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RESOLVING STRUCTURAL VIBRATION ISSUES ON A WATER FLOOD PUMP

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This case study is designed to outline how the high vibration issue of two Water flood modules was successfully diagnosed, the root cause for the high vibration and finally how it was mitigated using some structural analysis techniques.

Detailed transient data analysis, steady state Operating Deflection Shape modeling allowed localization of the problem and recommend correction actions to change supporting system natural frequency by increasing the supporting system stiffness during planned overhaul.



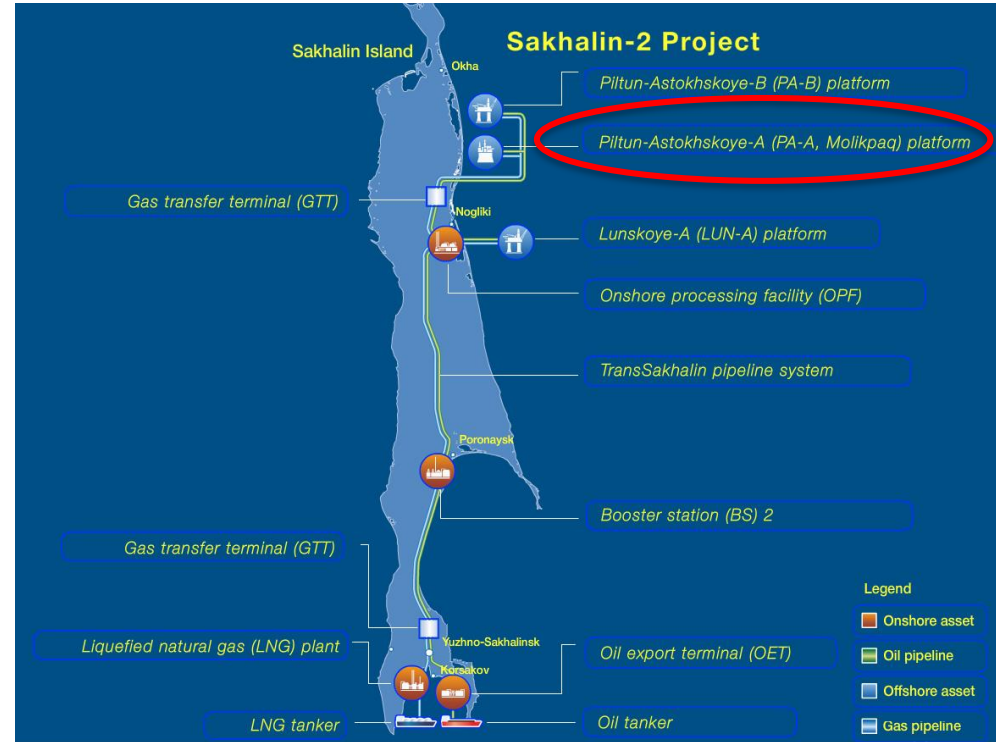
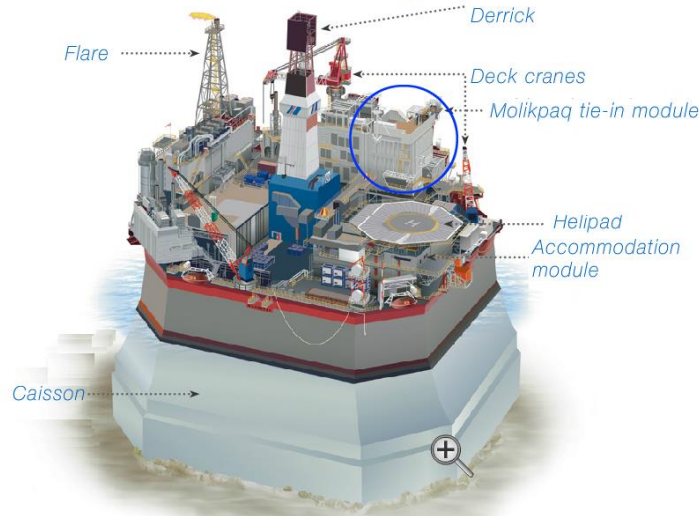


Travel time – 1 Day 11 hours. Minimum :?
Actual was 2 days 23 hours – delays...



