VIBRATION ANALYSIS OF CANTILEVER BEAM MADE UP OF MRAGNETO RHEOLOGICAL FLUID

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Abstract - *This study presents technique applied to smart beam to minimize an active vibration control. It consists of an aluminium beam modelled in cantilevered configuration. Now a days all the vibration control system have variety of applications using Magneto rheological fluids (MRF), it is widely used in seat suspensions, automobile suspensions damper, robotics, home appliances like washing machines, clutches, design of building and bridges etc. The success key of all these applications is the ability of MR fluids that is rapidly change in its rheological properties upon exposure when magnetic field is applied on it and MRF technology used for many applications because of its the precise controllability. We can apply this vibration control concept to any other application for detecting the vibration produces in that system. To use MR fluid of quantity, it is depend on the dimension of MR fluid pocket and vibrations intensity coming from the device. The testing is all about reduce the characteristics of MR fluid that is reduce the amplitude of vibration system by increase in the voltage applied to the MR fluid cantilever beam.(MRF-336AG).*
Form the table and graphs we conclude that if amplitude of vibration decrease then magnification factor decreases. Also if damping increases then damping coefficient increases and transmissibility decreases. Hence vibration reduces.

***Key Words*: MR Fluid, Cantilever Beam, Damping, Vibration, FFT Analysis**

1. INTRODUCTION

In general, initial conditions and external excitations show change in result of output of vibration systems. In engineering studies, vibration analysis of any physical system is carried out by four steps as follows:

1. Generate Mathematical Modeling of Physical system.
2. Formulation of required Governing Equations
3. Find Solution of mathematical Governing Equations.
4. Physical result interpretation.

Mathematical modeling is necessary to study features, aspects, physical elements or components involved in the physical system. Also existence and nature of physical system, we can determine by mathematical modeling.

1.1 Objectives

The aim of project is to study and analyze the phenomena of resonance, fundamental natural frequency, damping factor and mode shape of magneto rheological fluid cantilever beam system when system is subjected to forced vibration with and without magnetic field. In this analysis sandwich beam is used and Lyapunov stability theory is used to design the active vibration controller. To understand the behavior of Magneto rheological fluid under vibration, this analysis is carried out in this project.

1.2 Literature Review

Saeid Bashash, Amin Salehi-Khojin and Nader Jalili, in this paper a novel framework for forced motion analysis of Euler-Bernoulli beam with multiple jumped discontinuities in the cross section is given. According to this paper, the entire length of beam is partitioned into uniform segments between successive discontinuity points. Based on the boundary conditions and the continuity conditions applied at the partitioned point, Beam characteristics matrix can be derive. [1]
Mark R. Jolly, Jonathan W. Bender, and J. David Carlson explained study of the rheological and magnetic properties of magneto rheological (MR) fluids. Using appropriate figures of merit based on conventional design paradigms fluids are compared. Some applications of MR fluids are discussed. These various material properties may be balanced to provide optimal performance. [2]
Butz, T. and Stryk O, from this paper get an idea about basic properties of magneto rheological fluid and explains their applications. For passive suspension of quarter vehicle model gives numerical simulation results. [3]

2. THEORY OF CANTILEVER BEAM

If one end of the system is rigidly fixed to a support and the other end is free to move then system is said to be a cantilever beam system. Below given figures shows the cantilever beam structure of system.

Fig -1: Free Vibration of Cantilever beam

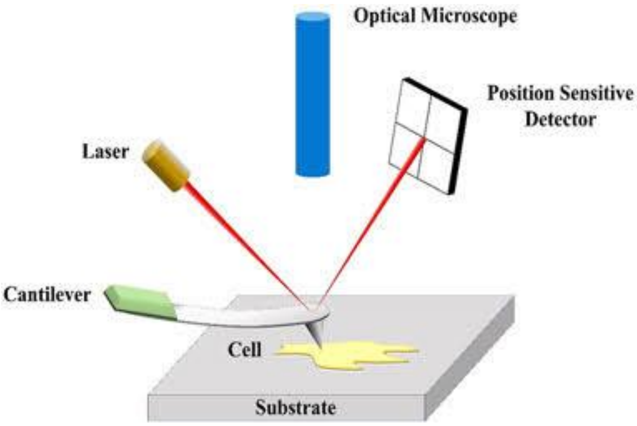


Fig -2: Atomic Force Microscopy

2.2 Model Analysis of Beam

Mathematical Analysis:

Whenever cantilever beam subjected to free vibration and beam considered as continuous system in which mass of beam is considered to distribute along with stiffness of shaft. In this case equation of motion for cantilever beam is given by Meirovitch as follows,

$$\frac{d^2}{dx^2}\left\{EI(x)\frac{d^2Y(x)}{dx^2}\right\} = \omega^2 m(x)Y(x)$$

Where, I is moment of inertia of beam cross section, ω is density of material, Y(x) is displacement of beam in y direction at a distance of x from fix end.

