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TEXAS A&M
UNIVERSITY



TURBOMACHINERY LABORATORY
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SILO EXHAUST FAN – STRUCTURAL VIBRATION ODS AND MA

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ABSTRACT

This case study outlines how structural vibration was resolved using two different technologies and highlighting secondary issues that can arise due to continued vibration because of structural resonance.

Continued high vibration due to structural resonance can induce fatigue in mechanical components and will cause them to fail. It is important to diagnose structural resonance very early to avoid catastrophic failures.

Two different technologies which have their own advantages and disadvantages were used to diagnose the root cause of the structural issue and corrective actions were carried out to improve the structural vibration.



Place of action- Kogan Creek PS- Chinchilla

Kogan Creek Power Station is located in the western down region in Queensland near a rural town, Chinchilla which is known as the Melon capital of Australia, about 300 Kms from Brisbane city.



FAN UNIT

Highly critical belt driven vacuum fan unit on an ash silo to prevent dust leakage to atmosphere

50% loss of production in case of failure

Motor Speed: 2640 RPM

Fan Speed : 2940 RPM



PROBLEM STATEMENT

During routine vibration survey high 1X vibration was noticed with harmonics of turning speed.

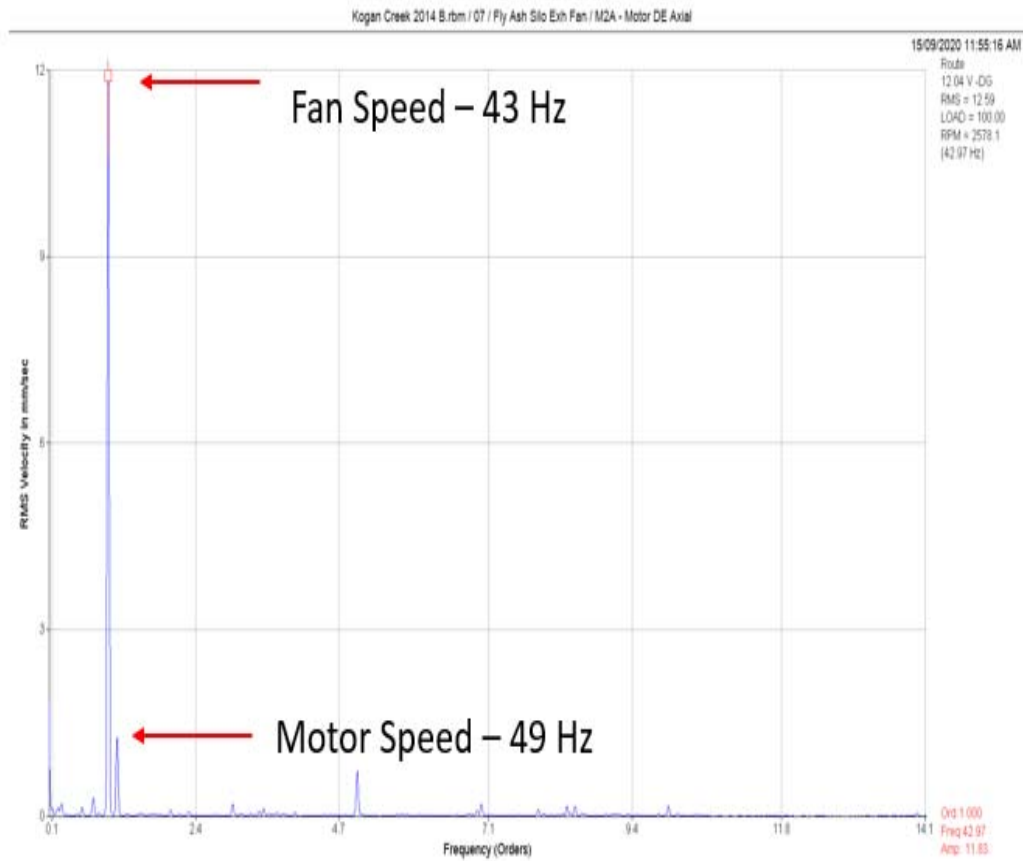
Due to operational requirements and criticality of this asset, a window of opportunity was not available to carry out repair work.