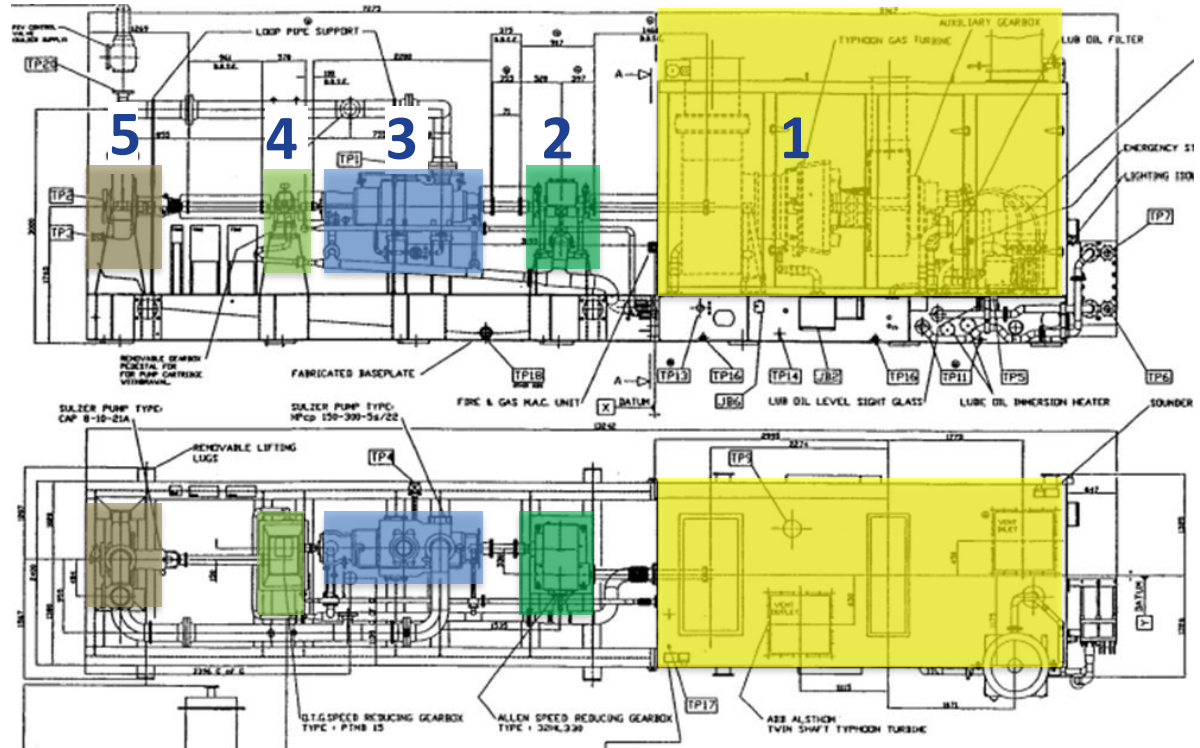
Sakhalin Energy Investment Company Ltd. (Sakhalin Energy) is developing the Piltun-Astokhskoye oil field and the Lunskeye gas field off the north-eastern coast of Sakhalin. Its activities include production, transportation, processing, and marketing of oil and natural gas.

The Molikpaq (PA-A) platform was installed in 1998 in the Astokh area of Piltun-Astokhskoye oil field.



Two identical water flood modules

1. Gas turbine and enclosure
2. Main gearbox
3. Pump
4. Booster gearbox
5. Booster pump



Problem statement

- Based on Operations request, to provide maximum designed water flow, the Unit's speed was increased up to maximum allowed state value.
- While units were operated at increased speed, Power Turbine Shaft relative vibration was exceeding Manufacturer defined *Alarm*, close to *Trip* state levels.
- This was repeated each time when Units were operating at speed close to maximum allowed speed.
- It had not been noticed earlier because both units did not reached that speed during previous operation, based on less flow needs.

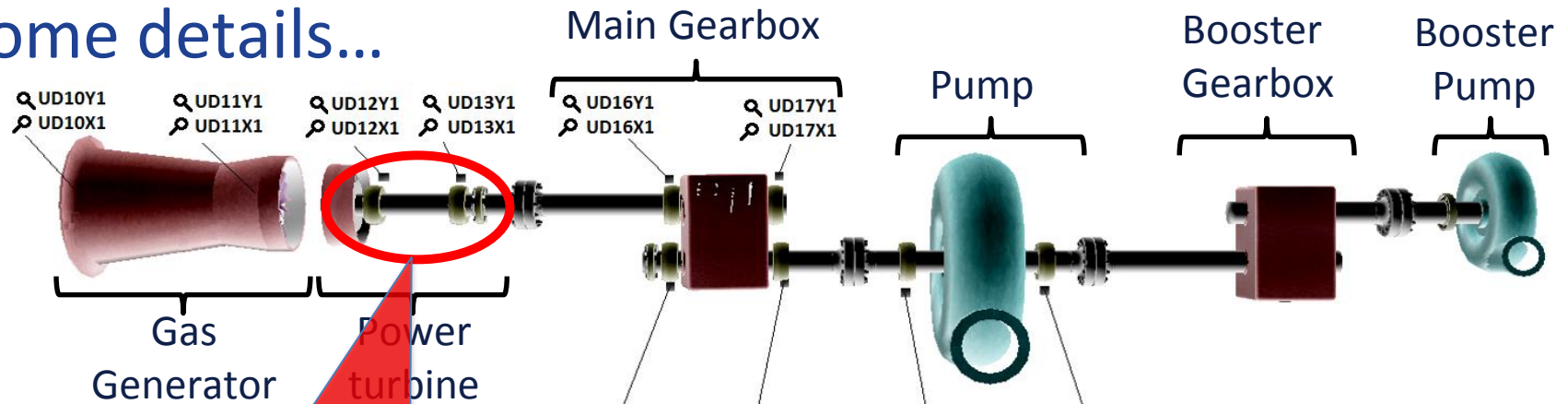


Summary of vibration tests data:

