Vibration Control of Rotating Machine through Balancing

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Abstract: There are so many devices in today's ever-growing world that have rotating parts, but rotating parts have the primary concern of regulating and managing the vibration. A summary of the research work conducted in the actual real-time balance and vibration regulation of rotating machinery in this article. This study paper also addressed the area of research carried out on the rotor system's dynamic and analysis techniques. A short discussion of the approach is also included, as well as a thorough review of the rotating parts technique. In a different application of the technology used in the world, rotating machinery is generally used, i.e. machining machines, automotive turbo machinery, cars and earthmovers. In the small equipment which can be used in the machine, household works, as well as cooking accessories, sometimes rotating parts are used. The consequence of incorrect balance is vibrations.In this review paper, the study has been done for the proper understanding of the Phenomenon and its causes as well as remedies.

Keywords: Balancing, vibration, dynamic analysis, automobile, machine balancing.

INTRODUCTION

The use of rotating parts in the mechanical system is very prevalent. We need to check the vibration induced by the rotation of the components whenever rotary parts are used in the mechanical components. Vibrations are created due to mass imbalance, or it is also said that if the rotating mass does not balance properly, a generation of vibrations will be induced. If the rotation axis of the parts is not coaxial with the inertia rotation axis, then the mass balance is created in the system. When a mass is rotating along its axis, a centrifugal force acts on the rotating mass and this force are increasing as the speed of rotation is increased. The current trend towards higher power density of rotating machinery results in higher operating speeds.

For high-speed turbines, compressors and other turbo machinery used in the petrochemical and power generation industries, great cost savings can be made using vibration control technology. It is well understood that the vibration of the rotating machines can be minimized by integrating devices into the system. Usually, an active control system is more difficult than a passive vibration control system. An active vibration control technique has many advantages over a passive vibration control technique. First, active vibration control on general is more effective than passive vibration control. Second, if several vibration modes are excited, passive vibration is of limited use.

Finally, as the active actuation mechanism can be adjusted during the process according to the vibration characteristics, the active vibration technique is much more robust than passive vibration control. The main aim of this paper is to review and reassess the active vibration control techniques of the rotating machinery and shed some light on the potential direction for research [1][2]. In active vibration control techniques for rotating machinery, there are two categories: first, direct active vibration control (DAVC) techniques directly apply a lateral control force to the rotor, and active balancing techniques adjust the mass distribution of a mass redistribution actuator.

In DAVC techniques, a lateral force produced by a force actuator like the magnetic bearing is the control variable. The advantage of DAVC techniques is that the input control force on the system can be modified rapidly. By applying a rapidly changing lateral force to the rotating machinery, the total vibration, including synchronous vibration, transient-free vibration and other non-synchronous vibration of the rotating machinery, can be blocked. The restriction of most force actuators is the maximum force they can provide.

The force caused by the imbalance could reach a very high level at high rotational speed. Many force actuators are unable to provide enough energy to account for this strain caused by imbalance.

Under this situation, successful balancing techniques can be used. In active balancing methods, a mass redistribution actuator (i.e., whose mass centre can be changed) is located on the rotor. The actuator's mass centre is balanced to account for the system imbalance after measuring the rotating mechanism vibration and estimating the rotating machinery imbalance. By suppressing the root cause of the vibration of the system instability, the spinning machinery vibration is removed. Unlike the force actuator, the mass redistribution actuator can provide a strong compensating force. The mass redistribution actuator speed is sluggish. While active balancing methods can remove synchronous vibration caused by instability, transient vibration and other non-synchronous vibration cannot be suppressed [3][4].

METHODOLOGY

Dynamic modeling:

The simplest rotor model is the planar rotor model. The plane perpendicular to the rotating shaft is considered. The geometric arrangement of the planar rotor is shown in figure 1.

