ASIA TURBOMACHINERY & PUMP SYMPOSIUM
MARCH 2018 | SUNTEC SINGAPORE

Resolving Structural Vibration Issues On a Multi Stage Pump

Nicolas Peton
Sankar Ganesh

TURBOMACHINERY LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION

TEXAS A&M UNIVERSITY

Presenter/Author bios

Nicolas Peton, Global Director - Machinery Diagnostics Services

Nicolas joined GE in 2006 in the Machinery Diagnostic Services (MDS) group. Previously he worked for two different manufacturers (Alstom Steam turbine and Cryostar expander/compressor) where he was in charge of on site of the startup activities worldwide.

He also worked as an operation and maintenance engineer in the chemical industry (PPG industry, USA) and as Free Lance for startup activities worldwide. He has been also a mechanical/acoustical research engineer in research institutes (Technion, Haifa and TU Berlin) . He is currently MDS Global Director for the Machinery Diagnostic Services. He has a Diplome d'ingénieur from the Université de Technologie de Compiègne, France.

Sankar Ganesh – Technical Leader, MENAT

Sankar is the Technical Leader for GE Bently Nevada Machinery Diagnostics Services in the MENAT region.

He received a Bachelor of Mechanical Engineering from Bharathidasan University, India, in 1993.

Over 20 years experience in vibration field and 10 years with GE Bently Nevada, including rotating equipment balancing, vibration analysis, diagnostics and root cause analysis. Published case studies in METS and Turbomachinery symposium.

Abstract

There are three multistage pumps supplied as part of a new project for transporting diesel from one location to another. Earlier, the transportation of diesel was carried out using trucks for this facility. The availability of these pumps are critical to ensure that the diesel transportation is smooth without the needing the truck services. The machine train is equipped with online vibration monitoring & protection system with online diagnostic software.

During the commissioning, it was noticed that the pumps were not able to reach the maximum continuous speed of 50.7 Hz (Max rated speed is 53.8 Hz) and were tripping on high vibration at the pump casing. The operation of these pumps were limited with the speed restrictions using the Variable Frequency Drive (VFD) system. The data review from the online diagnostics system revealed that these pumps were tripping on high vibration due to the excitation of pump vane pass frequency (195 Hz), when the pump was reaching the speed of 39Hz. Further tests concluded that the pump casing natural frequency was matching with the vane pass frequency of 195 Hz.

This case study is designed to outline how the high vibration issue was successfully diagnosed, the root cause for the high vibration defined and finally how the problem was mitigated using some of the structural analysis techniques (modal analysis, Operating Deflection Shape etc). Lessons learned are also discussed in view of the discovery methodology using expert system available on site, from the project point of view as well as from design point of view.

Problem Statement

- Three multistage pumps supplied as part of a new project.
- The pumps are being used for transporting diesel from one location to another.
- The availability of these pumps are critical.
- The machine train equipped with online vibration protection system & online diagnostics software for analysis.
- Pump is driven by an induction motor “VFD” through a flexible coupling.

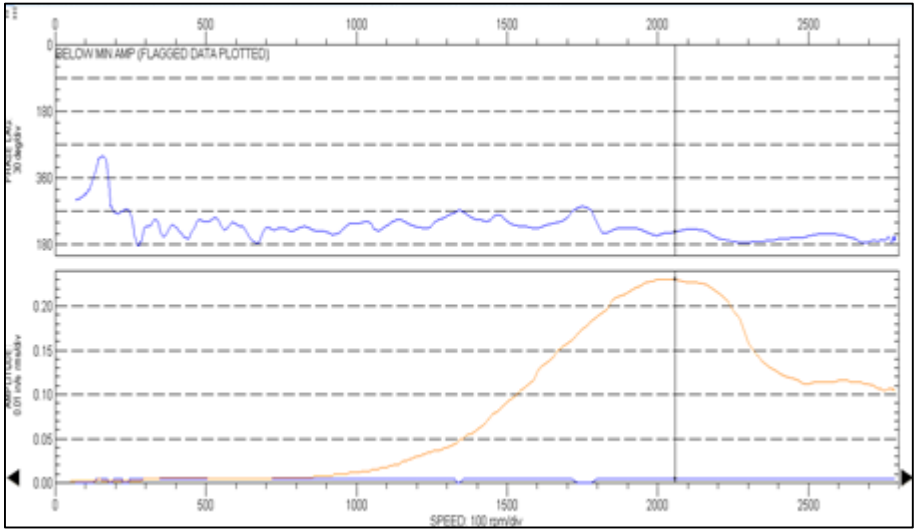
Problem Statement (Cont'd)

