ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 3, Issue 1 , January 2016

Crack Detection in Cantilever Beam by Frequency based Method

Kulkarni S. S., Rajmane U. C., Sawant P.J

.

PG Student, Mechanical (Design) Engineering Department, SSDGCT's Sanjay Ghodawat Institutes, Atigre, Maharashtra, India

PG Student, Mechanical (Design) Engineering Department, SSDGCT's Sanjay Ghodawat Institutes, Atigre, Maharashtra, India

Professor, Mechanical (Design) Engineering Department, SSDGCT's Sanjay Ghodawat Institutes, Atigre, Maharashtra, India

ABSTRACT: -A comprehensive maintenance and operations programs can identify and eliminate as many potential problems, helping to avoid catastrophic failures. Predictive maintenance is important consideration to predict and prevent future problems. In this work, a study is done on cantilever beam to analyse the effect of crack location and depth of crack on a natural frequency. Only single crack is generated on a cantilever beam. A crack is generated manually and by using its natural frequency, location of crack is predicted analytically. A comparative study is done by using analytical method and by taking experiment using FFT analyser and impact hammer to find the location of crack.

KEYWORDS: Frequency Response Function (FRF), Natural Frequency, Compliance, Rotational Spring, FFT Analyser, Impact Hammer

I. INTRODUCTION

Mechanical structures in service life are subjected to combined or separate effects of the dynamic load, temperature, corrosive medium and other type of damages. The importance of an early detection of cracks appears to be crucial for both safety and economic reasons because fatigue cracks are potential source of catastrophic structural failure. Damage identification methods are mainly based upon the shifts in natural frequencies or changes in mode shapes. Non Destructive Testing (NDT) methods are often employed for detection of cracks in machine and structural components. All of these NDT techniques require that the location of the damage is known a priori and that the portion of the structure being inspected is readily accessible. In order to detect a crack by this method, the whole component requires scanning. Their adoption becomes uneconomical for long beams and pipelines which are widely used in power plants, railway tracks, long pipelines etc. This makes the process tedious and time-consuming. The drawbacks of traditional localized NDTmethods have motivated development of global vibration based damage detection methods. 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 inthe natural frequency. They may enable determination of location and size of a crack from the vibration data collected from a single or at most a few, points on the component. These changes are mode dependent. Hence it may be possible to estimate the location and size of the crack by measuring the changes in vibration parameters. The technique using changes in natural frequencies as the crack detection criterion has received considerable attention.

Vibration principles are the inherent properties of the physical science applicable to all structures subjected to static or dynamic loads. All structures again due to their rigid nature develop some irregularities in their life span which leads to the development of crack. The problem on crack is the basic problem of science of resistance of materials. Considering the crack as a significant form of such damage, its modelling is an important step in studying the behaviour of damaged structures. Knowing the effect of crack on stiffness, the beam or shaft can be modelled using either Euler-Bernoulli or Timoshenko beam theories. The beam boundary conditions are used along with the crack compatibility relations to derive the characteristic equation relating the natural frequency, the crack depth and location with the other beam properties. Researches based on structural health monitoring for crack detection deal with change in natural frequencies and mode shapes of the beam. Beams are one of the most commonly used structural elements in numerous engineering applications (ex. aerodynamic structures, tankers and rotors, etc.,) and experience a wide variety of static and dynamic

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 3, Issue 1 , January 2016

loads. The crack modelling is an important step in studying the behaviour of damaged structures. The majority of published studies assume that the crack in a structural member always remains open during vibration. The cracks are always open in vibration is not realistic because due to repetitive loads the crack may open or close. The relation between the applied load and the strain energy concentration around the tip of crack is explained by Irwin (1957). Qian et al. (1990) developed a finite element model of an edge cracked beam.
The concerned work is to analyse the effect of nature of crack on the cantilever beam with the use of frequency response function (FRF) tool and crack should be modelled as rotational spring approach.

