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REVIEW OF NATURAL FREQUENCY CRITERION FOR CRACK DETECTION IN TAPERED CANTILEVER BEAM

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ABSTRACT

Tapered cantilever beams are widely used as machine elements and structural elements in mechanical, naval, civil, aeronautical engineering. There are unexpected sudden failures on machine elements. In order to attain maximum reliability of machine and structure, so the best way is to monitoring the health of susceptible critical component.Cracks are the most encountered damage types in the structures due to fatigue or manufacturing defects. Cracks found in structural elements may fail the whole system. Natural frequencies of structures are measured most easily and accurately. Experimental Modal Analysis (EMA) was performed on cracked beams and a healthy beam using ANSYS 18.1. In the inverse analysis, detect the location and size of a crack by providing the natural frequencies as inputs. The first three natural frequencies were considered as basic criterion for detection of crack size and location. Compare the experimental and EMA results for validate the method adopted.

Keywords: *Tapered cantilever beam,ANSYS, Experimental Modal Analysis, Natural frequency.*

I. INTRODUCTION

Damage is defined as any deviation introduced to a structure, which adversely affects the current or future performance of that system. It is clear from this definition that a comparison is needed between two states of a structure. Cracks are among the most encountered damage types in the structures due to fatigue or manufacturing defects. Cracks found in structural elements may arise due to fatigue cracks. Cracks take place under service conditions as a result of the limited fatigue strength, they may also be due to mechanical defects, as in the case of turbine blades of turbine engines, or may be because of defects due to manufacturing processes. Mechanical accidents, fatigue, corrosion and environmental attacks are issues that can lead to a crack in a mechanical structure.
NECESSITY OF CRACK DETECTION:
Mechanical structures in real service life are subjected to combined or separate effects of the dynamic load, temperature, corrosive medium and other type of damages. Crack detection plays an important role for structural health monitoring applications.

- Fatigue cracks are potential source of catastrophic structural failure.
- It is required that structures must safely work during its service life.
- Presence of cracks in structures or in machine members leads to operational problem.
- Presence of cracks in structures or in machine members leads as well as premature failure.
- Cracks present a serious threat to proper performance of structures and machines.

It is well known that when a crack develops in a component it leads to changes in its vibration parameters, e.g. a reduction in the stiffness and increase in the damping and a reduction in the natural frequency. These changes are mode dependent. Hence it is possible to estimate the location and size of the crack by measuring the changes in natural frequencies. The vibration parameters could be structural parameters (i.e. mass, stiffness and flexibility) or modal parameters (i.e. natural frequencies, modal damping values and mode shapes). The vibration based methods of crack detection utilize one or more of these parameters as the basis for crack detection.

II. REVIEW OF LITRATURE

The following paragraphs review the research that was done by earlier researchers related to detection of crack and its severity for different end conditions of beams.

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Chaudhari and Maiti (2000) proposed a method for detection oflocation and size of a crack using natural frequency. This method is applied totapered and segmented cantilever beam geometries. The analysis was based on concept of a rotational spring. The crack size was computed using a relation between stiffness and crack size. The maximum error in predicting crack locations was 8% and predicting crack size was 20%.

Tawfik (2014) developed the vibration-based analysis and Artificial Neural Networks to detect the transverse crack specifications (location and depth) in wind turbine blades, considering the complicated structure of the wind turbine blades. The input is the neural networks of first three relative natural frequencies. The output is the relative crack depth and relative crack location. In order to train the neural networks successfully, many actual sets of input-output data are required. It is extremely difficult and time-consuming to produce large enough training data sets from experiments. Hence, the actual data are obtained using Finite Element Method via ANSYS software for different crack location and depth. Experimental setup has been developed to validate the results obtained from the finite element software ANSYS.

Barad (2015) proposed a method of detection of the crack presence on the surface of beam-type structure. Fordetection of crack location and sizeNatural frequencies of the cracked beam have been obtained experimentally. Detected crack locations and size are compared with the actual results .It is found to be in good agreement. The effect of the crack location and the crack depth on the natural frequency is presented. The natural frequency is greatly affected by crack depth and crack location. Using this approach, damage detection can be done using natural frequency. The present method to detect crack location and size is fast and efficient.

Deokar(2011)proposed crack changes the dynamic behavior of the structure. After examining this change, crack size and position can be identified. Non-destructive testing (NDT) methods are used for detection of crack which are very costly and time consuming. Currently research has focused on using modal parameters like natural frequency, mode shape and damping. Detection of open transverse crack in a tapered cantilever beam is presented. Experimental Modal Analysis (EMA) was performed ona un-cracked beams and cracked beam. The first three natural frequencies were considered as basic criterion for crack detection. To locate the crack, graphs of the normalized frequency are plotted. The intersection of these three contours gives crack location and crack depth.