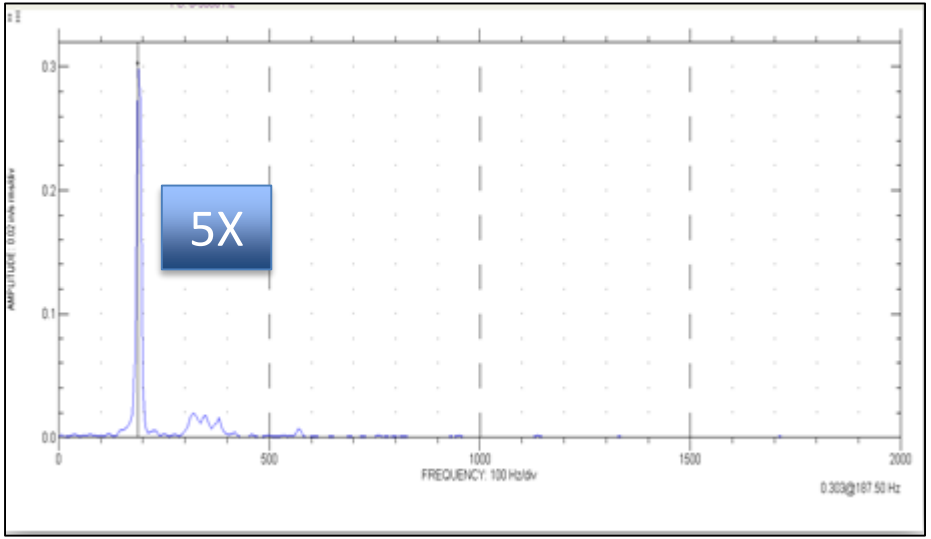
- Maximum continuous speed is 3040 rpm.
- Maximum Rated speed is 3229 rpm.
- Radial sleeve bearings, thrust bearing & 5 vanes per each stage.
- 4 proximity probes, 1 casing probe at pump NDE-Vertical.
- During the commissioning, pumps were not able to reach the maximum continuous speed of 50.7 Hz and were tripping on high casing vibration.

Problem Statement (Cont'd)

- Original Alarm / Danger set points were 0.17/ 0.26 in/s rms, revised to 0.26 / 0.35 in/s rms.
- At 39 Hz running speed "1X", pumps were tripping on high casing vibration with 195 Hz dominant frequency "5X".
- Shaft relative vibration levels were normal.
- Further tests concluded that the pump casing natural frequency at NDE was matching with the vane pass frequency of 195 Hz in vertical direction.

