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Mitigation of Resonance Problem in Turbine Generator Housings at Captive Power Plant

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Abstract: In a power plant, the Turbine and Generator are among the most critical assets in the power plant. Any high vibration behaviour during their operation or commissioning can raise serious unexpected failure and potential operational risks. Resonance is very typical condition in equipment which causes catastrophic failure of the equipment.

A chronic high-vibration issue was observed at the Generator Front Bearing (BRG-4) of Turbine Generator Detailed vibration analysis, including spectrum analysis, shaft orbit plots, phase analysis, and structural bump tests, identified the presence of a resonance condition, this condition effects in turbine and generator as Excessive vibrations, Fatigue and structure damage, Bearing and shaft misalignment and also reduces equipment's operational life.

Root cause investigation revealed a minor gap between the stator bolts and the concrete foundation, which compromised stiffness and enabled structural resonance. To mitigate the issue, epoxy grouting using Monopal liquid was strategically applied at identified antinode locations.

The grouting significantly improved structural stiffness and damping, thereby shifting the system's natural frequency away from the forcing frequency. Post-rectification measurements demonstrated a drastic reduction in vibration amplitude at BRG-4—from 30.91 mm/s to 7.95 mm/s, bringing the system back within safe operating limits. Other turbine section vibrations also normalized. This case effectively demonstrates how resonance-induced vibration can be addressed through structural modification and damping enhancement using epoxy grouting techniques.

Keywords: Resonance condition, Vibration analysis, Fatigue and structure, Stiffness, Catastrophic failure, Bump test, Epoxy grouting, Monopal liquid, Antinode points

I. INTRODUCTION

Hindalco Mahan plant having 6X150 MW captive power plant for supplying uninterrupted power to smelter. High vibration levels in mechanical systems are a critical concern in many industrial applications, as they can lead to equipment degradation, reduced operational efficiency, and catastrophic failure if left unaddressed. One of the most challenging and often overlooked causes of excessive vibration is resonance, this is condition that occurs when the natural frequency of a system coincides with the frequency of an external excitation source. When resonance is present, even relatively small excitation forces can result in disproportionately large amplitude responses, posing significant risks to system integrity and safety. In rotating machinery and structural systems, resonance-induced vibrations are particularly problematic due to the cyclic nature of dynamic loads and operating frequencies. These conditions can arise during start up, shutdown, or steady-state operation when excitation frequencies align with the system's natural modes. Identifying, diagnosing, and mitigating resonance is essential for ensuring long-term reliability and performance.

The SDOF model shown in Fig. 1. Here it will be referred to as system A. The stiffness, damping, and mass are *k*, *c*, and *m*, respectively. The undamped natural frequency is given by with a sinusoidal force applied to the mass, the differential equation of motion

$$m\ddot{x} + c\dot{x} + kx = F\sin(\omega t)$$

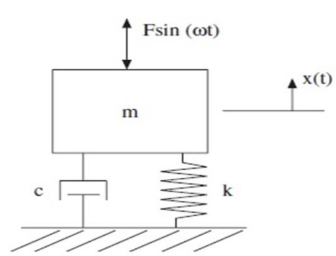

Fig-1: Single degree of freedom vibration model

Forcing function is opposed by only three things
1-System Inertia, 2- System Damping, 3-System stiffness
These three things are frequency dependant
At low frequency below resonance- Stiffness is primary control
At resonance frequency – Damping control the motion
At higher frequency above resonance- Inertia tends to control the motion
Hindalco Mahan turbine generator system having 5 nos bearing in which bearing no-4 was having chronic issue of high vibration, Due to this other problem were being developed like Misalignment, Looseness, Bearing oil film instability.

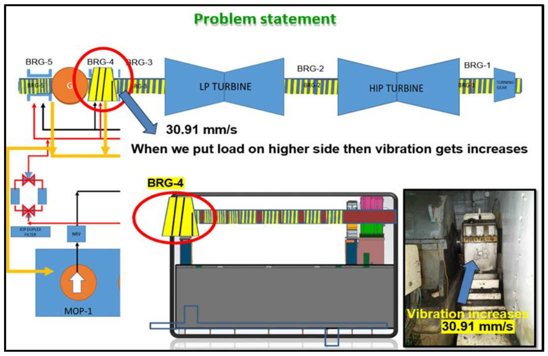

Fig-2: Vibration problem schematic view

This genrator front bearing housing is shown in fig-2 as BRG-4 this bearing having very high vibration amplitude at Horizontal direction. During vibration mappling antinode point of this condition were identified and it was mapped in concern structure sectional drawing.
Antinode points refer to locations along the shaft where the vibration amplitude is at a maximum

