SINGLE PLANE BALANCING OF ROTOR

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ABSTRACT

Balancingis the process of correcting or eliminating, either partially or completely, the effects due to resultant inertia forces & couples acting on the machine parts or components. The principal axis of the moment of inertia does not coincide with the axis of rotation, the condition of unbalance exits. To eliminate the imbalance, mass is usually permanently added or removed from the rotating parts. The force generated by the unbalance proportional to the square of the rotational frequency. Unbalancein a rotor is the result of an uneven distribution of mass. Unbalancein a rotor is the result of an uneven distribution of mass, which causes the rotor to vibrate. Mass imbalance is a common cause of vibration in rotating machinery. If the amount of unbalance exceeds permissible levels, even small increase in operating speed of the rotor can lead to significant increase in vibration levels. In this paper describe the how to reduce vibrations in rotating machinery by using an automatic ball balancer (ABB).

Keywords*: -vibration, automatic ball balancer*

1. INTRODUCTION

1.1 Rotary Balancing-Balancing of Rotating Masses

We know that whenever a certain mass is attached to the rotating shaft. It exerts some centrifugal force whose effect is to bend and to produce vibration in it. In order to prevent the effect of centrifugal force, another mass is attached to the opposite side of shaft, at such a position so as to balance the effect of centrifugal force of the first mass. This is done in such a way, that the centrifugal force of both the masses is made equal and opposite. The process of providing second mass in order to counteract the effect of centrifugal force of the 1st mass is called balancing of rotating mass, considering a disturbing mass M_1, attached to a rotating shaft at a radius rotation r1. In order to balance the effect centrifugal force produce by this mass a second mass M_2 called balancing mass must be attached in the same plane at a radius of rotation r_2 such that centrifugal force of both the masses is equal.

$$m_1 \omega^2 r_1 = m_2 \omega^2 r_2 \text{ or } m_1 r_1 = m_2 r_2$$

Where ω=angular velocity of shaft

1.2. Reciprocating Balancing

There are various forces acting on the reciprocating parts of an engine. The resultant of all forces acting on the body of the engine due to inertia of forces only is known as unbalanced force or shaking force. Thus, if the resultant of all forces due to inertia effect is zero, then there will be no unbalanced force, but even then an unbalanced couple or shaking couple will be present. The purpose of balancing the reciprocating masses is to eliminate the shaking force and a shaking couple. In most of the mechanisms we can reduce the shaking force and a shaking couple by adding appropriate balancing mass, but it is not practical to eliminate them completely. In other words the reciprocating masses are only partially balanced. We know that, the inertia force due to reciprocating parts or force required to accelerate the reciprocating parts.

$$\text{Unbalanced force, } F = m \omega^2 r \cos\theta$$

These conditions can only be corrected by accurately measuring the vibration response of the rotor at its fundamental frequency and following a series of steps designed to determine the amount of unbalance and adding (or subtracting) an appropriate amount of compensating mass at the necessary locations. In single plane balancing an automatic ball balancer (ABB) is used.

2. LITERATURE REVIEW

J.Rodrigues a et al (2008)[1] : The first study of an ABB was carried out by Thearle in 1932 and the existence of a stable balanced steady state at rotation speeds above the first critical frequency was demonstrated. More recently, the equations of motion for a planar Jeffcott rotor with an ABB have been derived using Lagrange’s method. In particular, Green et al. presented the first nonlinear bifurcation analysis of an ABB and the dynamics of the oscillating ball states were explored. However, ABB models which are based on a Jeffcott rotor do not include any tilting motions and so they are unable to explain phenomena that are related to principal axis misalignment.
J.Rodrigues a et al (2010) [2]: They present a paper in Journal of Sound and Vibration in September 2010. In this paper they conduct an experiment on single plane balancing of rotor on ABB machine and estimate the result. They prove that the vibrations can be reduced up to the considerable level.
V. DeepikaPoornimaet al (2012) [3] : She present a paper on Two Plane Balancing Of Conical Rotor Driven By Vertical Belt System Designed To Reduce Gyro Effect in International Journal of Mechanical Engineering and Robotics. In this paper she do an experiment on conical rotor driven by vertical belt system and illustrated the results.
F. S"evea,et al (2002) [4]: They present a paper in Journal of Sound and Vibration in May 2002. In this paper they do study on the balancing procedure of machines composed of a flexible rotating part (rotor) and a non-rotating part (Stator) mounted on suspensions is presented.
A.R. Champneys,et al (2008) [5]: They present an analysis of a two-plane automatic balancing device for rigid rotors. Ball bearings, which are free to travel around a race, are used to eliminate imbalance due to shaft eccentricity or misalignment. The rotating frame is used to derive autonomous equations of motion and the symmetry breaking bifurcations of this system are investigated. Stability diagrams in various parameter planes show the coexistence of a stable balanced state with other less desirable dynamics.