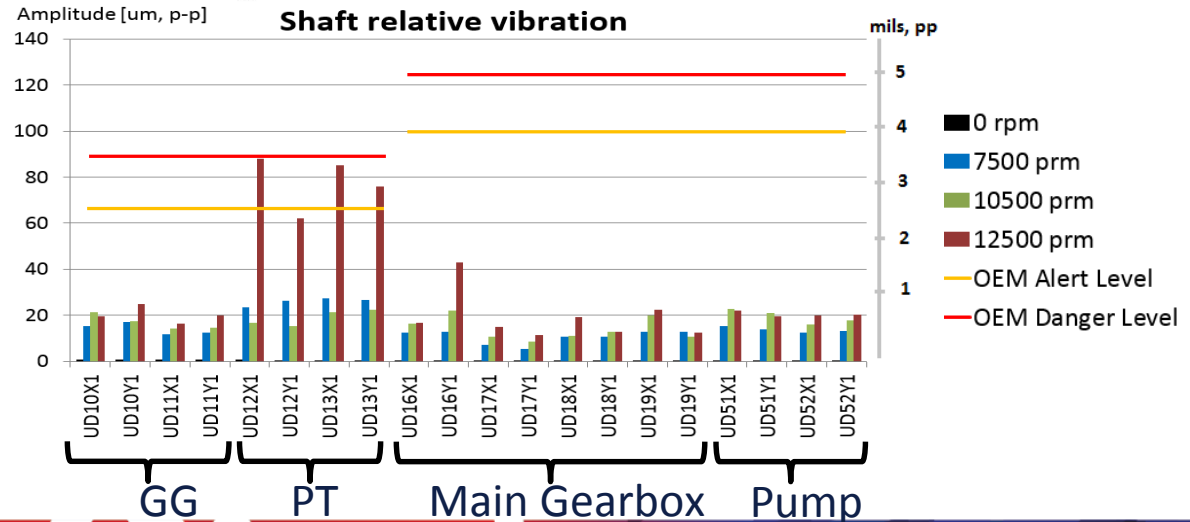
- Vibration data was recorded for few operation modes:
 - stopped Unit
 - 7500 rpm (minimum flow),
 - 10500 rpm (55% flow),
 - 12500 rpm (91% flow– maximum level before Unit trip)
 - Unit shutdown,
- high Power turbine shaft vibration level – 90um pp (3.5 mils pp) detected @ 12500 rpm,
- high Main Gearbox casing vibration level 12-16 mm/s RMS (0.47 – 0.63 in/s) detected @ 12500 rpm.



