VIBRATION ANALYSIS OF MAGNETO RHEOLOGICAL FLUID CANTILEVER BEAM

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Abstract - *This study presents an active vibration control technique applied to smart beam the smart beam consist of an aluminium beam modelled in cantilevered configuration. Magneto rheological fluids (MRF) find a variety of applications in almost all the vibration control system, it is now widely used in automobile suspensions, seat suspensions, clutches, robotics, design of building and bridges, home appliances like washing machines etc. The key to success in all of these implementations is the ability of MR fluid to rapidly change its rheological properties upon exposure to an applied magnetic field and the precise controllability make MRF technology use for many applications. We can also apply this concepts of vibration control to any other device by detecting the vibration produced in that system. Depending on the dimensions of MRF pocket and intensity of vibration coming from the device we can use the quantity of MR fluid. The testing was all about reduction in amplitude of vibration by increasing voltage applied to MR cantilever beam. (MRF-336AG) Form graphs we conclude that as amplitude of vibration decrease magnification factor decreases. As damping increases damping coefficient increases and transmibility decreases. Hence vibration are reduced*

Key Words: rheological fluids (MRF), Cantilever Beam, Vibration.

1. INTRODUCTION

This output of a vibrating system, in general, depend upon the initial conditions, and external excitations. The vibration analysis of a physical system may be summarized by the four steps:

a. Mathematical Modelling of a Physical System

b. Formulation of Governing Equations

c. Mathematical Solution of the Governing Equations

d. Physical interpretation of result.

The purpose of the mathematical modelling is to determine the existence and nature of the system, its features and aspects, and the physical elements or components involved in the physical system. The mathematical modelling of a physical vibrating system results in the formulation of the governing equations of motion. Mathematical modelling of typical systems leads to a system of differential equations of motion. The solution of the governing equations of motion for the physical system generally gives the performance. To verify the validity of the model, the predicted performance is compared with the experimental results. Physical interpretation of the results is an important and final step in the analysis procedure.

2. OBJECTIVE

The aim of the experiment is to analyze the forced vibrations of the continuous Magneto Rheological Fluid cantilever bean, the phenomena of resonance, fundamental natural frequency and damping factor mode shape of the system can be studied with and without magnetic field. In present project analytical model for the MR sandwich beam is to be formed and the governing differential equation of motion is to be derived & active vibration controller is to be designed using Lyapunov stability theory. The fundamental natural frequency, resonance & mode shapes are to be determined to understand vibration behaviour of the Magneto Rheological Cantilever Beam.

3. LITERATURE REVIEW

ShibabratNaik, WrikMallik This paper describes about Modal analysis of a cantilever beam describe a structure for dynamic properties like its natural frequency damping and mode shapes with the help of FFT analyzer. Theoretical modal analysis research on the description of physical properties of a system to derive the modal. Such description usually contains the mass stiffness and damping matrices of the system. Experimental modal analysis obtains theoretical modal from measured FRF data or measured free vibration response ,it is a path from response data to modal model once the modal model is derived a number of application can be investigated the comparison of experimental results with ansys results possible in this paper.

M. Kciuk R. Turczyn This paper presents basic properties of the magneto rheological fluids (MR) and their development in recent years. A variety of still growing practical applications in mechanical devices are presented The theoretical research results of the properties and applications obtained in the past decades and progressed in recent years are reviewed It is very clearly and well understood from the presented paper that replacement of the traditional devices with active, smart system better adapted to the environment stimulus are necessary. Many of them will include MR fluids as active component a very useful material for the engineers engaged in the design of brakes, dampers, clutches and shock absorbers systems.

Butz, T. and von Stryk, O This paper gives an overview on the basic properties of electro- and magnet rheological fluids and discusses various phenomenological models for whole devices and their applications. Numerical simulation results are presented for the passive suspension of a quarter vehicle model.