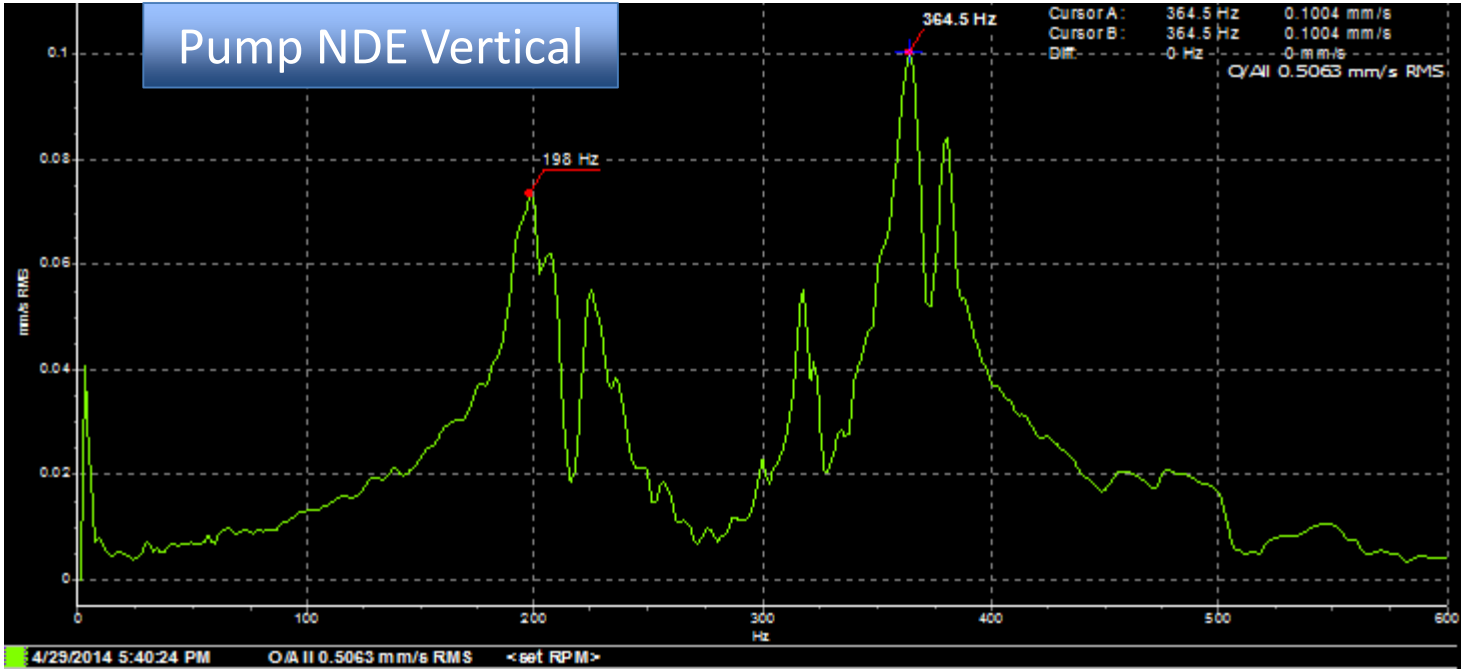
Data Analysis-Online Software





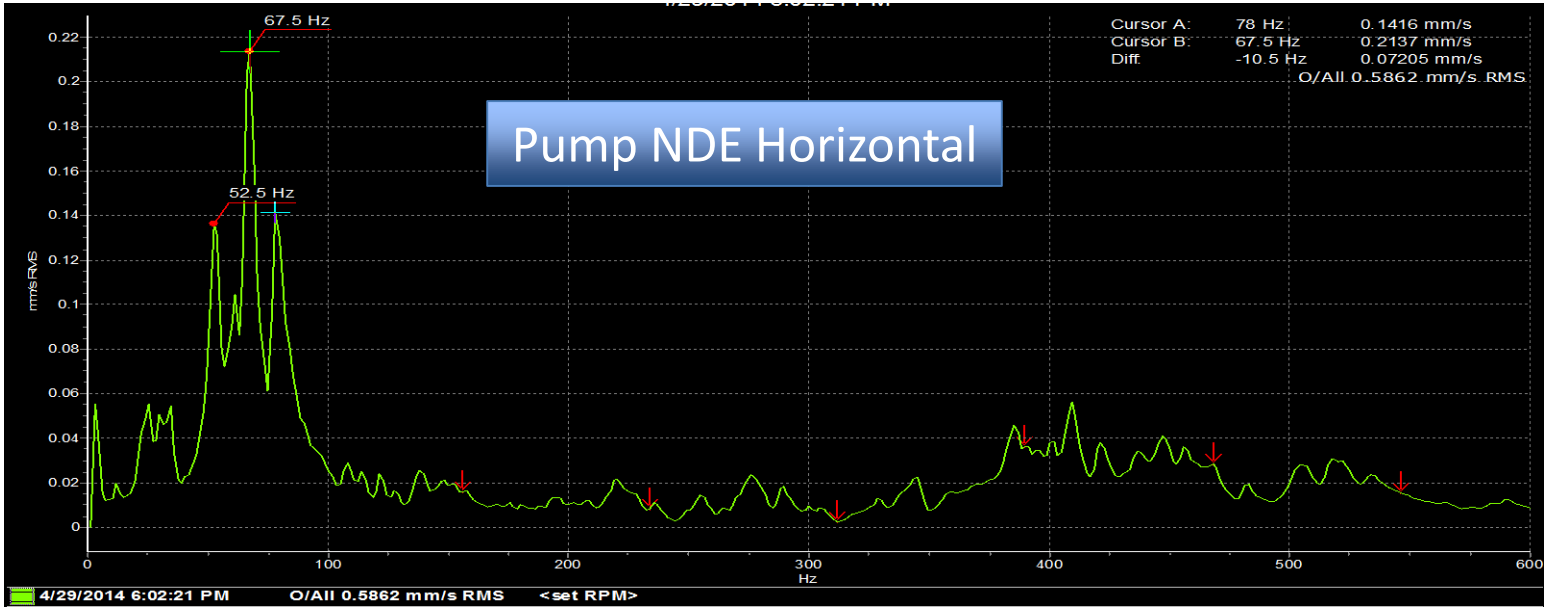
The online casing probe at Pump NDE Vertical showed high vibration (above 0.2 in/s rms) while crossing the speed range from 1850 to 2300 rpm.

Data Analysis-Bump Test “Vertical”



Pump NDE Vertical showed natural frequency at 198 Hz which is 5 times the running speed of 39.6 Hz

Data Analysis-Bump Test “Horizontal”

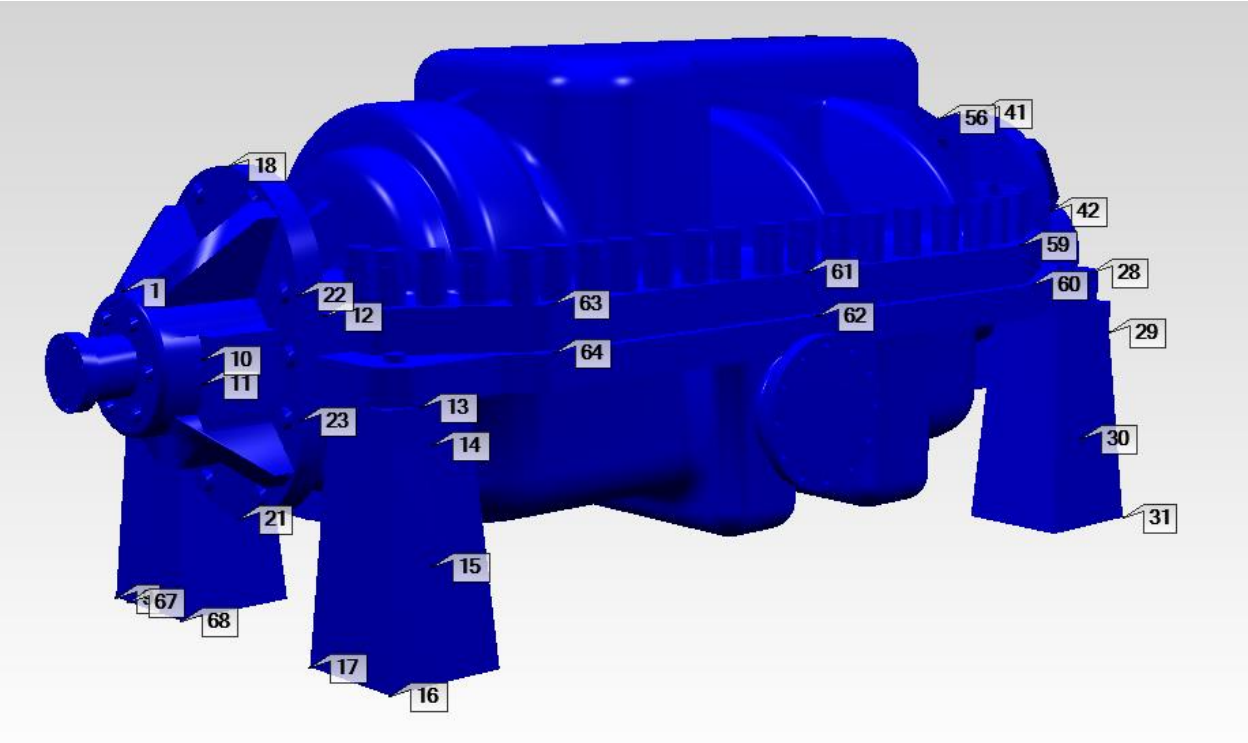


No evidence of natural frequency matching with the pump vane pass frequency in Horizontal direction

