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Effect Of Frequency On Cantilever Beam with Different Locations of Smart Patch

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Abstract - *We tried to observe the frequency changes and variations how it reacts using a modal analysis in ANSYS software. At different shapes or at different modes of cantilever beam we draw out the results of the frequencies and helps to further study its vibrations for future scope of work. The main future scope of work that can be build using these observations is converting mechanical vibrations on chassis of a body into electrical energy using piezo materials. It is also concluded in this report about what is the best suitable place for the piezo patch could be placed to get some productive and efficient outcome.*

Key Words: Frequency, beam, Patch, Location, Time period.

1. INTRODUCTION

Due to increasingly employed functionally graded materials in high-tech industries, studying behavior of structural components such as beams or plates made of that material under various loadings becomes vitally essential. The most important achievements in modelling and analysis of the material and structures were reported in the surveys given by Birman and Byrd [1] and Gupta and Talha [2]. Various problems in dynamic analysis of functionally graded beams were studied in the widespread literature, for instance, in the works [3–7]. A large number of works is devoted also to study vibrations of the beams with localized damages such as cracks [8–13]. Recently, some procedures were proposed by Yu and Chu [14]; Banerjee *et al* [15] and Khiem and Huyen [16] to detect cracks in functionally graded beams with natural frequencies measured by the traditional technique of modal testing. As well known, the traditional modal testing is restricted to use a limited number of discrete sensors and actuators that are usually unable to gather sufficient amount of data for solving the problem of damage detection in structural health monitoring. Therefore, using distributed sensors and actuators for modal testing would be surely promising to enhance solution of the damage detection problem.

Present study deals with location of piezo on cantilever beam with respective to the frequency for first 6 modes. To study frequency extraction ANSYS work bench Used.

2 Ansys Simulation

Ansys is a simulation software which helps in product design, testing and operation. So for this project we would like to use ansys for our observations. After simulating with the required conditions and inclined to the project basis we would like to draw the possible results and observations. To observe the change in frequencies on a cantilever beam using piezo material by placing it at different positions on the beam. Taking into consideration some of the technical advantages of piezo material we wanted to observe the frequency variations on a cantilever beam using this material. This study on frequency variations can be done using the ANSYS software by simulating the desired form. Ansys develops and markets engineering simulation software for use across the product life cycle. Ansys Mechanical finite element analysis software is used to simulate computer models of structures, electronics, or machine components for analysing strength, toughness, elasticity, temperature distribution, electromagnetism, fluid flow, and other attributes. Ansys is used to determine how a product will function with different specifications, without building test products or conducting crash tests. For example, Ansys software may simulate how a bridge will hold up after years of traffic, how to best process salmon in a cannery to reduce waste, or how to design a slide that uses less material without sacrificing safety. Most Ansys simulations are performed using the Ansys Workbench system, which is one of the company's main products. Typically Ansys users break down larger structures into small components that are each modelled and tested individually. A user may start by defining the dimensions of an object, and then adding weight, pressure, temperature and other physical properties. Finally, the Ansys software simulates and analyses movement, fatigue, fractures, fluid flow, temperature distribution, electromagnetic efficiency and other effects over time. Ansys also develops software for data management and backup, academic research and teaching. Ansys software is sold on an annual subscription basis.

3.Materials and technical information

Materials used

Beam material	aluminium
Patch material	piezo

Technical information

Beam material	aluminium
Size of Aluminium (l*b*h)	250*25*2
Density	2770 kg/m^3
Young's modulus	7.1E+10
Poisson's ratio	0.33

Patch material	**Piezo**
Size of Piezo patch (l*b*h)	25*25*1
Density	4500 kg/m^3
Young's modulus	2E+11 pa
Poisson's ratio	0.3

Table -1: Properties

Axis	Young's modulus	Poisson's ratio	Shear modulus
X	7.8561e10	0.28798	3e10
Y	7.8561e10	0.45204	2.6e10
Z	6.2498e10	0.45204	2.6e10

4. PROCESS AND METHODOLOGY

4.1 STEP 1 (SELECTION OF MATERIAL)

Material selection played a major role as project objective was observing and analysis of a material in ansys software and drawing out the results trying them with new material. Piezo materials were selected due to some of their interesting properties which help in converting mechanical energy into electrical energy, so this study would help other experiments which are done using piezo materials at some point where frequencies come into picture. Cantilever beam was selected to observe frequencies on it at different modes of the beam ,as cantilever beam can produce good vibrations this study can help projects using this beam.

