EXPERIMENTAL VIBRATION ANALYSIS OF INCLINED EDGE CRACKED BEAM WITH FIXED FREE BOUNDARY CONDITION

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Abstract - *Damage is one of the vital characteristics in structural analysis because of safety cause as well as economic prosperity of the industries. Identification of faults in dynamic structures and components are a significant aspect in judgment creating about their overhaul and retirement. Failure to identify the damages has various significances, and they change based on the use, and significance of the vibrating structures and elements. Premature identification of faults in engineering structure during their service period is the great challenge to the engineers because of its importance. Though dynamic based fault diagnosis has been advanced for last three decades and there is large number of literatures, still there are so many problems avoid doing it from application.*

***Key Words*: Fixed-Free Beam, Inclined crack, FFT Analyzer, Natural Frequency**

1. INTRODUCTION

Structures like Beams are widely used as structural element in civil, mechanical, naval, and aeronautical engineering. Damage is one of the important aspects in structural analysis and engineering. Damage analysis is done to promise the safety as well as economic growth of the industries. During operation, all structures are subjected to degenerative effects that may cause initiation of structural defects such as cracks which, as time progresses, lead to the catastrophic failure or breakdown of the structure. To avoid the unexpected or sudden failure, earlier crack detection is essential. Taking this ideology into consideration crack detection is one of the most important domains for many researchers. Many researchers to develop various techniques for early detection of crack location, depth, size and pattern of damage in a structure. Many nondestructive methodologies for crack detection have been in use worldwide. However the vibration based method is fast and inexpensive for crack/damage identification. Kaustubha V. Bhingeet. al, tried to establish a systematic approach to study and analyze the crack in cantilever beam. This work addresses the inverse problem of assessing the crack location and crack size in various beam structures. The study is based on measurement of natural frequency, a global parameter that can be easily measured at any point conveniently on the structure.[1] D.Y. Zheng, N.J. Kessissoglou have studied on the natural frequencies and mode shapes of a cracked beam are obtained using the finite element method. An 'overall additional flexibility matrix', instead of the 'local additional flexibility matrix', is added to the flexibility matrix of the corresponding intact beam element to obtain the total flexibility matrix, and therefore the stiffness matrix.[3] Malay Quila et. al., have studied on cracks which causes changes in the physical properties of a structure which introduces flexibility, and thus reducing the stiffness of the structure with an inherent reduction in modal natural frequencies. Consequently it leads to the change in the dynamic response of the beam.[4]Ranjan K. Behera, Anish Pandey, Dayal R. Parhi in their research work has developed the theoretical expressions to find out the natural frequencies and mode shapes for the cantilever beam with two transverse cracks.[5] As discussed above the failure of machine component is loss of time, money and life. Most of the machine components failures are because of the crack. So there is necessity to predict such failures in advance so that losses because of failure are avoided or minimized. Condition based monitoring is one of the preventive maintenance method used in the plant maintenance. So there is requirement to develop the methodology which can be used easily to predict the crack in the machine component from the machine condition such as vibration data.The present work is aimed at finding the natural frequency of a fixed free beam with a single crack and un-cracked crack using finite element analysis ANSYS software

2. EXPERIMENTAL APPROACH

The schematic block diagram of the complete experimental setup is shown in Figure: 6.1. An experimental set-up contains following devices for performing the experiment.Before the experimental study the beams surface has been cleaned and organized for straightness. Subsequently, transverse inclined crack is created at different location from fixed end in different specimens with the help of Wire EDM machine. Frequencies corresponding to1st, 2nd, 3rd and 4th mode are noted with different crack depth at different crack locations and different crack inclinations in the cracked cantilever and simply supported beam.

The experimental setup consists of a cantilever beam or simply supported beam structure, transducers (strain gauge, accelerometer, laser vibrometer) a data-acquisition system and a computer with signal display and processing software (Fig.1). Material properties are listed in Table 1.Accelerometer is a sensing element (transducer) to measure the vibration response (i.e., acceleration, velocity and displacement.) Data acquisition system takes vibrations signal from the accelerometer, and encodes it in digital form. Computer act as a data storage and analysis system. It takes encoded data from the data acquisition system and after processing (e.g., FFT), it displays on the computer screen by using analysis software. Fig. 6.2 shows an experimental setup of the cantilever beam. It includes a beam specimen of a particular geometry with a fixed end and at the free end an accelerometer is mounted to measure the free vibration response. The fixed end of beam is gripped with the help of clamp. For getting precise free vibration cantilever beam data, it is very important to ensure that clamp is tightened properly; otherwise it may not give fixed end conditions in the free vibration data.