Data Analysis-ODS

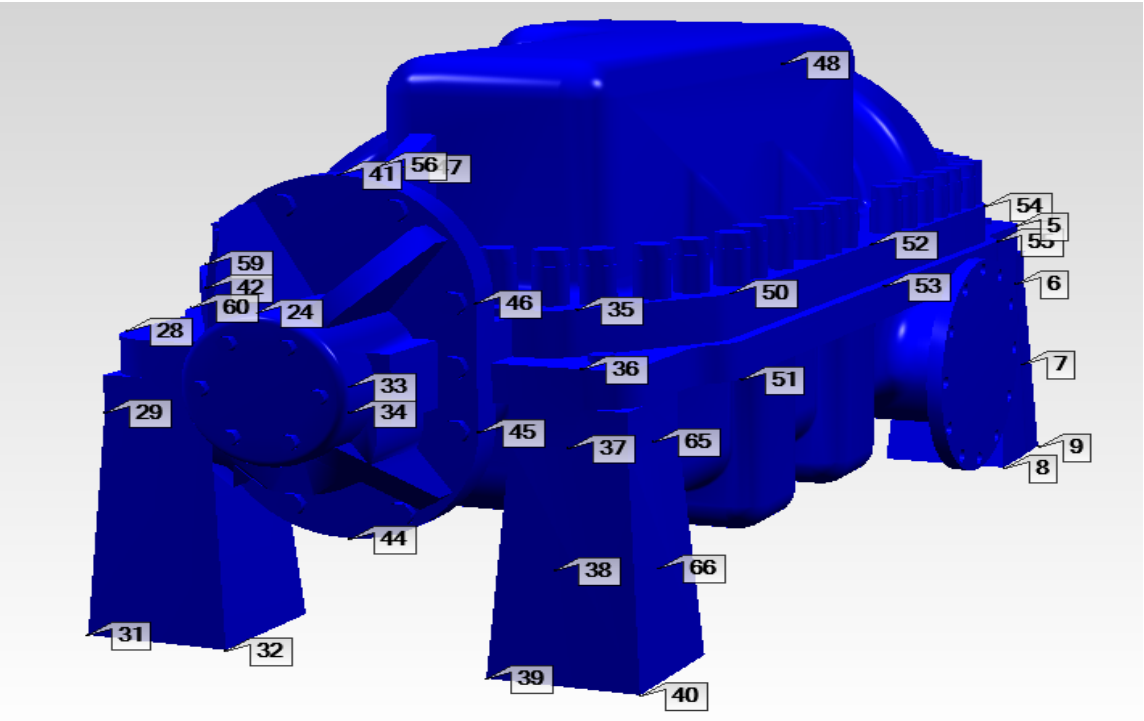
- The Operating Deflection Shape (cross spectrum) performed at 2388 rpm shows the motion of vibration at the rotating speed at 39.8 Hz and 199 Hz (5X).
- Both ODS from cross spectrum & ODS Frequency Response Function (FRF) shows a horizontal deflection at 1X.
- Both ODS from cross spectrum & ODS Frequency Response Function (FRF) shows a horizontal deflection at 5X.