4.2 STEP 2 (Design of the Model)

The model is designed using Solid works software and after that for the purpose of simulation it has been extracted into ANSYS software. So by using ansys we get final results and observations where we draw possible conclusions and outcomes.

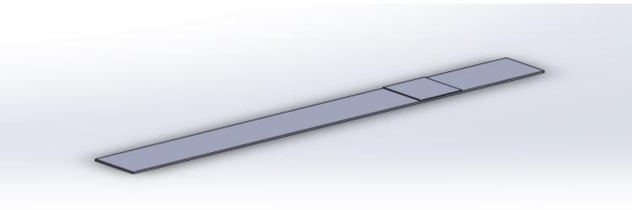

Figure 1. Cantilever beam model

4.3 STEP 3 (Usage of Ansys)

The model which is designed using solid works is imported into ANSYS software for further processing. Workbench is used in ansys for the purpose of simulation of the model. Modal analysis is selected for the materials to study its frequencies and their observations. After selecting the modal analsys we have to allocate the materials which are supposed to be assigned for the desired model designed. All the technical properties are given to the particular materials of beam and the patch accordingly. In ansys software there is a programme also written in the process of simulation to get the desired results for the given technical values. All the observations are taken by placing the patch starting at 20mm to 150mm on the cantilever beam. The frequency changes were observed for every 5mm in between from the starting point to the end point. In ANSYS we have observed for six different modes and six different frequencies. After that cumulative values are considered for the study of the model taken. Further process after getting the values a graph has been plotted which is shown in the results section and tabular values are also shown in results section chapter 5. Conclusions are drawn out using the observed values and the graphical representation.

