GT Thrust Bearing Failure: A Challenge
Failure of Thrust Pads: A Challenge

- Failure of Thrust Bearing in 2007.
- Repetitive Failures – Five Times.
- Only Generator side (working side) Thrust Pads got damaged, Turbine side Pads were intact.
- Final resolution of the problem in 2011.
Siemens V94.2 Gas Turbine

Component Review

- Combustion Chamber
- Rotor
- Compressor Blades & Vanes
- Compressor Vane Carrier
- Auxiliaries
- Middle Hollow Shaft
- Line Piping
- Inner Casing
- Turbine Vane Carrier
- Exhaust Casing
- Turbine Blades & Vanes
- Combustion chamber with flame tube and burners.
- Intake casing accommodating the compressor bearing.
- Rotor with all discs and shafts in assembled condition.
- Front hollow shaft consisting of journal for positioning compressor bearing.
Rectification Efforts: Three Phases

• **Phase I** – Repetitive failures of Thrust Pads. Period between Sept 2007 to December 2008. Rectification efforts by M/s BHEL & NTPC. Actions were concentrated on compensating extra thrust and to maintain bearing system healthiness.

• **Phase II** – Rectification efforts by M/s Siemens & NTPC. Period from Jan 2009 to March 2011. Phase of limited success.

• **Phase III** – Successful resolution of problem. Rectification along with the major inspection of Gas Turbine in 2011. NTPC itself devised rectification strategy.
Phase I - Thrust Compensation (Sept 2007-Dec 2008)

• Extra thrust on Rotor: Supporting Factors
  - Changes in rotor axial movement before and after the initiation of problem. [Details]
  - Centenary check of Turbine and Generator shaft. Deviation from the reference readings (acquired from BHEL). [Details]

• Actions taken for Thrust Compensation:
  - Catenary corrections up to best possible level. [Details]
  - Balancing chamber integrity check conducted. Leakage in Balancing line found. [Details]
  - Generator magnetic center offset check done. Generator stator shifted towards exciter end by 5 mm.
Phase I - Bearing System Wellness (BSW)

- Orifice size in lube oil supply line increased for increase flow of oil through bearing. Flow measurements were carried out. Flow was more than the second turbine installed at site.
- Both Journal and Thrust bearings changed with new one.
- Rubbing marks on generator side thrust collar observed after failure of thrust pads. Machining of thrust collar at BHEL Hardwar.

**Other Actions:**

- Re-alignment of rotor shafts.
- Detailed analysis of Flow path was carried out. Turbine blades which were put in April 2007 OH replaced again with original blades.
Phase II - M/s Siemens Intervention (Jan 2009 to Mar 2011)

- Detailed fact finding and analysis of problem.
- Evaluation of past rectification efforts, operating parameters and assembly protocols of Phase-I.

**Action Taken:**
- In-Situ machining of thrust collar done. Machining performed earlier in Phase-I was not up to desired accuracy.
- Replacement of existing combined journal & thrust bearing with Siemens manufactured bearing.
- Adjustment of lube oil supply pressure to as near to design pressure. From 3.0 bar to 2.2 bar (design 1.8 bar). High pressure was maintaining since last seven years.
INSITU MACHINING OF THRUST COLLAR

FINAL FINISHING OF THE COLLAR
Phase II – Limited Success

- Temp profile not improved but no immediate failure of bearing as in past.
- Machine operated with load restriction with limiting the bottom pad temp. to 100deg ⁰c.
- Thrust Pads temp. increased with increase in load, lube oil temperature and frequency.
- M/s Siemens offered system modification as a viable solution.
Further Solution Suggested By M/s Siemens

- For complete solution of problem M/s Siemens recommended system modifications:
  - (A) Modification of balancing line by extracting air from downstream of 10\textsuperscript{th} stage of compressor instead of 5\textsuperscript{th} stage as at present.
  - (B) Installation of modified –heavy duty combined journal & thrust bearing.
  - Replacement of existing throttle in lube oil line in order to achieve design lube oil pressure.

* M/s Siemens offered to execute the suggested modifications along with major inspection of GT, at an approx. cost of Rs 10 Cr. (But successful resolution was not assured)
NTPC relied on its potential and decided to rectify the problem itself during Major OH of GT in April 2011.

Formation of rectification team: Members from site, OS-CC-GT, NCR-OS, Dadri Gas. BHEL was involved in the execution process.

