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Active Vibration Control of Smart Cracked Structure Using Controller

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ABSTRACT

This work focuses on the frequency determination of a cracked Aluminum Beam at various locations .The influence of the crack location on natural frequency is studied and an analytical approach is proposed for the modeling of a cracked Al Beam with varying crack size. Laser cutting is used for making crack on the Aluminum Beam. An experimental validation is carried out on FFT Analyzer and Spectra plus Software. This natural frequency is determined by using Euler Beam theory. When cracks are present in structure, natural frequencies are deviates from original frequency and result are validated by using FEA like ANSYS. The control on damage of natural frequency is done by applying Piezoelectric Patch on the beam at various locations.

Keywords: Natural Frequency, Piezoelectric Patch, FFT Analyzer.

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I. INTRODUCTION

Damage is one of the important aspects in structural analysis because of safety reason as well as economic growth of the industries. Damage occur in structural element due to accidents, normal operation or natural events such as earth quake. To achieve their industrial goal, now a days the plants as well as industries are running round the clock fully. During operation, structures are subjected to structural defects such as cracks and it leads to failure or break down the structures. Thus the importance of inspection in the quality assurance of manufactured products is well understood. 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. This is basically appears in the vibrating structures while undergoes operations. The most common structural defect is the existence of a crack in machine member. The presence of crack induces local flexibility, which affects the dynamic behavior of the whole structure as a result the reduction occurs in natural frequency and mode shape. By considering the changes in those parameters crack can be identified in terms of crack depth and crack location.

Many researchers have been carried out their research works using open crack models, which means they have considered that a crack remains open during vibration. Numerous methodologies investigated over last few decades, however, indicate that a real fatigue crack opens and closes during vibration. It exhibits non-linear behavior due to the variation of the stiffness which occurs during the response cycle. As a result, a breathing crack gives rise to natural frequencies falling between those corresponding to the open and closed states. Therefore, if an always open crack is assumed, the decrease in experimental natural frequencies will lead to an underestimation of the crack depth.

Beams are one of the most commonly used structural elements in several engineering applications and experience a wide variety of static and dynamic loads. Considering the crack as a significant form of such damage, its modeling is an important step in studying the behavior of damaged structures. Knowing the effect of crack on stiffness, the beam or shaft can be modeled 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.

The most common structural defect is the existence of a crack. Cracks are present in structures due to various reasons. The presence of a crack could not only cause a local variation in the stiffness but it could affect the mechanical behavior of the entire structure to a considerable

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extent. Cracks present in vibrating/rotating components could lead to catastrophic failure. They may also occur due to mechanical defects. Another group of cracks are initiated during the manufacturing processes. Generally they are small in sizes. Such small cracks are known to propagate due to fluctuating stress conditions. If these propagating cracks remain undetected and reach their critical size, then a sudden structural failure may occur. Hence it is possible to use natural frequency measurements to detect cracks. To help in a continuous safety assessment of a machine or structure it is very necessary to constantly assess the health of its critical components. This calls for a continuous assessment of changes in their static and/or dynamic behavior. The development of a crack does not necessarily make a component instantly useless, but it is a signal that its behavior has to be monitored more carefully.

Many different methods have been developed in the area of crack identification and repair. Generally these methods can be categorized into frequency domain and time domain methods. These groups may be subdivided into different areas depending on the parameters used or method performed in the damage detection process.

II. LITRATURE REVIEW

Dr. Chandrashekhar Bendigeri and Ritu Tomar, [2011], have been presented the formulation of the finite element for static analysis based on isoparametric formulation. The element considered in the present study is eight noded hexahedral elements. A computer code based on the above formulation has been developed using MATLAB software to solve the three dimensional structures integrated with piezoelements. The experiments have been conducted on the piezoelectric smart structures consisting aluminum beam with piezoelectric materials for deformation due to applied voltage, steel beam with piezoelectric materials for deformation due to applied voltage and finally natural frequency for aluminum beam with piezoelectric materials natural frequency is estimated by application of electromechanical behavior of piezomaterial. The results obtained were used for validating the present finite element code developed and found to have good agreement

J. K. Sinha et. al., [2002], developed a new simplified approach to modelling cracks in beams undergoing transverse vibration is presented. The modelling approach uses Euler}Bernoulli beam elements with small modifications to the local flexibility in the vicinity of cracks. This crack model is then used to estimate the crack locations and sizes, by minimizing the difference between the measured and predicted natural frequencies via model updating. The uniqueness of the approach is that the simplified crack model allows the location and damage extent to be estimated directly. The simplified crack model may also be used to generate training data for pattern recognition approaches to health monitoring. The proposed method has been illustrated using the experimental data on beam examples.

K. B. Waghulde and Dr. Bimlesh Kumar, [2011] have studied the smart structures and smart materials. These materials has been an emerging area of research for last few decades. A smart structure would be able to sense the vibration and generate a controlled actuation to it, so the vibration can be minimized. For this purpose, smart materials are used as actuators and sensors. In this paper, some literature review is given about smart structure and smart material. Piezoelectric material is used as smart material and cantilever beam is considered as a smart structure. Different positions are considered for the model analysis. In this case, the modal analysis are found out by using ANSYS and MATLAB.

K. B. Waghulde and Dr. Bimlesh Kumar, [2012] have studied, the locations of actuators and sensors over a structure determine the effectiveness of the controller in controlling vibrations. If we need to control a particular vibration mode, we have to place actuators and sensors in locations with high control. In many cases of vibration control, low frequency modes are considered to be important. Hence, we only need to consider a certain number of modes in the placement of actuators and sensors. We extended the methodology for finding optimal placement of general actuators and sensors over a flexible structure. For vibration analysis ANSYS software is used. Experimentation is done for control vibration and to find optimal position of piezoelectric actuator/sensor over a thin plate. To obtain frequency response from PZT actuators and sensors, Spectra plus software is used.

K. Hari Prasad, Dr. M. Senthil Kumar, [2009], investigates the accuracy of predicting the dynamic response by finite element modeling of structures with cracks. Steel and composite materials are widely used in various construction elements and composites in particular have increased substantially over the past few years. These materials are subjected to various types of damage, mostly cracks and delaminations. These result in local changes of the stiffness of elements from such materials and consequently their dynamic characteristics are altered.