II.RELEVANCE/ MOTIVATION

All structures are prone to damage, may be due to over-stressing in operation or due to extreme environmental conditions or due to any accidental event. Crack present in the component may grow during service and may result in the component failure as they grow beyond a critical limit. It is desirable to investigate the damage occurred in the structure at the early stage to protect the structure from possible catastrophic failures. The choice of using the natural frequency as a basis in the development of Non destructive evaluation (NDE) is most attractive. The efforts are being made to make the method useful in practice. It results in a considerable saving in time, labour and cost for long beam like components, such as rails, pipelines, etc.FRF is useful tool in determining the natural frequency. Vibration Based Inspection (VBI) can be a potential method for crack detection.
There has been an intense study on crack detection through vibration based inspection. The changes in natural frequencies will be helpful in prediction of crack location and its intensity.

III. LITERATURE REVIEW

The adaptation of NDT becomes uneconomical for large components. The process becomes tedious and time consuming. NDE method offers scope for development of fast and global technique. For this purpose a literature review is conducted and research issues are declared.
Rizos et al (1) modelled the crack as a rotational spring and studied the effect of location of crack and depth of crack on cantilever beam using modal exciter. Experimental results were compared to analytical solutions and they find it in close agreement.
Barad et al (2) predicted crack location with depth of crack analytically using Euler's beam theory. The cracks are developed using wire-cut electro-discharge machining and natural frequencies ware measured using LMS make FFT analyzer.
Deokar and Wakchaure (3)investigated the effects of crack on the first three modes of vibrating cantilever beams. They tested 49 beam models with cracks at different locations starting from a location near to fixed end. The experimental data from the curve-fitted results were tabulated, and plotted in the form of frequency ratio (ω_c/ω) (ratio of the natural frequency of the cracked beam to that of the uncracked beam) versus the crack depth for various crack location.
Agarwalla and Parhi (4) analysed the effect of an open crack on the modal parameters of the cantilever beam subjected to free vibration and the results obtained from the numerical method i.e. finite element method (FEM) and the experimental method were compared.
Jena et al (5) analysed the fault detection of Multi cracked slender Euler Bernoulli beams through the knowledge of changes in the natural frequencies and their measurements. The spring model of crack applied to establish the frequency equation based on the dynamic stiffness of multiple cracked beams. Theoretical expressions for beams by natural frequencies had been formulated to find out the effect of crack depths on natural frequencies and mode shapes.
Chondros et al (6) developed a continuous cracked beam vibration theory for the lateral vibration of cracked Euler Bernoulli beams with single edge or double edge open cracks.
Gounaris et al (7) identified crack on the basis of measurement of the coupled vibration due to a single harmonic excitation. Excitation and measurements of the response were applied on the same or different points.

IV.SCOPE

In the beam structure mechanical irregularities, corrosion, static and dynamic loading increases probability of failure of structure and leading to accidents. To reduce the catastrophic failure, it is required to determine the effects of nature and orientation of crack on the natural frequency of beam.

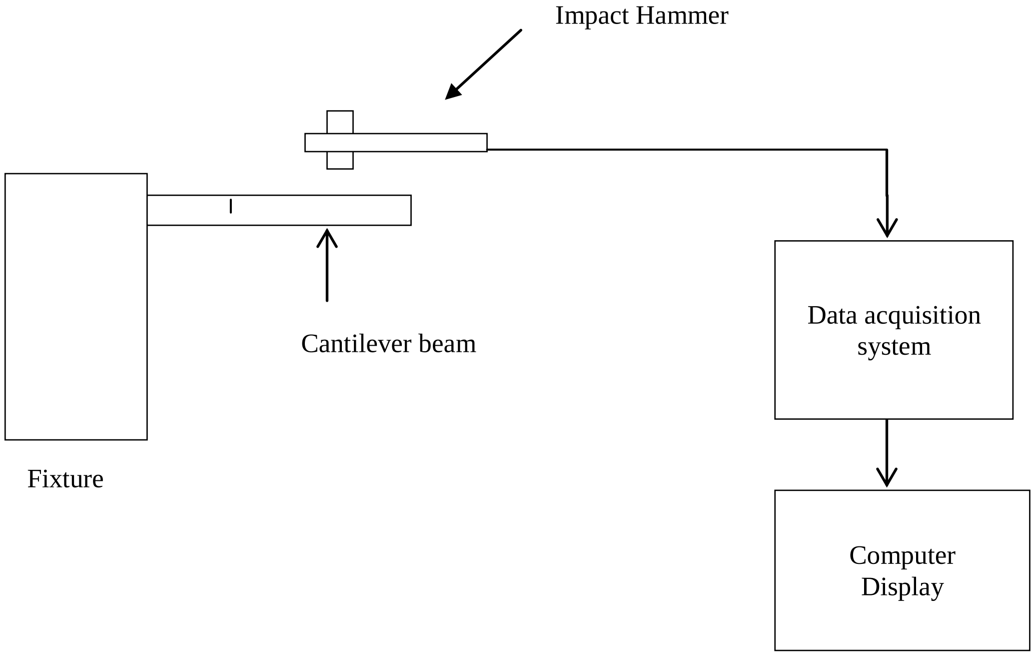
ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 3, Issue 1 , January 2016