Data Analysis-Measurement Locations



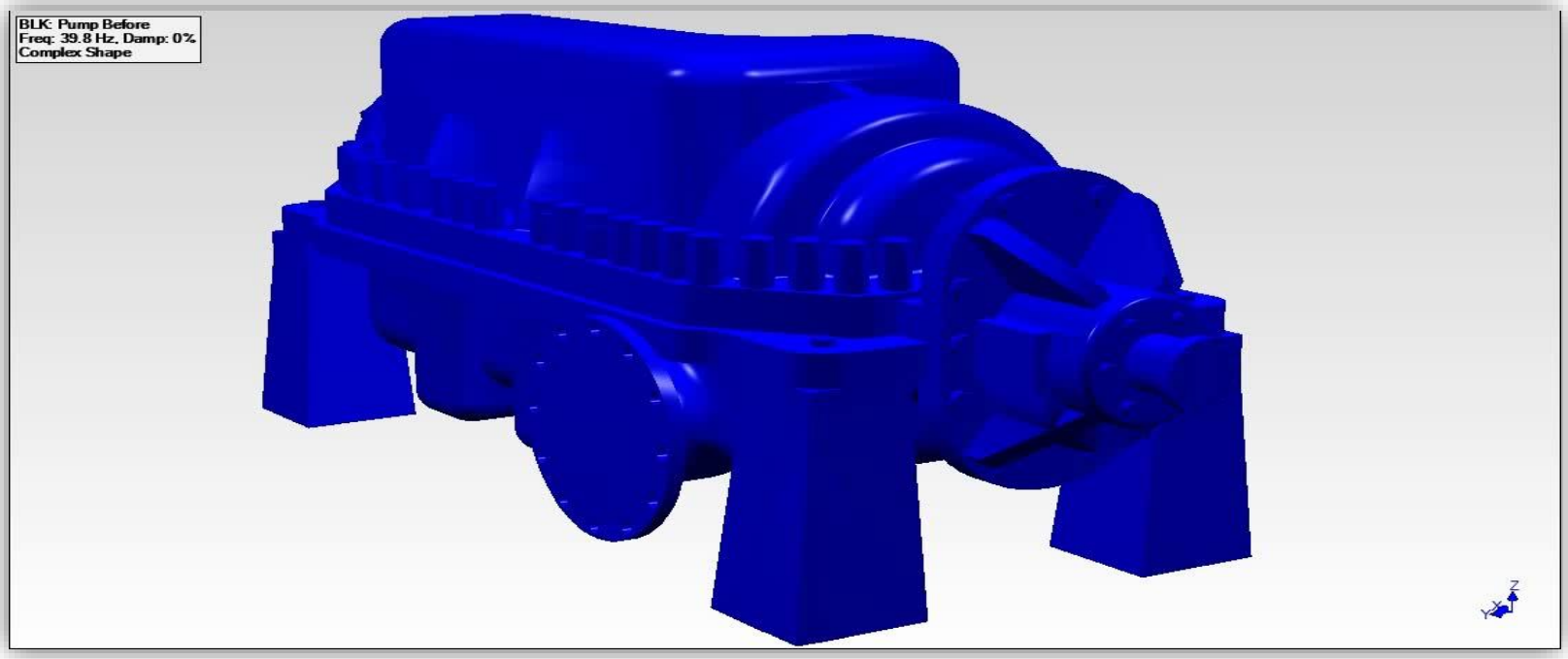
Looking from Pump DE side

Data Analysis-Measurement Locations



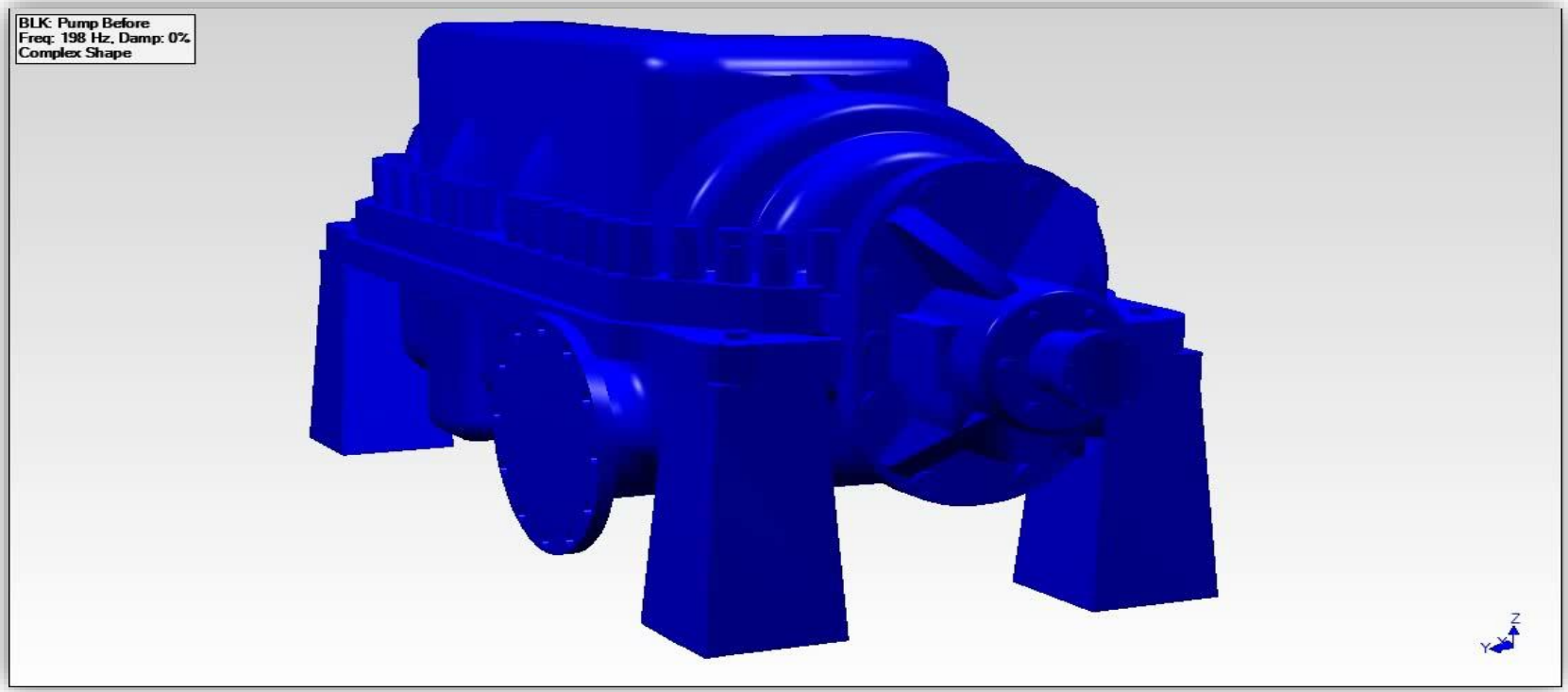
Looking from Pump NDE side

Data Analysis-ODS (At 39.8Hz “1X”)



Horizontal deflections at 1X (39.8 Hz)

Data Analysis-ODS (At 199Hz “5X”)