L. Rubio, [2009], developed an effective crack identification procedure based on the dynamic behavior of a Euler–Bernoulli cracked beam. It is very well known that the presence of a crack in a structure produces a change in its frequency response that can be used to determine the crack properties (position and size) solving what is called an inverse problem. In this work, such an inverse problem has been solved by the use of the classical optimization technique of minimizing the least square criterion applied to the closed-form expression for the frequencies obtained through the perturbation method. The advantage of this method with respect to the ones derived previously is that the knowledge of the material and its properties (Young's modulus and mass density) is not necessary, not even the behavior of the uncracked element. The methodology has been successfully applied to a simply supported Euler–Bernoulli beam.

S. Eswar Prasad et. Al., [2005], have describes piezoelectric materials, actuators and their use in smart structures. The paper provides criteria for the evaluation and selection of piezoelectric materials and actuator configurations. Typical applications using piezoelectrics in smart structures are also presented, with particular emphasis on shape and vibration control.

Samer Masoud Al-Said, [2007], has been developed a crack identification algorithm based on a mathematical model to identify crack location and depth in stepped cantilever Euler–Bernoulli beam carrying concentrated masses. In order to estimate crack location and depth in the beam the proposed algorithm utilizes the variation of the difference between the natural frequencies of cracked and intact systems versus single mass location along the beam span.

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The assumed mode method is used to derive the mathematical model for the system under investigation, in which the crack's effect is introduced to the system as a global effect. The advantage of the proposed algorithm is to identify the crack by monitoring a single natural frequency of the system. The algorithm can utilize the measurements of the first few system natural frequencies to check/reconfirm its identification results.

Wen Hui Duan, et. Al. [2010], have reviews the recent applications of piezoelectric materials in structural health monitoring and repair conducted by the authors. First, commonly used piezoelectric materials in structural health monitoring and structure repair are introduced. The analysis of plain piezoelectric sensors and actuators and interdigital transducer and their applications in beam, plate and pipe structures for damage detection are reviewed in detail. Second, an overview is presented on the recent advances in the applications of piezoelectric materials in structural repair. In addition, the basic principle and the current development of the technique are examined.

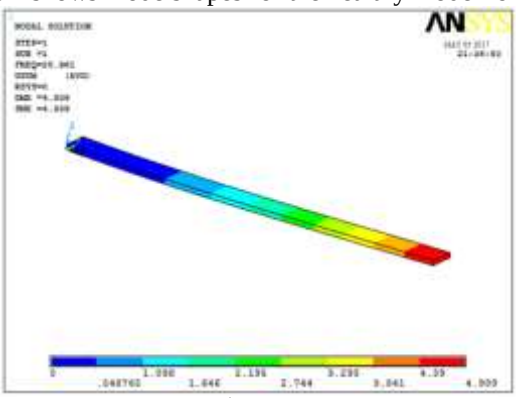
III. FINITE ELEMENT ANALYSIS OF CANTILEVER SMART BEAM

FEA helps the designer know all the theoretical stresses within the structure by showing all the problem areas in detail and thus helping the designer to predict the failure of the structure. It is an economic method of determining the causes of failure and the way the failures can be avoided. In our study we are analyzing the cracked beam in the FEA method by using a software known as ANSYS. It has several application in mechanical event simulation and computational fluid dynamics. Here the model is first designed in **CATIA** and then imported to the ANSYS software where after giving proper boundary conditions gives output in three modes of natural frequencies. The model is prepared by using commercial FE software ANSYS. In ANSYS, the beam is modeled with a 2-D elastic beam element (BEAM3). Material properties are taken from the Table 1. A unit step force is applied in the positive vertical direction at the tip of the beam. The Beam is considered to have three DOF, two translational and one rotational.

Table.1 Material Properties and Dimensions of Aluminium Beam and Piezoelectric Actuator

Dimensions/Properties	Aluminium	Piezoelectric actuator
Length	0.4 m	0.0762 m
Width	0.03 m	0.0254 m
Thickness	0.005 m	0.5x10-3 m
Density	2700 kg/m3	7600 kg/m3
Young modulus	70 Gpa	76 GPa
Poisson's ratio	0.3	---------
Piezoelectric Stain Constant	--------	-247 x 10-12 m/V

Figure 1 shows mode shapes for the healthy model for beam.



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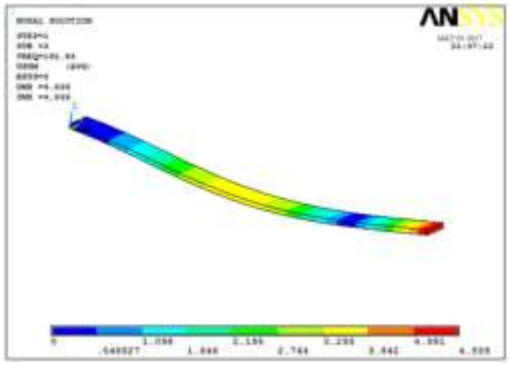

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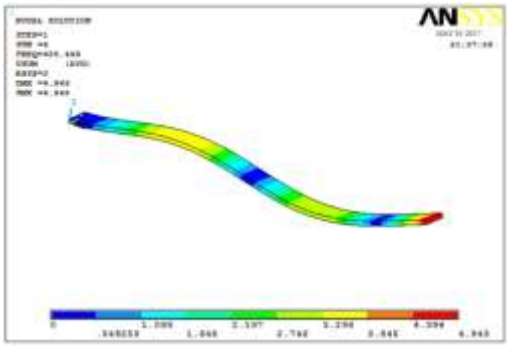
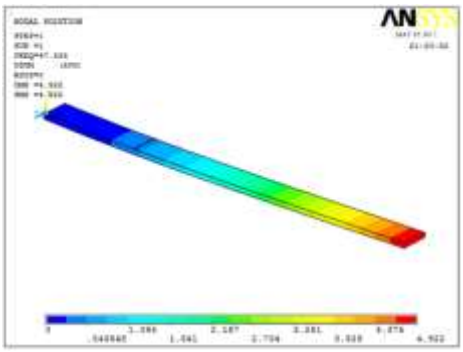


IIIrd Mode

Fig.1 Mode Shapes for Healthy Cantilever Beam Model

Figure 2, 3, & 4 shows mode shapes for the location at L1=0.1m, L2=0.2m, L1=0.1m and L2=0.2m (Combine) cracked model of 0.5mm depth for beam from cantilevered edge. Similar results and observations are found out for the cracks having depth 1.5, 2.5 and 3.5 mm. The results for all cases are compared in Table 3, 4 and 5.