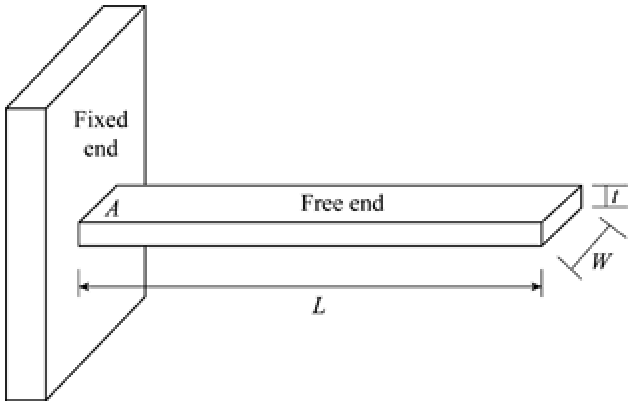


Fig -3: Cantilever Beam structure

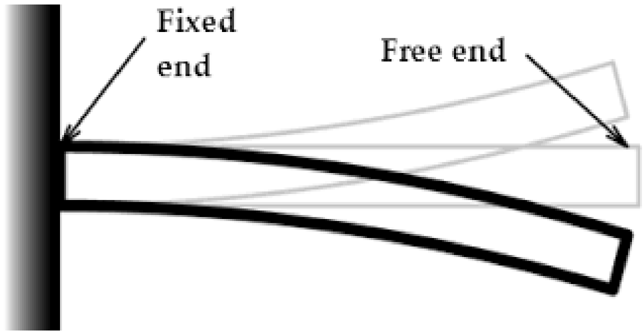


Fig -4: Cantilever beam under free vibration

2.3 Magneto Rheological Fluid

A Magneto Rheological fluid (MR fluid or MRF) is a type of smart fluid in a carrier fluid usually a type of oil. When subjected to a magnetic field greatly increases its apparent viscosity to the point of becoming a viscoelastic solid. This material responds to applied magnetic field with drastic change in their rheological behavior. MR Fluids has variety of applications in all vibration control systems used in industry. Main advantage of MR fluid is change rheological properties when magnetic field is applied on it.

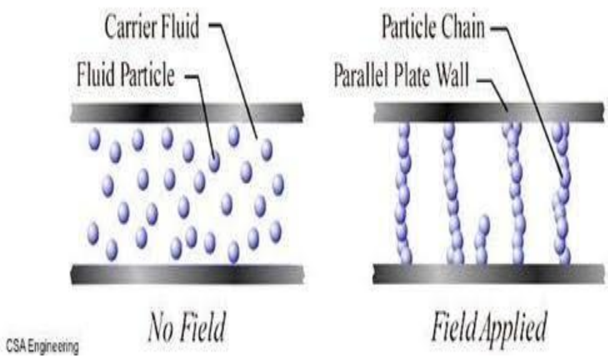


Fig -5: MR Fluid Behavior

When some low-density MR fluids exposed to rapidly applied alternating magnetic fields, their internal particles clump together. After some time they are settle into a pattern which shape looks like little bit fish viewed from the top of the tank. These clumpy MR fluids don't stiffen as when they are magnetized. The fish tank pattern is brittle and takes around an hour to fully develop the structure. After applying a magnetic field to MR Fluid causes align the particles in to the chain structure.

3. EXPERIMENTAL SET UP AND ANALYSIS

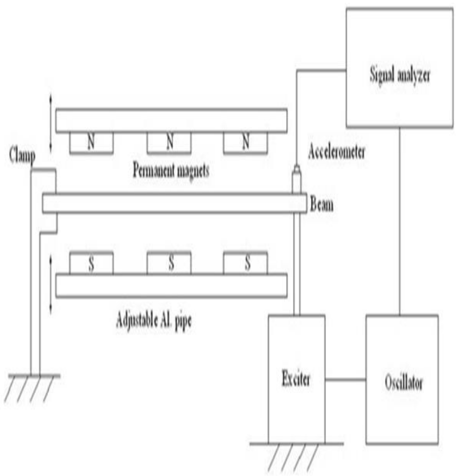


Fig -5: Experimental Setup and FFT analyzer

3.1 Procedure to Conduct Experiment

1. As shown in above figure fix the cantilever beam on the experimental set up.
2. To demonstrate experiments connect the copper wire coming from beam.
3. On the power supply to the experimental set up and start the computer In first reading – Magneto rheological fluid was not present inside the pocket of cantilever beam i.e we will take the first reading without MR fluid then we will observe the vibration of the cantilever beam because at the one end of the cantilever beam exciter starts its excitation and we will get the defection and damping frequency with the help of software used in computer system.
4. In Second reading – with the help of injection we insert the MR fluid inside the cantilever beam and then applied voltage of 2.75 V on beam.; After some time we will get another displacement and damping frequency table when exciter start the excitation of cantilever beam.
5. Repeat the above same procedure for readings with voltage 9 V, 12 V.
6. Collect the data for all readings and draw the necessary graphs. We will get results.

