Dynamic Behavior Analysis of Regenerated Rotor

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Abstract— *In the advance technology the rotating machines are becoming faster and lightweight in engineering science for longer periods of time. The horizontal rotors are always imposed to the periodic stress, therefore a crack due to a fatigue in unavoidable .A crack opens or closes due to the direction of the lateral deflection or the crack can develop in rotating rotors and can propagate to relevant depths without consistently the normal speed and magnitude of additional slop and continue running of rotors are reasons of the crack .The main objective of this paper is to obtain the speed and frequency deference between the cracked and regenerated rotor. This practical is possible with the help of rotor equipped with long journal bearings placed at both ends. Rotating speed is used as the control parameter to observe various forms of vibration in the regenerated rotor.*

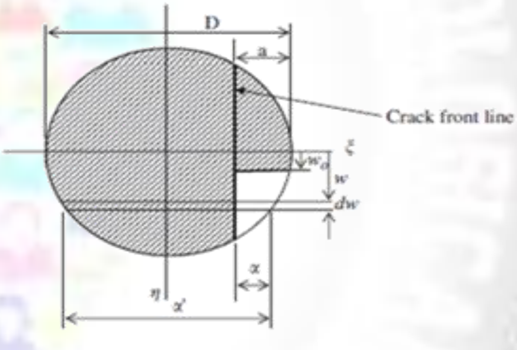
Keywords— Rotor Dynamics, Cracked Rotor, Critical Speed, Frequency, Lateral and Torsional Vibration, Harmonic Motion

I. INTRODUCTION

The crack in the rotor repeats breathing due to the gravity and produces dynamic stress on the crack front. The high speed rotating machinery having a crack may field the severe damage .Cracks can develop in the rotor propagate to relevant depth power requirement for the day to day work increase as technology used of human begin increasing .When the rotor is cracked, normally it has no works and no useful in industries. There are many different types of cracked in rotor which is produce the continuously such as inner surface crack, outer surface cracks, corner damage, depth damage etc. The rotors have been the most commonly used part of the machine and mechanism. The rotor rotation may be accompanied by various modes of vibration namely lateral, torsional and axial mode. Cracks result from rotor material, non-homogeneity like voids, porosity, inclusions etc. In the rotor crack may also occur during machine operation due to erosion or built up of deposits on the rotor, missing or loose. The unbalance may also occur due to rotor crack. If the crack is in small depth it can filling by the welding or other materials. So the rotor, which is filled with other material, is known as Regenerated rotor. Regenerated rotor that means the rotor which is make useful after the crack which can use in the machine industries for some times. The cracks can filled by the welding or through the other materials such as the cast Iron, steel, C7056 steel, aluminum360 etc.

II. LITERATURE REVIEW

Oh SungJun, Department of Mechanical and Automotive Engineering, Jeonju University, Jeonju 560–759, Korea, in this article additional slope and bending moment at crack position are used in analyzing the dynamic behavior of a general cracked rotor. The nonlinear motion of the cracked rotor, which results in the harmonic vibration, is simulated using the response including bending moment and the additional slope recursively. Even though the change of the orbit at the subcritical speed occurs, the magnitude of additional slope does not change if the crack-induced dynamic bending moment is smaller than the gravity-induced static bending moment at the corresponding critical speed range; the cause of the orbit change is the high value of the displacement influence coefficient at the corresponding critical speed. Only at the speed range where the dynamic bending moment is enough large to affect the total bending moment, the change of additional slope occurs with the speed change and it becomes one of the causes of the drastic orbit change. In the present research model, the orbit change due to the large dynamic bending moment as well as the high influence coefficient occurs at around subcritical speeds of the second critical speed. The continuous operation of the cracked rotor at such speed range having large dynamic bending moment may produce the fast crack propagation. And also it is analyzed that the second vibration mode happens when the speed closely approaches half of the second critical speed.



Cross section of shaft at crack position.