4. THEORY OF CANTILEVER BEAM

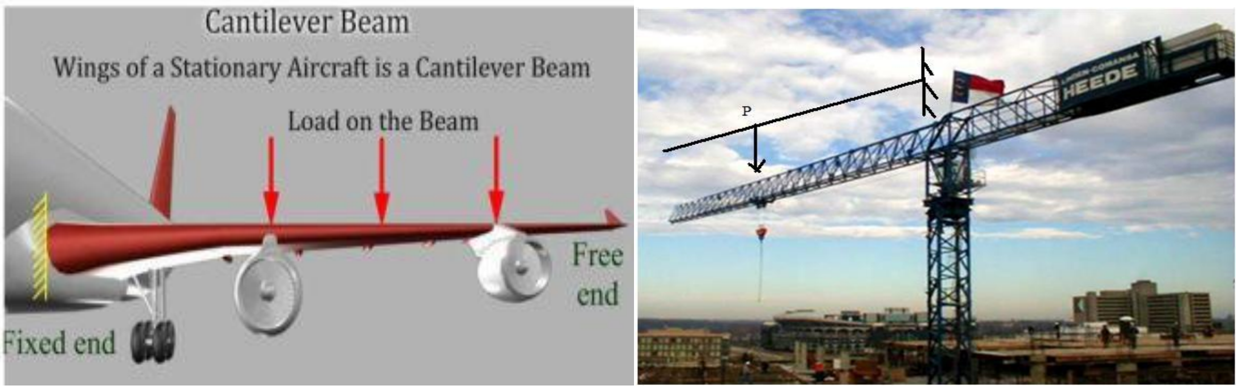


Figure.1 An aircraft wing as a cantilever beam

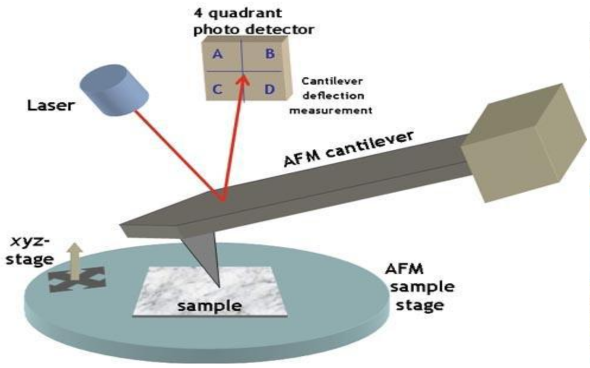


Figure 2. An atomic force probe **Figure 3.** A Double overhang folding bridge

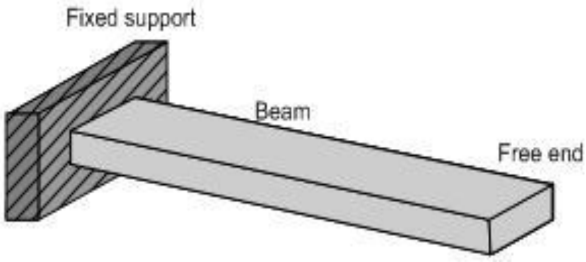
A system is said to be a cantilever beam system if one end of the system is rigidly fixed to a support and the other end is free to move.

5. MODAL ANALYSIS

When a system is subjected to free vibration and the system is considered as continuous system in which the beam mass is considered as distributed along with the stiffness of the shaft. In such case the equation of motion of a cantilever beam is given as (Meirovitch, 1967)

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

Where, E is the modulus of rigidity of beam material, I is the moment of inertia of the beam cross-section, Y(x) is displacement in y direction at distance x from fixed end, ω is the circular natural frequency, m is the mass per unit length, m = ρA(x), ρ is the material density, x is the distance measured from the fixed end.



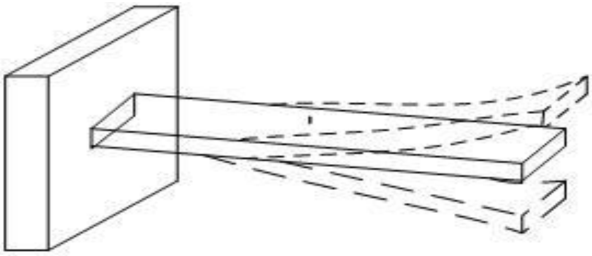


Figure 4. Cantilever beam **Figure 5.** The beam under free vibration

Figure (4) is a cantilever beam with rectangular cross section, bending vibration can be generated by giving initial displacement at end.

6. MAGNETO RHEOLOGICAL FLUID

Magneto rheological fluids commonly known as MR fluids are suspensions of solid in liquid whose properties changes drastically when exposed to magnetic field. Magneto rheological (MR) fluids are materials that respond to an applied field with a dramatic change in their rheological behaviour. The essential characteristic of these fluids is their ability to reversibly change from a free-flowing, linear, viscous liquid to a semi-solid with controllable yield strength in milliseconds when exposed to a magnetic field. Magneto rheological fluids commonly known as MR fluids are suspensions of solid in liquid whose properties changes drastically when exposed to magnetic field. It is this property which makes it desirable to use in different vibration controlling systems.