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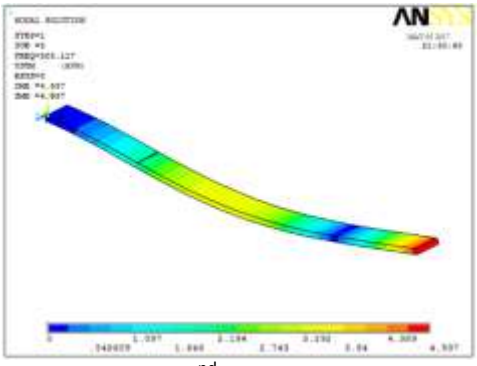

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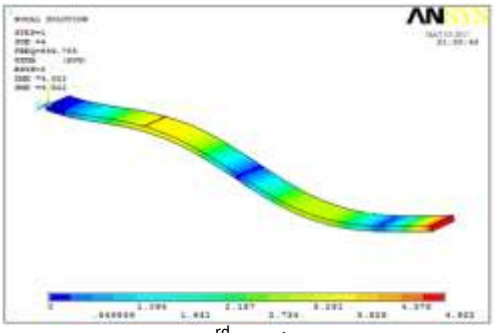
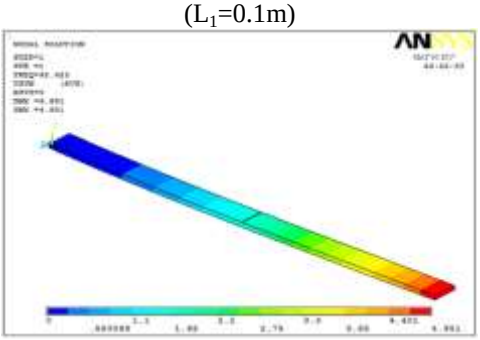


IIIrd Mode

Fig.2 Mode Shapes for 0.5mm crack for Cantilever Beam (L_1=0.1m)



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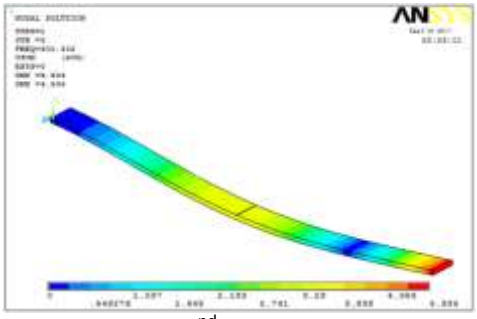

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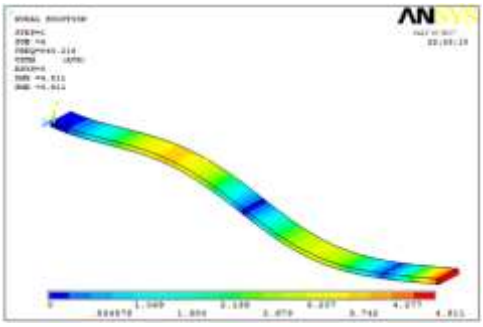
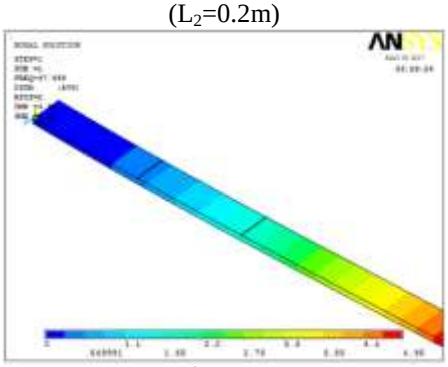


IIIrd Mode

Fig.3 Mode Shapes for 0.5mm crack for Cantilever Beam (L_2=0.2m)



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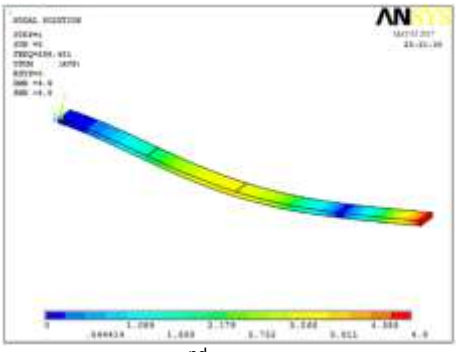

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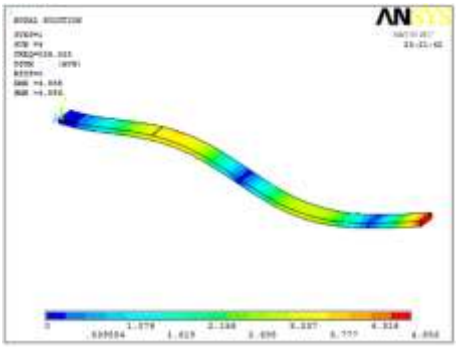

IIIrd Mode

Fig.4 Mode Shapes for 0.5mm crack for Cantilever Beam (L_1=0.1m and L_2=0.2m)

Table-2. Natural Frequencies for Healthy Beam by FEM

CRACK POSITION	DEPTH	NATURAL FREQUENCY				
		1st mode	2nd mode	3rd mode	4th mode	5th mode
		Ansys	Ansys	Ansys	Ansys	Ansys
UN-CRACKED	0mm	25.961	154.697	162.63	455.439	633.355

Table-3. Natural Frequencies for different Crack Depth at L_1=0.1m by FEM

CRACK POSITION	DEPTH	NATURAL FREQUENCY				
		1st mode	2nd mode	3rd mode	4th mode	5th mode
		Ansys	Ansys	Ansys	Ansys	Ansys
100mm	0.5mm	47.53	157.7	303.1	859.7	963.6
	1.5mm	47.35	157.7	301.3	845.2	963.8

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	2.5mm	46.56	157.1	304.0	837.1	963.7
	3.5mm	45.10	156.20	303.6	819.3	963.4

Table-4. Natural Frequencies for different Crack Depth at L_2=0.2m by FEM

CRACK POSITION	DEPTH	NATURAL FREQUENCY				
		1st mode	2nd mode	3rd mode	4th mode	5th mode
		Ansys	Ansys	Ansys	Ansys	Ansys
200mm	0.5mm	48.423	157.86	300.302	840.216	963.867
	1.5mm	48.261	157.815	297.775	842.455	962.863
	2.5mm	47.929	157.67	289.661	842.165	959.155
	3.5mm	47.559	157.401	281.476	842.399	952.424