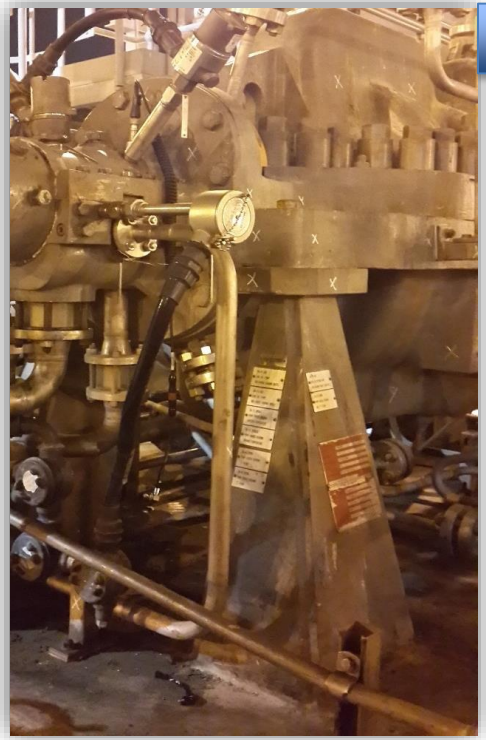
Vertical deflections at 5X (199 Hz)

Conclusion & Recommendations

- The pedestal of the pump support structure appears to be the weak point in the vertical and horizontal direction.
- The Non Drive End Bearing appears to move much more in the vertical direction than the Drive end bearing.
- Recommendation would be to modify the support pedestals of the pumps and to check the integrity of non drive end bearing housing mountings.