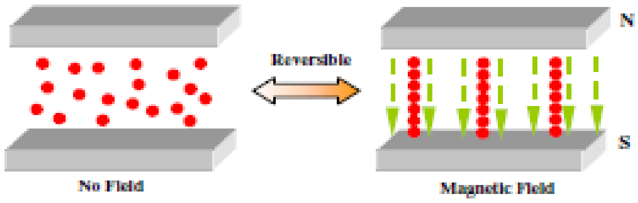


Figure 6 Behaviour of MRFluid

When some low-density MR fluids are exposed to rapidly alternating magnetic fields, their internal particles clump together. Over time they settle into a pattern of shapes that look a bit like fish viewed from the top of a tank. Such clumpy MR fluids don't stiffen as they should when magnetized. The fish tank pattern is fragile and takes about an hour to fully develop. It doesn't occur in MR fluids that are constantly mixed and agitated, as in a car's suspension, but it could prove troublesome in other situations.

7. EXPERIMENTAL SETUP AND ANALYSIS

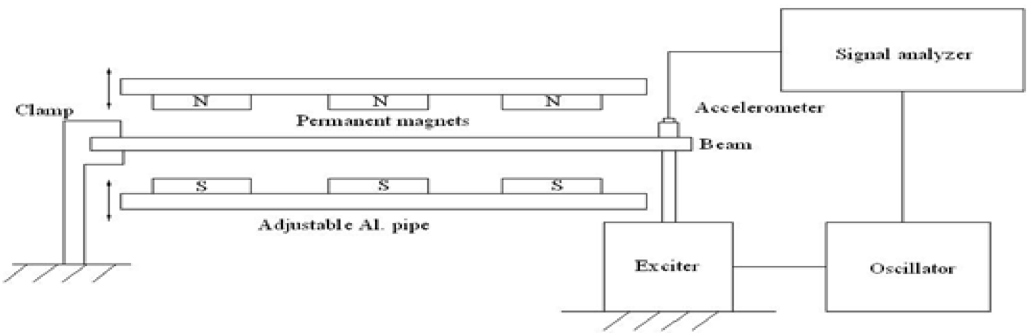


Figure 7. Experimental set up& FFT Analyzer

- **Experimental Procedure –**

1. First fix the cantilever beam on the experimental set up above the exciter as shown in figure.
2. Make the connection of copper wire coming from beam to demonstrate.
3. On the experimental set up and start the computer.
4. First reading – Here smart material (MRF) inside the pocket of cantilever beam was not present i.e without MR fluid we will take the first reading exciter starts its excitation at the one end of the cantilever beam we will observe the vibration of the cantilever beam and with the help of software present in the computer system we will get the table of defection and damping frequency.
5. Second reading – Here we have to insert the MR fluid inside the cantilever beam with the help of injection and then applied the voltage of 2.75 V on the cantilever beam. Again start the excitation on the cantilever beam, we will get another table of displacement and damping frequency.
6. Repeat the same procedure for other reading with voltage of 6 V, 9 V , 12 V
7. Collect the table and draw the graph. We will get the results.

- **Observation Table –**

1. Result without current

Sr.No	Damp Freq. ω_d rad/s	Natu. Frq ω_n rad/s	Frq Ratio $r = \omega_d / \omega_n$	Time in Sec Td(s)	Defn ∂ (micron)	Mag. Factor M.F	Trbty T
1	128.5	131	0.98	2.8	300	2.41	1.68
2	171.5	175.5	0.97	2.1	379	2.43	2.62
3	200.5	205	0.97	1.8	434	2.43	2.62
4	229	234	0.97	1.5	500	2.43	2.62
5	258	263.7	0.97	1.4	530	2.43	2.62

2. Result With 12 Volt

Sr.No	Damp Freq. ω_d rad/s	Natu. Frq ω_n rad/s	Frq Ratio $r = \omega_d / \omega_n$	Time in Sec Td(s)	Defn ∂ (micron)	Mag. Factor M.F	Trbty T
1	100	103	0.93	3.6	192	1.2	1.5
2	143	148	0.93	2.5	330	1.2	1.5
3	171.8	178	0.93	2.1	285	1.2	1.5
4	200.5	208	0.93	1.8	346	1.2	1.5
5	243	252	0.93	1.4	434	1.2	1.5