High vibration continued to be evident and it was decided to further diagnose with the ODS and MA camera recording to verify the findings of the vibration analysis.

Secondary damage in terms of bearing failure was also induced due to long term high vibration issue.



VIBRATION ANALYSIS



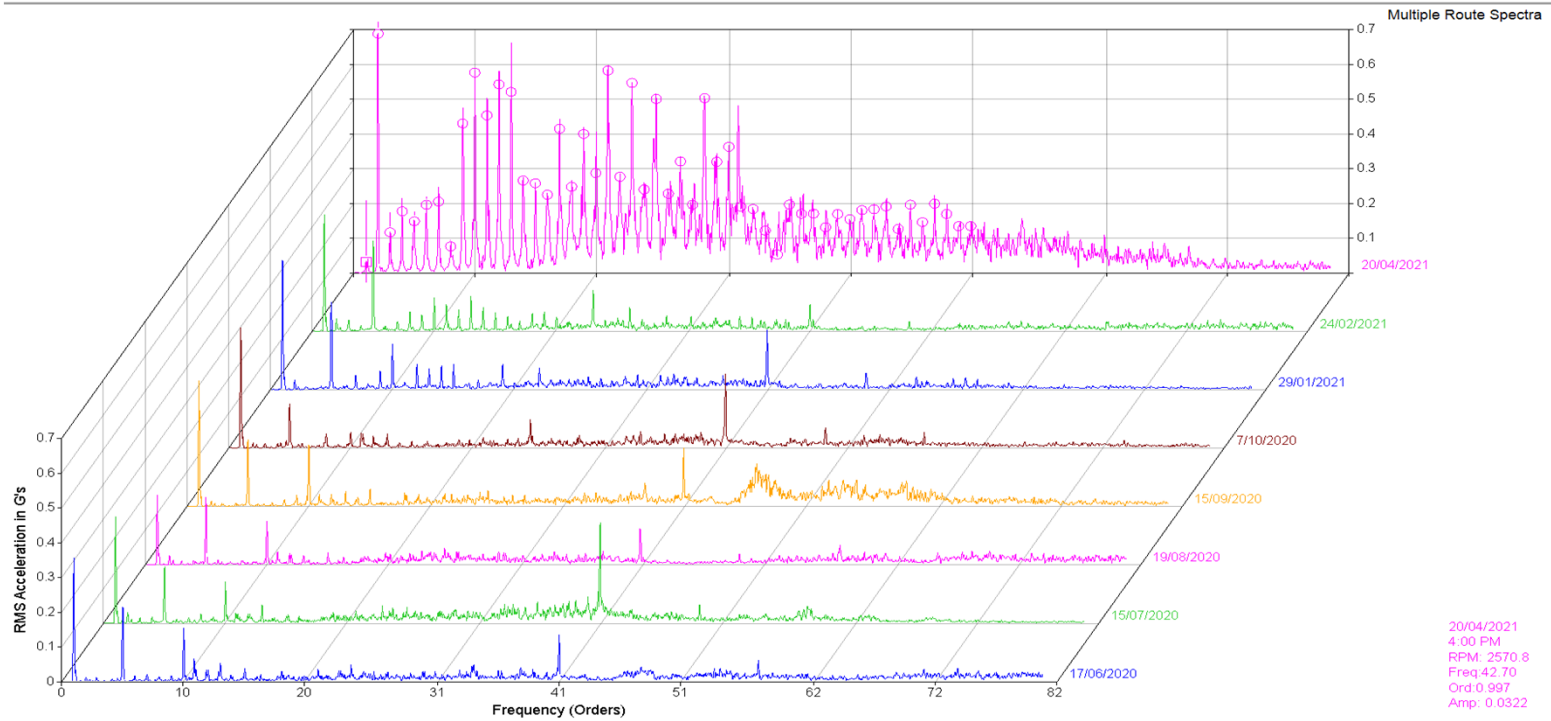


VIBRATION ANALYSIS

- High 1X Axial vibration evident at motor DE - 12 mm/s RMS. These high levels were consistent over couple of years.
- High 1X vibration in axial orientation is an indication of angular misalignment.
- Due to high structural deflection which we will see in the coming slides, motor and fan were out of alignment during operation.
