Design & Fabrication of Static and Dynamic Vibration Balancing Machine

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Abstract - *Unbalance is most common source of vibration in machine parts which are rotating it is very important factor to be considered in modern machine design. Especially where high speed and reliability are significant considerations. balancing of rotors will prevent excessive loading of bearings and avoids fatigue failure thus increases useful life of machinery. This paper will give the idea about how simple is to balance rigid rotors or loads during actual working conditions using portable vibration balancing machine. Static and dynamic balancing machines accepts rotating parts for production line balancing and laboratory use for practical demonstration.*

Key Words: Rotors, balancing mass, fatigue, vibration control,

1.INTRODUCTION

A level of unbalance that is acceptable at a low speed is completely unacceptable at a higher speed. This is because the unbalance condition produces centrifugal force, which increases as the speed increases. In fact, the force formula shows that the force caused by unbalance increases by the square of the speed. If the speed is doubled, the force quadruples. Prolonged exposure to the vibration results in damage and increased downtime of the machine.

1.1 Static Unbalance

Static unbalance is defined as distance between the centre of gravity of mass and axis of rotation of shaft. An equal mass placed at an angle of 180° to the unbalance mass and at the same radius, is required to restore center of gravity to the centre of rotation static balancing involves resolving primary forces into single plane if a rotor has a diameter of more than 7 to10 times its width, it is usually treated as a single plane rotor. It is basically resolving the centrifugal masses acting on to the system of rotating masses thus making the system free of forces.

1.2 Dynamic Unbalance

Dynamic unbalance is the combination of static and couple unbalance. It is the most common type of unbalance found in rotating mass system to correct dynamic unbalance, it is necessary to make vibration measurements while the machine is running and to add balancing masses in two or more planes . A rigid rotor can be balanced by making corrections in any two arbitrarily selected planes.

2. OBJECTIVES

Static and dynamic vibration balancing machine have the following objective to make necessary vibration calculations of rotating machine components under actual working condition:-

1. To demonstrate balancing of horizontal shaft with two three or four rotating masses.
2. To independent analysis of static and dynamic balancing.
3. To allow flexible mounting on test shaft assembly to vibrate in a dynamic balancing test.
4. Dynamic balancing of rotating mass systems by calculation and vector diagrams (triangle and polygon)

3. LITERATURE REVIEW

Tremendous amount of research is done on load balancing and is still going on. This section provides the briefing of work done by researchers.

It is well established that the vibration of rotating machinery can be reduced by introducing passive devices into the system (Cunningham, 1978; Nikolajsen and Holmes, 1979). Although an active control system is usually more complicated than a passive vibration control scheme, an active vibration control technique has many advantages over a passive vibration control technique. First, active vibration control is more effective than passive vibration control in general (Fuller et al., 1996). Second, the passive vibration control is of limited use if several vibration modes are excited. Finally, because the active actuation device can be adjusted according to the vibration characteristic during the operation, the active vibration technique is much more flexible than passive vibration control. The main purpose of this paper is to review and reevaluate the active vibration control techniques for rotating machinery and shed some light on future research directions.

3.1. Active Balancing Techniques

A large body of literature is available on rotor balancing methods. A rough classification of the various balancing methods is shown in Figure 3. The most recent development in active balancing is summarized in the dashed-line box in Figure 3. The rotor balancing techniques can be classified as off-line balancing methods and real-time active balancing methods. Because active balancing methods are extensions of off-line balancing methods, we also provide a review of off-line methods.

3.1.1. OFF-LINE BALANCING METHODS

The off-line rigid rotor balancing method is very common in industrial applications. In this method, the rotor is modeled as a rigid shaft that cannot have elastic deformation during operation. Theoretically, any imbalance distribution in a rigid rotor can be balanced in two different planes (Wowk, 1995). Methods for rigid rotors are easy to implement but can only be applied to low-speed rotors, where the rigid rotor assumption is valid. A simple rule of thumb is that rotors operating under 5000 rpm can be considered rigid rotor.

It is well known that rigid rotor balancing methods cannot be applied to flexible rotor balancing. Therefore, researchers developed modal balancing and influence coefficient methods to off-line balance flexible rotors. Modal balancing procedures are characterized by the use of the modal nature of the rotor response. In this method, each mode is balanced with a set of masses specifically selected so as not to disturb previously balanced, lower modes. There are two important assumptions: (1) the damping of the rotor system is so small that it can be neglected and (2) the mode shapes are planar and orthogonal. The first balancing technique similar to modal balancing was proposed by Grobel (1953). This method was refined in both theoretical and practical aspects by Bishop (1959; Bishop and Gladwell, 1959; Bishop and Parkinson,(1972). Many other researchers also published works on the modal balancing method, including Saito and Azuma (1983) and Meacham et al. (1988). Their work resolved many problems with the modal balancing method such as how to balance the rotor system when the resonant mode is not separated enough, how to balance the rotor system with residual bow, how to deal with the residual vibration of higher modes, and how to deal with the gravity sag. An excellent review of this method can be found in Darlow (1989). Most applications of modal balancing use analytical procedures for selecting correction masses. Therefore, an accurate dynamic model of the rotor system is required. Generally, it is difficult to extend the modal balancing method to automatic balancing algorithms.

