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Comparative Investigation on Modal analysis of LM25 Aluminium alloy with other Aluminim alloys using Finite element analysis software

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Abstract. The rudimentary steps of the modal analysis and simulation are carried out . The modal analysis is carried out on the different Aluminum Alloys cantilever beam. The cantilever beam is designed in the graphical environment of the ANSYS. The cantilever beam was fine-tuned on one end with all degree of liberation on this end were taken, beam cannot move and rotate. Mode shapes and natural frequencies are premeditated in platforms ANSYS with arithmetical formulation of the direct solver including the block Lanczos method. Aluminum alloys are widely utilized in much application due to their estimable weight to vigor property. Many examination works have been distributed out to make developments the mechanical properties of aluminum alloys. The composition of alloying elements plays a consequential role in deciding the properties of an alloy. In this study a numerical analysis implement i.e., finite element analysis (FEA) is utilized. The work obtainable in this paper is aimed at the study of effect of modal analysis of different aluminum alloys. The modeling and analysis is carried out utilizing ANSYS FEA software. A modal analysis is carried out to understand the modes of frequency demeanor of the material considered. The modal analysis play a vital role in the design of components subjected to high vibration.

1. Introduction

Comparative investigation on modal analysis deals with the dynamics comportment of mechanical structures under the dynamics excitation. Utilizing it, we can amend the overall performance of the system in certain operating conditions. A model testing has become to identify the considerate and simulate vibrant demeanor and replication of structure. Frequency replication functions are acclimated to extract such modal parameters as natural frequency and mode shape. Model testing is a non-destructive testing based on pulsation retort of the structures. It helps to vibrations that cause damage of the integrity of system components.. We ken two rudimentary methods of the modal analysis, namely the numerical modal analysis and the experimental modal analysis. In wide range of practical applications the modal parameters are required to evade resonance in structures affected by external periodic dynamic loads. modal analysis over sundry fields of science engineering and technology. In particular, numerous researches cognate to aeronautical engineering, automobile engineering mechanical engineering and dynamic FEM updating of structures. The present investigation reports the dynamic characteristics of mundane structural materials

The two rudimental methods of the modal analysis, namely the numerical modal analysis and the experimental modal analysis. The experimental modal analysis deals with quantification input data from which a mathematical model is derived. However, it has to take different calibers of analysis, from which the model is constructed[2].
Modal analysis provides a potent implement for efficiently simulating the demeanor of deformable objects. Modal analysis has been shown to be a subsidiary implement for interactively engendering authentic simulations of elastic deformation. Both the analytic calculation of modal amplitudes utilizing involute oscillators and the abstraction of high frequency modes have a stabilizing effect on simulations, sanctioning for immensely colossal time steps to be taken[8].
The method to study the dynamic nature of plate is to go for dynamic analysis. It predicts various modes of vibration. Plate because of high strength to weight ratio are in use for many structural applications. Such structures are subjected to dynamic load many times over its life span. It was found that modal frequency is increasing with the addition of stiffeners. Overall stiffness of the plate can be effectively increased by addition of stiffener which can yield better result[5].
In this paper it has been recorded that an increasingly extended movable wing has lower natural frequencies. The experimental statement is reliable with information in structural dynamics that a longer structure has lower natural frequencies. Aluminum and its alloy concrete gravity is approximately 2.7 g/cc, the composites of Aluminum plays a very momentous role in light weight machine components. Silicon, copper, magnesium, iron, manganese, and zinc are paramount elements in Aluminum composites[6].

2. Modeling and analysis of cantilever beam

A rectangular bar element has modeled and analyzed in ansys software. Plane 182 and solid 185 have been used as element type. The mechanical properties such as the young are modulus, poisson’s ratio and physical property density are applied in the material property and beam has considered as isotropic. The element edge length of 0.5 is given and meshed on the surface area, meshing is done to discretizes the area and boundary condition is given by arresting all degrees of freedom in one end and other end free. The figure 2 shows the boundary conditions and figure 3 to figure 8 show the six different set of modal frequency of beam.

