FORCED DAMPED VIBRATIONS: FREQUENCY RESPONSE CURVE FOR STEEL AND ALUMIMUM BARS

Ravindra R. Navthar *

Asst. Prof., Dept. of Mechanical Engineering, P.D.V.V.P. College of Engineering,
Vilad Ghat, Ahmednagar-414111Maharashtra India.
ravi_navthar@rediffmail.com

Prashant.A.Narwade

Asst. Prof ,Dept. of Mechanical Engineering, P.D.V.V.P. College of Engineering,
Vilad Ghat, Ahmednagar-414111,Maharashtra India.
narwadeprashant@gmail.com

Abstract :

Besides having some advantages Vibrations can be unpleasant and harmful because it can lead to catastrophic failures of components and materials. Unwanted vibration can interfere with our comfort, damage to structures, and reduction of equipment performance and machinery noise level. Thus it is necessary to analyze & reduce the excessive vibrations appeared in the equipment.

Analysis of beam vibrations is very crucial as it is being used in various real life applications. In this experiment vibrations of fixed beam measured and analyzed at various speeds. Various observations are taken at different conditions by using different type of beam material. Analysis for the reduction in vibration can be made from the frequency response curves which are obtained from the observations. The paper investigates the nature of beam vibration at various conditions for Mild steel and Aluminum material.

Keywords: Damped vibration, Beam, Natural frequency etc

1 Introduction

Analysis of beam vibration now a days is very important as beam is being widely used in various applications. These beams are continuously subjected to various types of loading. If these vibrations exceed beyond certain limits there will be danger of beam breakage or failure [1]. So it is necessary to study the vibrations which are set up or build up in the beam and try to reduce them. The analysis of moving loads on a beam structure has been a topic of interest for well over a century. Interest in these problem originated in civil engineering also for the design of railroads, bridges and highways structures[2].The problem arises from the observations that as a beam structure is subjected to moving loads, the dynamic deflection, as well as stresses are significantly higher than those for static loads. Most of the previous analysis work in this area was directed at the dynamic behavior of simple structure, such as simply supported beam, subjected to a simple loading, e.g. a concentrated load. The main causes of vibrations are the unbalanced forces in the machines mounted on structures. These forces are produced from within the machine itself. Also dry friction between the two mating surfaces. External excitations may be periodic, random or of the nature of an impact produce vibrations in the system. The effects of vibrations are excessive stresses, undesirable noise, and looseness of the parts & partial or complete failure of parts. In spite of these harmful effects, the vibration phenomenon does have some uses e.g. in musical instruments, vibrating screens, shakers, stress relieving, shock absorbers & dampers etc.

2. Elements Constituting Vibration

Consider a beam supported at both the ends and a disc with eccentric hole is used to create a vibration on beam. The beam stiffness $192EI/L^3$, restoring force acts on it, forcing it to vibrate about its mean position, causing certain acceleration & by the time it reaches the mean position, it has finite velocity & cannot stop there. Eccentric disc connected to the beam causes forced vibrations on the continuous system. However amplitude of vibrations is reduced due to damping. Here damping is in form of air & hydraulic fluid.

3. Design Of Beams Supported At Both Ends

3.1. Mild steel beam

Consider centrally loaded beam of size as follows
Width of beam = 30 mm
Thickness of beam = 5 mm

Mass of beam =1.22 kg
Length of beam = 1620 mm
Static deflection of beam
$= Wl^3/192\ E.I$
δ = 4.24 mm

3.2Aluminum beam

Width of beam = 25 mm
Thickness of beam = 6 mm
Mass of beam = 750 gm
Length of beam = 1620 mm
Static deflection of beam
$= Wl^3/192\ E.I$
δ = 5.25 mm

3.3Dimensions of disc with eccentric hole

Material for disc is En8 with following details
$\rho = 7.222\ gm/cc$
$r = 5\ cm$
Diameter of disc $= 10\ cm$
Thickness of disc $= 10\ mm = 1\ cm$
Mass of disc $= 0.567\ kg$
Let eccentric hole at a distance of 2.5cm from center hole of diameter2cm.
Diameter of hole for shaft = 10.6 mm
Total mass of disc = 563 gm
Mass moment of inertia of disc = 7037.5 gm.cm^2
C.G. of disc lies at a distance of 1.05 mm from centre.
Therefore Eccentricity = e =1.05 mm

