International Engineering Research Journal

Analysis of Damping Performance of Magnesium Alloy

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Abstract

Aluminium alloys are largely used in automotive industries but due to requirement of reducing weight finding new materials for replacing aluminium has become a necessity. Magnesium alloy is one such material which possess good mechanical properties and is light in weight. In this paper damping properties of AZ31B magnesium alloy has been evaluated for its damping characteristics i.e. frequency response and compared with aluminium alloy and stainless steel. The values have been evaluated using Modal and Harmonic Response in ANSYS software. Natural frequency for magnesium alloy is also determined using theoretical calculations.

Keywords:*Frquency response, natural frequency, magnesium alloy.*

1. Introduction

The damping of materials is an important property of a material which is often overlooked while designing a mechanical system. Insufficient damping provided by a material has led to many mechanical failures. The magnesium alloys have a hexagonal close packaging structure which provides a great energy absorbing capabilities.

A body once set freely to vibrate will not vibrate for infinite time. Due to friction the amplitude of vibration decreases over a period of time and becomes zero. This body is said to be damped. On the other hand if a body continues to oscillate for an infinite time with constant amplitude it is said to be undamped. However, every physical system possesses few internal forces which results in dissipation of energy during vibration cycles. The rate of energy dissipation depends on the properties of materials. The damping characteristics are important for selecting new engineering materials. Vibration is a factor which is least expected in a material. After excitation force is removed the material should damp quickly instead of vibrating for a longer time. (Chowdhury M. et al). Free vibration with same amplitude for infinite period of time does not exist in nature. It means that in an oscillating system the amplitude of vibration decreases due to friction over a period of time. Such motion is no a periodic one, but is none the less considered a vibratory movement. Damping is generally to types internal and external as friction occurs internally in the system or between the oscillating system and the environment. (Glovnea, M, et. al, 2009). Dynamic properties such as frequency, damping and mode shapes of a structural element can be described by a process called modal analysis. Structural conditions can be analyzed by monitoring the changes in mode shapes and frequencies. Every material has a certain amount of internal damping which is dissipated in the form of energy from the system. Internal energy present in the system is dissipated in the form of heat or radiated away from the system.

Magnesium has a desnsity of 1.7g/cm^3 and it is light-in weight as compared to other structural materials as well as commercially available. It provides good damping characteristics and dissipates heat efficiently also providing good electro-magnetic shield. Magnesium and its alloys have a hexagonally packed close crystal structure at room temperature which makes them difficult to deform. This structure restricts its ability to deform because it has fewer slip systems at lower temperatures. Magnesium is chemically unstable and is quite prone to corrosion in marine environment also it is easier to melt due to its low melting temperature. In powdered form magnesium ignites quickly and hence should be handled carefully.

2.Literature Review

V. Anes et al. had experimentally investigated the damping properties of AZ31B-F magnesium alloy for pure axial and pure shear loading conditions at room temperature. Hysteretic damping results were measured through stress-strain controlled tests. The frequency response function (FRF) and free vibration decay were used for measuring viscous damping of magnesium alloys using experimental method.

G.-F. QUAN et al. has experimentally studied that due to less weight, high specific strength and low density magnesium alloys can be used in railways instead of aluminium alloys and steel. For high speed trains high energy efficiency and improved running safety can be achieved by application of magnesium alloys due to its reduction in noise, weight and vibrations.

Siobhan Fleming has studied that magnesium is the lightest of all light metal alloys and therefore is an excellent choice for engineering applications when weight is a critical design element. This paper details specific alloys used for certain aerospace and automotive applications.

3. Objective

The objective of this paper is:

1. To determine the natural frequency of Mg Alloy using numerical method.
2. To compare natural frequency and amplitude of magnesium alloy with aluminium alloy and steel using ANSYS software.

4. Test Beam

2.1 Beam dimensions

In this experiment Magnesium alloy (AZ31B) is compared with aluminium and steel. Same as aluminium and steel magnesium alloy can be easily machined.

Length (l) = 400 mm
Width (b) = 50 mm
Thickness (t) 6mm

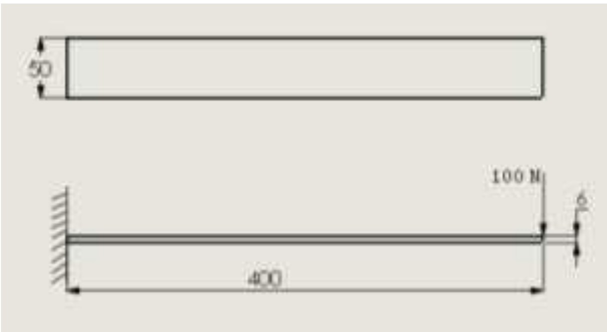


Fig. 1 Beam dimension (All dimensions are in mm)

2.2 Material of Beam

Three different materials are considered which are listed in Table 2.