Table 1. Properties of Aluminum alloys

Property	Aluminum Alloys				
	LM25M	Al2024	Al 5052	Al6061	Al 7075
Density kg/m3	2670	2780	2680	2700	2810
Elastic Modulus N/mm2	71000	73100	70300	68900	71800
Tensile strength (Map)	180	324	193	276	503
Percentage elongation (%)	3	19	12	12	11
Hardness (BHN)	60	120	60	95	150
Poisson's ratio	0.33	0.33	0.33	0.33	0.33

3. Properties of alloys

3.1Mechanical and Physical properties

The physical property density and mechanical properties young's modulus and Poisson's ratio play an important role in modal analysis. These properties are shown for different Al alloys in the table 1.

3.2. Chemical Composition

The table 2 shows the chemical composition of Aluminum alloy. In this LM 25 has considerable amount of silicon, and remaining alloys will have very minimum level of contribution. In AL2024 composition level of copper is more and other alloys are very less weight percentage. In all other aluminum alloys the chemical composition of other alloys weight fraction is very less. This clearly shows that only LM25 and Al 2024 has considerable amount of alloy content in their composition.

Table 2. Chemical Properties of Aluminum alloys

Al Alloy	Cu	Mg	Si	Fe	Mn	Cr	Zn	Ti	Al
LM25	0.1	0.2-0.6	6.5-7.5	0.5 Max	0.3		0.1	0.05	Rem.
Al 2024	3.8-4.9	1.2-1.8	0.5 Max	0.5 Max	0.3-0.9	0.1 Max	0.25 Max	0.15 Max	90.7-94.7
Al 5052	0.15-0.14	2.2-2.8	0.25 Max	0.4 Max	0.1 Max	0.15-0.35	0.1 Max		95.7-97.7
Al 6061	0.15-0.4	0.8-1.2	0.4-0.8	0.7 Max	0.15 Max	0.04-0.35	0.25 Max	0.15 Max	95.8-98.6
Al 7075	1.2-2	2.1-2.9	0.4 Max	0.5 Max	0.3 Max	0.18-0.28	5.1-6.1	0.2 Max	87.1-91.4

4. Result and Discussion

4.1. Modal Analysis

The experimental modal results (Modal frequency and mode shapes) are discussed in the following section. Natural Frequency: Modal analysis gives the value of natural frequency. These natural frequencies were calculated by beam theory. The natural frequencies of an aluminum alloy beam for the six modes are given in below table 3. The comparative analysis of modal analysis has been plotted in the Figure 1. This clearly shows the frequency is for LM25 and Al 2024 are comparatively higher than the other alloys.

Table 3. Modal frequency of different Aluminum alloys

	Frequency					
Al Alloy	1	2	3	4	5	6
LM25	38.04	57.20	227.31	309.24	312.95	410.08
Al 2024	38.36	57.17	228.33	306.37	313.61	409.55
Al 5052	37.85	56.91	226.18	307.71	311.41	408.05
Al 6061	37.33	56.13	223.09	303.42	307.15	402.47
Al 7075	37.33	56.13	223.08	303.48	307.13	402.45