Action Taken-Old Pump Support Pedestal

DE Side



NDE Side

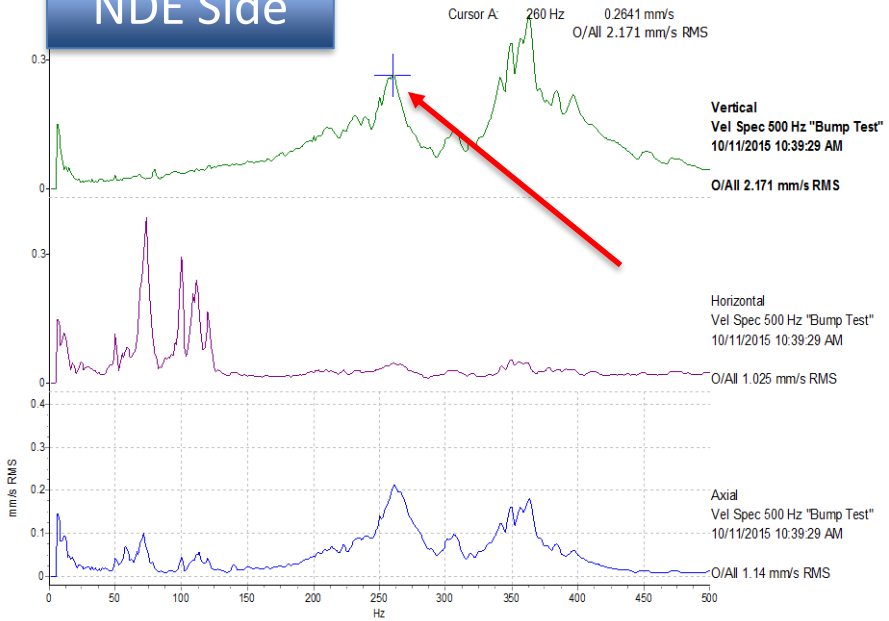
Action Taken-New Pump Support Pedestal

DE Side

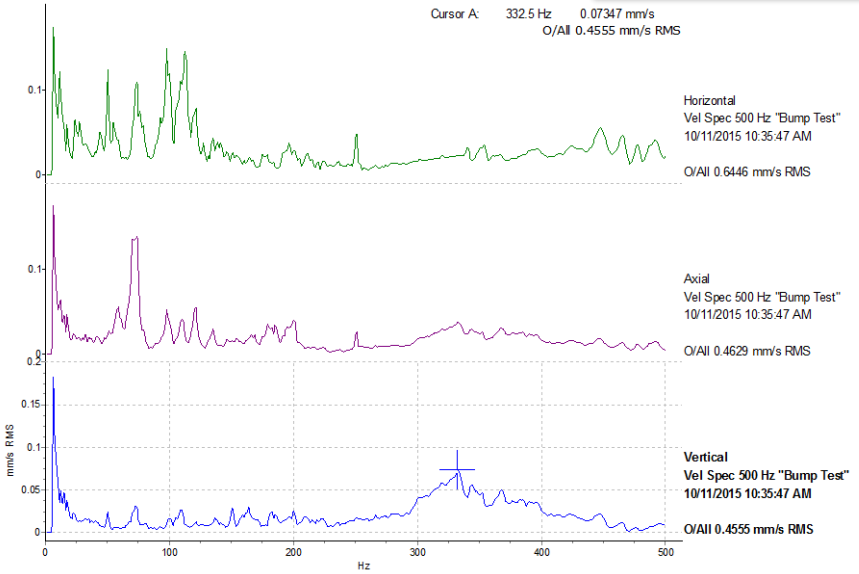
NDE Side

Post Analysis-Impact Test

NDE Side

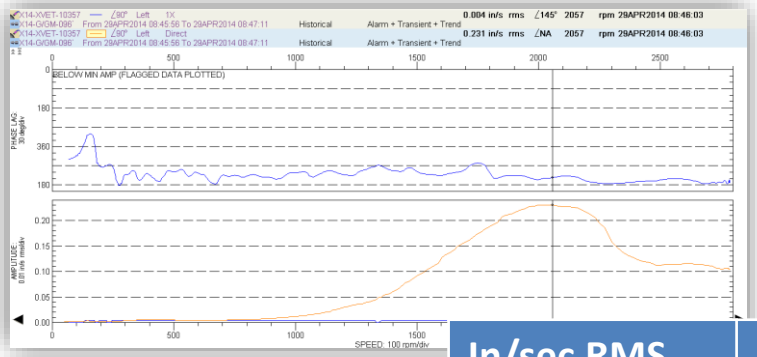


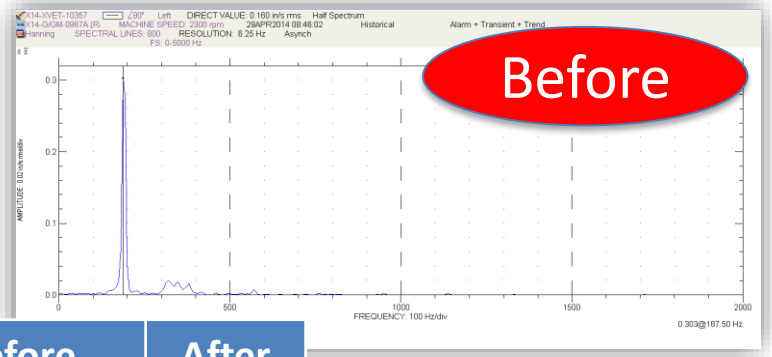
DE Side



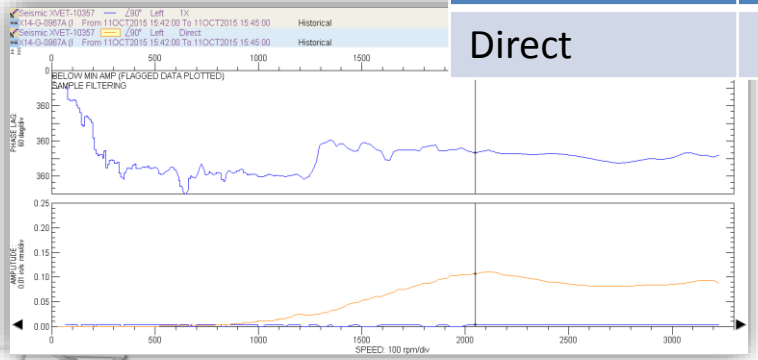
Pump NDE Vertical showed new natural frequency at 260 Hz after the modifications