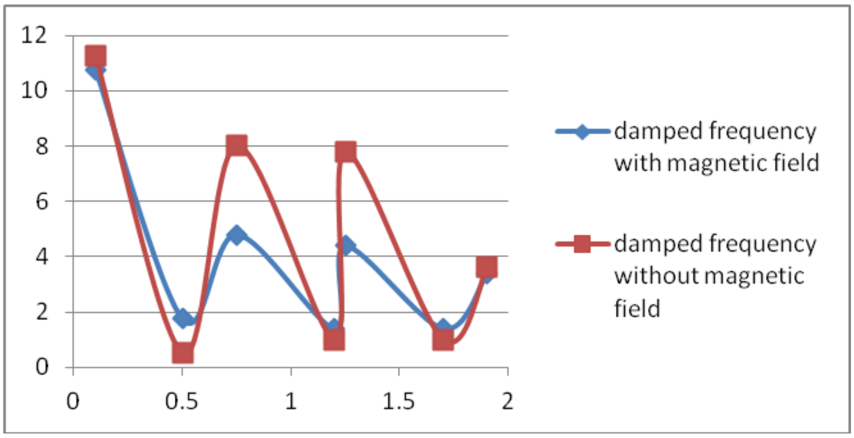
The above table shows several values of natural frequencies, frequency ratio, required time in second, deflection of beam in micron, magnification factor and transmissibility values which was got in the experimentation. For that corresponding damping frequency. Here we got the values of frequency ratio 0.93, Magnification factor 1.2 and transmissibility 1.5.

3. Result of Calculation

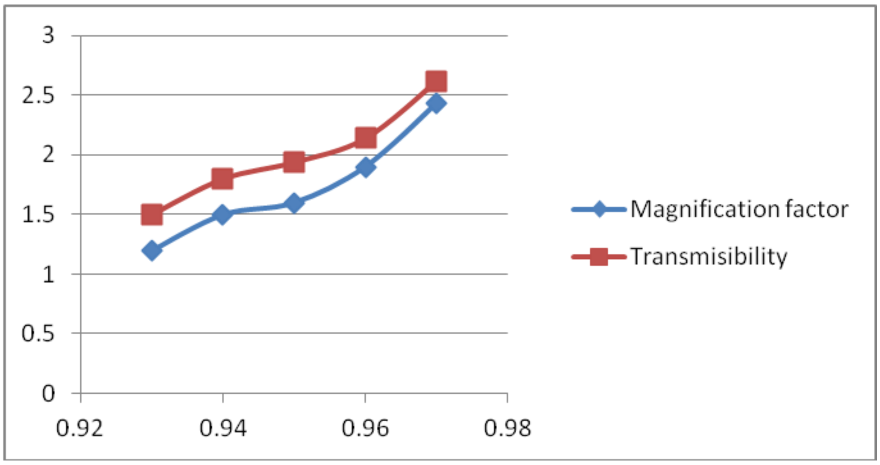
Sr.No	Defn ∂ (micron)	Damp Ratio	Damp Freq. ω_d rad/s	Natu. Frq ω_n rad/s	Stiffness K N/m	Damp. Coeff.
1	1.352	0.21	128.5	131	2.23 x 10^4	71.526
2	1.8	0.27	276	286	1.06334 x 10^5	200.7
3	2.1	0.31	257	270.3	9.49807 x 10^5	218
4	2.2	0.33	257	272.2	9.63206 x 10^5	233
5	2.6	0.38	276.9	299.4	1.165324 x 10^6	296

From above table we conclude that

1) As deflection increases damping ratio increases
2) As stiffness increases the damping coefficient increases.



Graph 01. Logarithmic decrement



Graph 02. Frequency ratio vs Magnification factor, Transmissibility

8. CONCLUSION

The answer to the question "What makes a good MR fluid?" is "It depends. It depends on the type of the application in which the MR fluid is used, the conditions to which the fluid is exposed and the duration of exposure. MR fluids that are considered good in one application may fail miserably in another type of application. MR fluid development is of course a balancing act that is highly coupled with MR device design. In evaluating the quality of an MR fluid it is important to consider the actual conditions to which it will be exposed and not just the rheological behaviour measured under normal laboratory conditions. The testing was all about **reduction in amplitude of vibration by increasing voltage applied to MR cantilever beam.**(MRF-336AG)

We can also apply this concept of vibration control to any other application by detecting the vibration produced in that system. Depending on the dimension of MRF pocket and intensity of vibration coming from the device we can use the quantity of MR fluid.

Form graphs we conclude that as amplitude of vibration decrease magnification factor decreases. As damping increases damping coefficient increases and transmibility decreases. Hence vibration are reduced.

Figure 3 shows the comparative study of heat transfer coefficient verses the wire diameter for the Shikekai and Reetha. From this graph we can say that for the same wire diameter the heat transfer coefficient for the Reetha is more than that of the Shikekai. Also the maximum heat transfer rate is observed for the 0.32mm diameter.

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