Fig. 1: Cross Section

The transverse crack on the horizontal rotor repeats breathing due to the gravity, and produces dynamic stress on the crack front. Accumulation of the repeated strain induces crack propagation and the high dynamic stress accelerates the propagation. Accordingly the high speed rotating machinery having a crack may yield the severe damage and lead to catastrophic disaster. Many researchers have studied the cracked rotor dynamics . Even the final purpose of the simulation research is to derive the proper crack identification technique based on the test, the research for crack identification has been performed by computer simulation using very simple model because of the difficulties in mathematical modeling and in fabrication of the test crack.

G. Bamnios & A.Trochides, Department of Physics and Mathematical Sciences, Thessaloniki 54006, Greece, in this article the influence of a transverse surface crack on the dynamic behavior of a cantilever beam is studied. Analytical and experimental investigations provide a link between the change in natural frequencies of vibration and in mechanical impedance to the location and size of the crack for flexural vibrations. It is shown that the mechanical impedance of the beam changes substantially due to the presence of the crack and can be used as an additional defect information carrier. The results have been used to propose an improved method of non-destructive testing for simple beam structures. The method is based on the combined examination of the change in natural frequencies and in mechanical impedance and allows an estimation of both location and size of the crack.

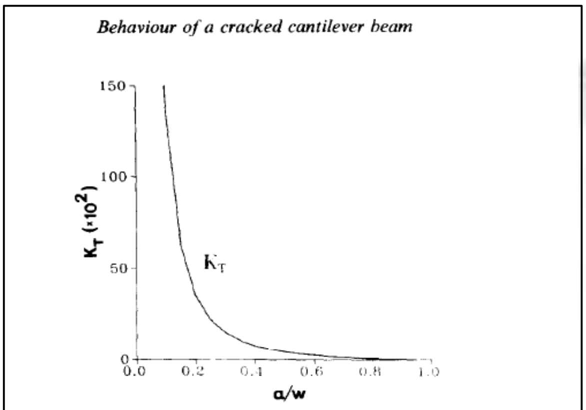


Diagram relating crack depth a to the torsional spring constant K_T.

Fig. 2: Diagram Cantilever Beam

Li-Hua Yang et al. [4] observed that the strong nonlinear behavior usually exists in rotor systems supported by oil-film journal bearings. The partial derivative method is extended to the second-order approximate extent to predict the nonlinear dynamic stiffness and damping coefficients of finite-long journal bearings. And the nonlinear oil-film forces approximately represented by dynamic coefficients are used to analyze nonlinear dynamic performance of a symmetrical flexible rotor-bearing system via the journal orbit graph. The effects of mass eccentricity on dynamic behaviors of rotor system are also investigated. Moreover, the computational method of nonlinear dynamic coefficients of infinite short bearing is presented. In analysis, the rotor gravity is balanced by the steady-state oil-film force of bearing. The nonlinear oil-film forces model of finite-long bearing is validated by comparing the numerical results with those obtained by an infinite-short bearing-rotor system model. The results show that the representation method of nonlinear oil-film forces by dynamic coefficients has universal applicability and allows one easily to conduct the nonlinear dynamic analysis of rotor systems.

Mohammad Hadi Jalali et al. [5] in this paper, full dynamic analysis of a high speed rotor with certain geometrical and mechanical properties is carried out using 3D finite element model, one-dimensional beam-type model and experimental modal test. Good agreement between the theoretical and experimental results indicates the accuracy of the finite element models. The, critical speeds, operational deflection shapes, and unbalance response of the rotor are obtained in order to completely investigate the dynamic behavior of the rotating system. The dynamic characteristics of a high speed rotor with certain geometrical and mechanical properties were evaluated at rest and under operating conditions. The model analysis of the rotor at rest under free boundary conditions was done with beam finite element model, 3D finite element model and model test and comparison of the results indicated satisfactory agreement between them. The results were compared and satisfactory agreement between themMN indicated that one-dimensional beam finite element method which is simple in modeling can be used for rotor dynamic analysis with acceptable accuracy.