Table-5. Natural Frequencies for different Crack Depth at L_1=0.1m and L_2=0.2m by FEM

CRACK POSITION	DEPTH	NATURAL FREQUENCY				
		1st mode	2nd mode	3rd mode	4th mode	5th mode
		Ansys	Ansys	Ansys	Ansys	Ansys
100mm & 200mm	0.5mm	47.95	157.8	299.4	839.3	963.8
	1.5mm	46.82	157.6	293.4	822.9	962.9
	2.5mm	45.62	156.95	287.82	816.56	958.93
	3.5mm	44.04	156.7	280.2	800.8	952.1

IV.EXPERIMENTAL ANALYSIS AND CONTROL OF CANTILEVER CRACK BEAM

Before the vibration control of smart structures for minimizing structural vibration, it need to understand the vibration analysis of the structure. Once the vibration analysis is understood, a good performance controller can be designed and implemented. In this section, Natural frequencies of smart structures are found out by experimental method.

In this case, a simple cantilever beam is tested for vibration analysis. The length, width and depth of the beam are taken as 0.4, 0.030 and 0.005 m, respectively. To actuate the beam, circular piezoelectric actuator is used and for sense the changes in the beam sensor is used. The system parameters are listed in Table.1. Dynamic signal analyzer, DASY-Lab version-11.00 software (Data Acquisition System Laboratory) and Spectra-PLUS version 4.0.24.0 (FFT Spectral Analysis System) were used to obtain frequency responses and time responses from the piezoelectric laminate beam. Figure 5.1 shows the experimental setup to find out the amplitude of natural frequencies for different modes.

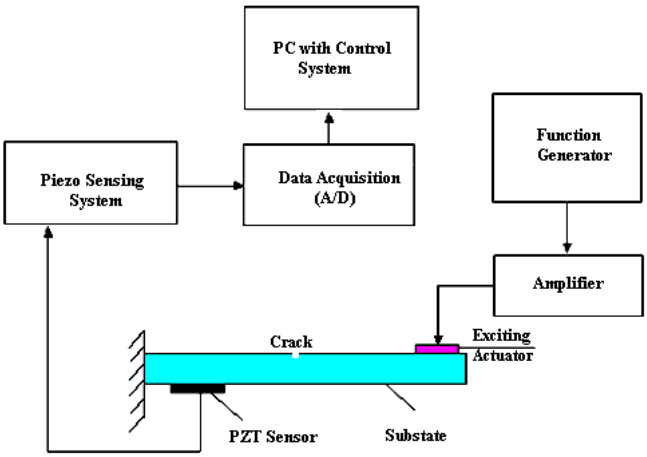

Fig.5. Experimental Setup for Cracked Cantilever Beam to Find Out Natural Frequencies

The cracked and un-cracked aluminum beam is considered as a cantilever beam. The free end has been vibrated by using exciting actuator. The function of the actuator is to produce under control vibration on the beam and the nature of the vibration is depend upon the input signal form the function generator. Whatever will be the nature of the waveforms, similar kind of vibration is produced in the beam. The function generator is used to generate the desired wave form which can be either of sinusoidal, triangular or Square in nature. The frequency range can be adjusted and set anywhere between 1Hz to 1000 KHz but as the present amplifier has limitations so it can set the frequency between 1Hz to 5Khz. The frequency is high but the amplitude of the wave form is very low to produce any notable vibration in the beam. Therefore an amplifier is used to amplify the signal. The range of amplification can be varied using the knob provider at the amplifier but should not amplify more than the safe limit of the actuator. The procedure has been repeated for all other conditions for cracked and un-cracked beam to find out their natural frequencies. Figure 6 shows the frequency response curve for healthy cantilever beam. For cracked beam having 0.5mm depth at L1=0.1m, L2=0.2m, L1=0.1m and L2=0.2m, the frequency response curves are shown in following figures 7,8 and 9. For cracked beam having different depth (0.5mm, 1.5mm, 2.5mm and 3.5mm) at L1=0.1m, L2=0.2m, L1=0.1m and L2=0.2m, the combine frequency response curves are shown in following figures 10,11 and 12.

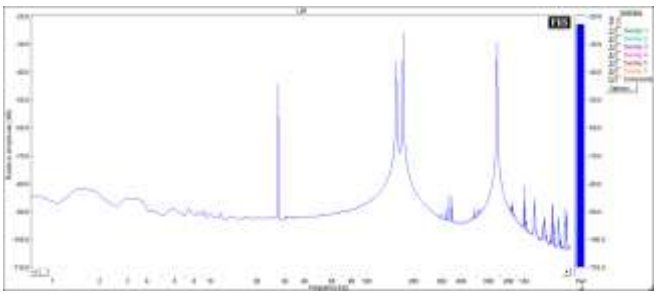

Fig. 6 Frequency Response Curve for Healthy Cantilever Beam

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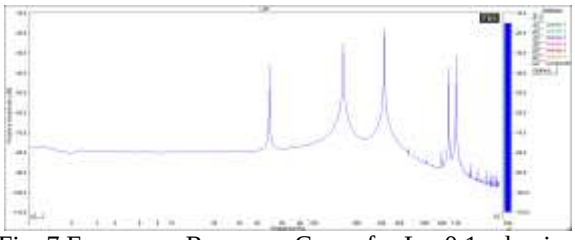