Material	Young's Modulus, E (MPa)	Density, ρ (kg/m^3)
Magnesium Alloy (AZ31B)	44800	1770
Aluminium Alloy	71000	2770
Steel	200000	7850

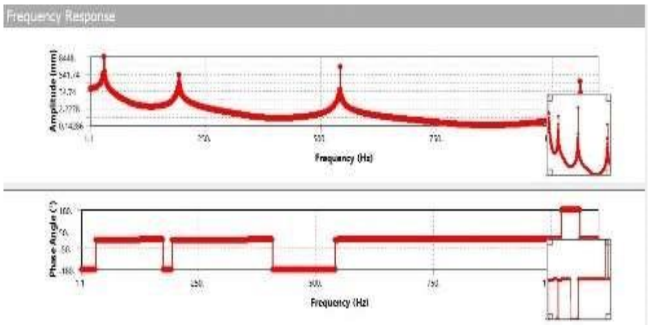
3. Theoretical Calculations

Calculating natural frequencies for any material

Considering the beam is rectangular,
Moment of Inertia (I) = $I = b.t^3/12 = 900mm^4$

And the Area (A) is given by,
$A = b.t = 300mm^2$

Mode1
Angular Velocity is given by,
$\omega_1 = (3.5). [EI / \rho A.L^4]^{1/2} = 189.15$ rad/s
Where,
Young's Modulus of material (E)



Density of material (ρ)
Natural frequency at mode 1
$F_1 = \omega_1/2\pi = 30.104$ Hz

Mode 2
Similarly,
$\omega_2 = (22.03). [EI / \rho A.L4]1/2 = 1190.56$ rad/s
Natural frequency at mode 2
$F_2 = \omega_2/ 2\pi = 189.48$ Hz

Mode 3
$\omega_3 = (61.7). [EI / \rho A.L4]1/2 = 3334.43$ rad/s

Natural frequency at mode 2
$F_3 = \omega_3/ 2\pi = 530.7$ Hz

4. Results and Discussion

Following graph indicate frequency response at each mode for Mg alloy (6mm) plate.

Fig.2 Frequency response curve for Mg Alloy.

Natural frequencies and amplitude values for Mg Alloy obtained from Fig.2 is given in Table 1 as below.

Table 1 Frequency response values for Mg Alloy

Mode	Natural frequency (Hz)	Amplitude (mm)
1	30.892	11.512
2	193.34	0.5198
3	251.66	5.2238
4	454.91	0.26469
5	541.17	0.1629
6	1060.5	0.65124

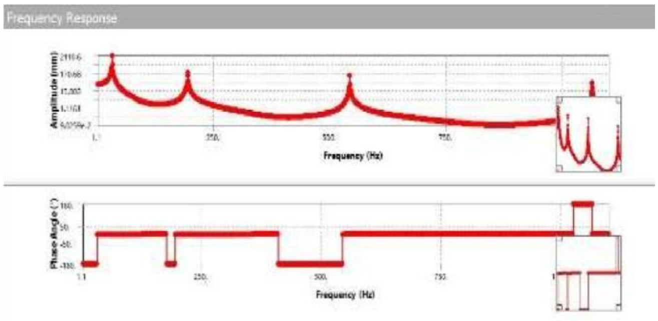


Fig.3 Frequency response curve

Natural frequencies and amplitude values for Al Alloy obtained from Fig.3 is given in Table 2 as below.

Table 2 Frequency response values for Al Alloy

Mode	Natural frequency (Hz)	Amplitude (mm)
1	31.035	6.6593
2	194.24	0.33291
3	253.18	4.5564
4	460.89	0.17141
5	543.64	0.10129
6	1065.1	0.46274

Following graph indicate frequency response at each mode for steel (6mm) plate.

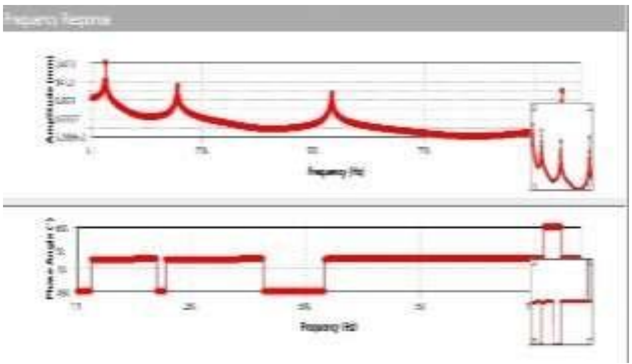


Fig.4 Frequency response curve

Following graph indicate frequency response at each mode for Al alloy (6mm) plate.

Natural frequencies and amplitude values for steel obtained from Fig.4 is given in Table 3 as below.

Table 3 Frequency response values for Steel

Mode	Natural frequency (Hz)	Amplitude (mm)
1	30.872	2.634
2	193.23	0.11678
3	252.34	1.22
4	464.33	0.059
5	540.73	0.037
6	1059.1	0.14209

Summary

The cantilever beams have been subjected to free vibration and damping ratio.

On the basis of work following conclusions have been drawn.

1. From analysis it is found that the natural frequency of magnesium alloy is almost same as that of aluminium and steel.
2. The vibration response amplitude for magnesium is higher as compared to aluminium and steel.

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