- Cross channel phase analysis was also carried out confirming misalignment.

VIBRATION ANALYSIS

Kogan Creek 2014 B.rbm / 07 / Fly Ash Silo Exh Fan / F6V - Blower Hor DE 80 X TS



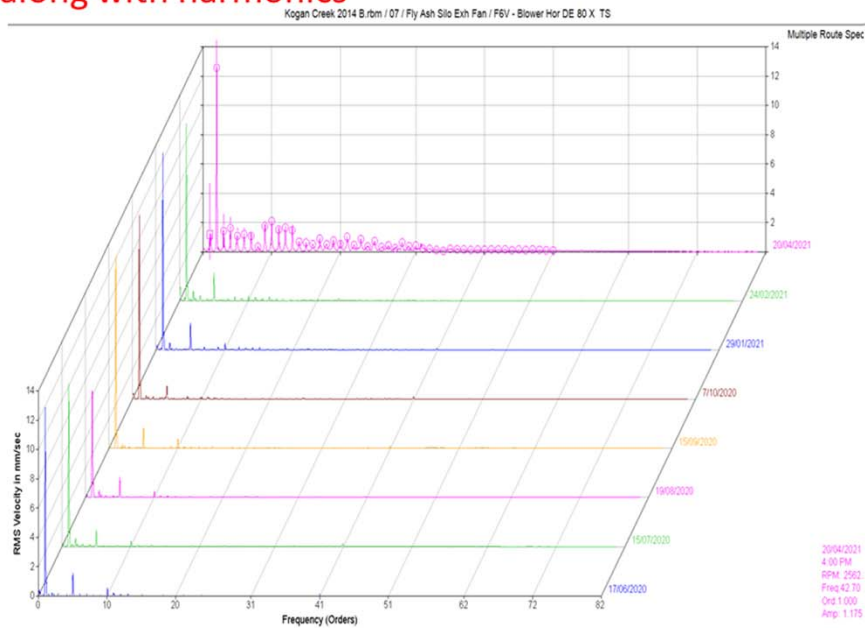
VIBRATION ANALYSIS

- Sudden appearance of fan speed harmonics which is an indication of developing looseness/clearance issue.
- Harmonics developed after the unit was already experiencing high vibration due to structural issue. Constant vibration has induced mechanical looseness.
- Raised noise floor activity is also an indication of rapid deterioration in the condition of the bearing.