4.4 FEW DEFORMATIONS FROM ANSYS AFTER OBSERVING THE MODAL ANALYSIS

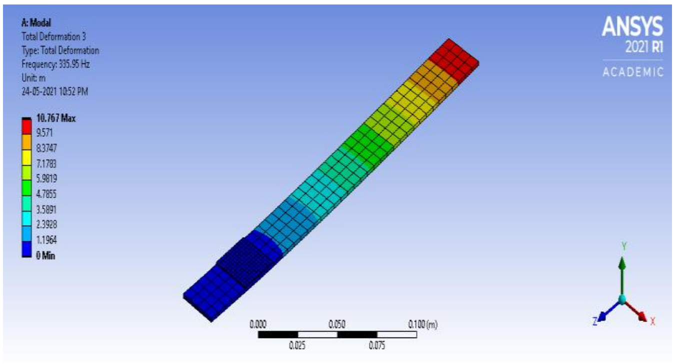

Figure 2. Deformation Mode-3 at 30mm

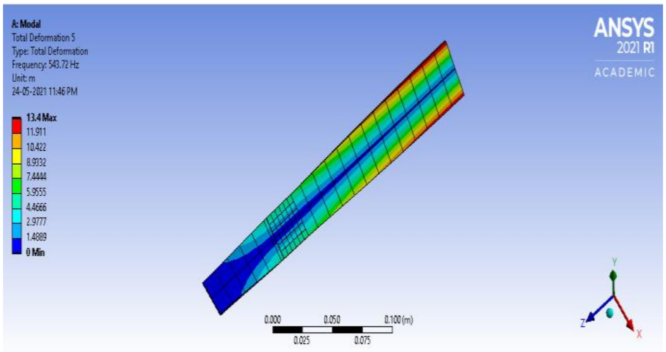

Figure 3. Deformation Mode-5 at 65mm

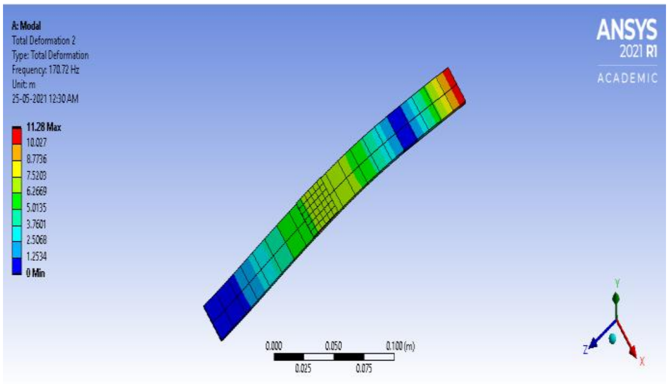

Figure 4. Deformation Mode-2 at 95mm

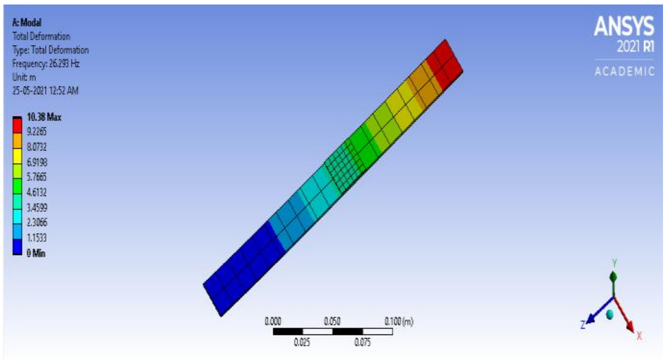

Figure 5. Deformation Mode-1 at 125mm

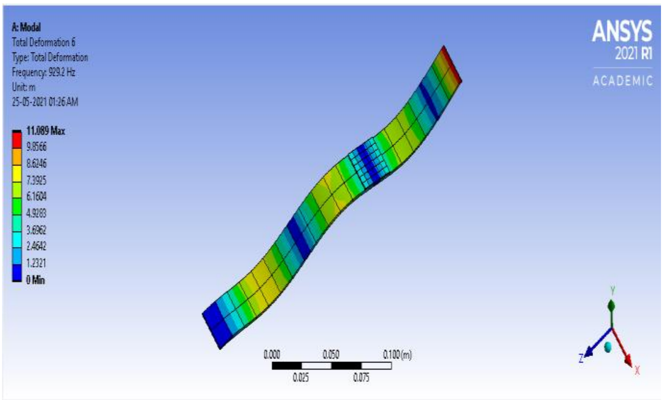

Figure 6. Deformation Mode-6 at 150mm

5. RESULTS AND DISCUSSION

We have discussed the process and methodology along with the step by step followed in the process to obtain the results. Here in chapter 5 we will discuss about the outcomes of the project and the observations which are obtained.

Observations are taken at distance from fixed end of every 5 mm by piezo patch on the aluminium beam. Ranging from (25mm - 225mm)Frequencies at these different position of piezo are observed. Frequency values for mode 1 and mode 2 at various locations of piezo patch.

Table -2: Mode 1,2 Results

MODE 1		MODE 2	
DISTANCE(mm)	FREQUENCY(Hz)	DISTANCE(mm)	FREQUENCY(Hz)
225	23.358	225	154.47
220	23.513	220	156.88
215	23.667	215	159.1
210	23.819	210	161.13
205	23.967	205	162.92
200	24.114	200	164.54
195	24.259	195	166.05
190	24.402	190	167.36
185	24.543	185	168.49
180	24.681	180	169.3
175	24.817	175	170.03
170	24.954	170	170.86
165	25.089	165	171.53
160	25.222	160	171.98
155	25.35	155	171.95
150	25.633	150	173.55
145	25.799	145	176.18
140	25.916	140	174.86
135	26.047	135	174.64
130	26.211	130	176.02
125	26.293	125	172.6
120	26.508	120	175.26
115	26.608	115	172.91
110	26.745	110	172.21
105	26.954	105	172.97
100	26.985	100	169.13
95	27.297	95	170.72
90	27.373	90	168.38
85	27.528	85	167.58
80	27.82	80	167.59
75	27.769	75	165.01
70	28.244	70	165.46
65	28.283	65	164.25
60	28.47	60	163.99
55	28.897	55	164.09

50	28.715	50	163.62
45	29.444	45	164.46
40	29.444	40	164.46
35	29.249	35	164.81
30	29.388	30	166.31
25	29.554	25	168.41
20	29.888	20	171.5

Frequency values for mode 3 and mode 4 at various locations of piezo patch.

