

FEA Simulation for Vibration Control of Shaft System by Magnetic Piezoelectric Control Mount

Thorat Puja A¹, Tipayale Amay R*², Londhe Babasaheb C³.

^{1,2}M.E. student, ³Associate Prof. Mechanical Engg. Dept., S.N.D. COE & RC Yeola, Dist.-Nasik, India.

Abstract: Advanced materials such as carbon fiber, ceramics, composite materials etc. all are more and more used in modern industry. They make the structures lighter and stiffer. In this work an adaptive vibration control method utilizing magnetically mounted piezoelectric elements is described. Piezoelectric elements are bonded to permanent magnets, termed here as a control mounts which are attached to the surface of steel shaft through their magnetic attraction. It is one damping method for controlling vibrations generated in the system. Instead of epoxy attachment to piezoelectric control mount, the magnets are effectively used for vibration control mounts. It is efficient in frequency damping 90-99%. It reduces amplitude and deformation 60% effectively.

Keywords: FEA, control mount, shaft system, vibration damping etc.

I. Introduction

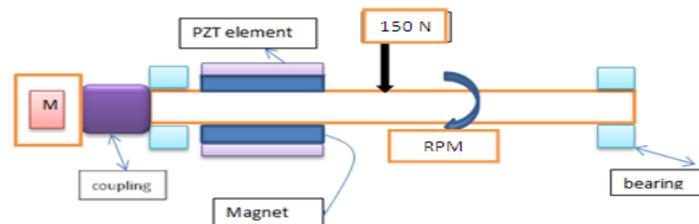
Rotating machinery is commonly used in mechanical systems, including machining tools, industrial turbo machinery and aircraft gas turbine engines. Vibration caused by mass imbalance is a common problem in rotating machinery. Imbalance occurs if the principal axis of inertia of the rotor is not coincident with its geometric axis. Higher speeds cause much greater centrifugal imbalance forces and the current trend of rotating equipment toward higher power density clearly leads to higher operational speeds. Therefore vibration control is essential in improving machine surface finish; achieving longer bearing, spindle, and tool life in high-speed machining; and reducing the number of unscheduled shutdowns also in space truss interferometer [1].

Shaft is the most important power transmission element. Transmission shafts transmit torque from one location to another. During power transmission, shaft subjected to torsion due to transmitted torque and bending from transverse loads (gears, pulleys, rotors, sprockets etc.) which creates vibration in the system which highly affects the system performance. So it is necessary to control the vibration there are different techniques used. But in this thesis magnetic-piezoelectric control mounts are used.

Traditional approaches to passive vibration control include the attachment of viscoelastic materials and mechanical vibration absorbers [2]. Piezoelectric materials, which have the ability to convert mechanical energy into electrical energy and vice versa, are often used in active and passive vibration control applications. When the piezoelectric material is strained, a charge develops across the element and energy is dissipated as current flows through an external electrical network or shunt.

II. Problem Statement

To avoid failure due to heat generation and vibration, the control mount is investigated for the shaft system which is rotating at 700 rpm conditions having 200 mm length supported by two bearing attached at left and right end of the shaft which is subjected to hammer load of 220 N at centrally as shown in following block diagram fig. 4.1 with control mount.



In this work the system is analysed with and without control mounts by Finite Element Analysis (FEA) technique

1. Finite Element Analysis: FEA works on the technique of Finite Element Method which is a numerical analysis technique for obtaining approximate solutions to wide variety of engineering problems. Because of its diversity and flexibility as an analysis tool, it is receiving much attention in engineering schools and industries. In more and more engineering solutions today, we find that it is necessary to obtain approximate solutions to problems rather than exact closed form solution.

2. Steps used in analysis:FEA works with help of following steps that depends upon the technique of Finite Element Method.

1. Pre-processing- geometry creation, material properties selection and meshing of model.
2. Solution- applying boundary conditions and solve it.
3. Post-processing-obtaining the result.

3. Methods of Analysis Used:

1. Modal Analysis
2. Harmonic Analysis

Modal Analysis:

It is used to determine the vibration characteristics i.e. natural frequencies and mode shapes of a structure or a machine component while it is being designed. Both these parameters are important in the design of a structure under loading conditions.