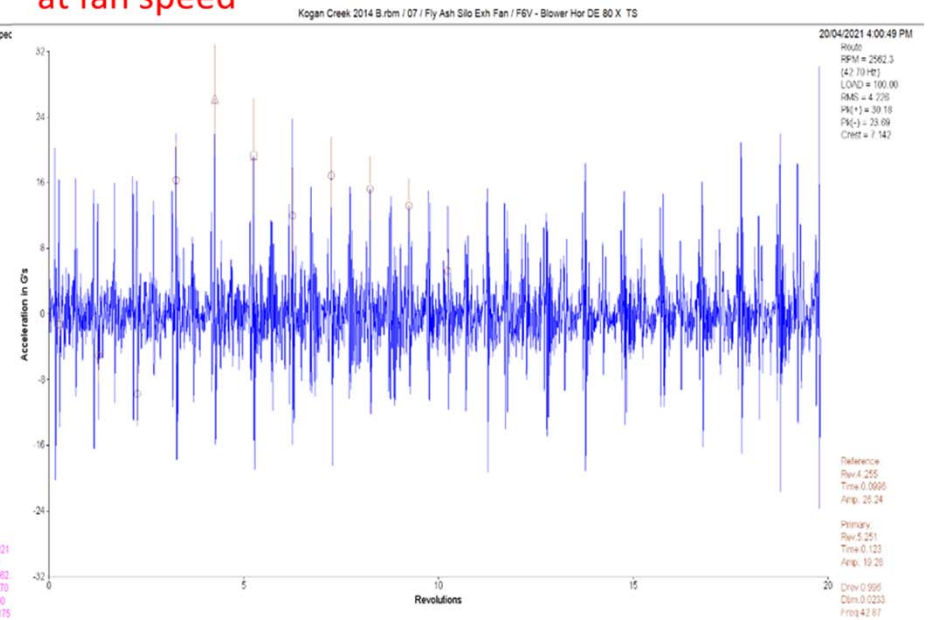


VIBRATION ANALYSIS

Spectrum showing elevated 2 X vibration along with harmonics



Time waveform showing impacting pattern at fan speed



VIBRATION ANALYSIS

- Waterfall plot in velocity scale showing high 2X (Fan speed) which is an indication of misalignment issue, deteriorated over a period.
- Also, time waveform showing high G's impact at fan running speed frequency.





DON'T GUESS, USE TECHNOLOGIES

- Troubleshooting involves using right tools to collect and analyze data to make correct recommendations, its not magic.
- For this case study various tools were used for diagnosing the issue and in this presentation ODS and MA camera will be highlighted.



WHAT IS ODS

- Operating deflection shape (ODS) determines how a structure vibrates in certain operating conditions.
- ODS is a combination of system natural frequencies and forces acting on the system.
- ODS shows the motion of a structure under various forces at any particular frequency or at a given time.
- ODS is any forced motion of two or more points on a structure and shape is the motion of each point relative to all other points.



WHAT IS MA

- Motion Amplification (MA) is a technology where it enables analysts to visually observe the displacement of a structure which may not be visible to the naked eye. High speed machine grade camera with patented algorithm is used to create a meaningful data file. The software effectively converts each pixel in the video image into a sensor that measures vibration and motions.
- In simple terms it's a video recording in ultra slow motion!



COMPARISON ODS AND MA – PRO's

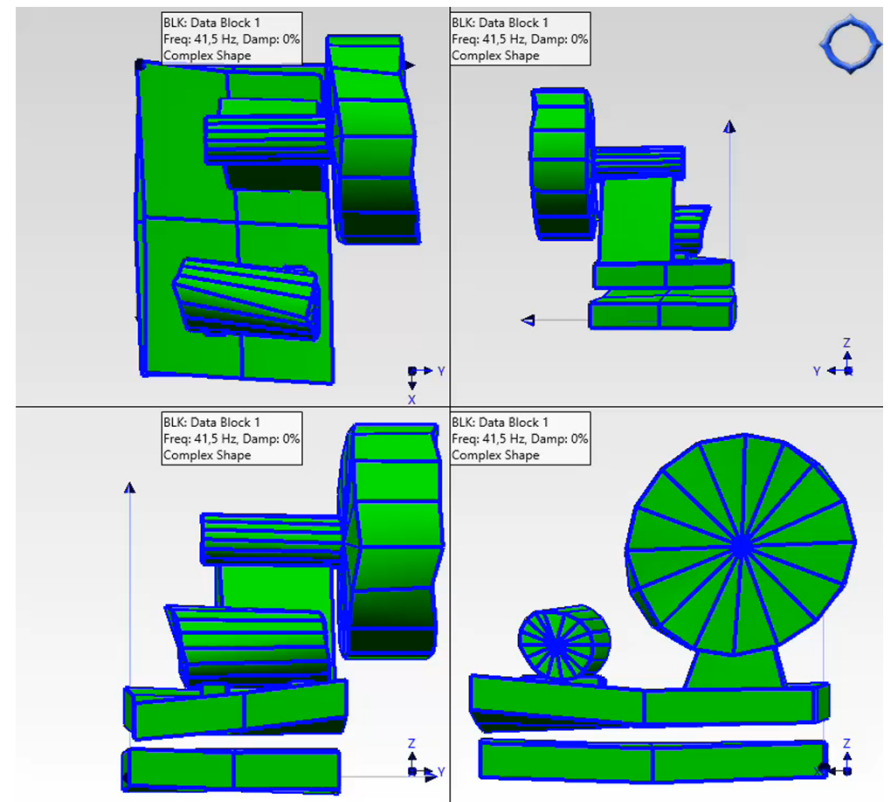
ODS	MA
<ul style="list-style-type: none">▪ Very Precise 3-dimensional data▪ Reliable amplitude and measurement▪ Good lighting not required	<ul style="list-style-type: none">▪ Easy to set up▪ Good communication tool for the customer to see in an instant▪ Instant results