Fig. 7 Frequency Response Curve for L_1=0.1m having 0.5mm Depth

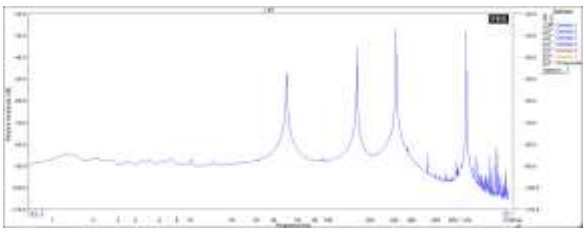

Fig. 8 Frequency Response Curve for L_2=0.2m having 0.5mm Depth

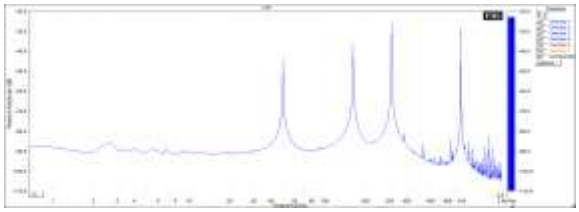

Fig.9 Frequency Response Curve for L_1=0.1m and L_2=0.2m having 0.5mm Depth

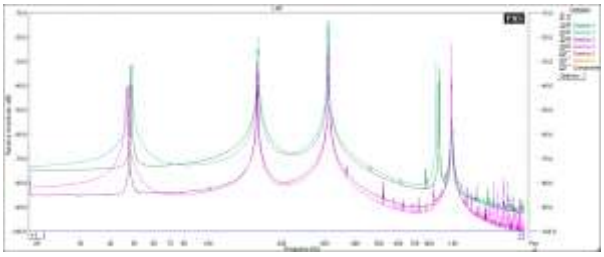

Fig. 10 Frequency Response Curve for L_1=0.1m having all Depth (0.5mm, 1.5mm, 2.5mm and 3.5mm)

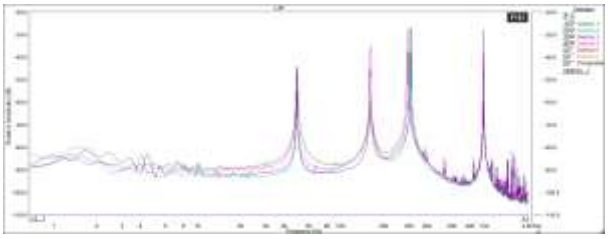

Fig. 11 Frequency Response Curve for L_2=0.2m having all Depth (0.5mm, 1.5mm, 2.5mm and 3.5mm)

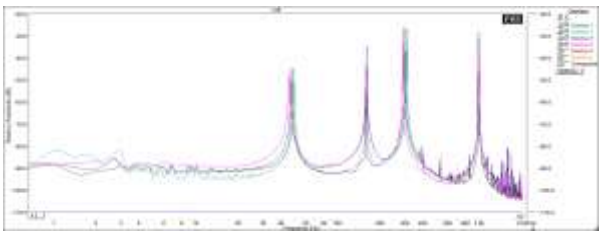

Fig. 12 Frequency Response Curve for L_1=0.1m and L_2=0.2m having all
Depth (0.5mm, 1.5mm, 2.5mm and 3.5mm)

Table 5.1 shows the natural frequencies for healthy beam by experimental method. The results for all cases are compared in Table 5.2, 5.3 and 5.4.

Table-6. Natural Frequencies for Healthy Beam by Experimental

CRACK POSITION	DEPTH	NATURAL FREQUENCY				
		1st mode	2nd mode	3rd mode	4th mode	5th mode
		Exp.	Exp.	Exp.	Exp.	Exp.
UN-CRACKED	0mm	27.10	152.83	168.42	481.93	667.36

Table-7. Natural Frequencies for Different Crack Depth at L_1=0.1m by Experimental

CRACK POSITION	DEPTH	NATURAL FREQUENCY				
		1st mode	2nd mode	3rd mode	4th mode	5th mode
		Exp.	Exp.	Exp.	Exp.	Exp.
100mm	0.5mm	48.43	158.97	308.42	875.24	983.59
	1.5mm	48.24	158.94	306.66	852.76	983.83
	2.5mm	47.45	158.38	309.33	844.66	983.73
	3.5mm	45.99	157.40	308.96	826.86	983.40

Table-8. Natural Frequencies for Different Crack Depth at L_2=0.2m by Experimental

CRACK POSITION	DEPTH	NATURAL FREQUENCY				
		1st mode	2nd mode	3rd mode	4th mode	5th mode
		Exp.	Exp.	Exp.	Exp.	Exp.
200mm	0.5mm	49.31	159.05	305.60	855.70	983.85
	1.5mm	49.15	159.01	303.08	849.94	982.84
	2.5mm	48.82	158.86	294.96	849.65	979.14
	3.5mm	48.45	158.59	286.78	849.88	972.40

Table-9. Natural Frequencies for different Crack Depth at L_1=0.1m and L_2=0.2m by Experimental

CRACK POSITION	DEPTH	NATURAL FREQUENCY				
		1st mode	2nd mode	3rd mode	4th mode	5th mode
		Exp.	Exp.	Exp.	Exp.	Exp.
100mm & 200mm	0.5mm	48.85	159.03	304.75	854.82	983.85
	1.5mm	47.71	158.84	298.70	830.47	982.93
	2.5mm	46.51	158.14	293.13	824.05	978.91
	3.5mm	44.94	157.92	285.60	808.31	972.11

Vibration Control of Cracked beam by using PZT Actuator and LQG Controller

the effect of position of actuator at different locations for controlling the amplitude of vibration of the cracked beam is tested using simulations (FEM) and experimental methods. The location of the sensor has been fixed throughout the simulation, where the actuators are placed at different locations. The LQG controller has been used to study the effect of the actuator positions. The LQG controller have been implemented such that the amplitude of vibration for the closed- loop system should be minimized.

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An LQG controller is added to the system as shown in Figure 5.10. The output voltage of the sensor is fed to the LQR controller. The signal from sensor is controlled by controlled gain parameters g_c and T_c in controller. Then corrected signal is fed to the actuator which gives punching action and produces shear force on the surface of cracked beam. This shear force is act as damping force in opposite direction of amplitude of original vibration and in this way minimize or control the vibration The values of g_c and T_c are find out by following equations. The actuator is placed in opposite direction of the crack.