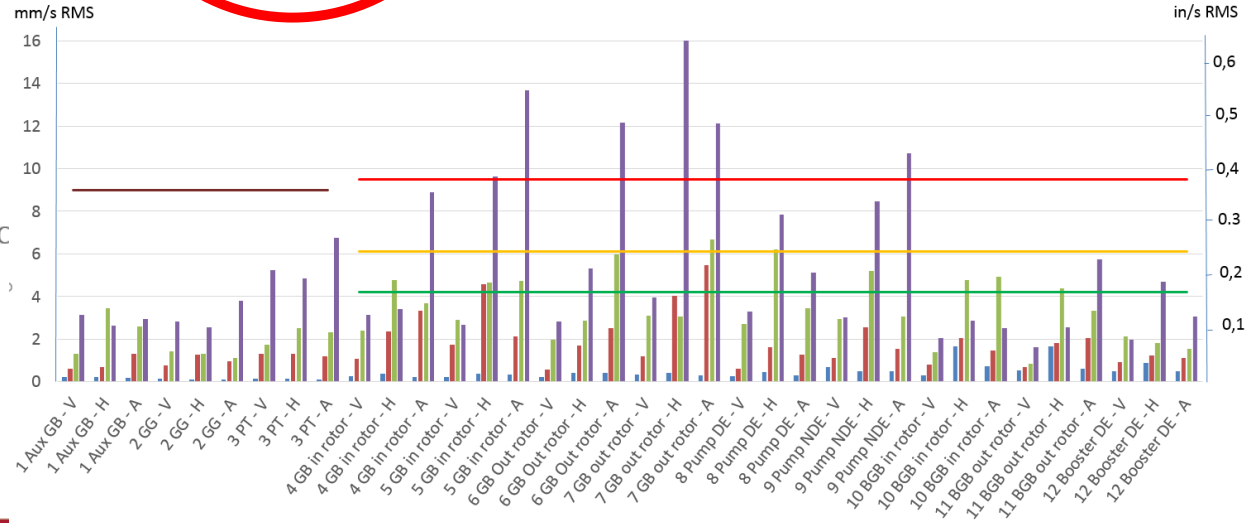
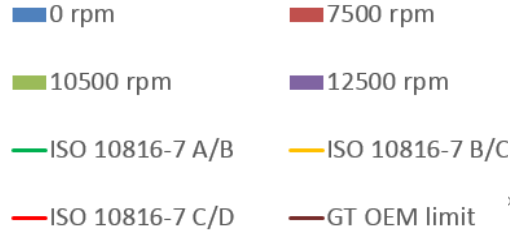
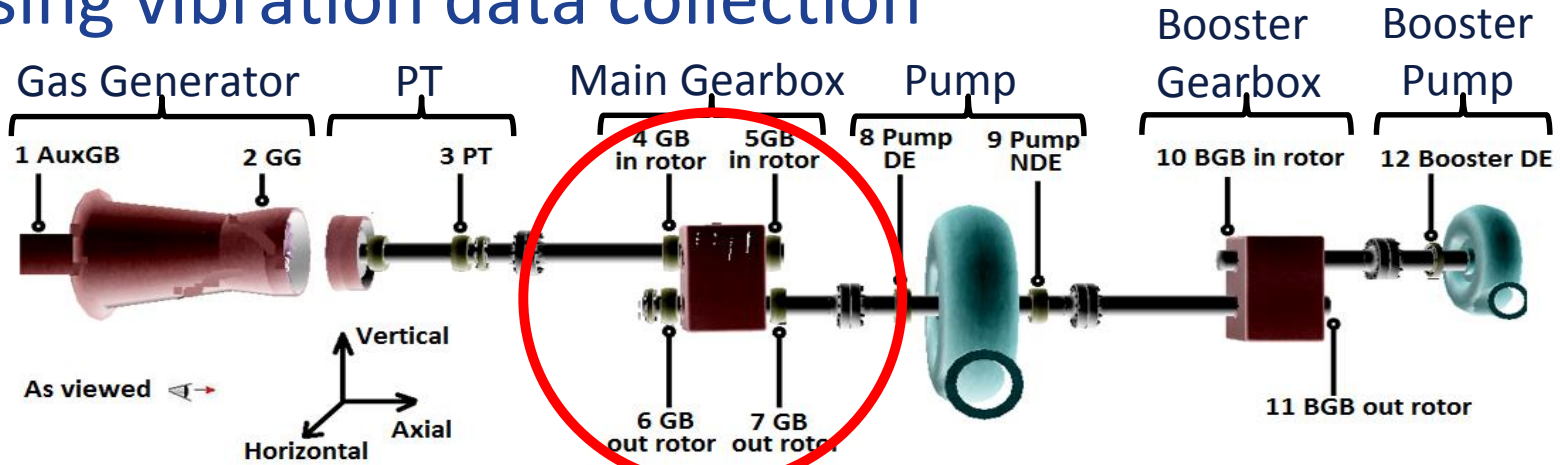
Some details...



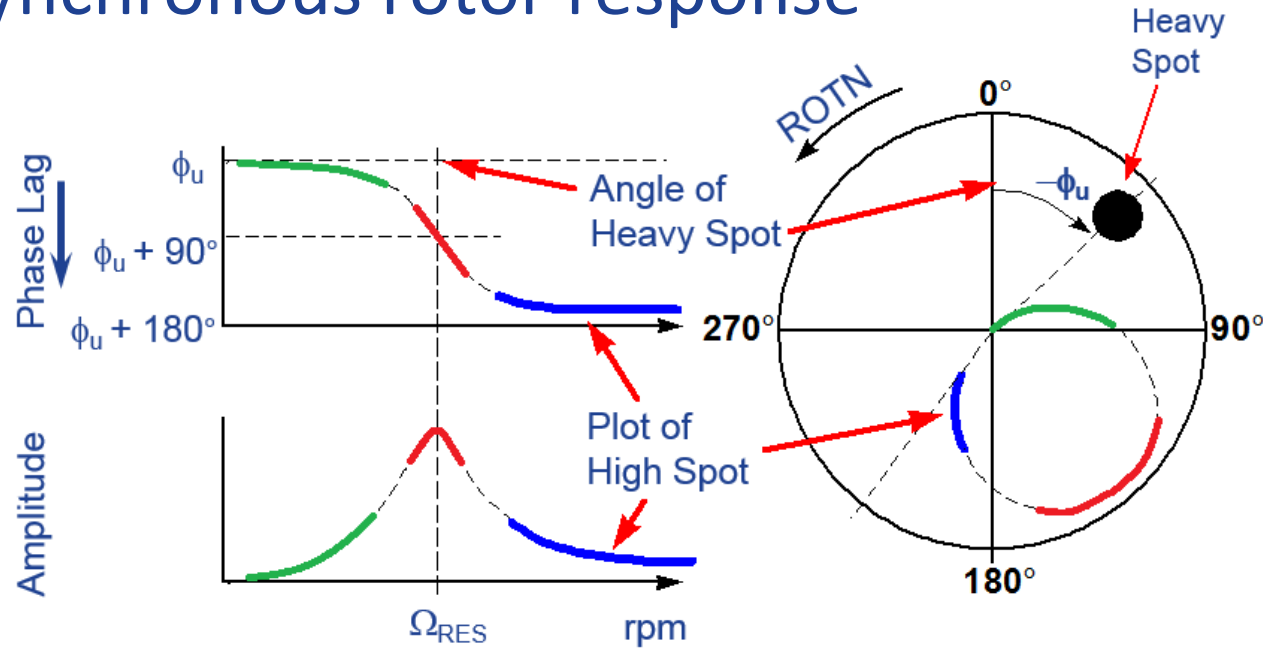
Power Turbine
 High level of Shaft
 relative vibration
 > 90 $\mu\text{m pp}$ (3,5 mils)



