal Energy Ltd., India, as Head of Maintenance & Reliability of high complexity Refinery complex, Guru Gobind Singh Refinery at Bathinda, India. Has over 30 years of experience in the areas of erection, commissioning, maintenance, equipment reliability, turnaround planning and execution, troubleshooting and performance improvement of Rotating Equipment, in Process Plant/ World Class Oil Refinery. Arun is mechanical engineering graduate with post-graduation in business management. He has presented number of technical papers at international venues and lectured at Turbomachinery and Pump Symposia, including tutorial and case studies. He is advisory committee member of Asian Turbomachinery Symposium, Turbomachinery Lab., Texas A&M University.

Anurag Chopra (Co-Author)
“The co-author is having more than 18 years of experience in field of Reliability & Maintenance of Rotating Equipment in the top refineries of India and presently working as Lead- Rotating Equipment Reliability at HMEL Refinery in India. Has been regular training faculty on rotating equipment for young engineers across refinery and has contributed in formulating overall rotating equipment strategies mainly predictive, preventive maintenance and bringing about transformation in rotating asset management by adapting latest technologies/tools available. The Co-author also has long exposure of rotary equipment vibration analysis – both casing and shaft and has designed, started and led condition monitoring programs in no. of refineries and has won accolades for the same.”
Summary of the Case Study

The case study depicts an unique reason for corrosion on blades of a Back Pressure Turbine (BPT) for Generator drive leading to huge maintenance cost within 4 years of turbine installation and commissioning.

Based on the observations collected during overhauling and analysis thereafter, it was concluded that reason for the corrosion on turbine blading was wet ambience inside the turbine casing during machine idle condition.

Action plan was prepared and implemented to avoid reoccurrence and is discussed in detail in subsequent slides.

The equipment overhauling was mainly planned due to higher vibration from equipment along with other reasons like increased steam leakages from turbine end seals leading to lube oil contamination.
STG-3 (Steam Turbine Generator) installed in Captive Power Plant of Refinery is back pressure control machine and drives electric generator with reduction gear-box. The brief equipment specifications are:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam Inlet Conditions</td>
<td>105kg/cm² g @ 505 degC</td>
</tr>
<tr>
<td>Steam Exhaust Conditions</td>
<td>5 Kg/cm²g @ 400degC</td>
</tr>
<tr>
<td>Turbine RPM</td>
<td>5000</td>
</tr>
<tr>
<td>Generator RPM</td>
<td>3000</td>
</tr>
<tr>
<td>Rating</td>
<td>32 MW</td>
</tr>
<tr>
<td>No of Impulse Stages</td>
<td>1</td>
</tr>
<tr>
<td>No of Reaction Stages</td>
<td>19</td>
</tr>
</tbody>
</table>
Brief Description

Steam Turbine major overhauling revealed deterioration to steam path components in the form of corrosion, erosion, pitting and other components in lube oil circuit like bearings.

The present case study is limited to investigation on corrosion on the steam path components, corrective actions taken and machine performance after corrective actions.
Brief History

Milestones

Mechanical Completion of Equipment : 19-12-2011
Ready For Commissioning : 06-04-2012
Commissioning (First Synchronization) : 28-04-2012
Hours From Date Of Commissioning : 30793 Hrs
Running Hours : 27187 Hrs

Note

• From April’12 to July’12, the no. of running hrs. 1121 against available 2280 hrs. due to intermittent running.
• From July’14 to Sep’14, the no of running hrs. 354 against available 2208 due to refinery shut down.
Start Stop History

Total No. of Stops Since Aug-12
21 Times

- Non availability of SLSS, 5
- Exhaust Pr. Low, 3
- Electrical System, 3
- Black Out, 2
- No power & steam demand, 3
- Load hunting issue, 3
- Instrument Malfunction, 1
- Major Overhauling, 1

Monthly Running hours
BPTG OPER HRS
Observations on steam path
Analysis of the Causal Factor

Wet Ambience In turbine during rotor standstill condition for longer duration

- Machine commissioned in April 2012.
- May’12 to July’12 - in intermittent start stop condition. Same time, the steam lines were charged and possibility of steam ingress inside turbine casing existed.
- July’14 to Sep’14 – machine stopped due to plant shutdown.
- More than 21 stoppages since Aug 12.
- BPSTG (Back Pressure Steam Turbine) flash tank -12 nos. drain lines : 9 no. intermittent (including 3 turbine casing drains) and 3 nos. continuous drains.
- Continuous drains are from VHP (Very High Pressure) header & remain in service during BPSTG trip condition too.
Analysis of the Causal Factor