Before Rectification	
TG#2 Housing Vibrations	Overall Vib.(mm/s)-Max
HP Turbine Housing Vibration (Vel.-pk)	1.74
IP Turbine Housing Vibration (Vel.-pk)	3.29
LP Turbine Housing Vibration (Vel.-pk)	3.88
Generator Front Housing Vibration (Vel.-pk)	30.91
Generator Rear Housing Vibration (Vel.-pk)	10.66

Table-1: Vibration readings before rectification

As shown in Table-1 Maximum vibration amplitude was 30.91 mm/s which was in critical zone according to ISO 10816 severity chart. Table-1 is showing turbine TG housing vibration data which is showing high.

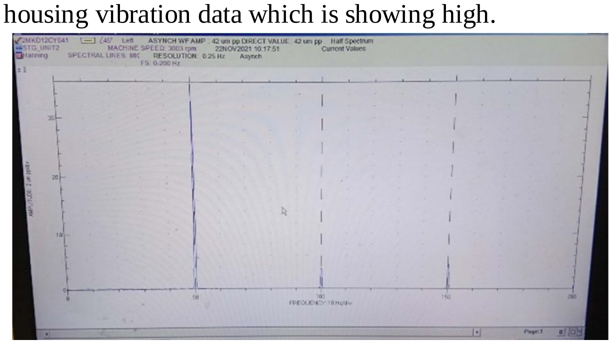

Fig-3: Vibration spectrum trend
Fig-3 showing the vibration spectrum at generator front bearing location, fig-3 is showing 1X is dominant.
Phase analysis of the bearing housing and foundation also done.

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II. METHODOLOGY

With vibration spectrum and signature analysis it was clear that 1X was dominant which is the indication of many problems of machine-like Unbalance, Misalignment, Bearing fault, Bearing looseness and many other problems.

During phase analysis phase was shifting 90 Deg which was indication of resonance problem, Resonance is the condition when natural frequency coincides with forcing frequency and can cause dramatic amplitude amplification which might result in premature or even catastrophic failure.

Fig-4: Bump hammering test

Fig-5: Bump testing negative averaging method

Structural bump test is good tool to identify the natural frequency of the object so generator natural frequency was identified with bump test as shown in fig-4 and fig-5 this frequency was matching the forcing frequency of the generator so this was a typical resonance condition resulting very high vibration amplitude in Generator front housing 30.91 mm/s (pk) resulting some other cracks were also being developed in other structures and foundation become weak.

As per bode plot in the fig resonance problem was there due to shifting the phase 90 ° as shown in fig-6

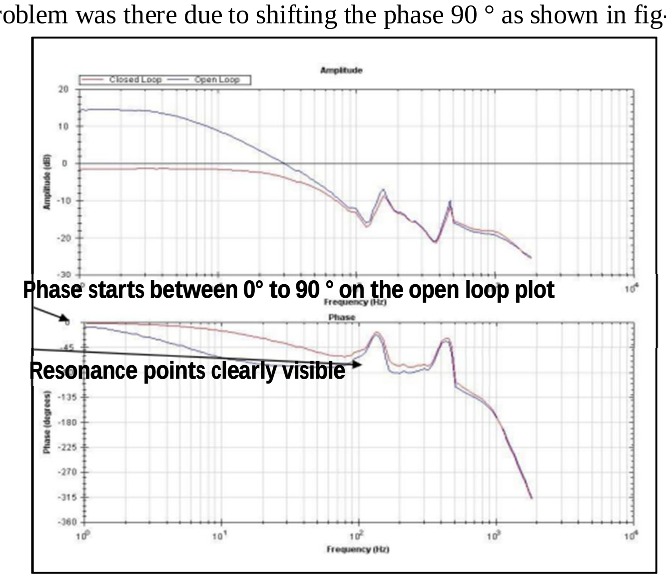

Fig-6: Bode plot

A. Factor Influence The Resonance Condition

- Natural frequency affected by mass, stiffness, Inductance and capacitance, length and tension.
- Damping reduces the amplitude of resonance.
- Driving frequency or external source frequency.