J.-J. Sinou [6] deals with the non-linear dynamic response of a flexible rotor supported by ball bearing. The excitation is due to unbalance force. The finite element rotor system is composed of a shaft with one disk, two flexible bearing supports and a ball bearing element where the nonlinearities are due to both the radial clearance and the contact between races and rolling element s. A numerical analysis is performed to analyze the non-linear behavior of this bearing rotor by using the Harmonic Balance Method with appropriate condensation located only on the non-linear coordinates of the system in order to minimize computer time.

Slim Bouaziz et al. [3] presented research in which, the dynamic behavior of misaligned rotor is presented. The rotor is mounted in two hydrodynamic journal bearings and has two degrees of freedom. Reynolds' equation is obtained by considering the effect of mass transfer across the fluid film. This is discretized by means of the finite difference method and solved numerically. By integrating the oil pressure distribution, the hydrodynamic forces are calculated. The elasticity of the fluid film is modeled by stiffness and damping matrices. The motion equations have been established for the rotor bearings system and simulated with Newmark method. The effect of bearings geometry on the dynamic coefficients is presented. A theoretical model describing the angular misalignment defect is analyzed in order to survey the vibratory response of the misaligned rotor. A theoretical model was developed to study the influence of angular misalignment on the dynamic behavior of a rotor supported by two hydrodynamic journal bearings.

M. Chandra Sekhar Reddy and A.S. Sekhar [2] focus on torque measurements for misalignment diagnosis. Experimental results using torque sensor for different cases of misalignment at different frequency of operation are reported. Fourier and wavelet transforms are used to detect the misalignment fault. The variation of the fault characteristics with respect to time are reported for sampled signals using wavelet transforms. The motor with belt driven system shown in figure drives a shaft coupled torque sensor system. The rotor can be run at different speeds below and above critical speed.

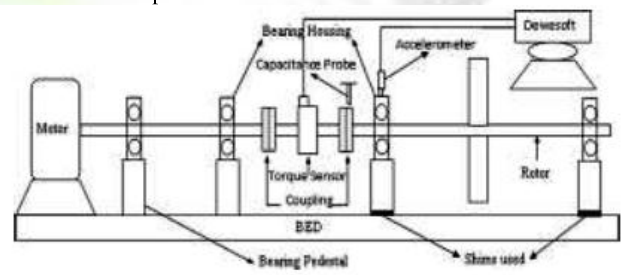


Fig. 3: Schematic Diagram of Shaft coupled torque sensor system

A special platform which facilitates inducing desired amount of misalignment in the rotor bearing system is fabricated. To measure vibrations, accelerometers are placed near bearings in radial direction. The accelerometers employed are precision quartz shear ICP type with sensitivity of 100 mv/g and frequency range 0.5 to 10 kHz.

The torque sensor is attached in between the motor shaft and the rotor shaft. In every measurement both accelerometer and torque sensor outputs are recorded.

Based on the result obtained in this work, it is concluded that dynamic Coefficients along the journal increase with the relative eccentricity. The effect of bearing geometry on the stiffness and damping coefficients is presented by considering short, long and finite bearings. The effect of angular misalignment on the dynamic behavior of rotor bearing system is essentially characterized, in the frequency domain, by the presence of two dominant peaks: the first corresponds to two times the running frequency and the second to four times the running frequency. The first harmonic is predominant. The present model shows that the vibratory level of the angular misalignment decreases with the increase of the relative eccentricity, but increases when the imposed angle increases. A comparison between rolling and hydrodynamic journal bearings shows that Hydrodynamic bearing permits to attenuate vibration due to the misalignment defect.

The result demonstrated if the rotor will be cracked at the outer surface or in the depth side can be filled that spot with the same or other material or by welding. Due to this operation the rotor has runs again and will give work continue.

III. Conclusion

The premise of this review paper has been that the review on the dynamic behaviors analysis between the cracked and regenerated rotor by using the mathematical and experimental techniques have been done. The rotary machine are operated in a very high speed thus accurate the speed difference, so as to design high reliable rotary machine and to avoid the occurrence of dangerous operation. Once the location of the crack is fixed the relative size of the crack can be estimated with acceptable accuracy again using the changes in natural frequency.

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