Table -2: Mode 3,4 Results

MODE 3		**MODE 4**	
DISTANCE(mm)	**FREQUENCY(Hz)**	**DISTANCE(mm)**	**FREQUENCY(Hz)**
225	287.46	225	445.18
220	289.34	220	453.46
215	291.2	215	460.68
210	293.02	210	466.19
205	294.82	205	467.16
200	296.59	200	468.25
195	298.32	195	469.57
190	300.02	190	470.92
185	301.69	185	472.39
180	303.31	180	473.95
175	304.9	175	475.58
170	306.46	170	477.56
165	307.98	165	479.47
160	309.46	160	481.52
155	310.88	155	483.64
150	313.06	150	490.89
145	314.5	145	493.86
140	315.8	140	486.75
135	317.06	135	483.32
130	318.36	130	481.34
125	319.44	125	473.97
120	320.77	120	473.93
115	321.84	115	471.21
110	322.9	110	470.62
105	324.08	105	472.1
100	324.84	100	470.95
95	326.16	95	476.16
90	327.01	90	476.38
85	327.91	85	477.5
80	329.04	80	482.5
75	329.46	75	477.43
70	330.92	70	484.58
65	331.59	65	479.83
60	332.38	60	478.13
55	333.59	55	478.84
50	333.66	50	469.37
45	335.43	45	470.62
40	335.43	40	470.62
35	335.3	35	456.86
30	335.95	30	455.56
25	336.52	25	455.69
20	337.73	20	459.1

Frequency values for mode 5 and mode 6 at various locations of piezo patch.

Table -3: Mode 5,6 Results

MODE 5		**MODE 6**	
DISTANCE(mm)	**FREQUENCY(Hz)**	**DISTANCE(mm)**	**FREQUENCY(Hz)**
225	463.87	225	889.76
220	464.56	220	907.91
215	465.31	215	923.23
210	466.98	210	936.76
205	471.88	205	946.1
200	476.36	200	955.36
195	481.09	195	965.58
190	485.07	190	973.11
185	488.35	185	975.48
180	489.56	180	970.46
175	490.5	175	960.38
170	492.63	170	950.68
165	493.81	165	941.07
160	492.74	160	929.06
155	489.42	155	920.01

150	491.89	150	929.2
145	495.43	145	937.13
140	496.6	140	938.4
135	498.7	135	944.06
130	502.08	130	960.15
125	504.19	125	959.15
120	507.94	120	980.91
115	511.18	115	977.45
110	513.94	110	977.03
105	517.53	105	978.99
100	519.65	100	956.99
95	524.06	95	957.4
90	527.54	90	942.26
85	530.43	85	936.8
80	534.15	80	935.76
75	535.85	75	927.95
70	540.54	70	938.68
65	543.72	65	941.04
60	546.27	60	945.39
55	549.48	55	958.45
50	550.15	50	951.14
45	554.4	45	962.53
40	554.4	40	962.53
35	549.67	35	924.84
30	551.03	30	915.47
25	551.13	25	905.16
20	552.09	20	899.26

6. CONCLUSION

This result shows that we can utilize piezo materials to generate energy. By using this data, we can generate maximum energy by using minimal material by placing it at the highest frequency point. These observations show that there is a short change in frequency which proves that there are vibrations. So, when there are vibrations there will be scope of electricity generation with the usage of piezo material. When it comes to graphical analysis it can be observed that at mode 1 the highest frequency generated was at the initial state and lowest frequency was observed at the edge of the beam almost at the end. Observing at mode 2 the frequency variations were like increased rapidly in between of the beam around 145mm , as well and the lowest frequency was seen at the end of the beam. There were similar results of mode 3 as of like mode 1 there is a gradual decrease in the graph and the frequencies while the piezo patch was placed from top to bottom of the beam at various positions. So same can be concluded that the highest frequency generated was at the initial state and lowest frequency was observed at the edge of the beam almost at the end.

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