Casing vibration data collection



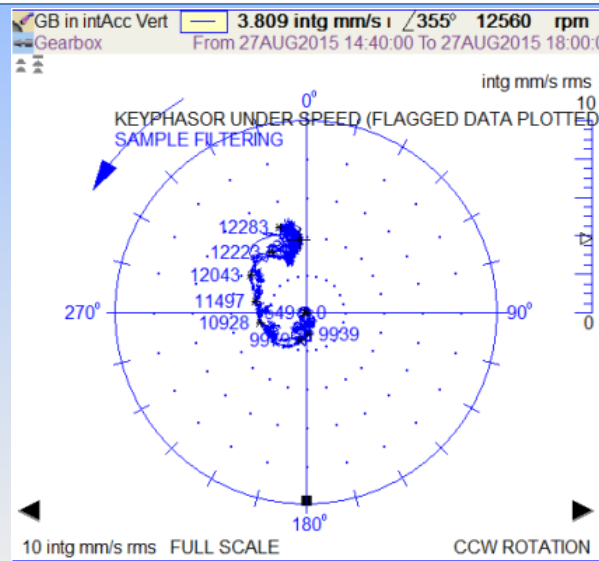
Synchronous rotor response



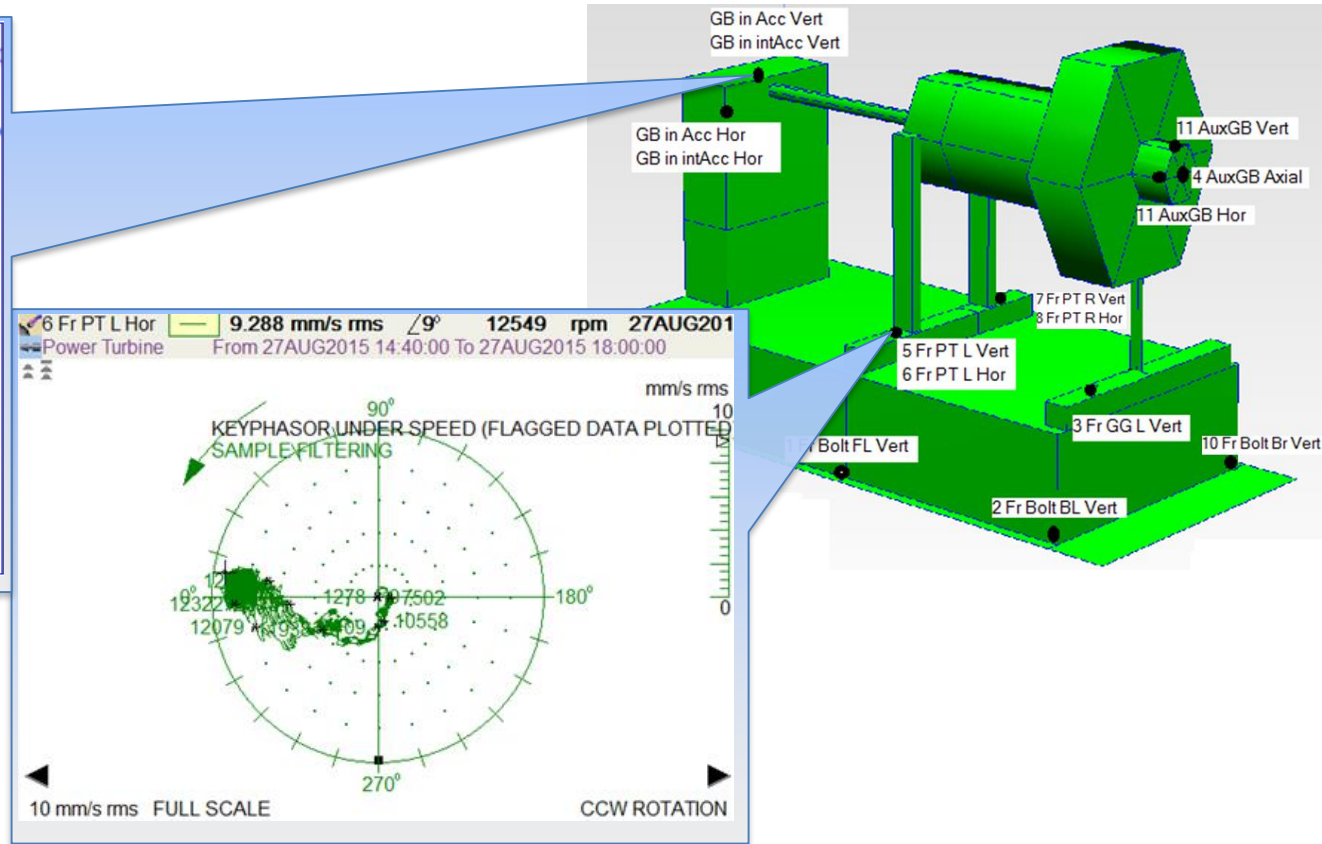
Green line - well below resonance, red line - on resonance, blue line - well above resonance.



