TO STUDY THE ACTIVE VIBRATION CONTROL OF A CANTILEVER BEAM IN OPEN LOOP SYSTEM

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Abstract - Research on Active Vibration Control System (AVCS) is being carried out to reduce structural vibrations caused by unwanted vibrations in many application areas such as in space, aircraft structures, satellites, automobiles and civil structures (bridges), particularly at low frequencies. In this paper; we have discussed Active Vibration Control technique by using open loop control system. Result from ANSYS and experimental results from FFT analyzer were compared. The experimental results are presented for the cantilever beam excited at one of its natural frequency using active vibration control system. For open loop control system, less reduction were observed and the reasons were discussed for it.

Keywords—Piezoelectric(PZT), Active Vibration Control(AVC), Cantilever beam, Actuator, Electro-dynamic shaker,ANSYS, FFT

INTRODUCTION

Vibration control of flexible structures is an important issue in many engineering applications, especially for the precise operation performances in aerospace systems, satellites, flexible manipulators, etc. When a structure is undergoing some form of vibration, there are a number of ways in which this vibration can be controlled. Passive control involves some form of structural augmentation or redesign, often including the use of springs and dampers, which leads to a reduction in the vibration. Active control augments the structure with sensors, actuators and some form of electronic control system, which specifically aim to reduce the measured vibration levels. Among the many materials, piezoelectric and shape memory alloys are most suitable for active control of the development of smart composite structures. They are able to generate a relatively large deformation. Piezoelectric materials like (lead-Zirconium-Titanate) can be used effectively in the development of smart systems. The proposed work is to study the irrational characteristics of cantilever beam with surface bonded PZT, particularly to control the vibration.

Concept of active vibration control

In AVC technique we are providing a 180 degree out of phase vibration signals to the beam by using actuators to cancel out the excitation vibration signals as shown in fig.1

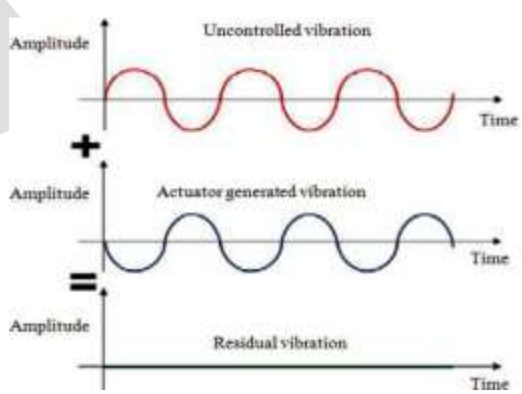

Fig. 1. Principle of active vibration control [9]

OPEN LOOP CONTROL SYSTEM

In open loop control system, the main components are

1. Cantilever beam
2. Exciter(electrodynamic shaker)
3. Actuator(PZT patch)

The excitation to the cantilever beam is provided by the exciter at the fixed end. The PZT patch is bonded on the beam near the fixed end as shown in fig.2

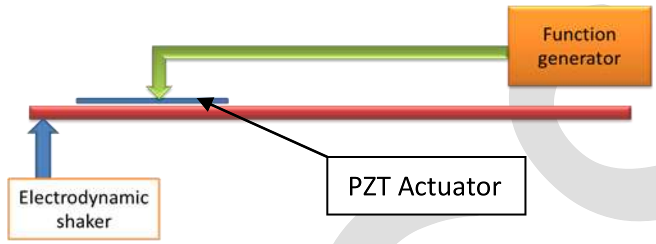

Fig.2 Block diagram of open loop control system.

Now the PZT patch is actuated using function generator. The actuation signal from the function generator was fed to the cantilever beam due to which the reduction in amplitude of vibration of beam was observed.

The positions of actuators have a critical influence on the natural frequencies of smart structures. For maximum effectiveness the actuators must be placed in high strain regions and away from areas of low strains [5].

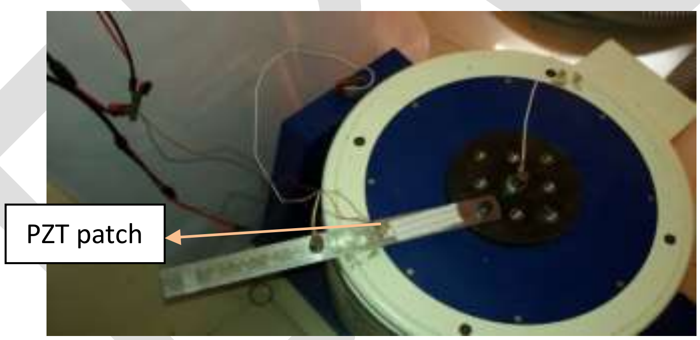

Fig. 3 mounting of beam on shaker

Fig.4 Experimental setup along with function generator

Table-1 Material Properties and Dimensions of beam

Dimensions/Properties		Stainless steel
Length (m)	*l*	0.34
Width (m)	*b*	0.029
Thickness (m)	*t*	0.002
Young's modulus (GPa)	*E*	200
Density (kg/m^3)	ρ	8000