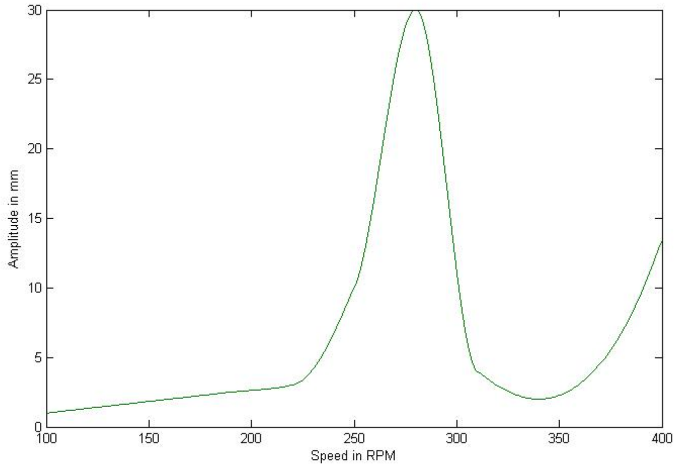
4. Experimental Setup

The aim of our research is to find frequency response curves for transverse vibration of beam supported at both the ends under various damping conditions as shown in Fig.1. It consists of beam fixed at two ends on support. A disc with eccentric hole is used to create a vibration on beam. The disc is mounted on shaft which is supposed on clamp shaft is rotated through spring coupling which is driven by D.C. motor. The clamp is welded to beam at center & pen holder arrangement is also attached to it to obtain graph.

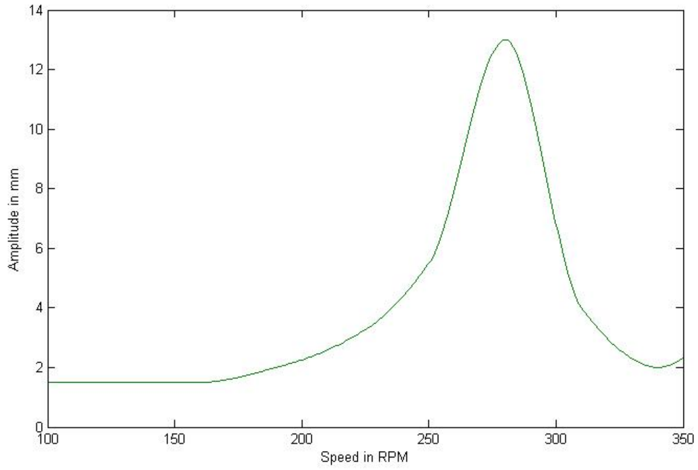
Fig.1 Experimental Set up.

Viscous damper (piston cylinder type) is attached to beam below clamp to resist the vibrations. The amount of damping can be varied according to the lobe position i.e. relative position. For different condition of damper, frequency response curve can be plotted.

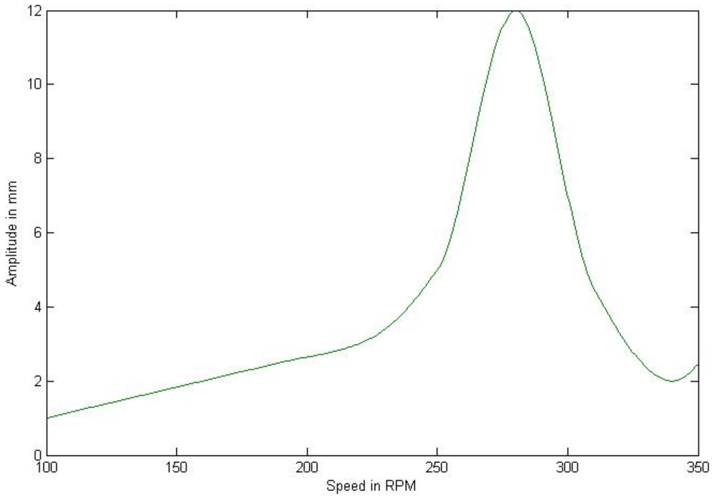
5. Frequency Response Curves



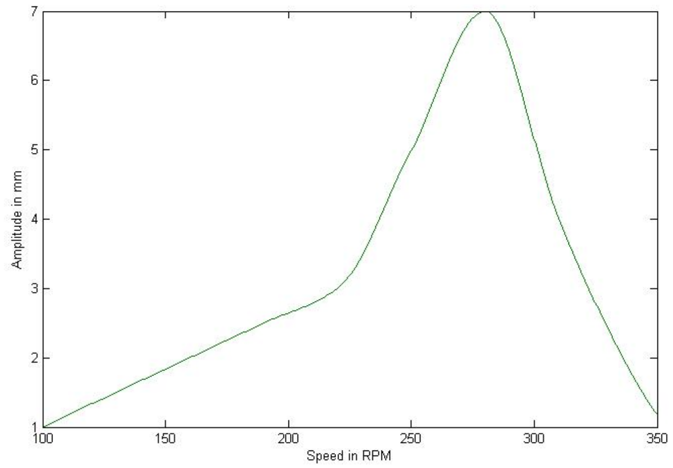
Graph 1. Frequency response curve for M.S at No damping condition