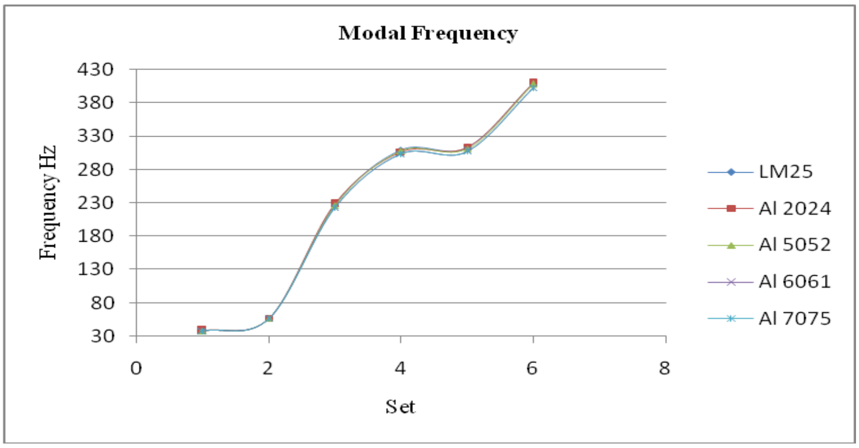

Figure 1. Comparative analysis of modal analysis of different aluminum alloy

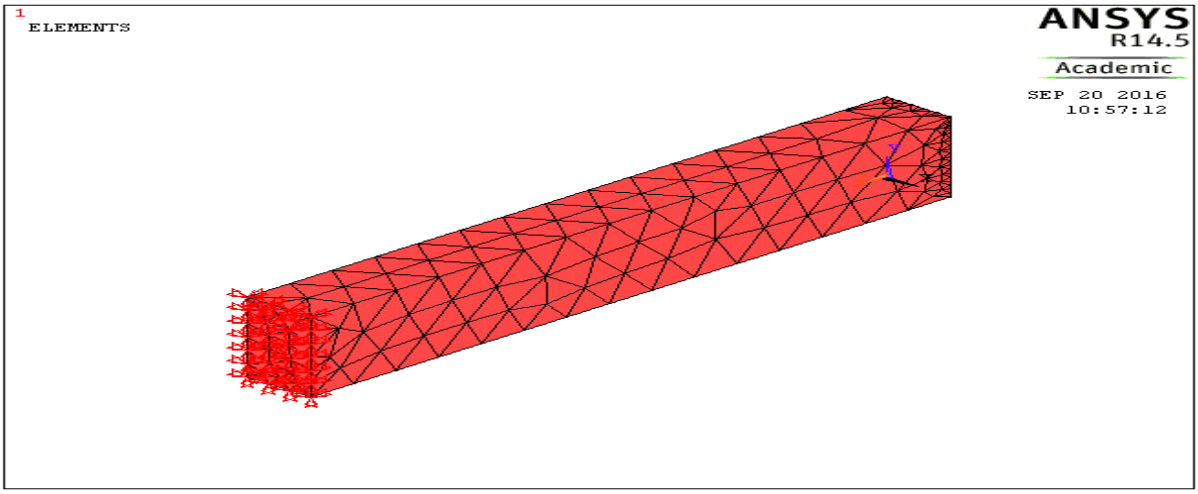