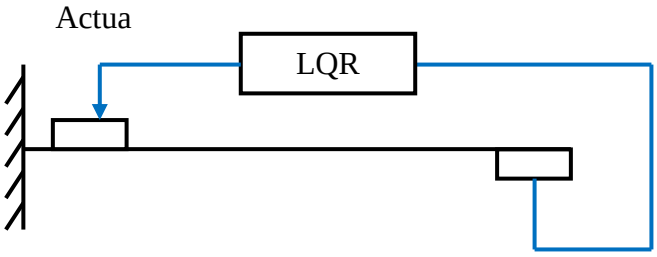
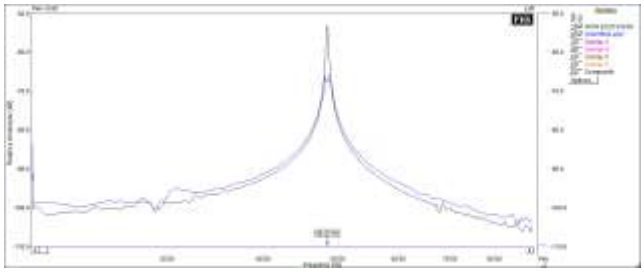
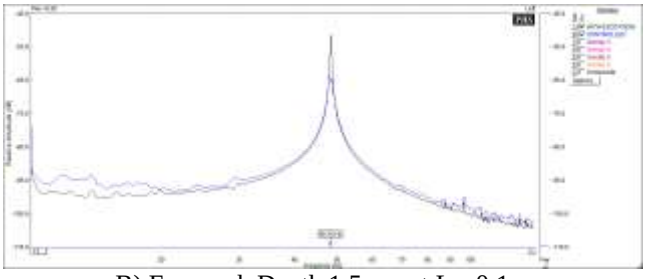


Fig.13. Smart Beam with LQR Controller for Cantilever

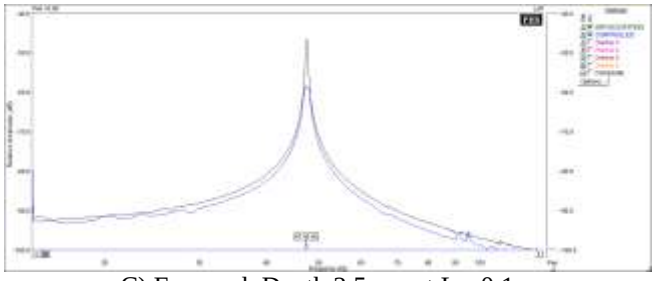
Figures 14 show the frequency response curves for open loop and closed loop system. It is clearly seen that for closed loop system the resonance of modes are reduced as compared to open loop system.