Harmonic Analysis:

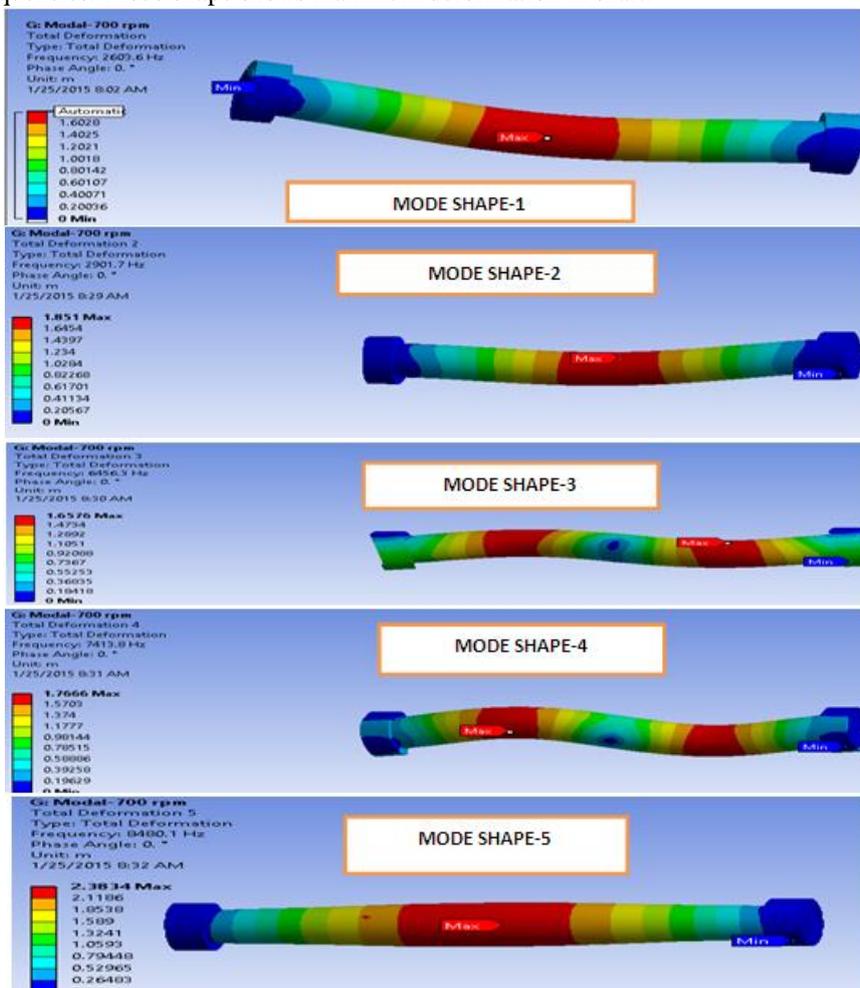
It is used to determine the frequency response and phase response sinusoidal with external load. By using this system frequency is calculated to avoid resonance.

The given system is Analysed for different rpm conditions.

a) Analysis Without Control Mount:

In this the shaft rotates at 700 rpm and subjected to 150 N load supported by two bearings. The material of shaft is SS-202.

1.Modal Analysis:In this method of analysis the natural frequencies and mode shapes are calculated. It is having high frequencies. Mode shape shows maximum deformation in shaft.



Results					
Minimum	0. m				
Maximum	1.8032 m	1.851 m	1.6576 m	1.7666 m	2.3834 m
Minimum Occurs On	Part 2				
Maximum Occurs On	Part 1				
Information					
Reported Frequency	2603.6 Hz	2901.7 Hz	6456.3 Hz	7413.8 Hz	8480.1 Hz

Fig 1: Mode shapes and frequency result by FEA without control mount.

2) **Harmonic Response Analysis:** In this graph shows harmonic response for 150 N load. It produces large amplitude due to high frequency of vibration.