Figure 2. Meshing and Boundary conditions

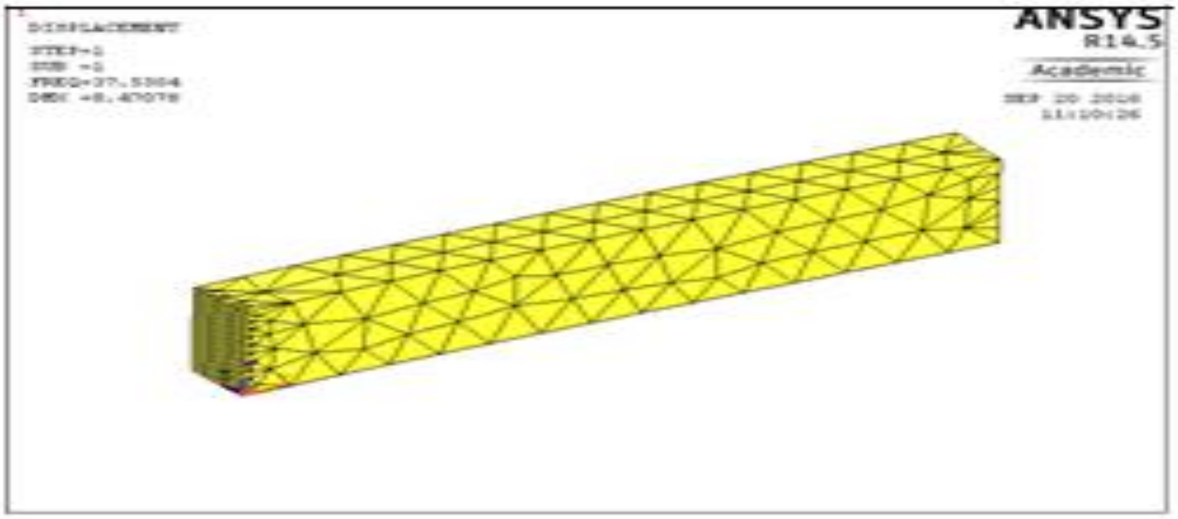

Figure 3. First mode shape at set 1

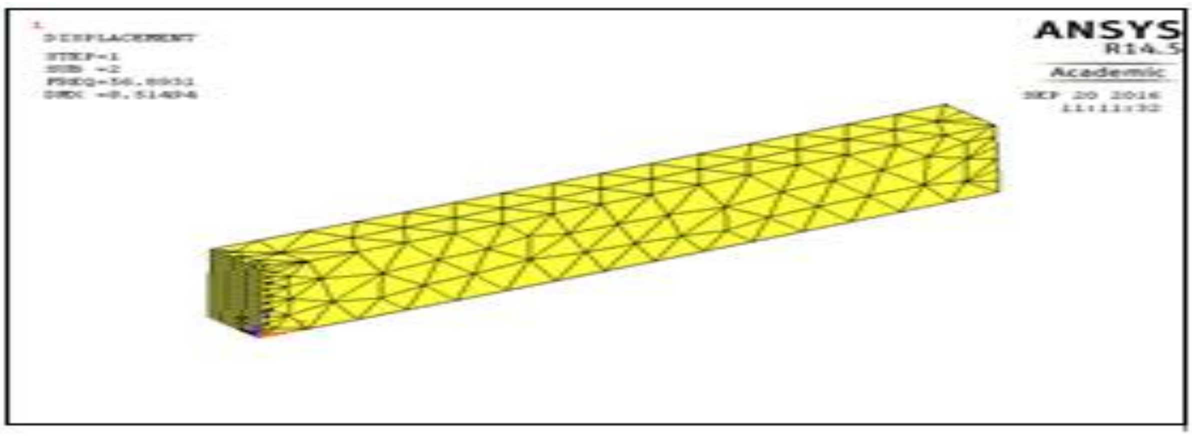

Figure 4. Second mode shape at set 2