Chinchalkar (2000) we describe a numerical method for determining the location of a crack in a beam of varying depth when the lowest three natural frequencies of the cracked beam are known. The crack is modeled as a rotational spring and graphs of spring stiffness versus crack location are plotted for each natural frequency. The point of intersection of the three curves gives the location of the crack. Earlier work in this area involved the use of the technique for solving the governing differential equation analytically and then using a semi-numerical approach to obtain the crack location. In this work, we use the finite element approach to solve the same problem.

Nandwana and Maiti (1997b)proposed the method of detection of location and size of a crack in a stepped cantilever beam based on measurements of the first three natural frequencies. They obtained curves for the variation of stiffness with crack location basing on the measured natural frequencies, and graphed them on the same axes. From the intersection of these curves, the crack location was extracted.

Patil and Maiti (2002) proposed method for detection of multiple open cracks in a cantilever beam is presented based on natural frequency measurements. The transverse vibration modeling through transfer matrix method and representation of a crack by rotational spring. The beam is virtually divided into a number of segments, which can be decided by the analyst, and each of them is considered to be associated with a damage parameter. The procedure gives a linear relationship explicitly between the changes in natural frequencies of the beam and the damage parameters.

Owolabi (2003) proposed a method of experimental investigations of the effects of cracks and damages. Also to detect, quantify, and determine their extents and locations. Two sets of aluminum beams were used for this experimental study. Each set consisted of seven beams, the first set had fixed ends, and the second set was simply supported. Cracks were initiated at seven different locations from one end to the other end (along the length of the beam) for each set, with crack depth ratios ranging from 0.1d to 0.7d (d was the beam depth) in steps of 0.1, at each

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crack location. Measurements of the acceleration frequency responses at seven different points on each beam model were taken using a dual channel frequency analyzer. The damage detection schemes used in this study depended on the measured changes in the first three natural frequencies and the corresponding amplitudes of the measured acceleration frequency response functions.

Patil (2005) registered a method for prediction of location and size of multiple cracks based on measurement of natural frequencies. It has been verified experimentally for slender cantilever beams with two and three normal edge cracks. The analysis was based on energy method and representation of a crack by a rotational spring. For theoretical prediction the beam was divided into a number of segments and each segment was considered to be associated with a damage index.

III. OBJECTIVE

The objective of this project is to analyze experimentally and numerically (by FEA software e.g. Ansys) the vibration characteristics of the cracked cantilever beams. Use the data of forward problem to detect crack location and calculate crack depth using changes in natural frequencies.

IV. METHODOLGY

In this case, for a given problem, it is necessary to measure or compute the first five transverse natural frequencies of the beam with a crack and the corresponding un-cracked beam. Crack location and the crack depth are both influence the changes in the natural frequencies of a cracked beam. Also a particular frequency could correspond to different crack locations and crack depths.Contour line plotted which has the same normalized frequency change. It is a combination of different crack depths and crack locations. It could be plotted in a curve with crack location and crack depth as its axes. Then plot contour lines from different modes on the same axes. The point of intersection, common to all the five modes, indicates the crack location, and crack depth.