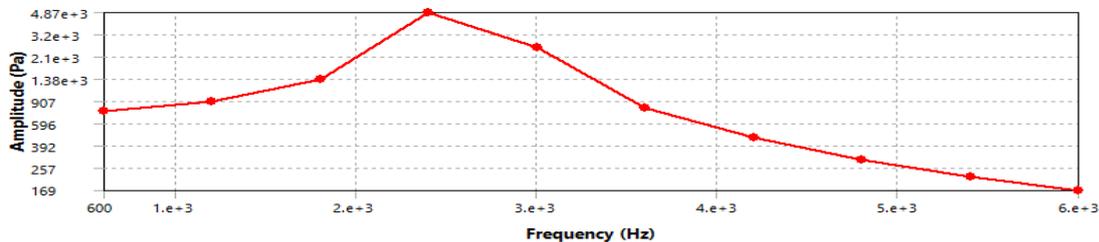
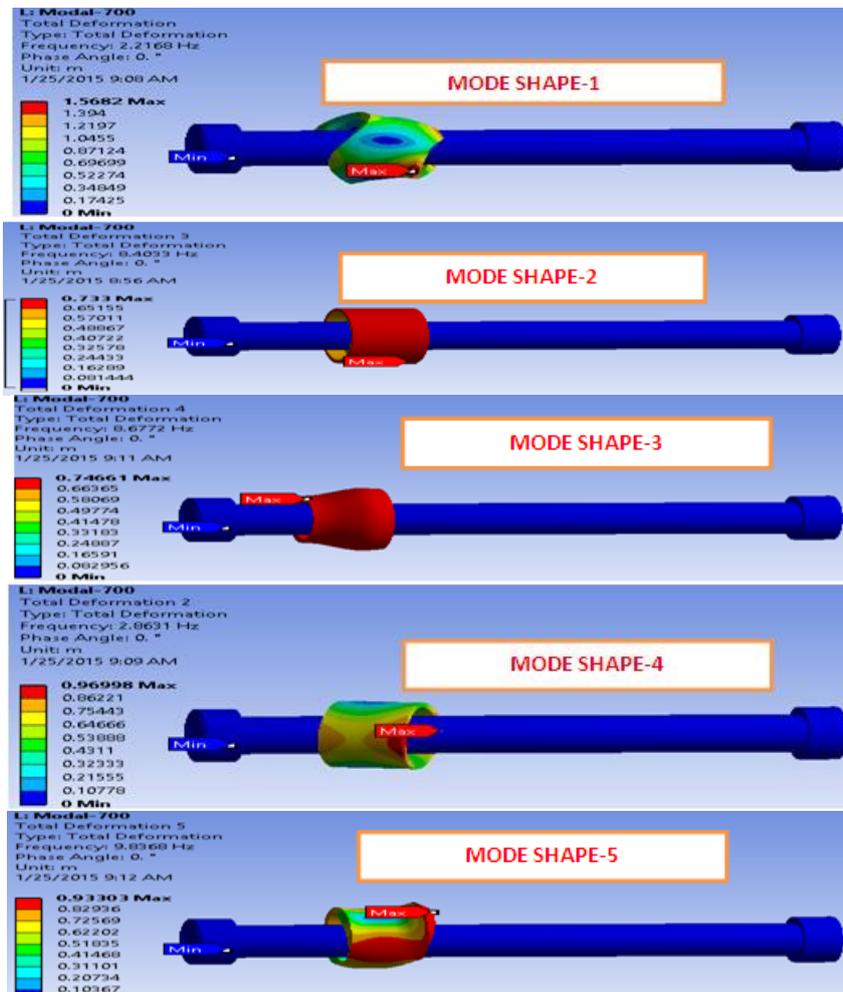


Fig 2. Frequency at harmonic response with load by FEA without control mount.

b) **Analysis With Control Mount:** Geometry is created in Pro-E 5.0 and then imported in ANSYS. Magnetic piezoelectric control mount is used for vibration control which has become very effective and successful, having dimensions, PZT=(44*38*24)mm and Magnet=(38*24*11)mm.

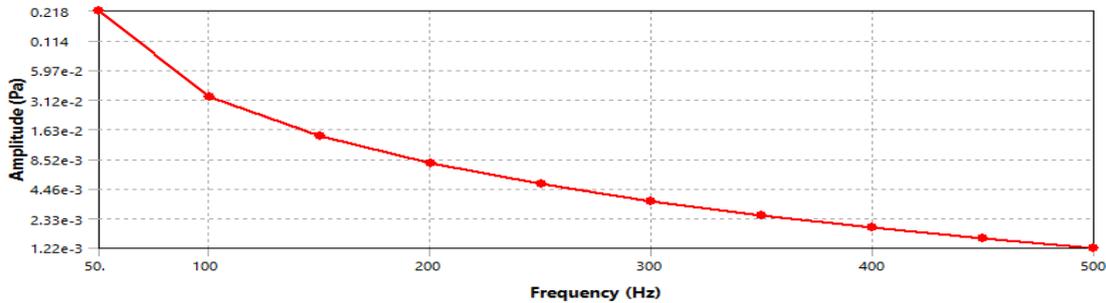
1) **Modal Analysis:** In this method of analysis the natural frequencies and mode shapes are calculated. It is having less frequencies and deformations due to control mount. Mode shape shows zero deformation in shaft Which is absorbed by a control mount.



Results					
Minimum	0. m				
Maximum	1.5682 m	0.96998 m	0.733 m	0.74661 m	0.93303 m
Minimum Occurs On	Part 2				
Maximum Occurs On	Part 5				
Information					
Reported Frequency	2.2168 Hz	2.8631 Hz	8.4033 Hz	8.6772 Hz	9.8368 Hz

Fig.3 mode shapes result by FEA with control mount.

2) **Harmonic Response Analysis:** it shows damped frequency and low amplitude due to control mount when it is subjected to load.



III. Conclusions

In this the control mount has damped vibrations successfully. It is very good and highly economical vibration damper. Without control mount the natural frequency is 2000-9000 hz while with control mount it is very less 2-9 hz. Hence the control mount is 99% efficient in vibration reduction. Due to control mount deformation is less 60% efficient. Amplitude also reduces due to control mount 98% effectively. Hence magnetic piezoelectric control mount is very good vibration damper, controller and absorber.

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