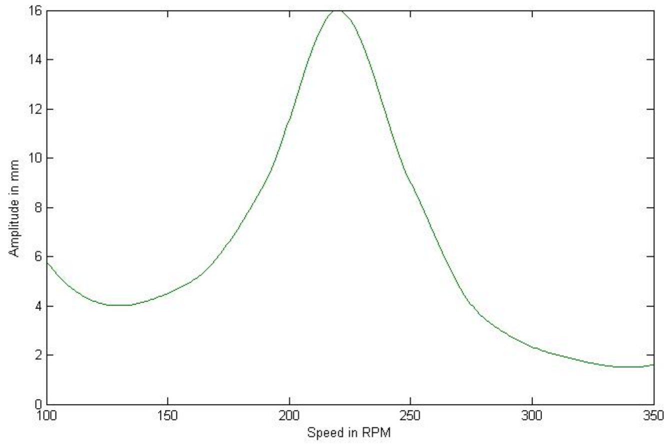
Graph 2. Frequency response curve for M.S at Low damping condition



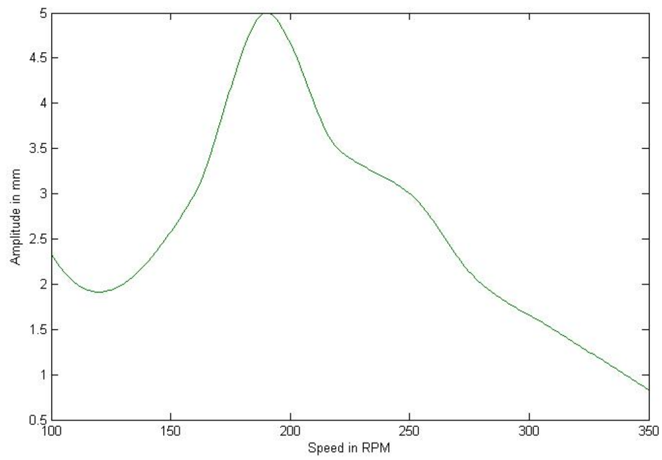
Graph 3. Frequency response curve for M.S at Medium damping condition



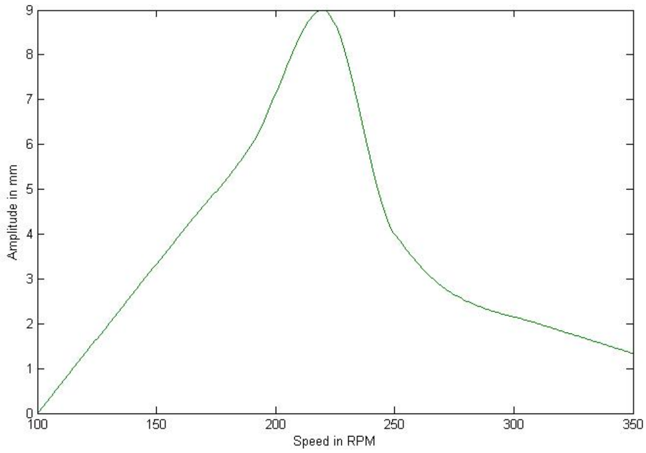
Graph 4. Frequency response curve for M.S at High damping condition



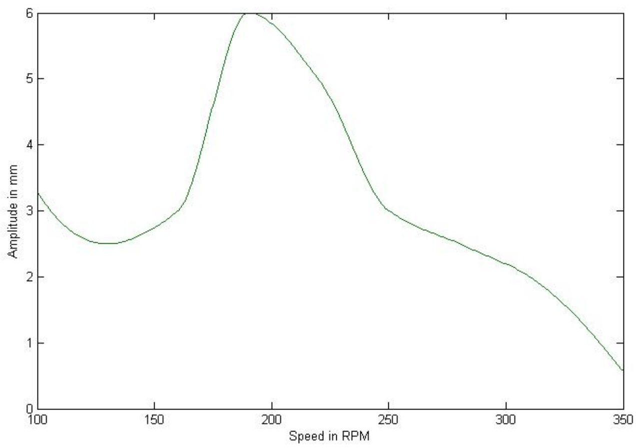
Graph 5. Frequency response curve for Al at no damping condition.