Machine dismantled for overhauling: Major findings

- Generator side Thrust Pads found burnt. Babbitt almost started flowing after being melted.
- Burn-out marks on both compressor and turbine journal bearing bottom halves.
- No other anomaly observed.
Phase III - Major Insp. 2011
Observations
• Brain storming conducted. Action Plan formulated for successful rectification of the problem.

• **Action Plan:**

• Decided to bring back the turbine pot level to erection values before final alignment of gas turbine.

• Alignment of Shafts without considering the BHEL catenary reference, as these references were not considered during erection.

• Close monitoring of every assembly reading and try to maintain it as close as possible to erection value.

• Not to consider any reference other than the erection protocols
Phase III

Turbine Pot Level Corrections

<table>
<thead>
<tr>
<th>Measuring Points</th>
<th>Erection values</th>
<th>Before Dismantling</th>
<th>During Assembly - after correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressor casing lifted by adjusting the support at compressor bearing pedestal.</td>
<td>1.53</td>
<td>1.58</td>
<td>4.28</td>
</tr>
<tr>
<td>2</td>
<td>4.19</td>
<td>1.66</td>
<td>4.28</td>
</tr>
<tr>
<td>3</td>
<td>1.32</td>
<td>2.66</td>
<td>0.63</td>
</tr>
<tr>
<td>4</td>
<td>0.00</td>
<td>0.96</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Generator Lifting For Alignment

I. Turbine Bearing
II. Compressor Bearing
III. Generator turbine-end bearing
IV. Generator exciter-end bearing

12.5 mm
7.5 mm
3.5 mm already lifted for turbine pot level corrections
Shaft Positions For Alignment

- Generator rotor
- Intermediate Shaft
- Turbine Rotor

**Design Values (mm)**

<table>
<thead>
<tr>
<th>Coupling</th>
<th>L - R</th>
<th>T - B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbine - Intermediate Shaft Coupling</td>
<td>± 0.02</td>
<td>0.08 ± 0.02</td>
</tr>
<tr>
<td>Intermediate Shaft - Generator Coupling</td>
<td>± 0.02</td>
<td>0.04 ± 0.02</td>
</tr>
</tbody>
</table>
## Final Parameters: A Journey to Success

<table>
<thead>
<tr>
<th>Period</th>
<th>Load</th>
<th>Temp.Thrust Brg .GS</th>
<th>Temp.Thrust Brg .TS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before O/H, 2007</td>
<td>130MW</td>
<td>69.0</td>
<td>68.0</td>
</tr>
<tr>
<td>After O/H, 2007</td>
<td>130MW</td>
<td>93.9</td>
<td>66.2</td>
</tr>
<tr>
<td>After Final Rectification in 2011</td>
<td>130 MW</td>
<td>69.0</td>
<td>68.0</td>
</tr>
<tr>
<td></td>
<td>154 MW</td>
<td>70.0</td>
<td>68.0</td>
</tr>
</tbody>
</table>

Phase III
THANK YOU
Normal Behavior Of Gas Turbine Rotor

Up to 70 MW, Rotor shifting towards generator

Loading beyond 70 MW, shifting towards turbine

Generator

Turbine

Load variation

Phase 1
Altered Behavior Of Gas Turbine Rotor

On synchronization, rotor shifts towards turbine and during rolling, no axial shift is observed.

Phase 1
Catenary Check: Deviation From BHEL Reference

Bearings relative positions

<table>
<thead>
<tr>
<th>Measured Values</th>
<th>BHEL Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. L1- 0</td>
<td>I. L1- 1.147</td>
</tr>
<tr>
<td>II. L2- 2.89</td>
<td>II. L2- 0</td>
</tr>
<tr>
<td>III. L3- 6.50</td>
<td>III. L3- 1.002</td>
</tr>
<tr>
<td>IV. L4- 22</td>
<td>IV. L4- 6.925</td>
</tr>
</tbody>
</table>

Phase 1
I. Turbine Bearing
II. Compressor Bearing
III. Generator turbine-end bearing
IV. Generator exciter-end bearing

Phase 1
Balancing Chamber Integrity Check

• Air extracted from downstream of compressor 5th stage goes to balancing chamber via a balancing air line.

• This air releases into gland box after last stage of turbine blades, this acts as balancing chamber.

• Crack in balancing line observed, just at the entry point to balancing chamber. Crack welding done.

Phase 1