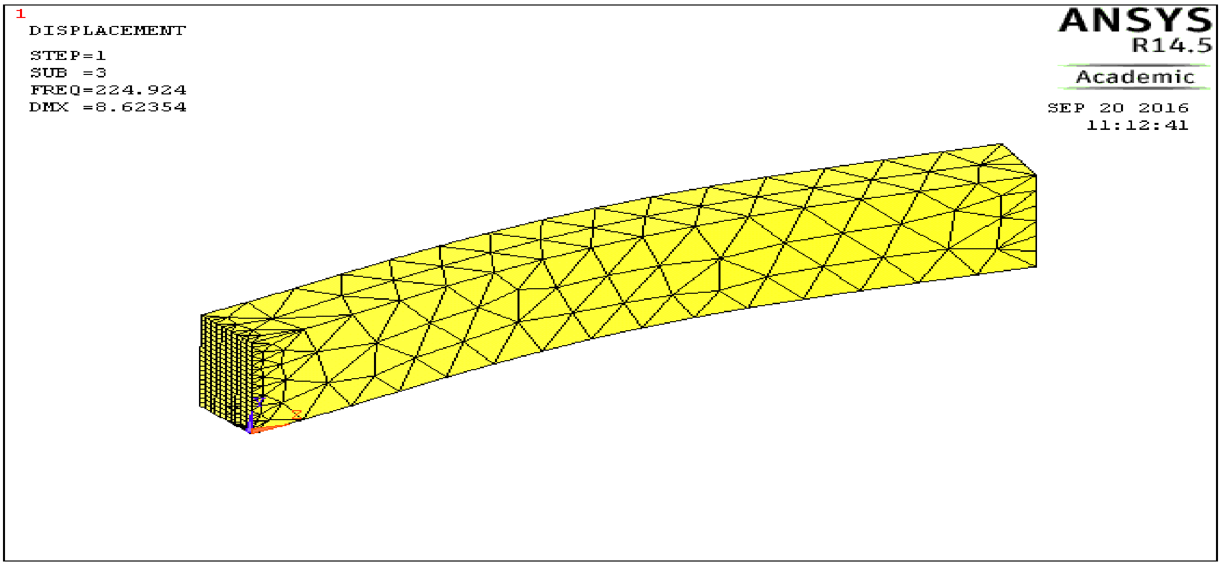

Figure 5. Third mode shape at set 3

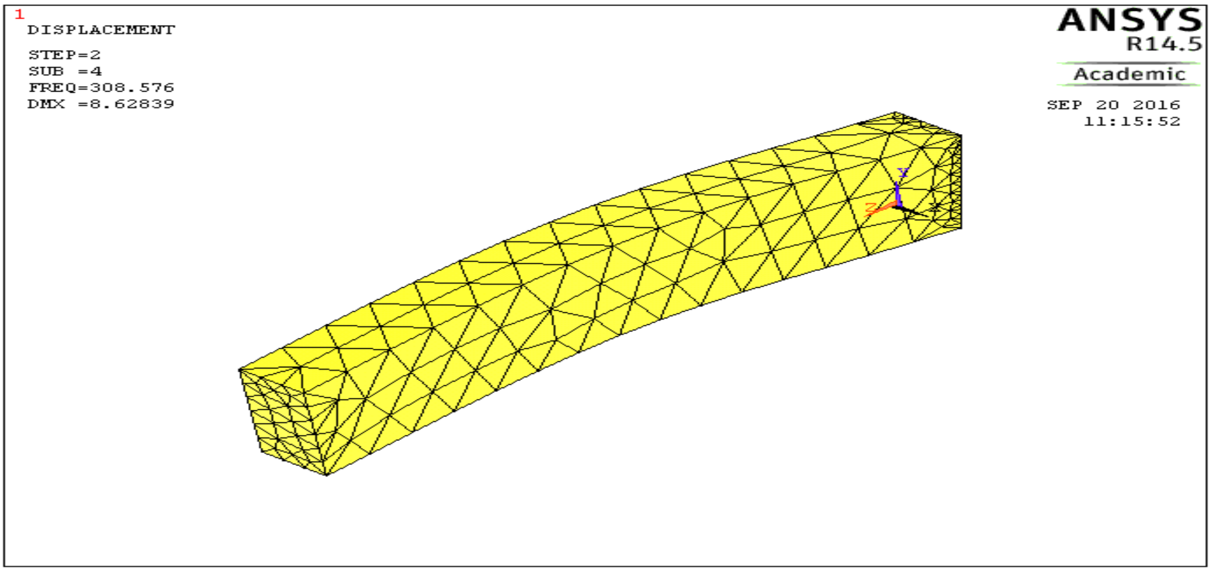

Figure 6. Fourth mode shape at set 4.