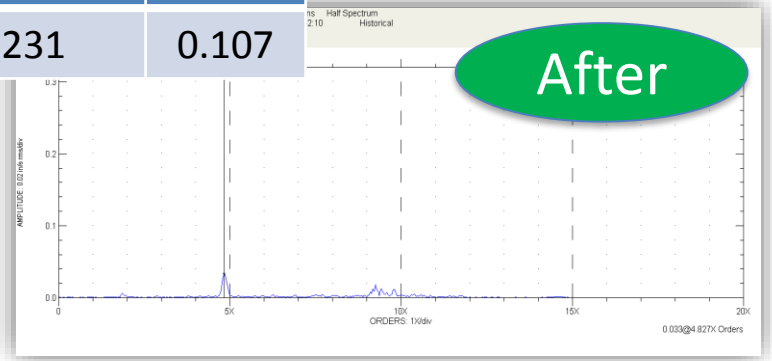
Post Analysis-System1 Data Comparison



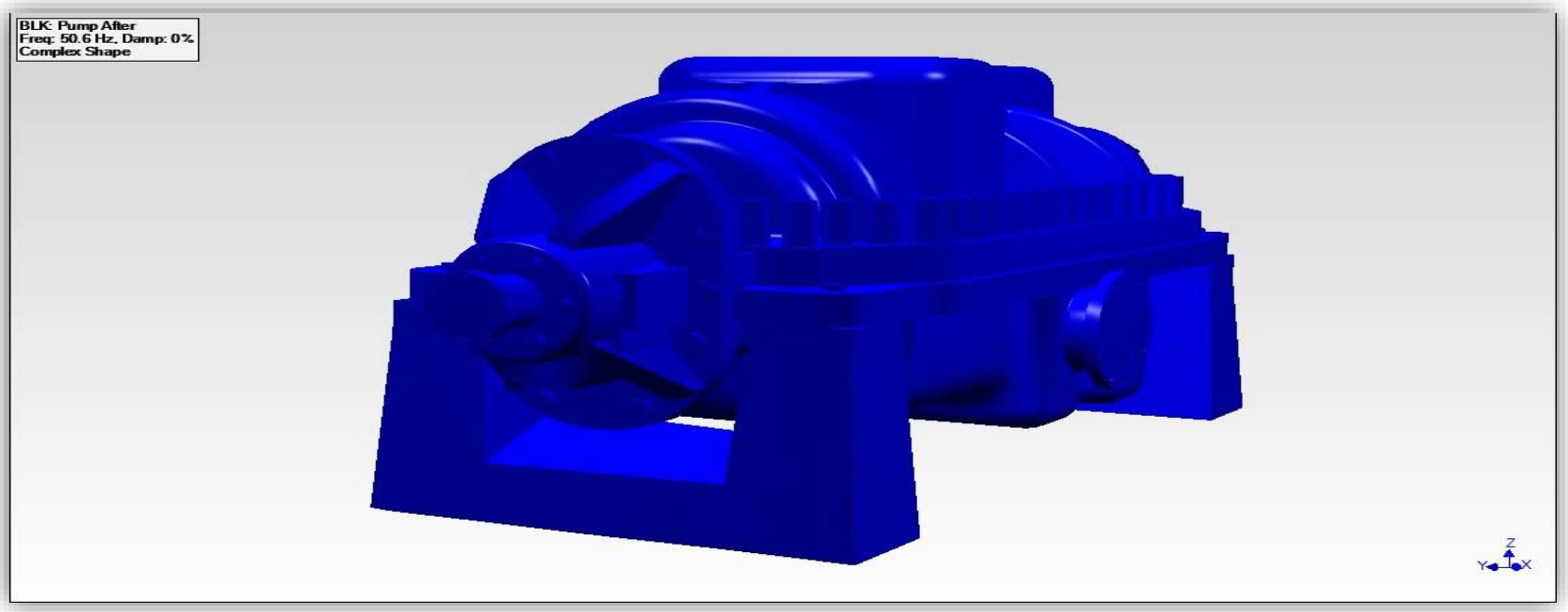


In/sec RMS	Before	After
Direct	0.231	0.107



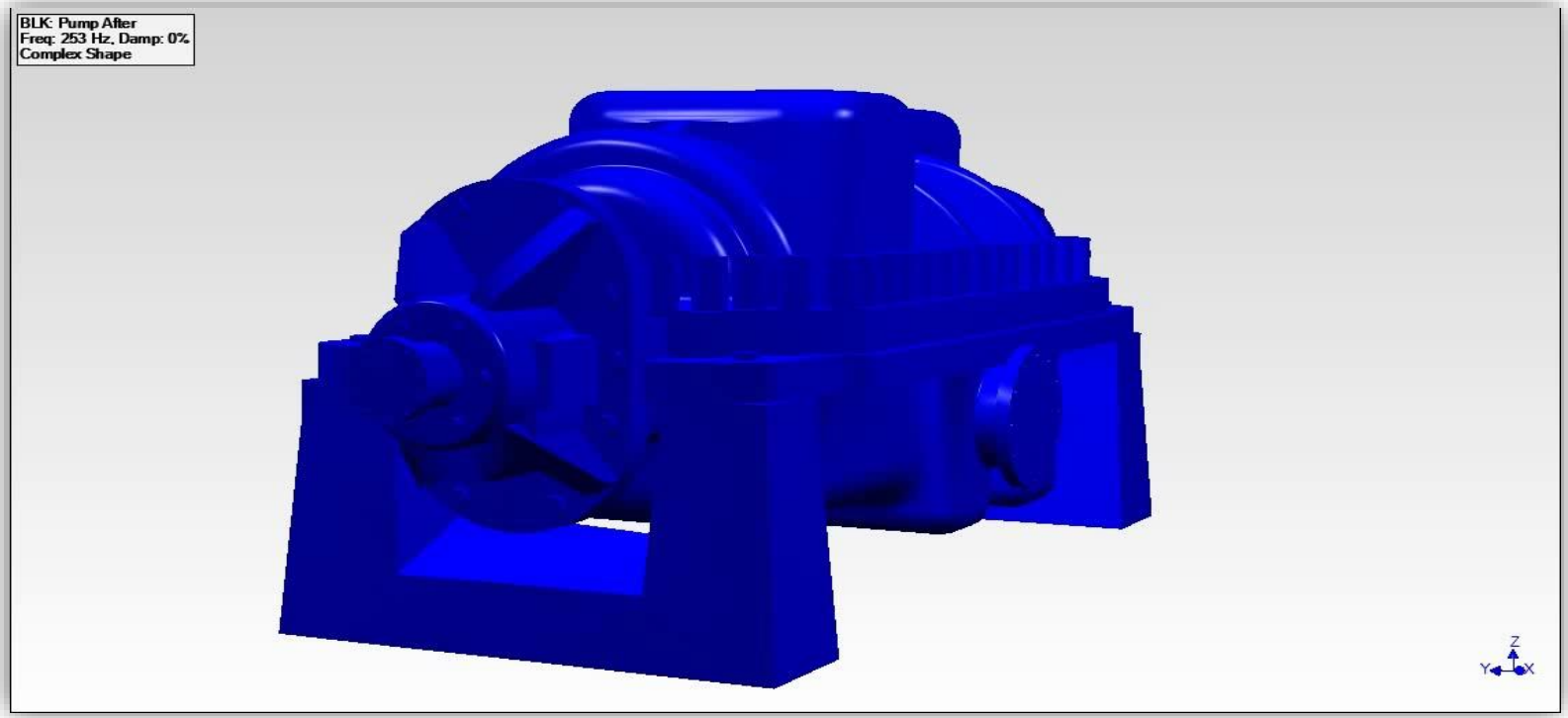


Post Analysis-ODS at 50.6Hz “1X”



Horizontal deflections at 1X (50.6 Hz)

Post Analysis-ODS At 253Hz “5X”



Vertical deflections at 5X (253 Hz)

Lessons Learned

- All contractual limits must be carefully verified during Factory Acceptance Test. Solving the problems during FAT will be much easier than during Site Acceptance Test (SAT).
- Understand the size of problem since beginning could save time, cost and efforts.
- Major modifications might be required whenever the problem is complex.

Questions??