ANALYSIS IN ANSYS

The beam is analyzed in ANSYS [4]. Beam has given excitation at one end to get the deformation and stresses in the beam. fig.5

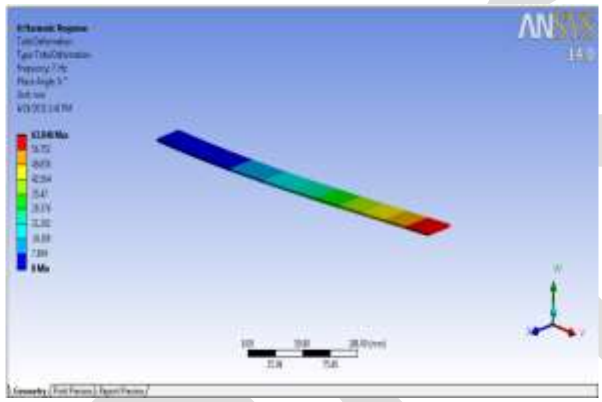

Fig.5 Before control deformation in beam

Now the actuating force has been given to the beam from opposite direction and again deformation and stresses in the beam is observed. Fig.6

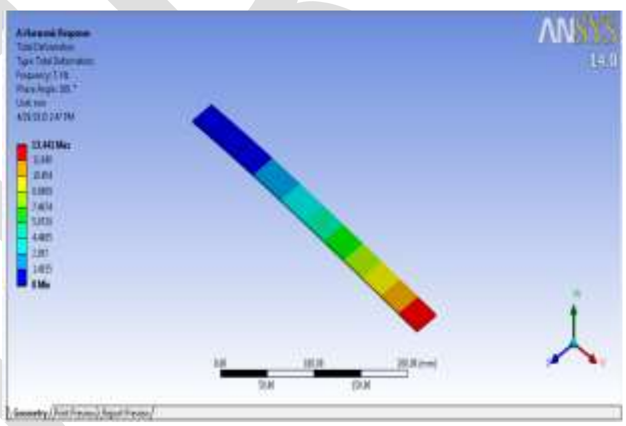

Fig.6 After control deformation in beam

ANALYSIS IN FFT

Tri-axial (X,Y,Z) accelerometer is used for analysis. Accelerometer is placed in such a way that X-axis denotes displacement of beam.

Displacement Vs Time graph is observed in FFT

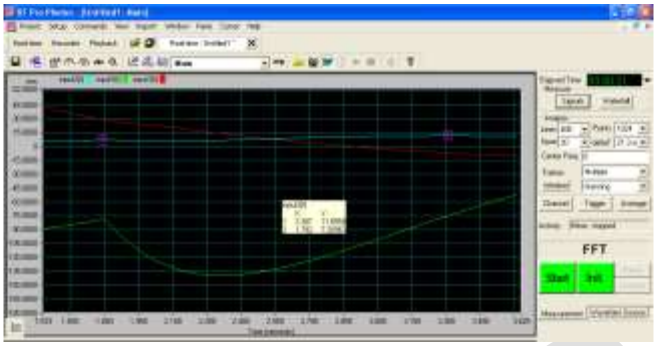

Fig 7.Displacement before control

Then the PZT patch is actuated and results are observed.

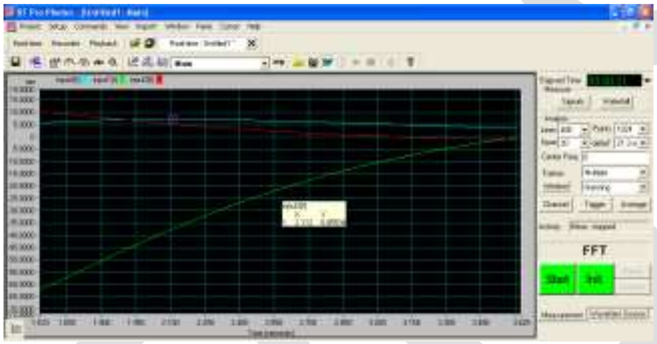

Fig 8.Displacement after control

In Fig.7&8, Input2 (t) indicates displacement in X direction.

Before control, we got displacement of 7.269 mm neglecting first peak value. After control, displacement of 6.895 mm is observed.