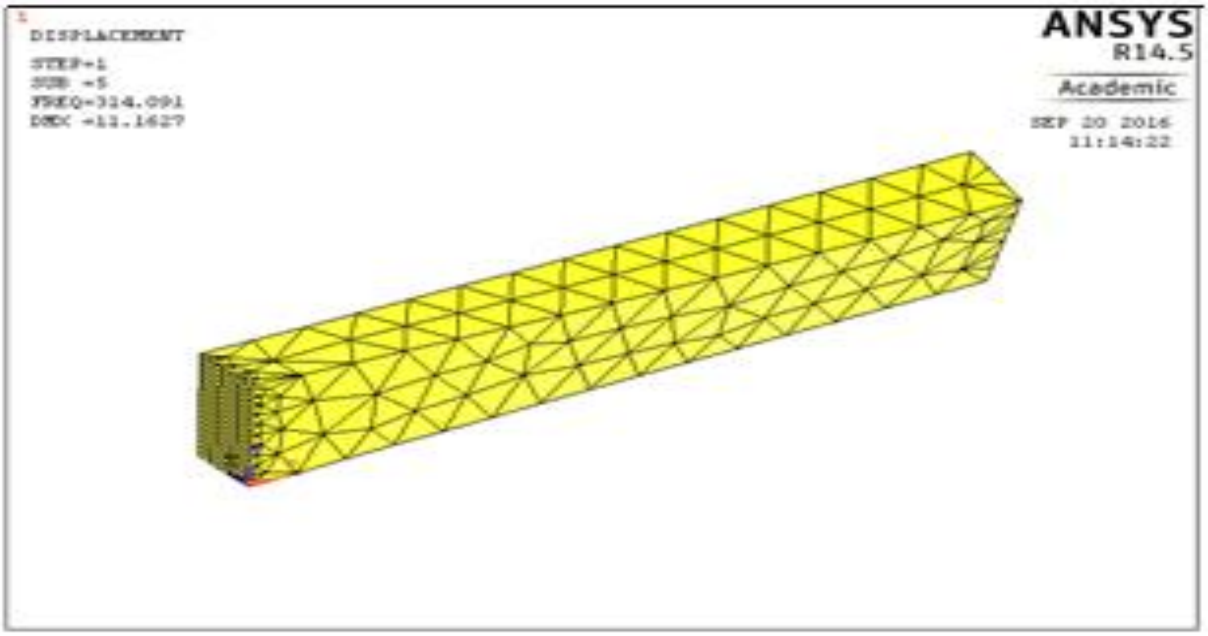

Figure 7. Fifth mode shape at set 5

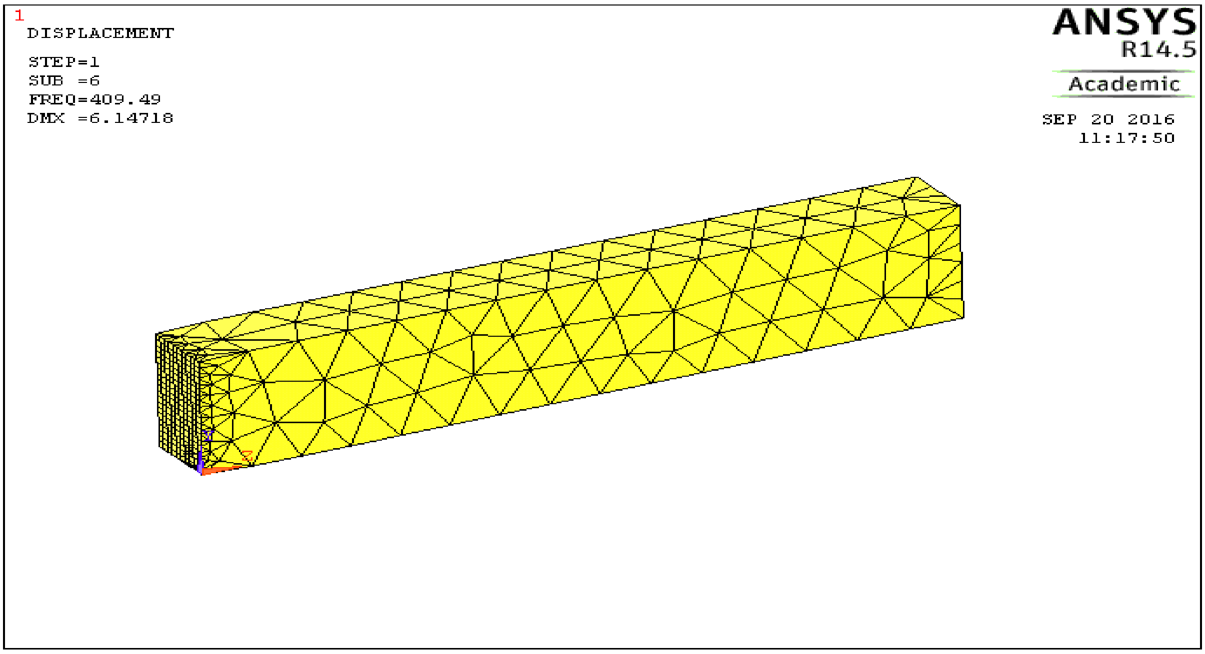

Figure 8. Sixth mode shape at set 6

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Given the following equations have the frequencies of the modes and their shapes and have been deduced from

4.2. Euler-Bernoulli Beam Theory.

$\omega_n = \alpha^2_n \sqrt{}(E\ I\ /mL3\ )$; n= 1, 2, 3….