3.2 Observations and Results

1. **Result without Current**

Sr.No	Damp Freq. rad/s	Natu. Frq rad/s	Frq Ratio	Time in Sec Td(s)	Defn (micron)	Mag. Factor M.F	Trbty T
1.	329	336	0.97	1.1	497	2.43	2.62
2.	358	366	0.97	1	460	2.43	2.62
3.	401	410	0.97	0.9	262	2.43	2.62
4.	129	439	0.97	0.8	315	2.43	2.62
5.	472	483	0.97	0.7	284	2.43	2.62

2. **Result with 6 volt**

Sr. No	Damp Freq. rad/s	Natu. Frq rad/s	Frq Ratio	Time in Sec Td(s)	Defn (micron)	Mag. Factor M.F	Trbty T
1	343	360	0.95	1	473	1.6	1.94
2	372	391	0.95	0.9	362	1.6	1.94
3	429	451	0.95	0.8	249	1.6	1.94
4	501	527	0.95	0.7	152	1.6	1.94
5	613	644	0.95	0.5	93	1.6	1.94

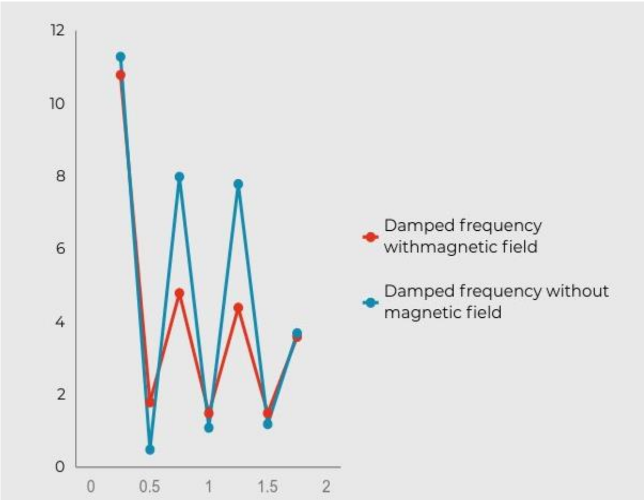
Above observations table gives several values of frequency ratio, natural frequency, magnification factor, deflection of beam and transmissibility value after experimental trials are taken on cantilever beam. From this frequency ratio is 0.95, transmissibility is 1.94 and Magnification factor is 1.6.

3. **Result of Calculation**

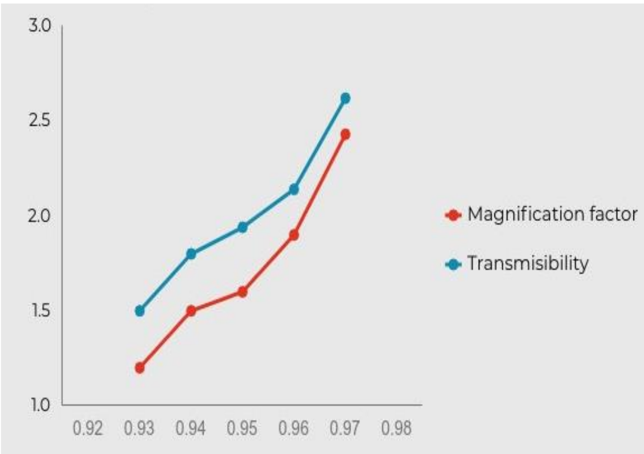
Sr. No	Def n (micron)	Damp Ratio	Damp Freq. rad/s	Natu. Frq rad/s	Stiffness K N/m	Damp. Coeff.
1	1.35	0.21	128.5	132	2.26 x 10^4	72.07
2	1.8	0.27	277	284	1.06334 x 10^5	199.7
3	2.1	0.31	258	270.1	9.49807 x 10^5	217.7
4	2.2	0.33	259	273.2	9.63206 x 10^5	234.4
5	2.6	0.38	274.9	299.6	1.165324 x 10^6	296

Above observations table gives several values of frequency ratio, natural frequency, magnification factor, deflection of beam and transmissibility value after experimental trials are taken on cantilever beam.
From this table we conclude that

1) If deflection increases then damping ration also increases.
2) If stiffness increases then damping coefficient increases.



Graph -1: Logarithmic Decrement



Graph -2: Frequency ratio v/s Transmissibility, Magnification factor

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4. CONCLUSIONS

"What makes MR fluid s good fluid?" answer of this question is depends on the applied alternating magnetic conditions that when fluid is start expose to change its properties and the time taken for exposure and type of the MR fluid application where it is used. MR fluids considered good for one application may not have same properties and good for another type of application. MR fluid development is a balancing act which has highly coupled with MR device design. It is important to consider the actual conditions of fluids to which it is exposed and also rheological behavior measured under normal laboratory conditions for evaluating the quality of an MR fluid. The testing is all about reduce the characteristics of MR fluid that is reduce the amplitude of vibration system by increase in the voltage applied to the MR fluid cantilever beam.(MRF-336AG).

We can apply this vibration control concept to any other application for detecting the vibration produces in that system. To use MR fluid of quantity, it is depend on the dimension of MR fluid pocket and vibration intensity coming from the device.

From the tables and graphs we conclude that if amplitude decreases then magnification factor decreases. Also if damping increases then damping coefficient increases and transmissibility decreases. Hence vibration reduces.

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