VIBRATION TEST REPORT

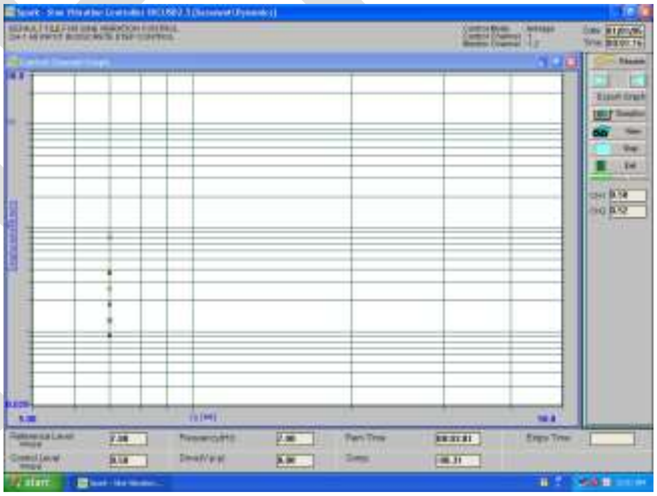

Fig 9. Control channel graph.

The following report is generated by shaker system. Amplitude of 7 mm is observed before control and it is reduced to 6 mm after control.

Table 2- Vibration test report

"VIBRATION TEST REPORT"

File Name:- 22.ASC

Date :- Fri Apr 17, 2015 15:15:46

Test ID-1:- DEFAULT FILE FOR SINE VIBRATION CONTROL

Test ID-2:- CH-1 AS INPUT IN DISCRETE STEP CONTROL

Time HH:MM:SS	Freq (Hz)	AMP.	CTRL	CH-1	CH-2	CH-3	CH-4	Unit
15:15:56	7.0	7.00	0.65	0.59	1.12	------	------	mm,p-p
15:16:06	7.0	7.00	0.89	0.90	1.61	------	------	mm,p-p
15:16:16	7.0	7.00	4.20	3.35	0.85	------	------	mm,p-p
15:16:26	7.0	7.00	0.94	0.72	1.52	------	------	mm,p-p
15:16:36	7.0	7.00	0.47	0.52	0.91	------	------	mm,p-p
15:16:46	7.0	7.00	0.94	0.78	0.96	------	------	mm,p-p
15:16:56	7.0	7.00	0.66	0.59	8.51	------	------	mm,p-p
15:17:06	7.0	7.00	1.14	1.35	1.50	------	------	mm,p-p
15:17:16	7.0	7.00	0.54	0.64	1.46	------	------	mm,p-p
15:17:26	7.0	7.00	4.62	4.52	0.56	------	------	mm,p-p
15:17:36	7.0	7.00	10.33	5.48	0.76	------	------	mm,p-p
15:17:46	7.0	7.00	0.46	0.34	0.91	------	------	mm,p-p
15:17:56	7.0	7.00	0.48	0.38	0.52	------	------	mm,p-p
15:18:06	7.0	7.00	0.65	0.63	0.60	------	------	mm,p-p
15:18:16	7.0	7.00	0.55	0.50	1.38	------	------	mm,p-p
15:18:26	7.0	7.00	0.45	0.38	0.96	------	------	mm,p-p
15:18:36	7.0	7.00	0.86	1.34	1.23	------	------	mm,p-p
15:18:46	7.0	7.00	0.53	0.57	0.81	------	------	mm,p-p
15:18:56	7.0	7.00	0.85	0.73	0.94	------	------	mm,p-p
15:19:06	7.0	7.00	0.73	0.63	1.31	------	------	mm,p-p
15:19:16	7.0	7.00	0.83	1.04	0.58	------	------	mm,p-p
15:19:26	7.0	7.00	0.42	0.43	1.12	------	------	mm,p-p
15:19:36	7.0	7.00	0.62	0.66	1.07	------	------	mm,p-p
15:19:46	7.0	7.00	0.63	0.63	1.07	------	------	mm,p-p
15:19:56	7.0	7.00	2.12	1.35	0.75	------	------	mm,p-p
15:20:06	7.0	7.00	0.42	0.39	0.77	------	------	mm,p-p
15:20:16	7.0	7.00	0.69	0.77	1.12	------	------	mm,p-p
15:20:26	7.0	7.00	0.46	0.36	1.27	------	------	mm,p-p
15:20:36	7.0	7.00	0.52	0.45	1.29	------	------	mm,p-p
15:20:46	7.0	7.00	1.71	2.28	4.01	------	------	mm,p-p
15:20:56	7.0	7.00	4.03	4.08	7.58	------	------	mm,p-p
15:21:06	7.0	7.00	4.04	4.03	7.78	------	------	mm,p-p
15:21:16	7.0	7.00	4.01	3.92	7.55	------	------	mm,p-p
15:21:26	7.0	6.10	1.23	1.34	2.30	------	------	mm,p-p
15:21:36	7.0	6.80	1.34	1.35	2.18	------	------	mm,p-p
15:21:46	7.0	6.00	1.33	1.32	2.29	------	------	mm,p-p
15:21:56	7.0	6.77	1.32	1.39	2.43	------	------	mm,p-p
15:22:06	7.0	6.20	1.35	1.34	2.20	------	------	mm,p-p
15:22:16	7.0	6.50	3.16	2.27	1.89	------	------	mm,p-p
15:22:26	7.0	6.43	1.31	1.12	0.95	------	------	mm,p-p
15:22:36	7.0	6.89	1.34	1.32	2.20	------	------	mm,p-p
15:22:46	7.0	7.00	0.75	0.92	2.11	------	------	mm,p-p
15:22:56	7.0	7.00	7.00	3.93	8.71	------	------	mm,p-p
15:23:06	7.0	7.00	7.00	3.88	8.86	------	------	mm,p-p
15:23:09	7.0	7.00	4.05	3.97	9.00	------	------	mm,p-p