COMPARISON ODS AND MA – CON'S

ODS	MA
<ul style="list-style-type: none">▪ Time consuming▪ More prone to errors during data collection▪ Needs separate software▪ Needs to be trained in modelling	<ul style="list-style-type: none">▪ Lighting can affect video quality▪ Only 2 axis measurement▪ False amplitude reading if there is instability▪ Maximum frequency limitation

DATA REVIEW - ODS

- From the modelling it was clear that substantial deflection was noticed at the base of the structure especially below the motor NDE.
- Twisting motion of the motor is also evident, potentially inducing dynamic misalignment.
- Animation shows structural stiffness issue.



DATA REVIEW- MOTION AMPLIFICATION

- From the MA camera recording we can see the support base flexing similar to what was seen in ODS animation.
- As seen in ODS animation significant movement is also noticed in motor and pulley structure causing the unit to go out of alignment.



CORRECTIVE MEASURES

- Post recommendations customer carried out modelling and stiffened the structure on all three sides of the base plate and the rubber isolators were replaced.
- From the image it is evident the deflection is minimized post modification when same load is simulated

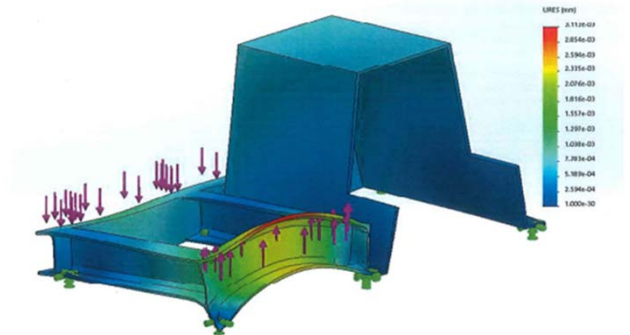


Figure 4: Original Frame - Deflection Simulation Result - Deflection Scaled up by 46000:1