3. SINGLE PLANE BALANCING OF ROTOR

3.1 Automatic Ball Balancer (ABB)

In single plane balancing an automatic ball balancer (ABB) is used. An automatic ball balancer (ABB) is a device which reduces vibrations in rotating machinery by compensating for the mass imbalance of the rotor. The mechanism consists of a series of balls that are free to travel around a race which is set at a fixed distance from the shaft. During balanced operation the balls find positions such that the principal axis of inertia is repositioned onto the rotational axis. Because the imbalance does not need to be determined beforehand, automatic balancers are ideally suited to applications where the amount of imbalance varies with the operating conditions. For example, automatic balancers are currently used in optical disk drives, machine tools and washing machine.

Fig-1: Automatic Balancer

3.2 Experimental Setup for Single Plane Balancing of Rotor

The experimental test rig is shown in Fig. 3.2 comprises of an ABB disk that is positioned midway along a horizontal silver steel shaft of 10mm diameter. This shaft is mounted at each end onto nominally identical single- row ball bearings, which are fitted into housings and attached to the supports through a set of springs. The support structure consists of our posts that are reinforced with lateral beams and fixed to a wooden base board. Next a motor is suspended by rubber bands drives the shaft via a rigid coupling and the speed of this motor is controlled through a space DS1104 digital signal processing board.