Graph 6. Frequency response curve for Al at Low damping condition



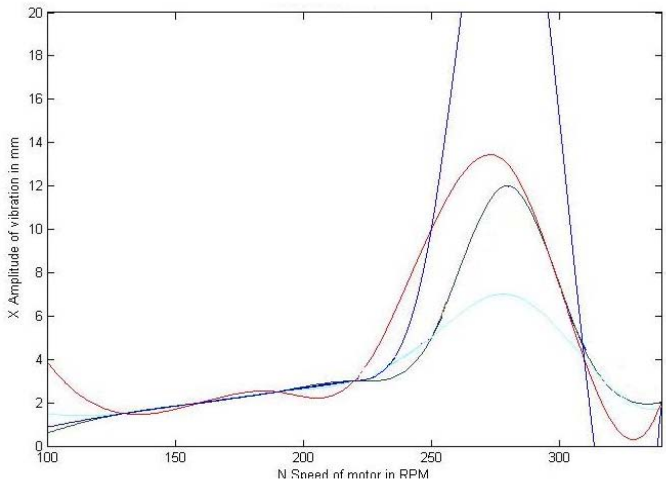
Graph 7. Frequency response curve for Al at Medium damping condition



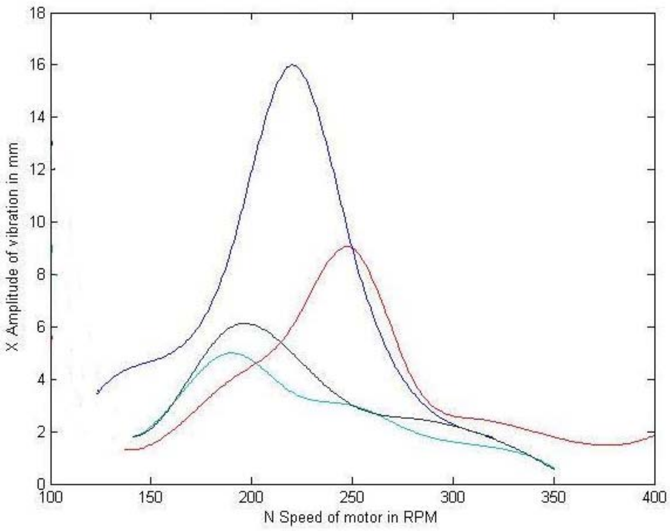
Graph 8. Frequency response curve for Al at High damping condition

6. Results

Following Graphs shows the comparison of frequency response curves for mild steel and aluminum at no damping, low damping, medium damping and high damping. For condition of no damping amplitude at resonance for steel beam is more than the Aluminum beam.



Graph 9.Comparision of Frequency Response Curves for Mild Steel



Graph 10. Comparision of Frequency Response Curves For Aluminium Beam

7. Conclusion

For Mild Steel Beam as seen from the Graph no.9 as speed increases the amplitude of vibration increases simultaneously, then at particular speed the amplitude reaches the point at which resonance occurred, then further increasing the speed the amplitude decreases simultaneously. The response of particular system of any particular frequency is lower for higher value of damping. At resonance ($\omega = \omega n$) the amplitude of vibration become excessive for small damping and decreases with increase in damping and for Zero damping of response the amplitude is very high.

When damping is increased the amplitude at resonance decreases. By comparing M.S. & aluminum beam curves for high & medium damping, it is observed that M.S. beam reaches the higher value of amplitude than the AL beam. For no & low damping, as seen from the graph the M.S. beam reaches the maximum amplitude as compare to AL beam.

References

[1] W. L. LI: Free Vibrations of beams with general boundary conditions, Journal of Sound and Vibration Volume 237, Issue 4, 2000, Pages 709-72

[2] Benning, R.D., Hodgins, M.G. and George G. Z., Active Control of Mechanical Vibration. Bell Labs Technical Journal. 1997

[3] H. K. KIM and M. S. KIM: Vibration of beams with generally restrained boundary conditions using Fourier series, Journal of Sound and Vibration Volume 245, Issue 5, 30 August 2001, Pages 771-784

[4] Seon M. Han, Haym Benaroya :Dynamics of Transversely vibrating beams using four engineering theories Journal of Sound and vibration (1999) 225(5), 935 to988

Nomenclature

E = Modulus of elasticity for beam in N/m^2

$=2*10^{11} N/m^2$…for Mild steel

$=0.69*10^{11} N/m^2$… for Al

l = Length of beam in mm

δ= Deflection of beam in mm

ρ=Mass density in gm/cc

I= Mass moment of inertia in $gm\text{-}cm^2$

r= Radius of Disc in mm

e =Eccentricity in mm.

m= Mass of Disc in kg

W= Load in kg.

ωn = Natural Frequency

Al=Aluminum

M.S= Mild Steel