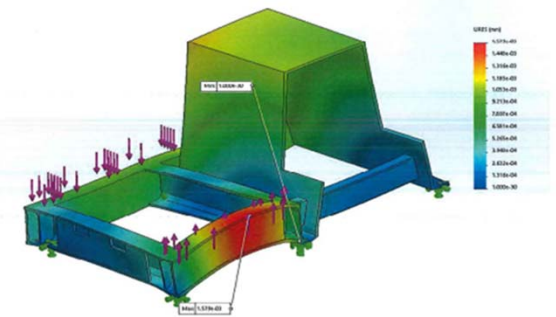
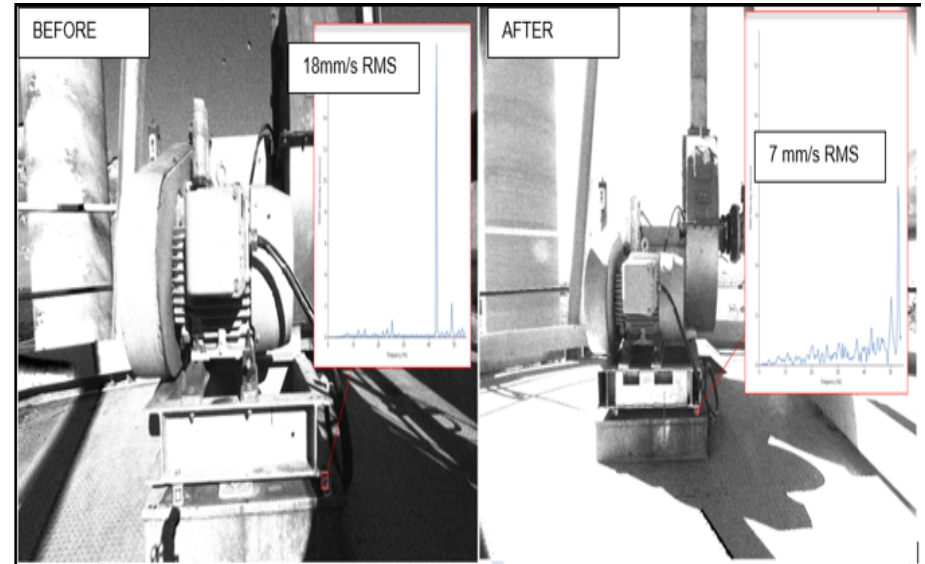
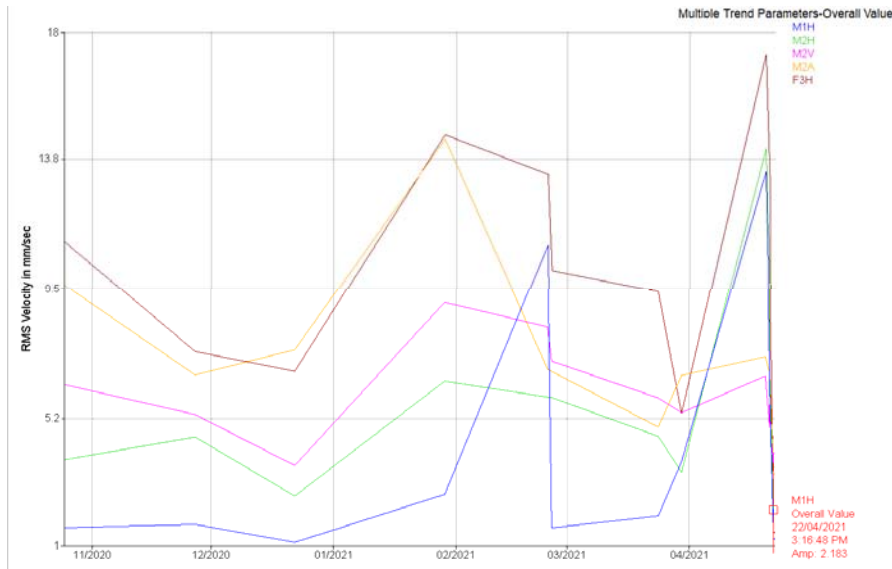


Figure 5: Modified Frame with Stiffener Plates with reduced peak deflection - Deformation Scaled up by 16000:1