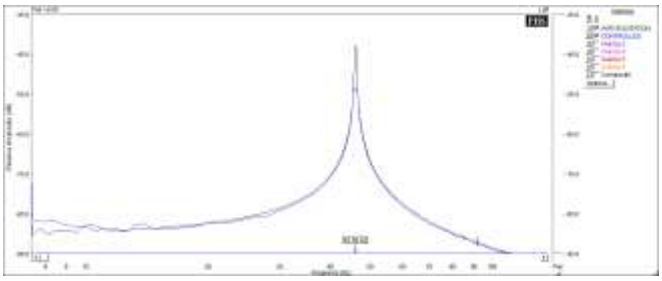
A) For crack Depth 0.5mm at L_1=0.1m



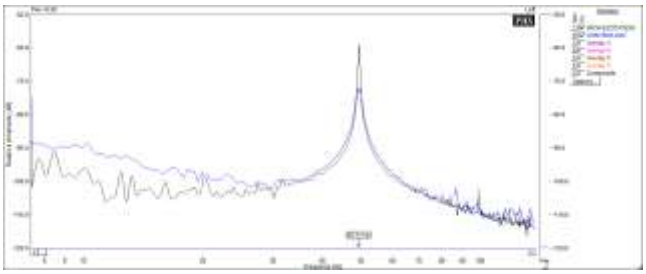
B) For crack Depth 1.5mm at L_1=0.1m



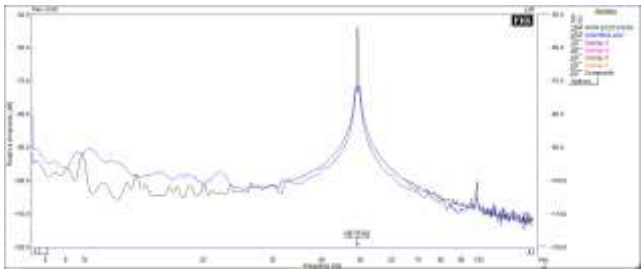
C) For crack Depth 2.5mm at L_1=0.1m



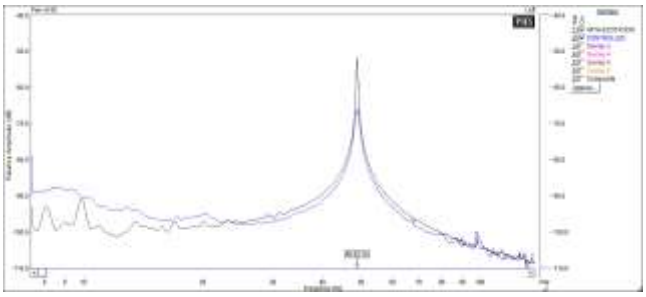
D) For crack Depth 3.5mm at L_1=0.1m



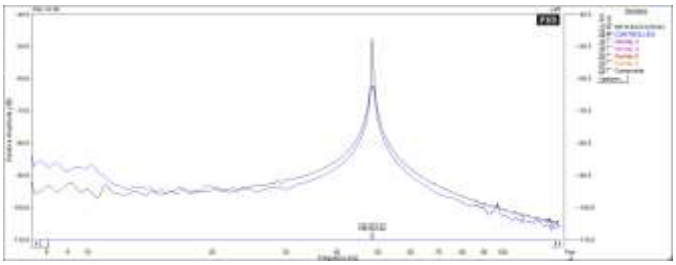
E) For crack Depth 0.5mm at L_2=0.2m



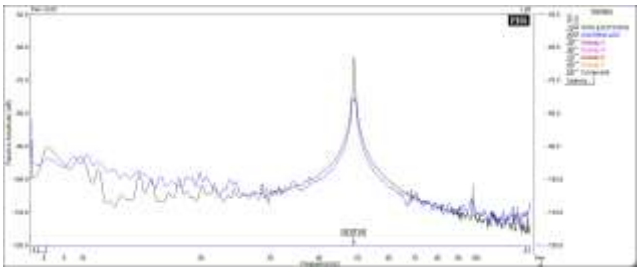
F) For crack Depth 1.5mm at L_2=0.2m



G) For crack Depth 2.5mm at L_2=0.2m



H) For crack Depth 3.5mm at L_2=0.2m



I) For crack Depth 0.5mm at L_1=0.1m and L_2=0.2m

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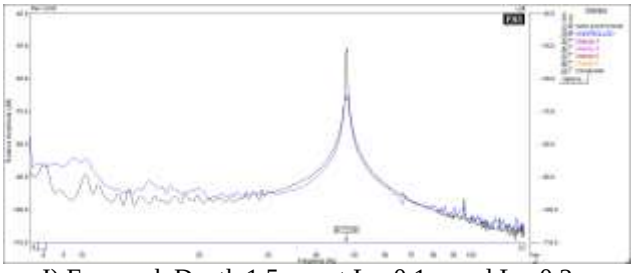
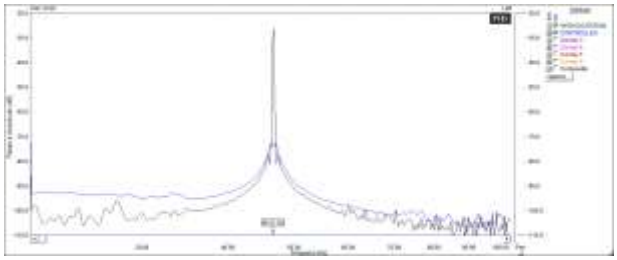
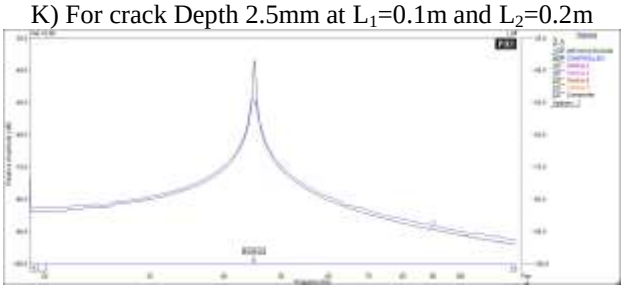


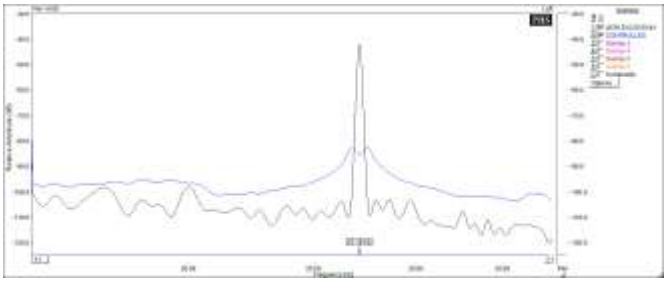
J) For crack Depth 1.5mm at L_1=0.1m and L_2=0.2m



K) For crack Depth 2.5mm at L_1=0.1m and L_2=0.2m



L) For crack Depth 3.5mm at L_1=0.1m and L_2=0.2m



M) For Healthy Beam

Fig. 14. The Frequency Response Curves for Open Loop and Closed Loop System

V. RESULT

I have compared the results of Finite Element Method with Experimental method for natural frequencies at first five modes. Following tables and graphs shows the variation of FEM with Experimental for all positions with all crack depth

Table 9. Natural Frequencies for position of crack at L_1=0.1m

CRACK POSITION	DEPTH	NATURAL FREQUENCY					
			1st mode	2nd mode	3rd mode	4th mode	5th mode
100mm	0.5mm	Ansys	47.535	157.779	303.117	859.755	963.612
		Exp.	48.43	158.97	308.42	875.24	983.59
	1.5mm	Ansys	47.35	157.746	301.355	845.284	963.848
		Exp.	48.24	158.94	306.66	852.76	983.83
	2.5mm	Ansys	46.563	157.185	304.032	837.179	963.747
		Exp.	47.45	158.38	309.33	844.66	983.73
	3.5mm	Ansys	45.102	156.207	303.655	819.38	963.421
		Exp.	45.99	157.40	308.96	826.86	983.40
UN-CRACKED		Ansys	25.961	154.697	162.63	455.439	633.355
		Exp.	27.10	152.83	168.42	481.93	667.36

Table 10. Natural Frequencies for position of crack at L_2=0.2m

CRACK POSITION	DEPTH	NATURAL FREQUENCY					
			1st mode	2nd mode	3rd mode	4th mode	5th mode
200mm	0.5mm	Ansys	48.423	157.86	300.302	840.216	963.867
		Exp.	49.31	159.05	305.60	855.70	983.85
	1.5mm	Ansys	48.261	157.815	297.775	842.455	962.863
		Exp.	49.15	159.01	303.08	849.94	982.84
	2.5mm	Ansys	47.929	157.67	289.661	842.165	959.155
		Exp.	48.82	158.86	294.96	849.65	979.14
	3.5mm	Ansys	47.559	157.401	281.476	842.399	952.424
		Exp.	48.45	158.59	286.78	849.88	972.40
UN-CRACKED		Ansys	25.961	154.697	162.63	455.439	633.355
		Exp.	27.10	152.83	168.42	481.93	667.36

Table 11. Natural Frequencies for position of crack at L_1=0.1m and L_2=0.2m

CRACK POSITION	DEPTH	NATURAL FREQUENCY					
			1st mode	2nd mode	3rd mode	4th mode	5th mode
100mm & 200mm	0.5mm	Ansys	47.955	157.838	299.451	839.335	963.865
		Exp.	48.85	159.03	304.75	854.82	983.85
	1.5mm	Ansys	46.821	157.651	293.403	822.985	962.951
		Exp.	47.71	158.84	298.70	830.47	982.93
	2.5mm	Ansys	45.621	156.954	287.825	816.566	958.931
		Exp.	46.51	158.14	293.13	824.05	978.91
	3.5mm	Ansys	44.048	156.731	280.295	800.827	952.132
		Exp.	44.94	157.92	285.60	808.31	972.11
UN-CRACKED		Ansys	25.961	154.697	162.63	455.439	633.355
		Exp.	27.10	152.83	168.42	481.93	667.36

Table 12. Amplitude of Tip Displacement for Open Loop and Closed Loop System

CRACK POSITION	0.5mm		1.5mm		2.5mm		3.5mm	
	excited	controlled	excited	controlled	excited	controlled	excited	controlled
0mm	-42.01	-81.65	-42.01	-81.65	-42.01	-81.65	-42.01	-81.65
100mm	-52.42	-66.28	-50.23	-63.52	-44.28	-57.70	-40.50	-52.71
200mm	-57.21	-71.23	-53.11	-70.99	-50.12	-65.35	-46.49	-61.63
100 & 200 mm	-60.43	-74.38	-54.40	-69.50	-31.18	-76.15	-40.70	-53.46