Casing vibration transient data collection



Over 160° phase shift –
well above resonance



Close to 90° phase shift – on resonance



Vibration data analysis:

- the dominating frequency component for the Main Gearbox Shaft relative and casing vibration was the 1X rotational speed of low speed shaft,
- the Power Turbine Support Casing vibration Polar plots shows vibration amplitude grows, starting at speed 12000 rpm and approx. 90° phase shift from low speed to 12500 rpm,
- this indicates rotor is operating on or close to the Power Turbine supporting system resonance frequency.



It is time for ODS

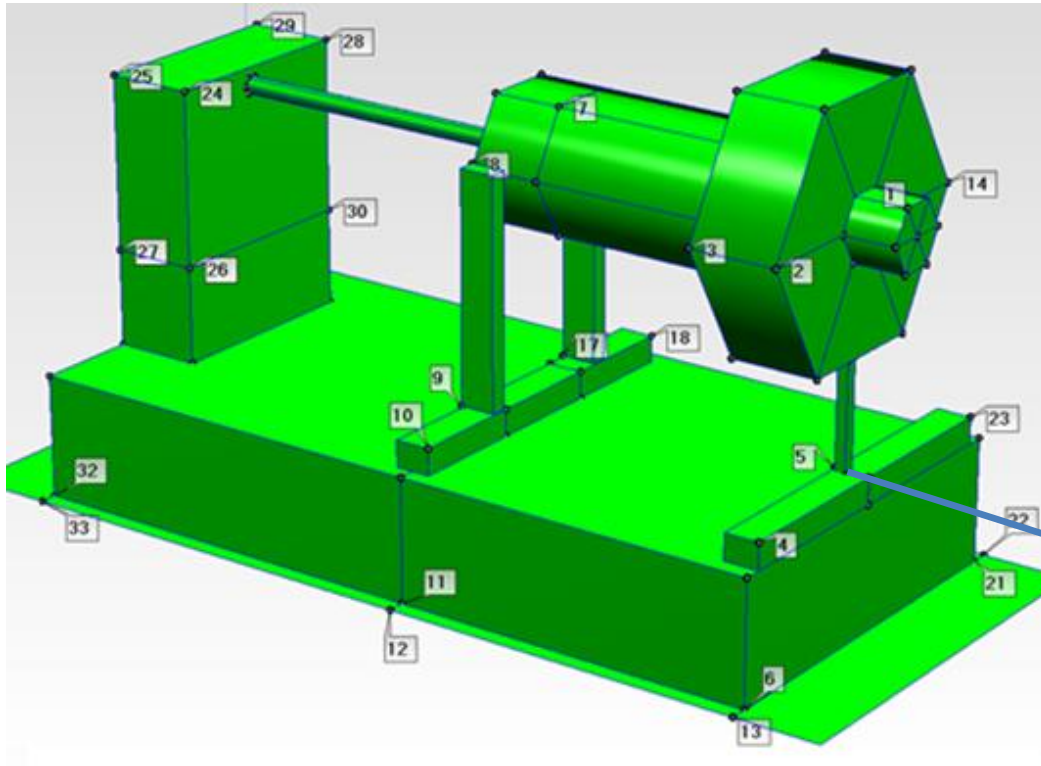
To visualize Power Turbine movement, demonstrate consequences of detected resonance phenomena, Operational Deflection Shape (ODS) animations were done for different Unit operation conditions:

- stopped Unit
- 7500 RPM (minimum flow),
- 10500 RPM (55% flow),
- 12500 RPM (91% flow— maximum level before Unit trip)

Measurements done by roving three axis accelerometer in orthogonal directions – vertical, horizontal and axial and reference accelerometer, installed in vertical direction at the Non-drive end (NDE) Gas Turbine support.



It is time for ODS



Roved Triaxis
accelerometer
(points 1-35)

