A Brief Review On Dynamic Analysis Of Rotating Shaft With Crack

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Abstract: - *The issue of crack detection and identification has gained wide unfold industrial interest. Failure of shaft is directly affects on the security of surroundings round the machine. Damage is analyzed through visual examination or by the strategy of measuring frequency, mode form and structural damping. Injury detection by visual examination could be a time overwhelming methodology and measuring of mode form furthermore as structural deflection is troublesome instead of measuring frequency. As Non- destructive methodology for the detection of crack is favorable as compared to destructive ways. So, our analysis has been created on the premise of non-destructive ways with the thought of natural frequency.*

Keywords: *- Cracked Shaft, Breathing Mechanism, Tensional Vibrations, Longitudinal Vibrations*

1. INTRODUCTION

The study of cracks and its location is very important as the shaft is main parameter to transmit power from one point to another point in various industries and also in various machines like turbine, generator, and aero engines. Failure of shaft is directly affects on the safety of environment around the machine. Also, to increase the power transmission efficiency in machines shafts should not be defected.

2. DIFFERENT APPROACHES FOR DYNAMIC ANALYSIS OF CRACKED SHAFT.

Many research works has been done in the field of cracks on shaft. Every researcher has done experimental investigation of cracks on shafts for confirmation of the results obtained by theory with the experimental results.

2.1. Breathing Mechanism

Qinkai Hann et. al. [1] has analyzed a geared rotor bearing system with slant breathing crack. In his study vibration problems associated with geared systems has been focused. With his research, torque is mainly transmitted by geared system and slant crack is more likely to appear on the gear shaft. Due to this slant crack the dynamic behavior of cracked geared system had different behavior than uncracked system. With past research, less work efficiency reported for slant crack in the geared rotor system. So, author had done study on dynamic analysis of a geared rotor bearing system with a breathing slant crack. The finite element model of a geared rotor with slant crack was presented in his paper. For stress intensity factors, flexibility matrix for slant crack had derived using fracture mechanics. For whirling analysis, parametric instability analysis and steady state response analysis three methods were introduced. Then, by taking one stage geared rotor bearing system, the whirling frequencies of the equivalent time invariant system, two types of instability regions and steady-state response under the excitations of unbalance forces tooth transmission errors were computed numerically. The effects of crack depth, position and type (transverse or slant) on the system dynamic behaviors were considered in this paper. The comparative study with slant cracked geared rotor was carried out for distinctive features in his modal, parametric instability and frequency response behaviors.

2.2. Dynamic Behavior.

R. Ramezanpour et. al [2] has investigated dynamic behavior of a Jeffcott rotor system with a slant crack under arbitrary crack orientations. Flexibility matrix and stiffness matrix of the system were calculated in this paper using fracture mechanics. In four directions system equations obtained, two transversal, one torsional and one longitudinal, and solved using numerical method. In this paper a symmetric relation for global stiffness matrix was presented. Also investigation on the influence of crack orientations on the flexibility coefficients and the steady state response of the system had done. The results from this paper indicate that, results of flexibility coefficients were greatly varied by increasing the crack angle from 300 to 900 (transverse crack).

Maximum values of the flexibility coefficients were observed at 600 crack orientations.

2.3. Wavelet Transform and Wavelet Finite Element Approach

Wavelets method may be used to detect the damage location and depth by considering modal frequencies, modal shape, and modal damp, and so forth. Zheng et al. has applied the wavelet transform technique for bifurcation and chaos study. Wavelet transform can reveal the local property in both time domain and frequency domain. They introduced a method to analyze the existing domains of different types of motion in the parametric space of a nonlinear system. Yang et al. have worked on characterization and detection of crack-induced rotary instability. They developed and presented a wavelet-based algorithm to characterize periodic, period-doubling, fractural-like, and chaotic motions as results of the inherent nonlinearity associated with crack opening and closing during vibration.

2.4 Tensional and longitudinal vibrations

Yanli Lin et. al. [3] has done work for a Jeffcott rotor system with a 450 slant crack on the shaft. In this study, the motion equations were developed with four directions, i.e. two transversal directions, one torsional direction and one longitudinal direction. From the deducing process of the stiffness with the strain energy release approach, that there were coupling stiffness of bending torsion, bending tension and torsion tension for the slant cracked shaft calculated. The paper shows that besides the coupling stiffness, there was bending torsion coupling caused by the eccentricity. All these couplings affect the responses of the slant cracked shaft and for the transverse cracked shaft. In this paper, Comparison of responses of a cracked shaft with open crack model and with a breathing crack model find outs that, there were same characteristic frequencies for shafts. The cracked shaft with a breathing crack model behaves more non linear than open crack model. All studies in this paper done for the open crack model, since it needs more time to compute responses of a breathing cracked shaft than open cracked shaft. Analysis of steady responses indicates the combined frequencies of the rotating speed and the torsional excitation in the transversal response. The frequency of the torsional excitation in the longitudinal response used to detect the slant crack on the shaft of the rotor system.

2.5. Investigation through Finite Element Approach

A. S. Sekhar [11] has analyzed the dynamic behavior of structures in particular rotors containing cracks as a subject of considerable current interest. The dynamic behavior of rotors having cracks was a subject of interest for several researchers. Many researchers had developed models of cracked rotor systems considering mainly the transverse surface crack. In this paper the study of finite element "FEM" analysis of a rotor bearing system for flexural vibrations had considered by including a shaft having a slant crack. This slant crack had resulted from the fatigue of the shaft due to the torsional moment. A flexibility matrix and stiffness matrix for a slant cracked element had been developed which had used subsequently in the FEM analysis of rotor bearing system. In this study, the frequency spectrum of the steady state response of the cracked rotor was found to have sub harmonic frequency components at an interval frequency corresponding to the torsional frequency. This torsional frequency used for crack detection.