Table. 1 Material Property and Dimensions of Aluminium Beam

Dimensions and Properties	Aluminum
Length	0.8 m
Width	0.03 m
Thickness	0.006 m
Density	2700 kg/m^3
Young modulus	70 Gpa
Poisson's ratio	0.3

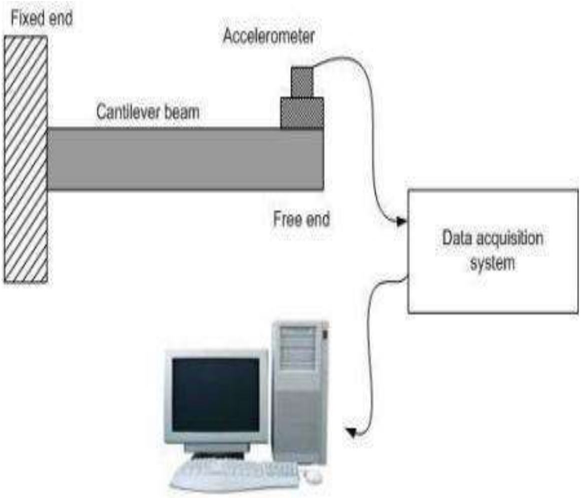


Fig. 1: An experimental setup for the free vibration of a cantilever beam

2.1 Experimental procedure:

1. Choose a beam of a particular material with dimensions (L, w, t) and transducer (i.e., measuring device, e.g. strain gauge, accelerometer, laser vibrometer).

2. Clamp one end of the beam while other end is free for the cantilever beam condition and for simply support beam condition clamp one end of the beam while other end is just rest on support

3. Place an accelerometer (with magnetic base) at the free end of the cantilever beam and at the middle point along the length for simply support beam, to measure the free vibration response (acceleration).

4. Give an initial deflection to the cantilever beam or SSB and allow it to oscillate its own. To get the higher frequency it is suggested to give initial displacement at an arbitrary position apart from the free end of the beam (e.g. at the mid span).

5. This could be done by bending the beam from its static equilibrium position by applying a small static force at the free end of the beam for cantilever condition and at middle of total length of beam in case of SSB and suddenly releasing it, so that the beam oscillates its own without any external force during the oscillation.

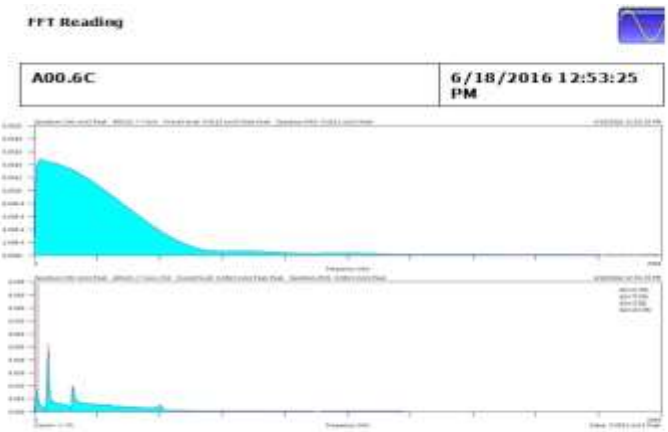
6. The free oscillation could also be started by giving a small tap at the free end of the beam or middle of beam.

7. Record the data obtained from the chosen transducer in the form of graph (variation of the vibration response with time).

8. Repeat the procedure for 5 to 10 times to check the repeatability of the experimentation.

9. Repeat the whole experiment for different specimen and different condition.

10. Record the whole set of data in a data base.



Graph 1 :- FFT Readings for cantilever beam condition

Table 2: First four Mode Natural Frequencies for cantilever Beam (By Experiment with FFT Analyzer)

Crack Angle	α	Natural Frequency			
		Mode 1st (Hz)	Mode 2nd (Hz)	Mode 3rd (Hz)	Mode 4th (Hz)
0	0.6	15.00	95.50	265.50	519.50
0	1.2	15.00	94.00	262.50	513.50
0	1.8	15.50	95.50	262.50	511.00
15	0.6	15.50	95.50	269.50	526.00
15	1.2	14.50	95.50	265.50	522.00
15	1.8	14.00	94.00	265.50	512.00
30	0.6	15.00	95.5	261.50	511.00
30	1.2	15.00	95.5	268.50	526.50
30	1.8	15.00	94.5	267.50	523.50
45	0.6	15.5	95.5	265.00	516.50
45	1.2	15.5	95.5	261.00	522.50
45	1.8	15.5	95.5	261.00	518.50

3. RESULTS AND DISCUSSION

Natural frequencies of the cantilever beam with a inclined edge crack at various crack inclination and crack depths for first, second, third, fourth modes of vibration respectively. Results show that there is an appreciable variation between natural frequency of cracked and un-cracked beam.

It is observed that natural frequency of the cracked beam decreases both with increase in crack inclination and crack depth due to reduction in stiffness. It appears therefore that the change in frequencies is not only a function of crack depth and crack inclination but also of the mode number.

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