From above mentioned issues it is found that depth, location and orientation of crack greatly imparts the natural frequency. Hence these parameters have to be studied on cantilever beam.

V.OBJECTIVE

Therefore the objectives of the work are

1. To study the analytical solution for free vibration of beam.
2. To find natural frequency of available beam without crack by using impact hammer.
3. To find natural frequency for straight crack
   i. At various locations for fixed depth ratio.
   ii. With fixed location with change in depth of crack (d)



Block diagram of Experimental setup for crack detection in cantilever beam

VI.METHODOLOGY

Beams are one of the most commonly used structural elements in numerous engineering applications (ex. aerodynamic structures, tankers and rotors, etc.,) and experience a wide variety of static and dynamic loads. In many application beams is subjected to combined or separate effects of the dynamic load, temperature, corrosive medium and other type of damages.
As mentioned in objectives the methodology can be carried out as follows.

1. Study analytical solution of the straight cracked beam. Rotational spring approach to be used for modelling of crack.
2. The generated equation is solved as non-trivial solution to find out location of crack analytically.
3. Development of experimental setup by using fixture, beam, impact hammer, DAQ and computer display.
4. Using the developed setup, the natural frequency of beam without crack to be determined by using the impact hammer kit.

5. Determine the natural frequency for straight crack by experiment.
    i. At various locations for fixed depth ratio. Depth ratio is the ratio of depth of crack (d) to the total thickness of beam (h)
    ii. At fixed location with change in depth of crack (d)

For above mentioned cases there exists a ratio of natural frequencies of cracked and beam without crack which is known as normalized natural frequency.

6. Compare results of analytical solution by experimental values for straight crack.

REFERENCES

[1] P. F. Rizos, N. Aspragathos and A. D. Dimarogonas, “IDENTIFICATION OF CRACK LOCATION AND MAGNITUDE IN A CANTILEVER BEAM FROM THE VIBRATION MODES”, Journal of sound and Vibration (1990) 138(3), 381-388

[2] Kaushar H. Barad, D. S. Sharma, Vishal Vyas, “Crack detection in cantilever beam by frequency based method.”Chemical, Civil and Mechanical Engineering Tracks of 3rd Nirma University International Conferenceon Engineering (NUiCONE 2012)

[3] A.V.Deokar, V.D.Wakchaure, “Experimental Investigation of Crack Detection in Cantilever Beam Using Natural Frequency as Basic Criterion”. Institute Of Technology, Nirma University, Ahmedabad – 382 481, 08-10 December, 2011

[4] D.K. Agarwalla, D.R. Parhi, “Effect of Crack on Modal Parameters of a Cantilever Beam Subjected to Vibration”**.** Chemical, Civil and Mechanical Engineering Tracks of the 3rd Nirma University International Conference (NUiCONE 2012)

[5] P. K. Jena, D. N. Thatoi, J. Nanda, D. R. K. Parhi, “Effect of damage parameters on vibration signatures of a cantilever beam”. International Conference on Modelling, Optimization and Computing (ICMOC 2012), April 10 - 11, 2012

[6] T. G. Chondros, A. D. Dimarogonas, J. Yao, “A Continuous Cracked Beam Vibration Theory”, Journal of Sound and Vibration 1998 215(1), 17-34, Article No (sv981640)

[7] G. D. Gounaris, C. A. Papadopoulos and A. D. Dimarogonas, “Crack Identification in Beams by Coupled Response Measurements”, Computers & Structures Vol. 58. No. 2. pp. 299-305. 1996