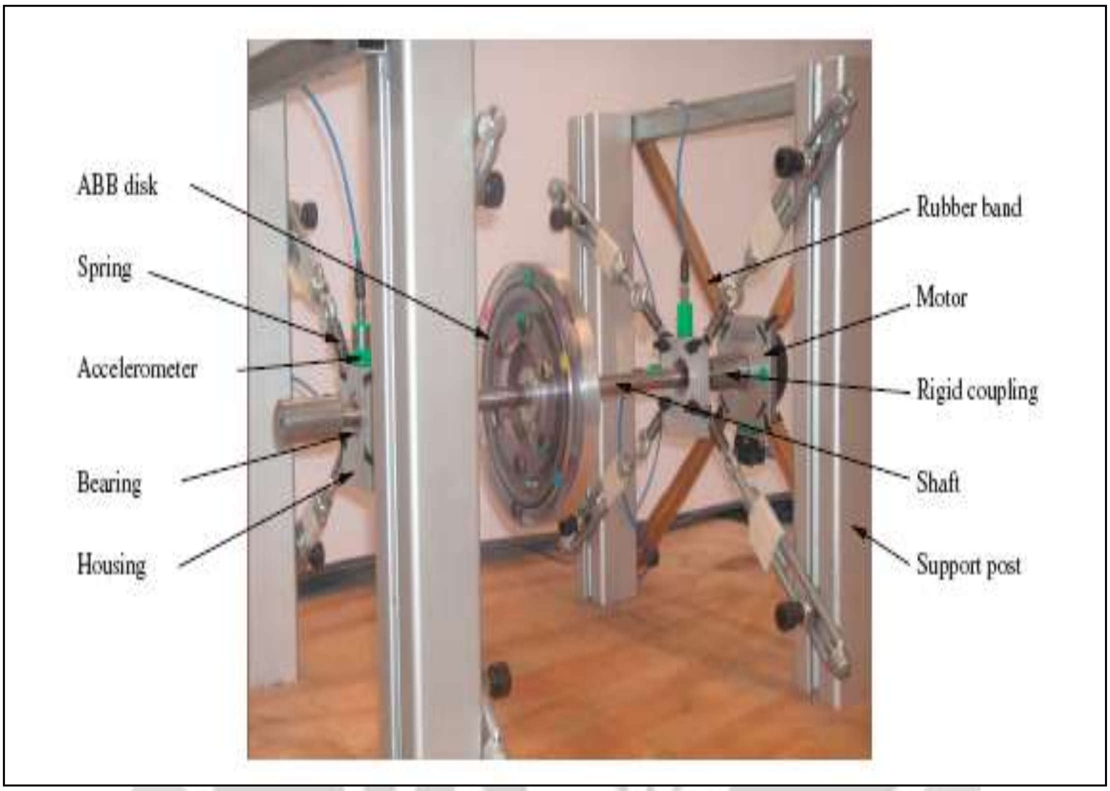

Fig-2: Test Rig

The automatic balancer, which is shown in Fig. 3.2, consists of an aluminum hub into which a hardened steel ball race of 50mm outer radius has been fitted. Steel balls of 4.76 mm diameter and 0.44 gm mass are used as the balancing masses. The balls can be viewed through a Perspex cover that is attached to the balancer with a circular array of screws. A light coating of oil, which provides damping for the motion of the balls, is applied to the race and a rubber seal is used to prevent any oil from escaping. The balance of the disk can be adjusted, either by adding washers to the screws, or by changing the angular position of adjustable outer masses that can be rotated around a groove in the hub and fixed in place with grub screws. At this point, let us highlight some considerations relating to the design of the ABB disk. The steel ball race comes from the outer part of a single row, deep groove, SKF 16013 ‘explorer’ bearing. According to the company literature, these bearings are made from high grade steel that is cleaner and more homogeneous than that which is used in their standard bearings. Also, the steel has been hardened through a heat treatment procedure and the finish on the contact surface has also been improved. It is hoped that these features reduce the rolling friction between the balls and the race and thereby improve the performance of the ABB .In addition, the deep groove in the race prevents the balls from rattling between the hub and the Perspex cover, as during operation a centrifugal force acts on the balls so that they are confined to lie in the deepest part of the channel.

3.3 The Plain Rotor Response

The frequency response of the plain rotor (i.e. with the balls removed from the ABB disk) can be used to give a good of the support parameter values. In addition, the results of these tests provide a control against which the performance of the ABB can be compared.

