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# Structural Integrity Deterioration causing Rotating machine Failures

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***Abstract:*** In Thermal power plants Rotating Equipment plays a vital role, the structural integrity of rotating machinery is critical for safe and efficient operation, Rotor lifetime and safety primarily depends on the level of rotor vibration. In order to avoid unwanted consequences for the plant due to rotor damage and to meet the highest requirements of design reliability, accurate rotor dynamic predictions are mandatory. Having the correct rotor model is critical issue in dynamics prediction. Often research activities are focused only on the rotor-bearing system analysis. However, generally the whole system, which includes the rotor, bearings, casing and structural supports should be considered. Special attention should be paid to the influence of structural supports which reveals when the rotor is supported with ball bearings because of low damping and high bearing stiffness.

The approach presented in this paper allows to simulate the influence of structural supports on rotor dynamics response and as a result, the full picture of rotor-bearing-support system resonances can be analyzed to avoid potential problems. The methodology is based on support vibrations modal reduction technics. According to the approach, the natural frequencies and their mode shapes should be calculated for the separate support structure applying a three dimensional finite element model and the relative displacements at bearing location points are measured. Supports' normalized model characteristics (model mass and model stiffness) for each vibration mode should then be imported in a rotor dynamics algorithm for rotor unbalance response analysis.

## I. INTRODUCTION

Rotating machinery, critical in industrial applications, often faces structural challenges such as fatigue, resonance, and deformation, which can lead to catastrophic failures and significant downtime. In this case study reviews the common failure mechanisms affecting rotating machinery, including high-cycle fatigue, resonance-induced vibrations, and structural deformations due to thermal or mechanical stress. Through a comprehensive analysis of existing literature and case studies, this paper identifies key factors contributing to structural issues, such as material defects, design flaws, and operational conditions. The review also discusses advanced diagnostic techniques and predictive maintenance strategies, including vibration analysis, acoustic emission monitoring, and finite element modelling, to detect early signs of structural degradation. Finally, the paper outlines best practices and mitigation strategies to enhance the structural integrity and reliability of rotating machinery, emphasizing the importance of design optimization, regular maintenance, and condition monitoring in preventing failures and extending the lifespan of critical equipment's.

In this case, we are discussing about Cooling water pipe stress & Base structural stress can significantly impact rotating machinery in several ways.

**IMPACT ON ROTATING MACHINERY & PROBLEMS FACED:**

Pipe-induced forces excessive stress or misalignment in cooling water pipes can exert forces on the machine's supports or nozzles, leading to shaft misalignment due to pipe-induced loads can cause vibration, increased wear on bearings, and potential failure, casing distortion stresses transferred to the machine casing can cause distortion, affecting clearances and leading to rubbing or increased vibration. leakage and contamination stressed pipes are more prone to leaks, which can introduce water into the machine's electrical or lubrication systems, causing, electrical failures, short circuits or corrosion in electrical components, lubrication issues, water contamination in oil systems can lead to premature wear and failure, it also reduces the pipe life, stressed pipes are more susceptible to fatigue, corrosion, or failure, leading to un-planned downtime, pipe failures can cause unexpected shutdowns, impacting production and safety, maintenance challenges, repairing or replacing pipes under stress can be time-consuming and costly.

**Effected on Machine Reliability :**

Increased vibration, pipe-induced forces or misalignment can lead to increased vibration, accelerating wear on bearings, seals, and other components, reduced mean time between failures (MTBF), stressed pipes and induced forces can reduce the machine's overall reliability and lifespan, increased maintenance costs, frequent repairs, replacements, and downtime can significantly increase maintenance costs and impact overall plant efficiency.

**Methodology :**

Proper pipe design and installation ensure pipes are designed and installed to minimize stress and loads on the machine, pipe stress analysis perform thorough pipe stress analysis to identify potential issues and optimize pipe routing and support, regular inspection and maintenance, regularly inspect pipes for signs of stress, corrosion, or damage, and perform maintenance as needed, use of flexible pipe connections, consider using flexible pipe connections or expansion joints to reduce stress and loads on the machine.

By addressing cooling water pipe stress and its impact on rotating machinery, we had improve machine reliability, reduce downtime, and optimize maintenance costs, when rotating machines are mounted on a concrete base, vibration issues can arise due to the dynamic interaction between the machine and the foundation. Here's a breakdown of the vibration transfer:

Vibration transfer mechanism, machine-generated vibrations, rotating machines produce vibrations due to, unbalance, misalignment, bearing defects, & electromagnetic forces
Transmission to concrete base, vibrations are transmitted to the concrete base through the machine's mounting points (e.g., anchor bolts, grout, or pads), base response the concrete base responds to the transmitted vibrations, which can amplify or attenuate the vibration, Introduce additional vibration modes, like rocking, torsional.

**Mitigation Strategies :**

Proper foundation design, the concrete base is designed to minimize vibration transmission and resonance, vibration isolation pads are used vibration isolators, like springs, pads, to decouple the machine from the concrete base, tuned mass dampers installed tuned mass dampers to absorb vibrations and reduce resonance, In regular maintenance practices, we regularly inspected and maintain the machine and foundation by using motion amplification methods, to prevent issues and ensure optimal performance.

By understanding the vibration transfer mechanism and implementing effective mitigation strategies, we had reduce vibration issues and improve the reliability and performance of the rotating machines.

When rotating machines are mounted on a structural base on the steel frame, platform, vibration issues can arise due to the dynamic interaction between the machine and the structure. these vibrations are transmitted to the structural base through the machine's mounting points, Eg-anchor bolts, welds, the

structural base responds to the transmitted vibrations, which can amplify or attenuate the vibrations, introduce additional vibration modes, Eg- bending, torsion.

In vibration Issues, the resonance, of the machine's operating frequency coincides with the natural frequency of the structural base, resonance can occur, amplifying vibrations and potentially leading to, increased machine vibration, reduced machine lifespan, increased stress on structural members or welds, vibrations can be transmitted to surrounding structures or equipment, potentially causing, disturbances to nearby equipment or sensitive instruments increased noise levels, structural damage or fatigue.

In the Mitigation Strategies, ensuring the structural base is designed to minimize vibration transmission and resonance, use vibration isolators springs, pads to decouple the machine from the structural base, structural reinforcement, like stiffeners, gussets are to increase the structural base's stiffness and reduce vibration, by regular inspection and maintenance the machine and structural base to prevent issues and ensure optimal performance.

By understanding the vibration transfer mechanism and implementing effective mitigation strategies, we had reduced vibration issues and improve the reliability and performance of your rotating machines.

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