- Back flow of flash steam from these continuous drains can create wet ambience in turbine during rotor standstill condition.
- BPSTG drains from upstream and downstream of exhaust steam (LP)
- Motor operated valve (MOV) are connected to same drain header, which has potential to create wet ambience in turbine during rotor standstill condition. (Refer schematic)
BPTG Flash Tank Drain Details

<table>
<thead>
<tr>
<th>S No.</th>
<th>Type of Drain</th>
<th>Drain From</th>
<th>Valve near flash tank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Intermittent Casing MP</td>
<td>Near Flash Tank</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Intermittent Casing LP</td>
<td>Near Flash Tank</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Intermittent Aux Steam Drain Header</td>
<td>No Isolation</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Intermittent Casing HP</td>
<td>Near Flash Tank</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Intermittent Common Header under QC NRV, after QC NRV, LP Vent</td>
<td>No Isolation</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Continuous ESV Drain</td>
<td>No Isolation</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Intermittent LP Steam to VAM drain</td>
<td>No Isolation</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Continuous VHP drain trap near Startup vent MOV</td>
<td>Near Flash Tank</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Intermittent VHP drain by Pass near Startup vent MOV</td>
<td>Near Flash Tank</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Continuous VHP drain trap near Flash Tank</td>
<td>Near Flash Tank</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Intermittent VHP drain by Pass near Flash Tank</td>
<td>Near Flash Tank</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Intermittent LP Exhaust</td>
<td>Before Q C NRV</td>
<td></td>
</tr>
</tbody>
</table>

Note: During site test as part of RCA, back flow of steam from flash tank to turbine casing noted from HP casing drain and back flow from LP exhaust line.
Exhaust Steam Line Drains

BPSTG drains from upstream and downstream of exhaust steam (LP) MOV connected to same drain header and has potential to create wet ambience in turbine during rotor standstill.
Graphics-Corrosion on Rotor and Carrier Blading

BPSTG TURBINE ROTOR

GUIDE BLADE CARRIER - 1

GUIDE BLADE CARRIER - 2

GUIDE BLADE CARRIER - 3

ROTATING BLADES

STATIONARY BLADES

ROTATING & STATIONARY BLADES TO BE REPLACED

Drain
# Action Plan Based on the Analysis

<table>
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<tr>
<th>Causal Factor</th>
<th>Root Cause</th>
<th>Action Taken</th>
</tr>
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</table>
| Wet Ambience Inside Turbine leading to corrosion on turbine components. | **Back flow of steam to the turbine casing from:**  
1. Casing Drains connected to common flash tank having total 12 no drains connected.  
2. LP exhaust end drains.  
3. Machine stoppages for longer duration. | 1. Shifting of turbine header drain trap and bypass valve (Before MOV) from flash tank to atmospheric drain.  
2. Shifting of Drain trap upstream Inlet valve, Trap root Inlet valve and Trap Bypass valve to approachable locations  
3. Shifting of header after MOV drain trap and bypass valve from flash tank to atmospheric drain.  
4. Shifting of VAM Boiler Drain Trap and bypass valve common drain header (2”) from flash tank to atmospheric drain. |
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1. Casing Drains connected to common flash tank having total 12 no drains connected.  
2. LP exhaust end drains.  
3. Machine stoppages for longer duration. | 5. Shifting of Aux. Steam Drain Trap and bypass valve common drain header (4”) from flash tank to atmospheric.  
6. Shifting LP Exhaust After MOV Drain trap and drain bypass from flash tank to atmospheric  
7. Shifting of LP Exhaust After NRV Drain from flash tank to atmospheric and provision of Trap.  
8. Separation of Steam and oil Leak off drains.  
PRESENT BPTG FLASH TANK PIPING CONNECTIONS
Learnings

Based on the turbine satisfactory performance after taking corrective actions, following learnings can be implemented horizontally across all steam turbines:

1. Process Flow Diagrams must be verified at site during erection stage and during handover/take over. The same was overlooked in the subject case and resulted in huge maintenance cost.

2. During long shutdown of the turbine, OEM guidelines for preservation should be followed. The same were not followed in our case leading to creation of wet ambience inside turbine casing and hence corrosion on blades.

3. In subject case, OEM recommended “The turbine unit will be protected against internal corrosion during prolonged shutdown of more than 2 weeks after cooling down the turbine, by admitting Nitrogen into the turbine and maintain a low positive pressure of about 50 to 75 mm W.G. during whole time of shutdown at standstill condition, the protection shall include all steam spaces including the gland sealing”.