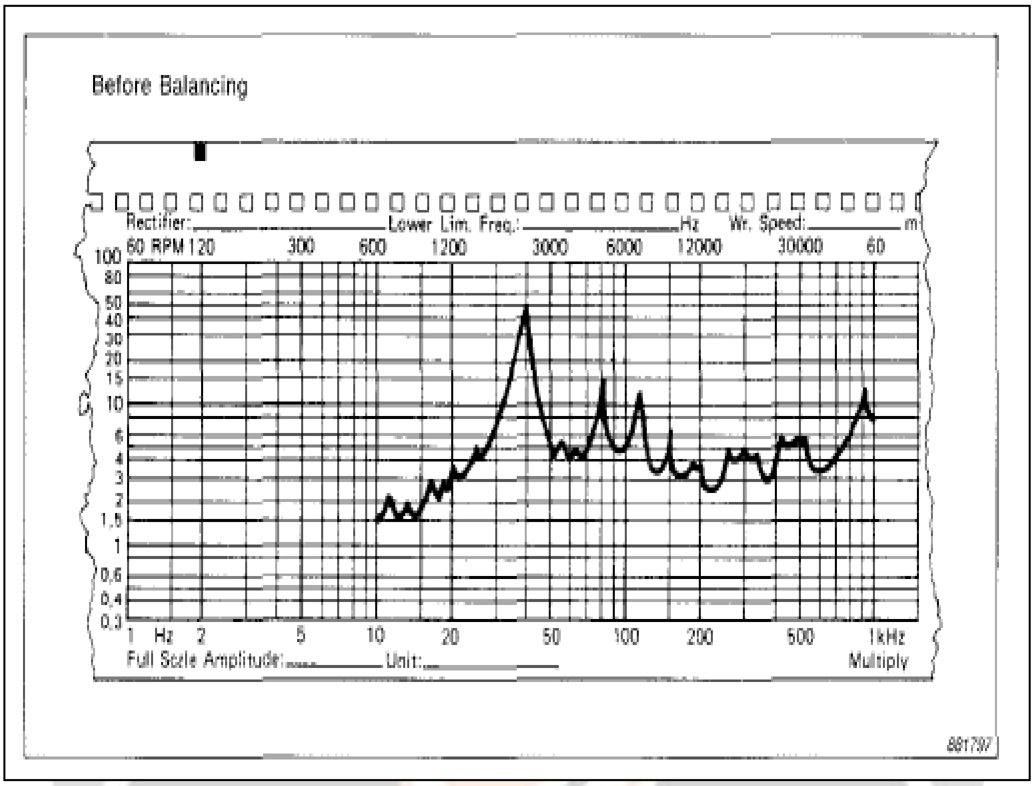

Fig-3: Frequency Spectra of the Vibration Signal before Balancing

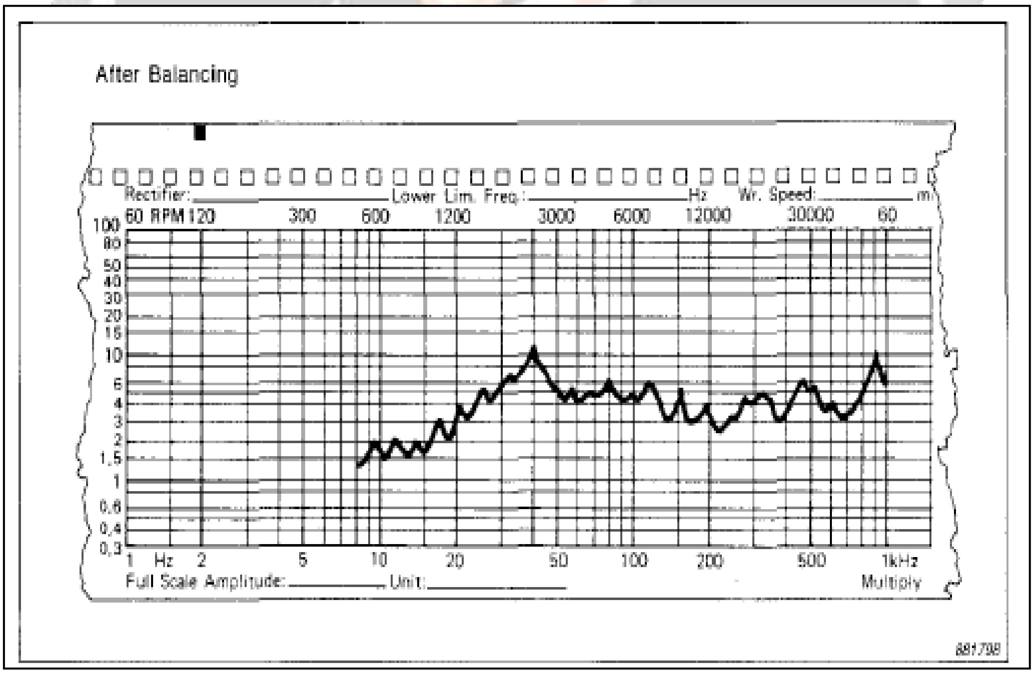

Fig-4: Frequency Spectra of the Vibration Signal, After Balancing

4. RESULT AND DISCUSSION

The performance of the ABB has been assessed for a variety of different applied imbalances for which both the eccentricity and misalignment of the rotor were taken into account. It was found that for all but the case in which the rotor was already nominally balanced, the ABB reduced the vibration levels in the speed range that was supercritical to the rigid body resonances. Some evidence was presented that suggests that the ABB also performs best when the mass of the balls is matched to the size of the imbalance. We believe that this behavior occurs because the errors in the position of the balls are reduced when they are touching in the balanced state; however, further tests are needed in order to confirm this hypothesis.

5. SUMMARY

In single plane balancing, in order to accurately describe the behavior of this ABB system we have used a model that is based on a four degree of freedom rotor that not only includes the effect of rotor misalignment and eccentricity, but also includes the effect of support anisotropy.For the supercritical frequency range the model produces an approximate quantitative match with the measured data and the causes of the discrepancies have been discussed in relation to both the presence of rolling friction, and also, race eccentricity. During the rigid body resonances the dynamics of the ABB is highly nonlinear and for this speed range the agreement between theory and experiment is mainly qualitative.

6. REFERENCES

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BIOGRAPHIES

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