2.6. Wavelet transforms

Ashish K. Darpe [6] has presented a way to detect fatigue transverse cracks in rotating shafts. In this paper proposed detection methodology explains the typical nonlinear breathing phenomenon of crack and coupling of bending torsional vibrations due to presence of crack. At specific angular orientation a transient torsional excitation had applied for a short time, with this its effect in the lateral vibrations had investigated. Wavelet transforms (WTs) was used in revealing the transient features of the resonant bending vibrations, which were set up for a short time upon transient torsional excitation. Variation of peak value of wavelet coefficient with angle at which torsional excitation applied was calculated. The study of correlation of this variation with the breathing pattern of the crack had done in this paper. In this paper the detection methodology gives a vibration response signature that closely correlates with and was specific to the behavior of transverse surface crack in a horizontal rotor. The response features were not exhibited by other common rotor faults under similar excitation conditions. The detection process was applied for a rotating shaft for short period, transient external excitation made the methodology more convenient.

A. S. Sekhar [8] has done the detection and monitoring of slant crack in the rotor system using mechanical impedance. In this paper the modeling of slant crack was discussed. Propagating fatigue cracks had effects on the reliability of the rotating machinery such as turbo machinery, process machinery. This paper also synthesizes several works of the authors on cracked rotors to compare the two types of shaft cracks. Crack detection based on changes in mechanical impendence, Eigen value analysis, steady state and transient response. Wavelet techniques had been discussed in this paper to compare slant crack with transverse crack.

3. PROPOSED WORK

Majority authors have focused on different crack location, with variable shaft speed and orientation of crack angle. Less focus was enlightened on load variation and effect of helicoidally crack. Hence experimentation with various load and speed condition with helicoidally crack can propose.

4. CONCLUSIONS

After an exhaustive survey of literature, the potential researchers in this field have various tools and methodologies to be applied to detect and proper identification of a crack. The methodologies have some specific advantages over the other. Now, there is a choice before the dynamics people to adopt proper techniques. The paper may be concluded as follows.

Finite element method is a better choice and applied by various researchers to analyze the dynamic behavior of a shaft having different kind of cracks, for example, transverse crack, two cracks, slant crack, and so forth. The crack element must be accurately discretized to depict the real behavior of a cracked rotor

REFERENCES

[1] Qinkai Han, Jingshan Zhao, Fulei Chu, “Dynamic analysis of a geared rotor system considering a slant crack on the shaft”, (Journal of Sound and Vibration, vol.331 (2012), pp. 5803–5823).

[2] R. Ramezanpour, M. Ghayour, S. Ziaei-Rad,“Dynamic behavior of Jeffcott rotors with an arbitrary slant crack orientation on the shaft”, (Applied and Computational Mechanics, vol.6 (2012), pp.35–52).

[3] Yanli Lin, Fulei Chu, “The dynamic behavior of a rotor system with a slant crack on the shaft”, (Mechanical Systems and Signal Processing, vol.24 (2010), pp.522–545).

[4] A.S. Sekhar, “Multiple cracks effects and identification”, (Mechanical Systems and Signal Processing vol.22 (2008), pp.845–878).

[5] Ashish K. Darpe, “Coupled vibrations of a rotor with slant crack”, (Journal of Sound and Vibration vol.305 (2007), pp.172–193).

[6] Ashish K. Darpe, “A novel way to detect transverse surface crack in a rotating shaft”,(Journal of Sound and Vibration vol.305 (2007),pp.151–171).

[7] J.J. Sinou, A.W. Lees, “The influence of cracks in rotating shafts”, (Journal of Sound and Vibration vol.285 (2005), pp.1015-1037).

[8] A. S. Sekhar, A. R. Mohanty, S. Prabhakar,“Vibrations of cracked rotor system: transverse crack versus slant crack”, (Journal of Sound and Vibration vol.279 (2005), pp. 1203–1217).

[9] D. P. Patil, S.K. Maiti, “Detection of multiple cracks using frequency measurements”, (Engineering Fracture Mechanics vol.70 (2003), pp.1553–1572).

[10] O.S. Jun, H.J. Eun, Y.Y. Earmme, C.W. Lee, “Modeling and vibration analysis of a simple rotor with a breathing crack”, (Journal ofSound and Vibration vol.155 (1992), pp.273–290).

[11] C.A. Papadopoulos, A.D. Dimarogonas, “Coupled vibration of cracked shafts”, (Journal of Vibration and Acoustics vol.114 (1992),pp.461–467).

[12] A. Muszynska, P. Goldman, D.E. Bently, “Torsional/lateral vibration cross-coupledresponses due to shaft anisotropy: a new tool in shaft crack detection”, (Vibrations in Rotating Machineries Proceedings of the International Conference, Institution of Mechanical Engineers, (1992), pp. 257–262).

[13] K.R. Collins, R.H. Plaut, J. Wauer, “Detection of cracks in rotating Timoshenkoshaftsusing axial impulses”, (Journal of Vibration andAcousticsvol.113 (1991),pp.74–78).

[14] S. S. Rao,“Mechanical Vibrations”, Pearson Higher Education, 5th Revised Edition