α_n =1.875, 4.694, 7.855; m = ρV = ρxlxhxw; I =wh3/12;

ρ = density in kg/mm^3

From Strength of Materials, the deflection, x, at the tip of a cantilever beam is given by

x = P * L3 / 3 E I

Where x - tip displacement; P - applied load (also referred to as F); L - length of the cantilever beam

E - Young's Modulus of Elasticity; I - bending moment of inertia

The deflection at the end of the cantilever beam can be expressed as

F = k x and therefore, the stiffness of the cantilever beam can be expressed as

k = 3 E I / L3.

Realizing that the natural frequency is

$\omega_n = \sqrt{}$ (k/m) (in rad/Sec) and the natural frequency of the first mode of the cantilever from the continuous solution is

ω_n = (1.875)2 $\sqrt{}$ (E I g/wL4) (where w - weight and g – gravitational constant) allows the effective mass at the tip of the cantilever beam to be determined. This approximation allows the cantilever beam to be modeled as a single degree of freedom system since the mass and stiffness are known.

4.3. Deformation

The deformation for different Al Alloy is shown in table 4. The values show that for LM25 the deformation is more compared to other aluminum alloy. Al 2024 and Al 7075 have less deformation. The density and young's modulus are more than other Al alloy plays a vital role in deformation of Al alloy.

Table 4. Deformation of different Aluminum alloys

	Deformation					
Al Alloy	1	2	3	4	5	6
LM25	8.47	8.51	8.64	8.58	11.15	6.15
Al 2024	8.24	8.25	7.95	8.12	11.04	6.06
Al 5052	8.47	8.51	8.64	8.58	11.15	6.15
Al 6061	8.44	8.48	8.61	8.55	11.11	6.13
Al 7075	8.27	8.31	8.44	8.38	10.89	6.01

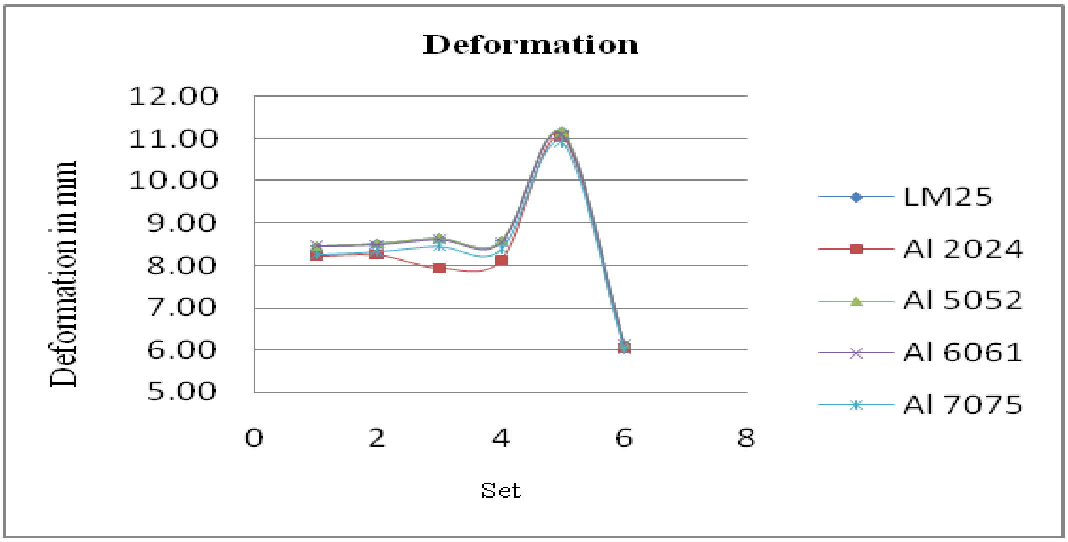

Figure 9. Deformation graph of different aluminum alloy

5. Conclusion

The work obtainable in this paper is intended to investigate the effect of the vibration characteristics and deformation of different Aluminum alloys. The performances of vibration on the alloys are tabulated. From the analysis, it is concluded that the natural frequency of the beam and deformation is related to young's modulus and density. It is observed that the natural frequency is nearly equal for Al 2024 and for LM25 Aluminum Alloy. The deformation for AL2024 and AL7075 is less than other AL Alloys.

This clearly indicates that increase of silicon content in the alloy LM25 increase modal frequency and decrease of young's modulus, density and copper content increases the deflection in LM25.

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