B. Why Epoxy Is Considered For Fixing The Problem

Vibration amplitude at one bearing was very high while other bearing vibration was Normal so change in natural frequency through stiffness, mass change shifted resonance frequency.

Epoxy grouting can improve damping by enhancing contact and reducing micro-movement.

Epoxy Increased Stiffness with Some Energy Absorption, although epoxy is typically a stiff material, it can absorb some vibrational energy due to its viscoelastic nature, especially when used in polymer-modified or hybrid formulations. This contributes to higher structural damping compared to dry or poorly bonded interfaces.

By improving the stiffness and bonding of the system, epoxy grout helps shift natural frequencies, which can reduce resonance effects and improve dynamic performance.

After detailed brainstorming, drawing study and why why analysis we identified the root causes of resonance problem.

This resonance was due to minor gap between starter bolt and concrete which was creating resonance condition in the system resulting high vibration at generator front bearing. During our inspection we found some strategic points in stator, we thought that we can go for increasing the damping at that point for shifting resonance frequency and reducing the vibration amplitude.

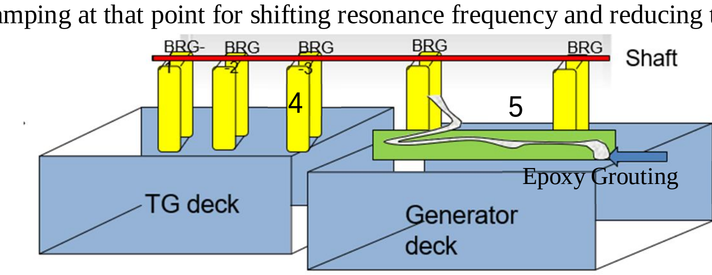

Fig-7: Schematic diagram where epoxy grouting done

As shown in Fig-7 at two strategic antinode points locations we had done the epoxy grouting wherein monopal liquid absorbed approx. 100 litre. And after 72 hrs of soaking period we again started the machine.

III. RESULTS

After implementing epoxy grouting monopal liquid at strategic locations and proper curing. There was drastically change in vibration amplitude at generator front bearing which was reduced and come in Normal range as shown in Table-2.

Now Equipment overall health was improved from critical zone to Satisfactory zone.

TG#2 Housing Vibrations	Overall Vib.(mm/s)-Max
Before Rectification	
HP Turbine Housing Vibration (Vel.-pk)	1.74
IP Turbine Housing Vibration (Vel.-pk)	3.29
LP Turbine Housing Vibration (Vel.-pk)	3.88
Generator Front Housing Vibration (Vel.-pk)	30.91
Generator Rear Housing Vibration (Vel.-pk)	10.66
After Rectification Vibration reduced	
HP Turbine Housing Vibration (Vel.-pk)	2.13
IP Turbine Housing Vibration (Vel.-pk)	1.65
LP Turbine Housing Vibration (Vel.-pk)	3.02
Generator Front Housing Vibration (Vel.-pk)	7.95
Generator Rear Housing Vibration (Vel.-pk)	7.11

Table-2

IV. CONCLUSIONS

The persistent high vibration issue at the generator front bearing (BRG-4) in Unit-2 of the Hindalco Mahan captive power plant was identified to be a result of a resonance condition. Detailed vibration spectrum, phase, and bump test analyses confirmed that the natural frequency of the generator structure matched its forcing frequency, amplifying the vibration to a critical level of 30.91 mm/s (as per ISO 10816 standards).

Through root cause analysis, it was discovered that a minor structural gap between the stator bolts and the concrete foundation was enabling resonance. Epoxy grouting using monopal liquid at identified antinode points significantly enhanced the stiffness and damping characteristics of the foundation, effectively shifting the natural frequency and mitigating the resonance effect.

Post-rectification results demonstrated a substantial drop in vibration levels at the generator front bearing—from 30.91 mm/s to 7.95 mm/s—bringing it within acceptable limits. This case study underscores the importance of accurate vibration diagnostics, resonance identification, and the effectiveness of structural enhancement using epoxy grouting in improving machine reliability and preventing catastrophic failure.

