Unbalance - The Common Cause of Vibration & Premature Bearing Destruction within Rotating Machinery Equipment

Unbalance is defined as an unequal distribution of mass causing the mass axis to differ from the bearing axis. During rotation, the unequal mass along with the radial acceleration due to rotation create a centrifugal force. This results in force on the bearings and/or vibration of the bearings.

Balancing is a procedure in which the mass distribution of a rotor is assessed and if necessary, adjusted via addition or subtraction of weight to ensure that the vibration of the journals and/or forces on the bearings are within specified limits. Vibration is a mechanical movement where an object oscillates about an equilibrium point. It commonly produces unwanted sound and wastes energy. Vibration in rotating equipment can greatly reduce the life of the equipment and the bearings.

Before studying the basic principles of balancing, one must keep in mind that there are many causes of vibration other than unbalance. In some cases, balancing may result in only a partial or temporary reduction in vibration, while in other cases balancing is the only effective course of action. Mechanical unbalance, which produces a force at 1 X RPM, has been found to be one of the most common causes of machinery vibration, present to some degree on nearly all rotating machines.

Causes of an Unbalanced Rotor

Unbalance is often defined as simply the unequal distribution of the weight of a rotor about its rotating centerline. Causes of unbalance include the following:

- Blow Holes in Castings
    - Occasionally, cast rotors such as pump impellers or large sheaves have blow holes or sand traps which result from the casting process. While undetectable through normal visual inspection, blow holes may be present within the material and create a significant source of unbalance.
- Eccentricity
    - Eccentricity exists when the geometric centerline of a part does not coincide with its rotating centerline. The rotor itself may be perfectly round; however, for one reason or another, the center of rotation is off centered.
- Addition of Keys and Keyways
    - A manufacturer may balance their product with a full key, a half key, or no key at all. Thus, if both a pulley and a motor manufacturer were to balance their components without keys, they would be unbalanced when assembled together with the added weight of a key.

- Distortion
    - Following manufacture, distortion, or change in shape, can alter the weight distribution and balance of a rotor. Distortion is commonly caused by stress relief or thermal distortion. Stress relieving, if not performed during manufacture, is sometimes a problem with rotors which have been fabricated by welding. Any part that has been shaped by pressing, drawing, bending, extruding, etc., will naturally have high internal stresses. Over time, they may distort to relieve this stress. Thermal distortion occurs with a change in temperature. Most metals expand when heated. Commonly, rotors will contain minor imperfections and experience uneven heating, causing uneven distortion. Thermal distortion is common on machines that operate at elevated temperatures including electric motors, fans, blowers, compressors, expanders, turbines, etc. Thermal distortion can sometimes require the rotor to be balanced at its normal operating temperature.
- Clearance Tolerances
    - The most common source of unbalance is the accumulation of tolerances in the assembly process of a machine. An example of when this occurs is when the bore in a pulley is larger than the shaft diameter. A key or setscrew would be required to fill the gap, thus pushing the shaft to one side of the shaft rotating centerline.
- Corrosion or Wear
    - Many rotors, particularly fan, blower, compressor, pump rotors, or any other rotors involved in the material handling processes, are subject to corrosion, abrasion, or wear. If the corrosion or wear does not occur uniformly, unbalance will result.
- Deposit Build-Up
    - Rotors used in material handling may become unbalanced due to the unequal build-up of deposits (dirt, lime, etc.) on the rotor. The resultant gradual increase in unbalance can quickly become a serious problem when portions of the deposits begin to break away. As small deposits break off, the vibration increases, which in turn, breaks off even more deposits, thus, creating a serious unbalance. Routine inspection and cleaning can minimize the effect, but usually the rotor will need to be removed and balanced eventually.
- Manufactured Unsymmetrical Configurations
    - Many rotors are manufactured in ways that produce dissymmetry. Examples of these include: rough surfaces on forgings, core shifts in castings, uneven number or position of bolt holes, and unsymmetrical parts, such as crankshafts, etc.
- Hydraulic or Aerodynamic Unbalance
    - Oil trapped in oil galleries, oil trapped in grinding wheels and cavitation or turbulence can sometimes produce unbalance forces.

In summary, all of the above causes of unbalance can exist to some degree in a rotor. However, the vector summation of all unbalance can be considered as a concentration at a point termed the "heavy spot." Balancing is the technique for determining the magnitude and location of this heavy spot so that an equal amount of weight can be removed at this location, or an equal amount of weight added directly opposite.