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Discipline RT 4319 «Repair technology»

Module AP 9 «Production automation»

LECTURE NOTES

Topic 9. Rotor Balancing

1. Introduction to Rotor Balancing

Rotor balancing is an important maintenance and engineering procedure used to improve the reliability and operational stability of rotating machinery. It involves correcting the distribution of mass around the rotational axis of a rotor to minimize vibration during operation.

Rotating components are widely used in industrial equipment, including electric motors, pumps, compressors, turbines, fans, blowers, and gearboxes. During operation, even a relatively small uneven distribution of mass can generate significant centrifugal forces, particularly at high rotational speeds.

These forces create vibration, which can negatively affect bearings, shafts, mechanical seals, couplings, and machine foundations. Therefore, proper rotor balancing is essential for reducing dynamic loads, extending equipment service life, and improving operational efficiency.

2. Causes and Consequences of Rotor Imbalance

Rotor imbalance occurs when the mass of a rotating component is not distributed evenly around its rotational axis. As the rotor rotates, the uneven mass distribution generates centrifugal forces that act on the shaft and its supporting components.

Common causes of rotor imbalance include:

- Manufacturing and machining inaccuracies.
- Uneven material distribution.
- Accumulation of dust, dirt, or other deposits on rotating components.
- Corrosion and material loss.
- Wear of blades and impellers.
- Improper installation of rotating components.
- Damage or deformation during operation and maintenance.

Rotor imbalance can result in excessive vibration, increased bearing loads, shaft fatigue, loosening of mounting bolts, and premature failure of mechanical

components. In severe cases, it can cause equipment shutdown and damage to surrounding structures.

3. Types of Rotor Imbalance

There are three main types of rotor imbalance.

3.1. Static Imbalance**

Static imbalance occurs when the center of mass of a rotor does not coincide with its rotational axis. The rotor has a heavy point that tends to move toward the lowest position when the rotor is allowed to rotate freely.

This type of imbalance is commonly associated with relatively narrow rotating components, such as discs and wheels.

3.2. Couple Imbalance

Couple imbalance occurs when two equal but opposite imbalance forces act in different planes along the rotor. In this condition, the rotor may be statically balanced but still generate vibration during rotation due to the resulting rotating couple.

This type of imbalance is particularly important for long rotors.

3.3. Dynamic Imbalance

Dynamic imbalance is a combination of static and couple imbalance. It occurs when the mass distribution is uneven in several planes along the rotor.

This is a common condition in industrial rotating machinery and generally requires balancing in two or more correction planes.

4. Rotor Balancing Methods

Several methods can be used to identify and correct rotor imbalance.

- **Static balancing:** The rotor is placed on low-friction supports, allowing the heavy point to move downward. Material can be removed or additional balancing weights installed to correct the imbalance.

- **Dynamic balancing:** The rotor is rotated using specialized equipment that measures vibration and identifies the magnitude and angular position of imbalance.

- **Single-plane balancing:** Correction is performed in one plane and is generally suitable for relatively narrow rotors.

- **Two-plane balancing:** Correction is performed in two separate planes to compensate for both static and couple imbalance.

Dynamic balancing is widely used in industrial applications because it allows engineers to evaluate rotor behavior under rotational conditions.

5. Rotor Balancing Equipment

Modern balancing equipment includes balancing machines, vibration sensors, accelerometers, tachometers, and electronic measurement systems.

A balancing machine measures the vibration generated by an unbalanced rotor and determines the required correction mass and its angular position.

Portable balancing instruments can also be used to balance rotating equipment directly at the installation site. This approach is particularly useful when removing the rotor from the machine would require significant time and resources.

6. General Rotor Balancing Procedure

The balancing process generally includes the following stages:

1. Inspecting the rotor for mechanical damage, dirt, corrosion, and material accumulation.

2. Checking the condition of bearings and supporting structures.

3. Measuring the initial vibration level.

4. Determining the magnitude and angular position of the imbalance.

5. Calculating the required correction mass.

6. Installing or removing balancing material at the appropriate location.

7. Repeating the measurement to verify the correction.

8. Recording the final balancing results.

It is important to remember that balancing cannot correct all causes of vibration. Misalignment, bearing defects, looseness, bent shafts, and resonance may produce

similar symptoms. Therefore, these conditions should be investigated before performing balancing operations.

7. Benefits of Proper Rotor Balancing

Proper rotor balancing provides several advantages:

- Reduced vibration and mechanical stress.
- Increased bearing and shaft service life.
- Reduced noise during operation.
- Improved machine stability.
- Lower maintenance and repair costs.
- Increased equipment reliability and availability.

Conclusion

Rotor balancing is an essential engineering procedure for maintaining the reliability of rotating