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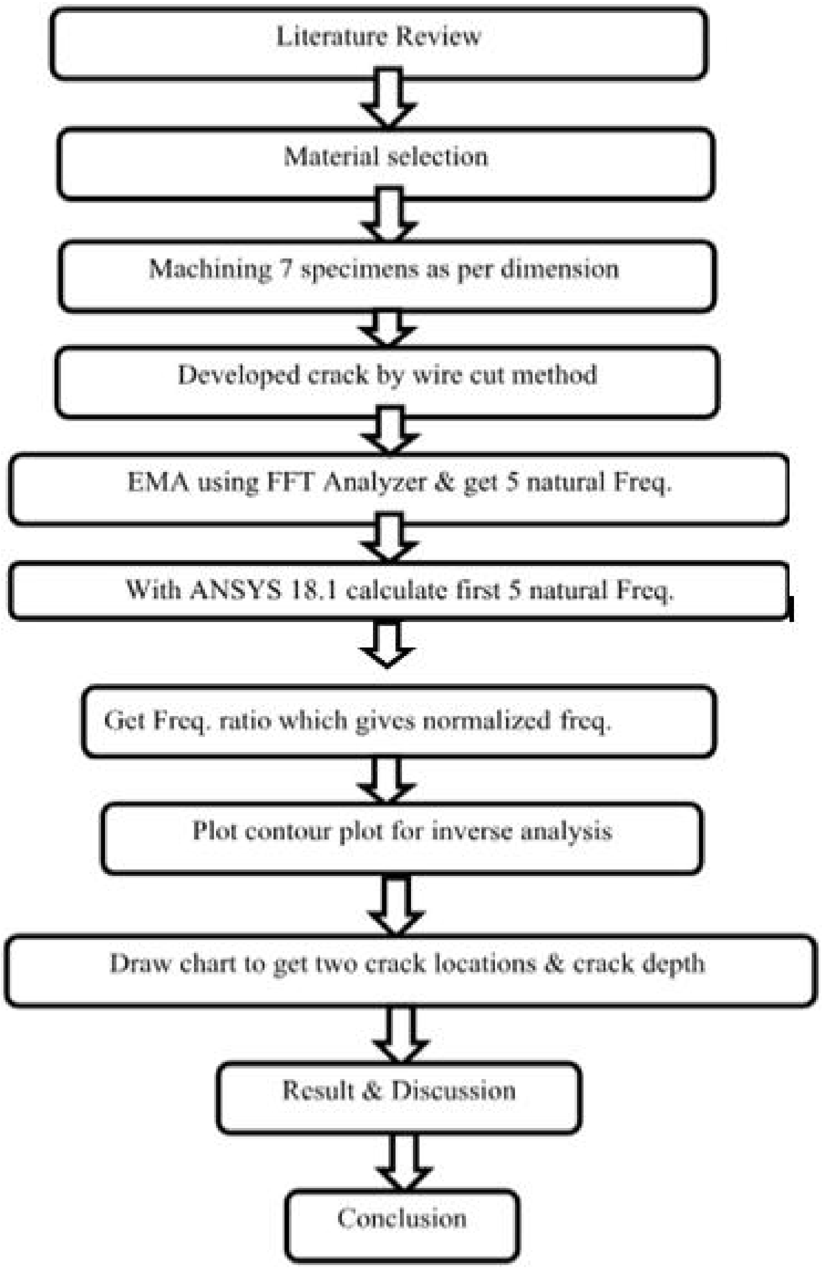

Assumptions:
For the purposes of crack identification the following assumptions are made:

- The crack is open.
- The crack is regular over the surface of the specimen, uniform in propagation.
- The crack is a transverse crack.
- The vibrations are flexural in nature.

Tools to be used:

- Ansys18.1 - ANSYS18.1will be used to calculate five natural frequencies of cracked and un-cracked beam.
- MINITAB - MINITAB is used to plot contour lines.
- Microsoft Excel - Microsoft Excel is used to plot five contour lines on the same axis to get their common intersection point. For this the data is collected from MINITAB software.
- DigivibeMX M20 - DigivibeMX M20 is used to find experimental values of natural frequency of cantilever beam for testing specimen.
- Test Rig - FFT analyzer is used to measure natural frequencies of cracked and un-cracked beam. Experimental set up is used to carry out experimental modal analysis.

V. PROBABLE OUTCOME

This project is to be devoted to the study of damage levels of a beam with a lateral cut to test and demonstrate the applicability of the method suggested. Modal analysis using ANSYS18.1 and experimental modal analysis result to be examined to see the effect of the cut on the test beam. In the modal analysis results of ANSYS18.1 are to be utilized for the detection and localization of the crack. The first five natural frequencies of different damage levels are to be used in the assessment of these vibration based techniques. The vibration behavior of the beams is to be shows very sensitive to the crack location and crack depth. A simple method for predicting the location(s) and depth(s) of the crack(s) based on changes in the natural frequencies of the beam is to be presented and discussed

REFERENCES

1. *Chaudhari T.D, S.K.Maiti," Modeling of transverse vibration of beam of linearly variable depth with edge crack", Engineering Fracture Mechanic, vol.63, 1999, pp. 425- 445.*
2. *Dr.Mauwafak, A.Tawfik, "Vibration Based - Crack Detection in Simplified Wind Turbine Blades Using Artificial Neural Networks" Eng.& Tech.Journal,Vol.32,part(A) No.8,2014.*
3. *Brad A. Butrym, "Crack Detection in Aluminum Structures", M.S. Thesis, Virginia Polytechnic Institute and State University, 2010.*
4. *Chinchalkar S, "Determination of crack location in beams using natural frequencies", Journal of Sound and Vibration 247, 2001, pp.417–429.*
5. *Prabhakar M.S.,"Vibration Analysis of Cracked beam", Thesis of M Tech. National Institute of Technology, Rourkela, 2009.*
6. *Dackermann Ulrike, "Vibration based damage identification methods for civil engineering structures using artificial neural networks", PhD Thesis, University of Technology, Sydney, 2010.*
7. *Owolabi G.M., A.S.J. Swamidas," Crack detection in beams using changes in frequencies and amplitudes of frequency response functions", Journal of Sound and Vibration, vol. 265 (1),2003, pp. 1–22.*
8. *Rizos R.F., N.Aspragathos, "Identification of crack location and magnitude in a cantilever beam from the vibration modes", Journal of Sound and Vibration 138(3),1990, pp. 381–388.*