From above observations, considering sample values, graph of Displacement of beam is plotted.

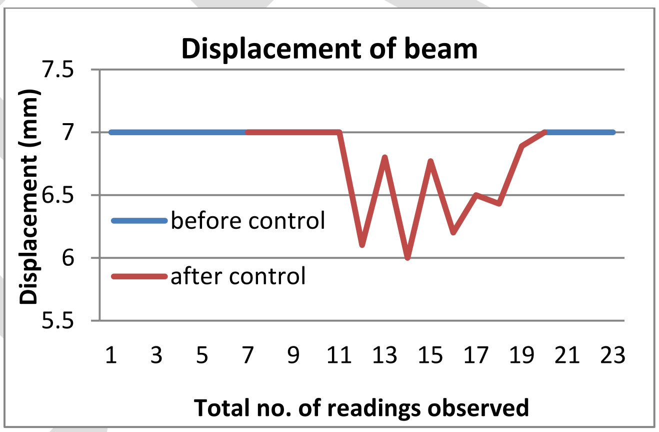

Fig 10. Graph plot on the basis of experimental results.

FREE VIBRATION ANALYSIS IN OPEN LOOP SYSTEM USING FFT

Beam is excited freely with amplitude of approximately 4 mm and the results are observed in FFT analyzer. Now the patch is actuated which is bonded on the beam. It is then vibrated freely and results are observed.

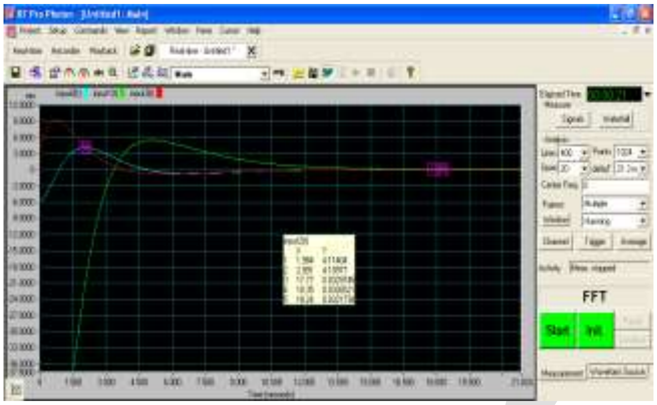

Fig.11 Displacement before control

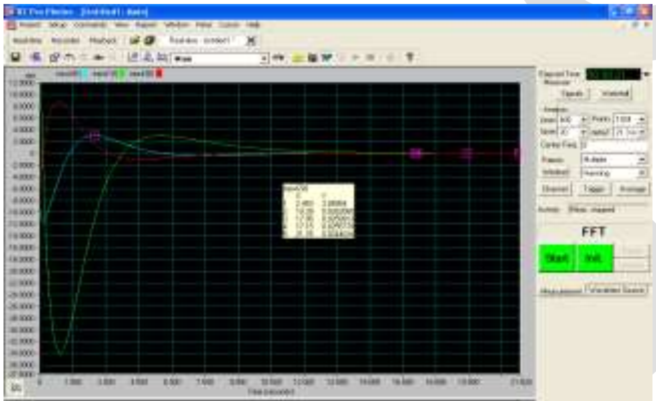

Fig.12 Displacement after control

RESULTS

From practical results for forced vibration, we got 15% reduction in amplitude. While for free vibrations 25% reduction in amplitude is observed

CONCLUSION

PZT patch will control the system i.e. reducing the vibrations amplitude and frequency so as to improve the damping effectiveness factor. The characterization and testing of PZT actuator for AVC has been discussed in this paper and it has been be found that the PZT actuators can be used for AVC.

ACKNOWLEDGMENT

We would like to thanks **Prof. S. M. Narayankar** and **Prof. N. Vivekanadan** , **Prof. A. A. Panchwadkar** for their valuable support , during completion of this project.

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