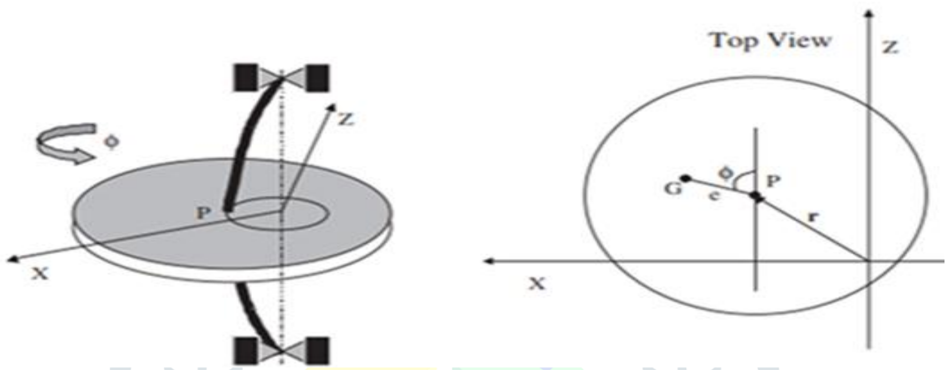

Fig.1 Geometric Arrangement of Planar Rotor

In this arrangement, the mass imbalance induces the generation of the vibration defined by the motion of the particle around the geometric centre of the disc, where the mass centre of the disc is represented by G. The planar rotor is a basic model that can be used to research the fundamental nature of rotor dynamics, such as critical speed, damping, etc. The rotor was designed to be a rigid disc mounted on fixed rigid bearings with a less elastic shaft mass. Also, this arrangement is similar to a rigid shaft backed by an elastic bearing. The main change over the simple planar rotor model is that rigid body movement rather than particle movement reflects the motion of the rotor. While this is a single body model, it can demonstrate the basic phenomena of the rotor in motion, including forward and backward whirling under the force of imbalance, critical velocities, gyroscopic impact, etc. This model will simulate the fact that the natural frequency is a function of rotating speed [5]. A general geometric arrangement of the model is depicted in the fig.2.

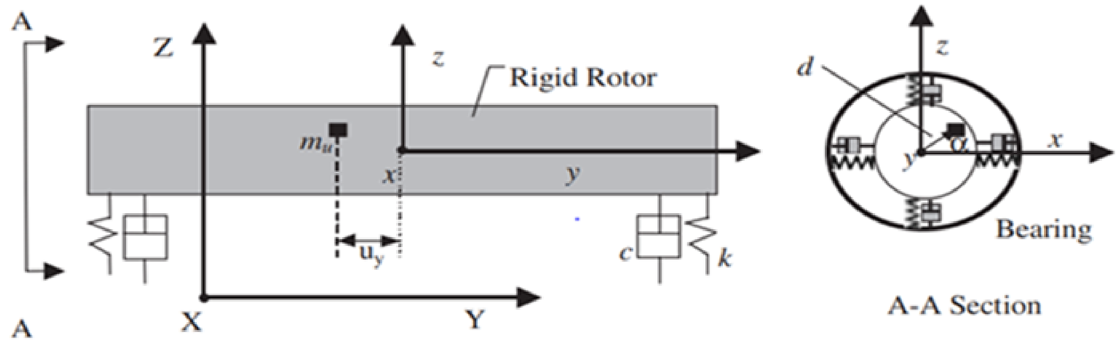

Fig.2 General Geometric Figure Of The Model

In the present arrangement, bearing are configured as the isotropic linear spring and damper. And the mass to be balance is fixed as the concentrated mass on the rigid shaft. To represent the system, two coordinate system are used: fixed body system oxyz and the inertial coordinate OXYZ. The y axis of the body fixed system is the rotating axis of the shaft and origin of this system is the geometric center of the rotating shaft. This model can be used on a real system even when the shaft's stiffness relative to the supporting bearing is strong [6][7]. The equation of the motion of the flexible rotor is written as:

$$M\ddot{q}+C\dot{q}+Kq = f(\phi)$$

Where q is the coordinate for the motion and M, C and K is representing the mass, damping coefficient and the stiffness. The above method focuses on linear systems, which means that the system equations are a series of linear ordinary differential equations, and the system's rotational speed was presumed to be constant during the studies. In fact, a simple shift in the position of the critical velocity can occur in transient time, which is higher when speed increases and lower when speed decreases than the true critical velocity. These effects, in fact, are often observed. This delay may be due to a lack of time to consume energy at a critical speed.

Real time active balancing method:

The real time method of the balancing is classified into the passive balancing methods and also in active balancing method depending upon the type of the balancing device. It has been shown that plane rotors exhibit auto-balancing with this tool, a property attributable to the plane rotor's dynamic characteristics. The perturbation theory has also been tested to demonstrate that some fairly general rotor systems are self-balancing. Their research was based on a model of a simple rotor. The system requires particle axial movement. In industry, however, this is usually not feasible. Therefore, the passive form of balancing is not commonly used in industry [8]. Nevertheless, if the spinning speed is close to critical speed, the calculation errors and affect the estimate of the coefficient can result in serious errors in the correction of the balancer [9].

Active vibration control for rotating machinery:

For a versatile structure, active vibration control for rotating equipment is a special case for active vibration control. It was found that the difference between rotating machinery and other flexible structures is that the rotor dynamics change with the rotor system's rotating velocity. Best control efficiency is achieved if the control gains vary with the speed of rotation. Additionally, because the shaft is a moving part, a non-contact actuator is applied to the rotating shaft with the control power. There are many types of actuators, including electromagnetic, hydraulic, piezoelectric, and so on, for direct active vibration control. An emerging industrial technology with a rapidly increasing number of applications is the active magnetic bearing [10].

CONCLUSION

Machinery with rotating parts is widely used in industry. The analysis for dynamics and vibration control of rotating machineries are important engineering issues for industry and academia alike. A study of the active balance and direct vibration control was performed in this review paper for rotating machinery. A control action is preferable if it is able to obtain small vibration induced by imbalance and at the same time excite the system to obtain the good estimation of imbalance. The coupling effect should therefore be investigated by taking into account the estimation algorithm, the dynamics of the system, and the performance of the control. This research can also play a scientific basis for designing a generic adaptive control system that is efficient and reliable for the balancing and vibration control.

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