Unlike the modal balancing method, the influence coefficient method is an experimental method. It was originally proposed by Goodman (1964), refined by Lund and Tonneson (1972), and verified by Tessarzik and others (1972).

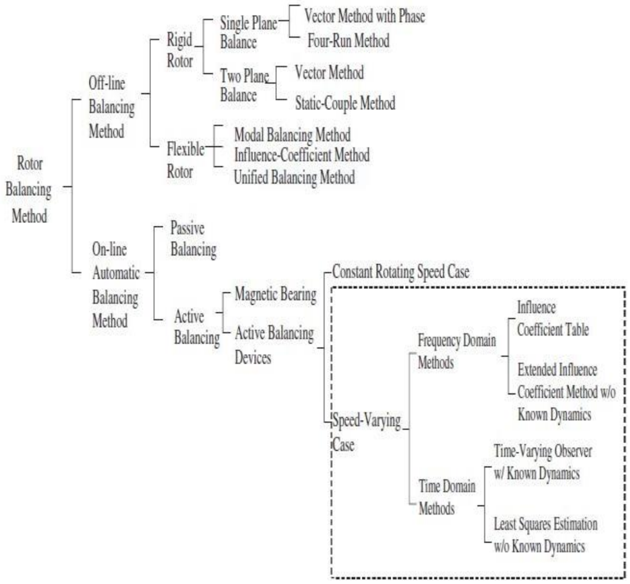

Fig - 1: Types of balancing methods

4. METHODOLOGY

In the past various methods have been used to design more efficient vibration balancing instruments among which balancing of the unbalance or disturbing mass by providing balancing mass in similar plane of rotating mass in case of static balancing or by providing two or more masses in different plane of rotating at certain distance and at an certain angle is the most efficient way for balancing of the vibrating system. It allows reducing vibrations of a rotating machine up to the greater extent with relatively low cost of manufacturing. It provides a greater accuracy towards vibration analysis and reduces the work of dynamic balancing of rotating mass system by calculations and vector diagram (triangle and polygon).also this machine allows students to do experiments in balancing rotating mass system and check the result against accepted theory.

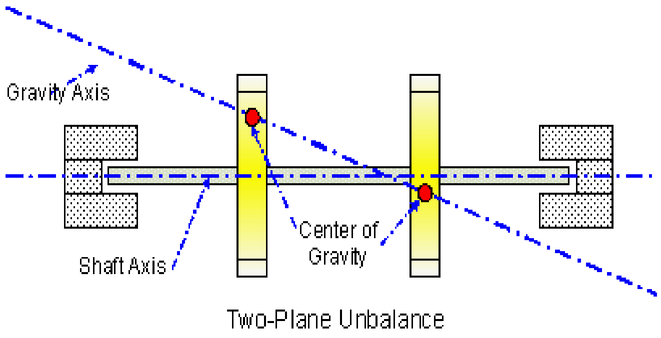

Fig - 1: Dynamic Unbalance

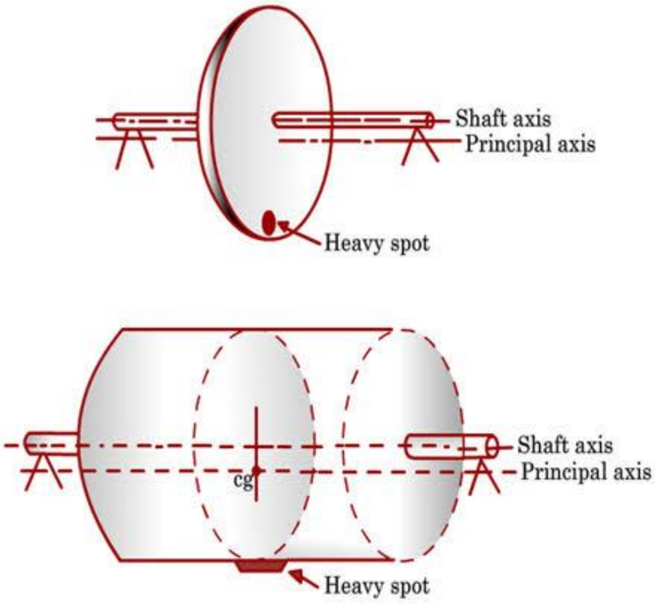

Fig -3: Static Balancing

5. LEARNING OUTCOMES

- Demonstration of simple static and dynamic balancing of two three or more rotating masses
- Dynamic balancing of rotating mass by checking against the results of theoretical calculations and vector diagrams
- Demonstration of cantilever type weight or mass addition to the rotating mass system by extension shaft and pulley.

6. CONCLUSION

The major problem faced by the active vibration control scheme is the use of a limited number of actuators to control an infinite number of vibration modes. To design an active control scheme, a reduced-order model should be used and the effect of the spillover of higher vibration modes assessed. Although the available techniques developed for dynamic analysis, rotor imbalance estimation, and active real-time balancing and vibration control can be extended to high-order systems theoretically, the static and dynamic vibration balancing machine will reduce machine vibration up to the greater extent with the comparatively low cost. But it will not completely eliminate the vibration. This system can be used more accurately in industries like automobile, gear box etc.

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