V. ACKNOWLEDGE

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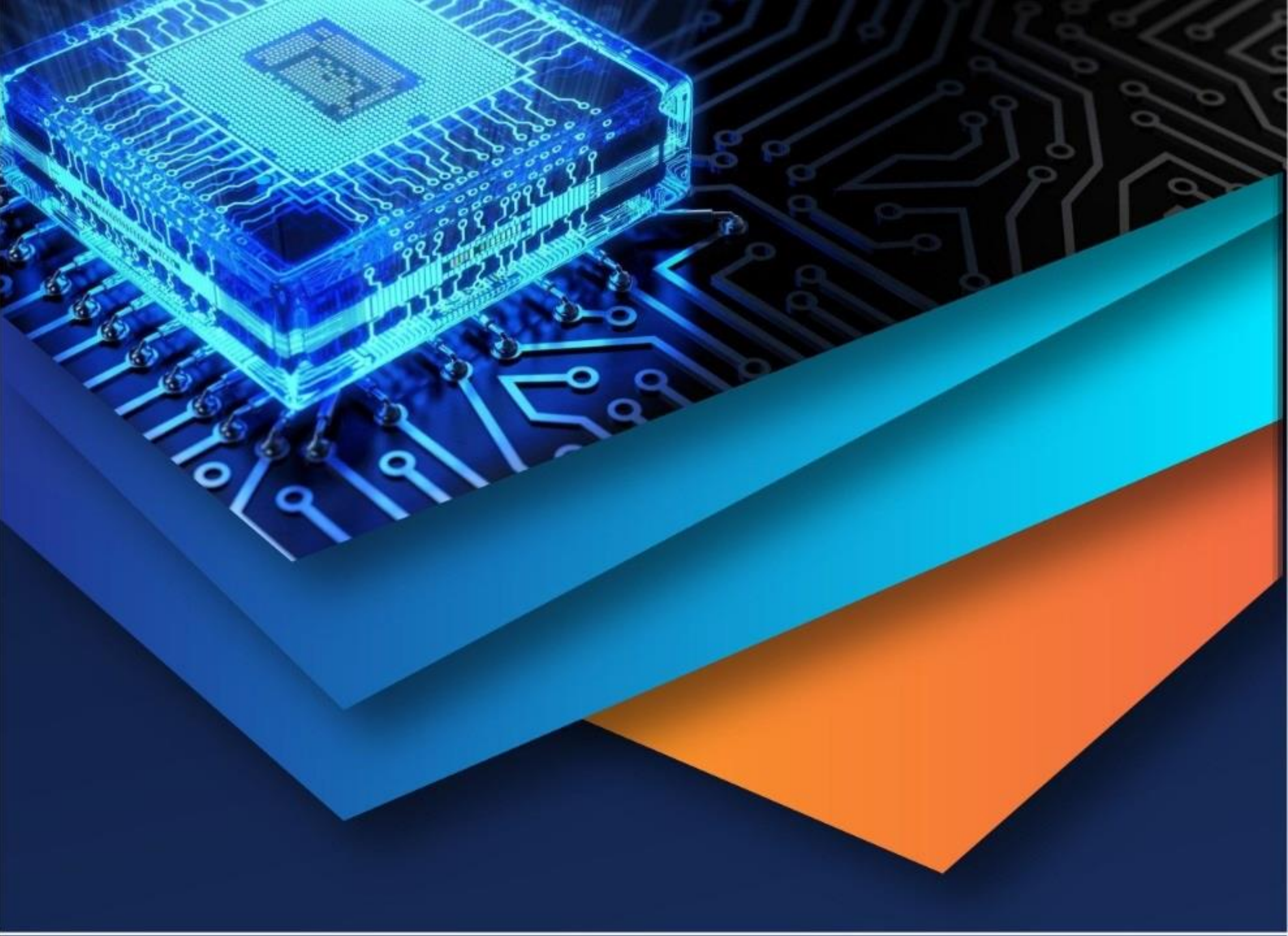
REFERENCES

[1] Vance, John M. Machinery vibration and rotordynamics / John Vance, Brian Murphy, Fouad Zeidan.p. cm.
[2] BHEL turbine generator civil base GA and sectional drawing.
[3] Mobius VCAT-III vibration analysis literature.
[4] NASA conference publication 3344 on Rotor dynamics problems in high performance machinery 1996.
[5] Vibration standards ISO10816 and ISO7919, ISO 20816-3:2022.
[6] Vibration standards ASTM E756.



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