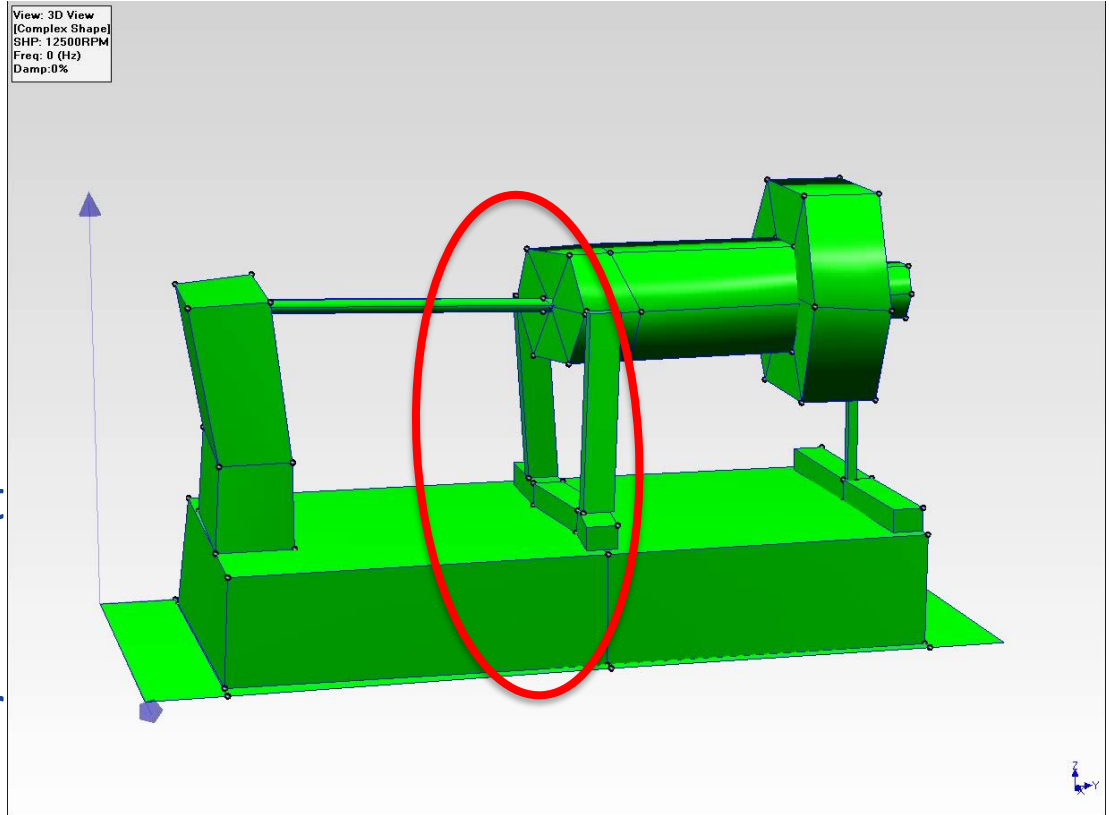


Reference probe (point 5)

It is time for ODS

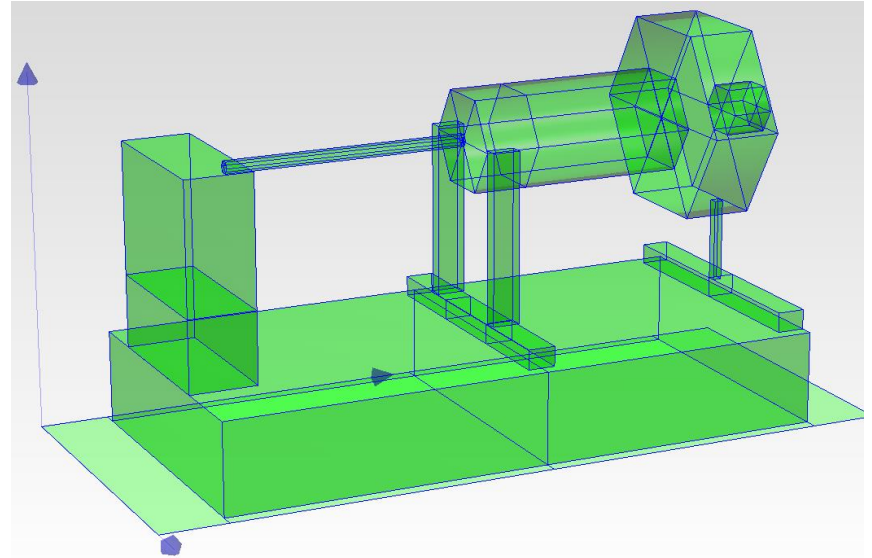
12500 RPM mode shows clear picture of Power turbine Drive end side supporting system resonance.

This PT Drive end side supporting system movement can be the result of supporting system stiffness degradation, or lack of supporting system or frame design.



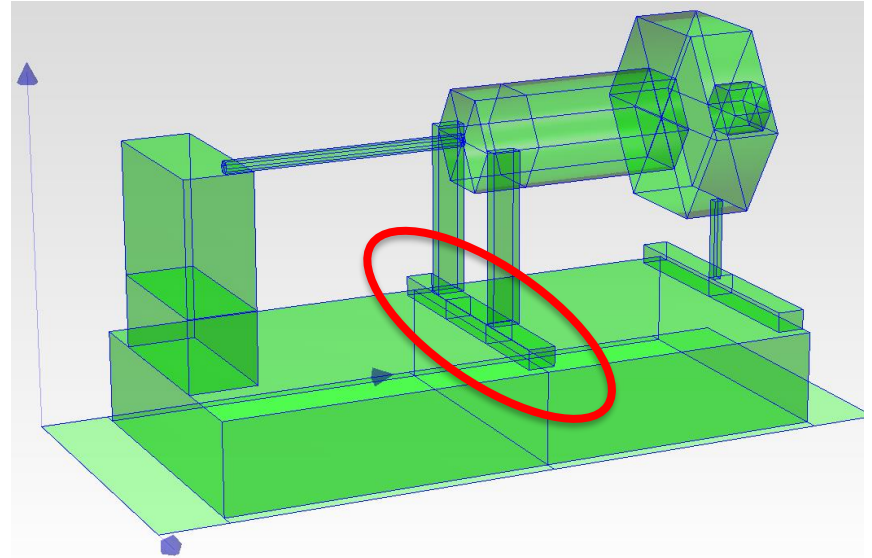
Problem and short term solution

The short term solution was to limit operation speed up to 12000 rpm, to avoid Units operation at resonance.