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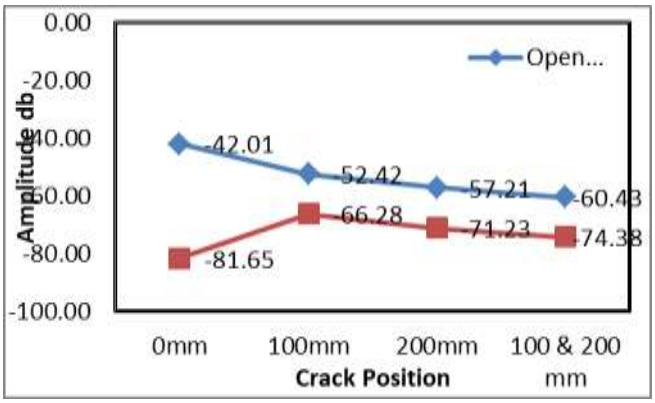

Fig. 15. Tip Displacement for Open Loop and Closed Loop System for 0.5mm Crack Depth

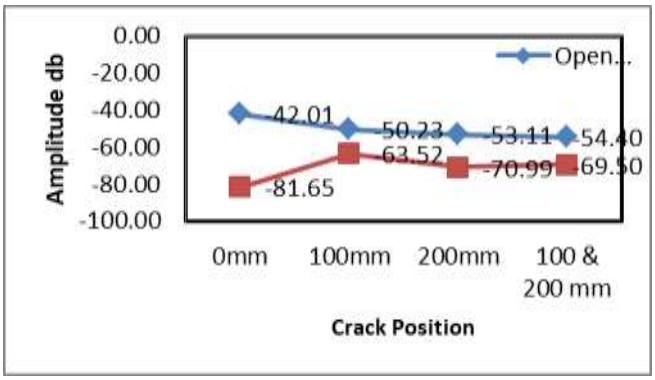

Fig. 16. Tip Displacement for Open Loop and Closed Loop System for 1.5mm Crack Depth

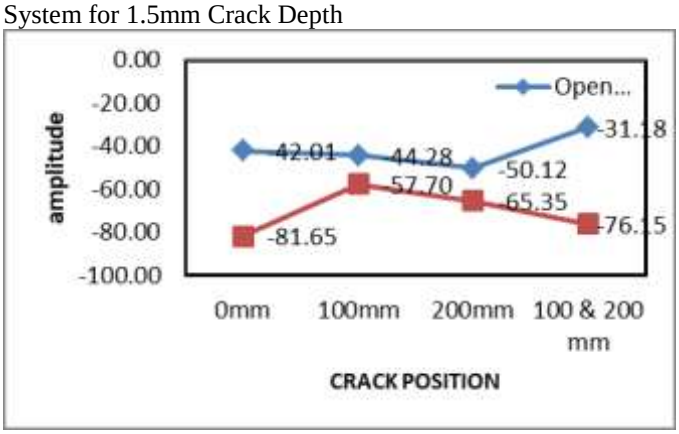

Fig. 17. Tip Displacement for Open Loop and Closed Loop System for 2.5mm Crack Depth

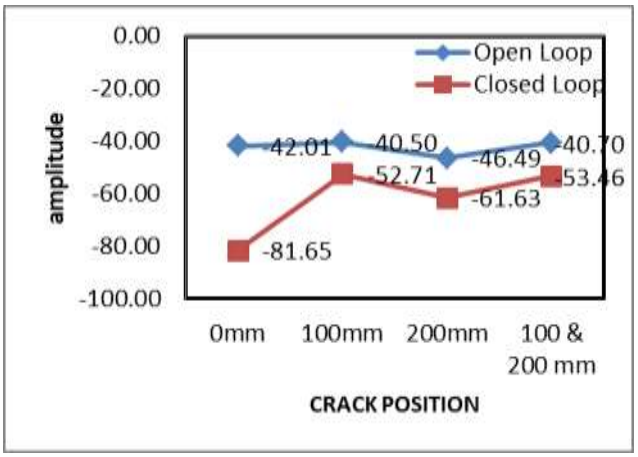

Fig. 18 Tip Displacement for Open Loop and Closed Loop System for 3.5mm Crack Depth

From figure 15 to 18, it is clear that when the system is excited by piezoelectric patch for open loop system, the amplitude of vibration obs
erved is much more as shown in the figures. But when the same system is excited with piezoelectric patch for closed loop system with LQG controller, the amplitude of vibration decreases which shows that the smart materials with controller can be utilize for controlling the amplitude of vibration.

VI. CONCLUSION

The difference in deflection value is found to be maximum at the crack section and this information may therefore be used to detect the resistance of a crack including its location and the severity of the crack. The proposed method is simple and easy to implement as it entails only static effect measurements. Repair is carried out by placing a small piezoelectric patch directly under the crack so as to induce a local moment upon application of a suitable voltage to the piezoelectric actuators.

The vibration analysis of a structure holds a lot of significance in its designing and performance over a period of time. In aluminum cantilever beam with one end fixed and one end free, it was seen that the results were in good co-ordinance with FEA by ANSYS and Experimental by spectra plus software values. It is seen that the natural frequency changes substantially due to the presence of cracks. The changes depending upon the location and depth of cracks. In the FEA and Experimental setup, crack depth and crack location are taken as the input and the structural natural frequencies are taken as output. From the both methods, it is observed that the first natural frequency increases as the crack location moves from the clamped end to the free end when the crack depth is kept constant. Whereas, the second to fifth natural frequencies decreases as the crack depth increases. Also it is seen that,

1. The frequencies of vibration of cracked beams decrease with increase of crack depth for crack at any particular location due to reduction of stiffness.
2. The effect of crack is more pronounced near the fixed end than at far free end.
3. The natural frequency decreases with increase in relative crack depth.
4. The position of the cracks can be predicted from the deviation of the fundamental modes between the cracked and un-cracked beam.

The results obtained are expected to be useful to other researchers for comparison. The study in this work is also necessary for a correct and thorough understanding of the Vibration analysis techniques.

With the purpose of active vibration suppression of the smart beam, piezoelectric sensor and actuator pair are used to sense the disturbance of the smart beam and counteract to suppress the disturbance with the designed LQG controller. The results of the active vibration control experiments proved that piezoelectric sensor/actuator pair is an effective sensor and actuator configuration for active vibration control to reduce the amplitude of vibration for closed loop system.

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