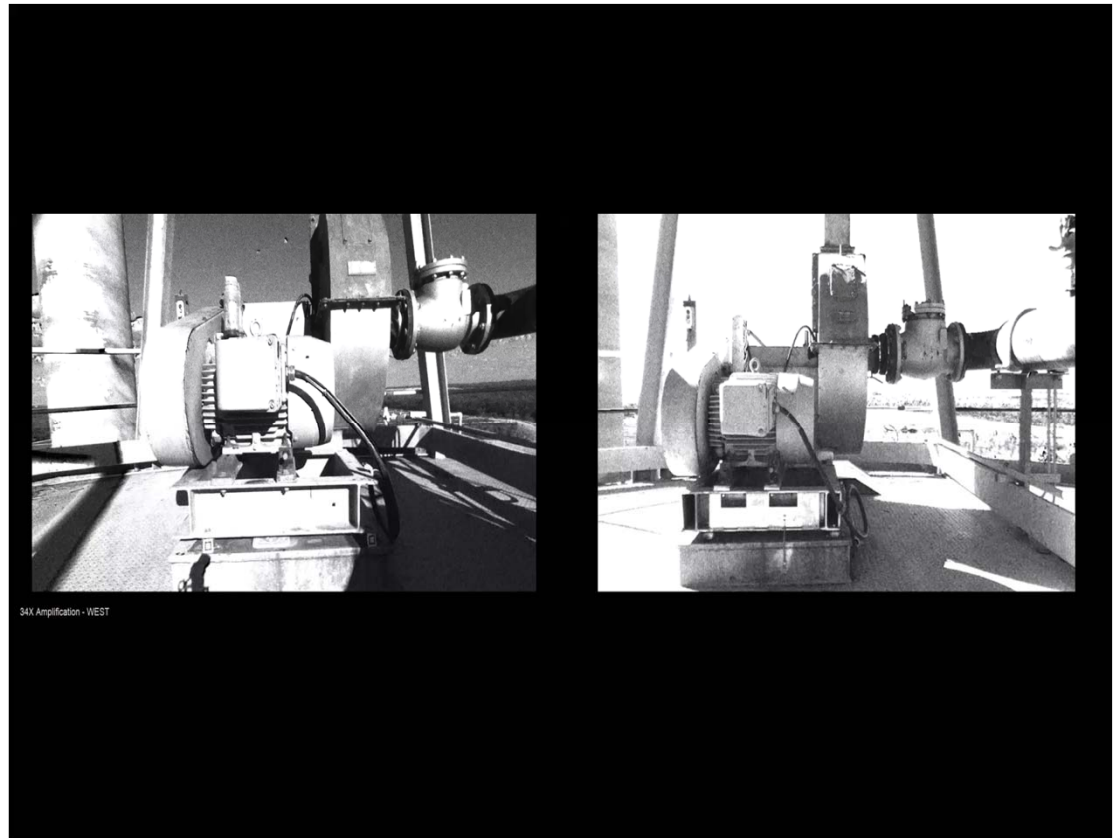
POST-CORRECTIVE MEASURES



Substantial improvement was noticed at both motor and fan points post repair.

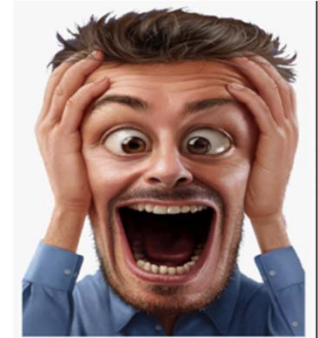
POST MODIFICATION – MA CAMERA REC

Post modification
substantial
improvement was
noticed in the vibration
levels



LEARNINGS

- Continuous high vibration over a long period can cause significant secondary damage and, in some cases, environmental and safety issues.
- In the image we can see the taper lock has worked its way into the middle of the shaft at high level of vibration whilst in operation.



CONCLUSION AND RECOMMENDATION

- From the evidence collected from ODS and MA it was quite evident a structural stiffening was required along with replacement of rubber isolators.
- Modelling was carried out to identify the flexing points and appropriate stiffening exercise was carried out to improve the vibration levels.
- Increased structural vibration can lead to secondary structural damage which is shown in the following slides.
- For any asset it is important to have a very strong structural base to avoid resonance issues and other secondary induced problems.