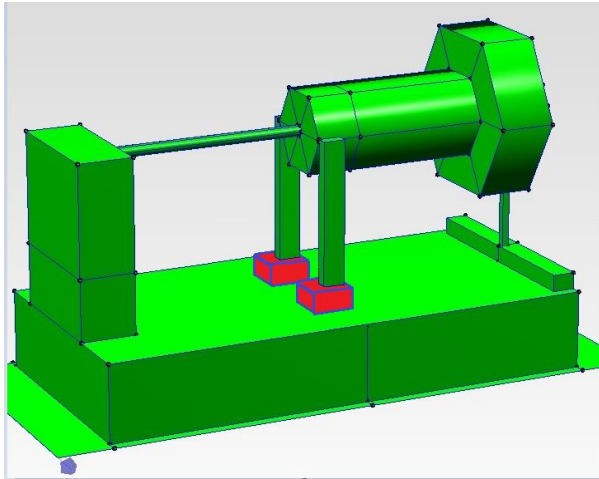
Problem and long term solution

The long term solution was to increase Power turbine Drive end side supporting system stiffness in the axial direction .



Problem and long term Solution

Increase supports stiffness in the axial direction



New design of Unit A Power turbine Drive end supports was implemented by Customer during next planned overhaul.

The stiffness of supporting system was increased in axial direction, U beam was removed and Power turbine legs supports were replaced by new, more stiffer design. This modification was done by Customer and new supports design wasn't scope of this job.



Problem and long term Solution



**Original design of
PT support**

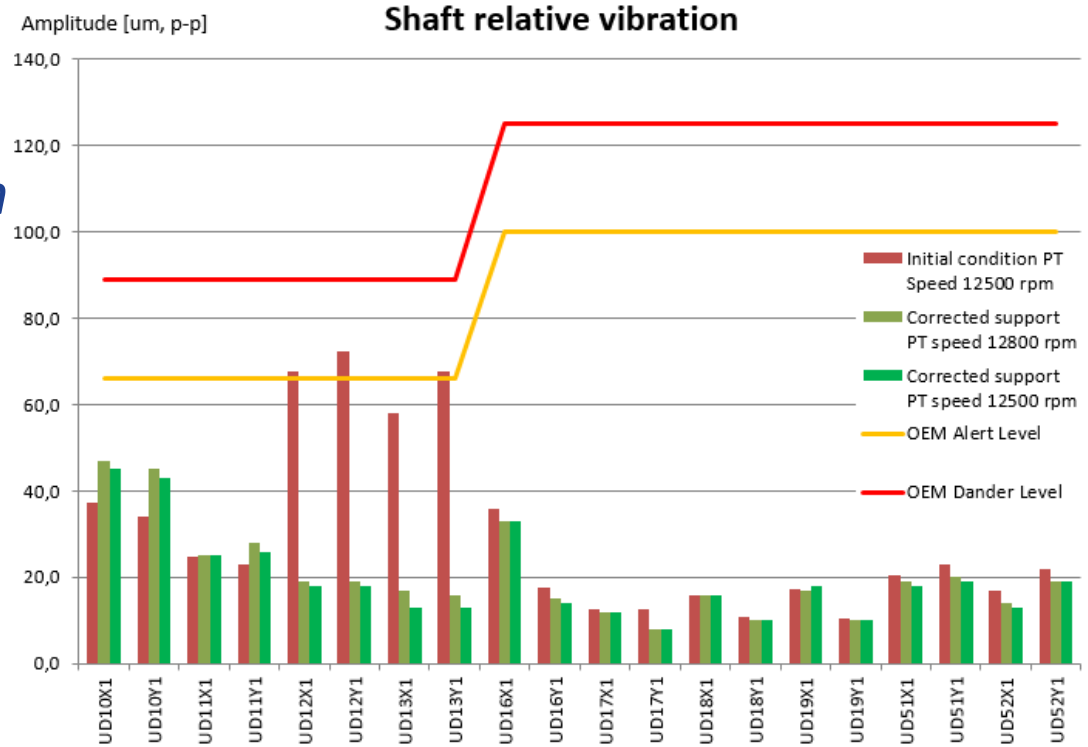


**PT support after
modification**

Outcome

After supporting system modification it was possible for Unit A to reach maximum designed speed, maximum flow with acceptable vibration level.

Unit B modification done during next planned overhaul.



Lesson learned

- *There was no onsite Acceptance Test data.*
- *A Factory Acceptance Test done separately for the different parts of the unit can not give information about assembled Unit operation.*
- *Site acceptance test is required to confirm Units ability to run for whole designed operation range.*

