Modeling and Analysis of Vibrating Fixtures

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Abstract-Vibration is one of the most common causes of avionic device failure. The aircraft's avionic equipment must be able to resist high vibrations. Because it is not possible to place vibration equipment directly on the shaker table of a vibration machine, a mechanical structure known as a fixture is used to place the equipment and the machine. The proposed work's main goal is to develop the overall performance of the vibrating fixture to study the vibration characteristics of that particular structure at static and dynamic loading conditions, as well as performing random vibration analysis on various types of fixtures made up of Aluminum 2024 andAZ31B magnesium alloy. In this scenario, the natural frequencies, strength, strain and deformation of the structure are calculated at static load and dynamic loading conditions. By determining all of these findings, the proper selection of material for vibrating fixture can be done for mechanical design analysis.

INTRODUCTION

Avionics be electronic devices are use in aeroplanes and it requires a high level of mechanical design knowledge in order to produce sound and reliable products. Avionics are increasingly being used in strategic or military operations, and these devices are becoming more sophisticated. As a result of these considerations, the Lea wires, solder junctions, cables, castings, and the like have high failure rates. behavior of structures, such as vibrations, shock, dust and temperature are the most common causes of equipment failure in the field.

Only the parameter of vibrations is used to put the avionics to the test in this study. Frequency levels of aircraft's working conditions, according to military requirements, range from 20Hz to 2000Hz. Due to the difference in pitch of holes on the unit and vibration machine, the equipment under test cannot be placed directly on the Shaker table. If the fixture's natural frequency falls within the test range, resonance occurs, causing the input to be amplified, which is undesired. An excellent design of the fixture is necessary to ensure effective trans mission of input to the avionic equipment. Vibration experimentation may requires the use of an external exciter to provide the required vibration. When a certain amount of vibrations is applied to the test and the response is measured; this is applicable in controlled tests such as product testing. Vibration exciters come in a range of configurations, each with its own set of characteristics and operating principles.

A fixture is a structure that is bolted to a shaker and shock testing machine, as well as some devices that are being tested, and is driven by it. A vibration machine's shaker head usually has some sort of hole design that allows machine screws to be installed. Small electronic components can be mounted in these holes for vibration testing. For large parameter of vibrations electronic boxes, a mechanical adapter is required to allow shaker table head to transmit vibration motion to electronic box. Vibration test fixture is the common name for this converter. As a result, the vibration test fixture serves as a link between the object and machine. The armature's extension, which take the form of very rigid structures, are what allow the required force to be transferred at the required frequency. Vibration fixtures come in many different sizes and shapes. Making broad statements that can be applied to a specific design is difficult. Serving fixture resonance can be reduced by using a highly damped fixture structure. This can take form of laminated structure in which energy is degenerate at multiple fixtures. Because resonance amplifies acceleration forces, it's best to keep a fixture's natural frequency was atleast 50% morethan the highest or largest forcing frequency.

Levine et. nl [1] "emphasized the importance of the rigidity of fixture". Nabata & Terasaka[2] "in this research paper proposed that the large vibration can occur in tools and workpiece during the machining operation". Kang and Peng [3] "concludes with in the research trend of computer aided fixture panning". Kaya [4] "in this researched paper proposed that clamping is very

Figure 1 V875-640 shaker system

critical in fixture design to achieve fixture stiffness" Zheng[5] "develops experimental methodologies to detect interaction stiffness and constructs the finite element analysis of fastening unit stiffness." "The most frequent instrument for stress and computational modeling," according to Akin[6]. "Multiple fixture-related failure sources are recognized as contributing to the part positioning error, which will lead to negative quality," according to Anad Raghu of Melkote [7]. "Facility flaws effect quantitative variation on conventional machining," say Camelio and S.Jack[8]. "The FEA is the cornerstone of a billions of dollar per year industry," Rylance[9] claims. Quality and timeliness stability, according to Deng[10], "is a significant consideration in machined fixture design and relates to a fixture's capacity to fully constrain a workpiece that is subjected to the external factors produced by milling operation." S. Ratchev, K. Phuah, et. nl. [11] "suggested that a precise and effective fixture design validation technique be established to lower the overall cost and lead-times of a new fixture production." "Understanding of work piece deformation generated by loading in fixture-workpiece system is vital to produced excellent part manufacturing," Siebenaler, Shreyes [12] writes.. As per the literature surveys are concerned, there is some sluggish for the vibration analysis of fixtures".

PROBLEM FORMULATION

The main aim of the project is to design a suitable vibration fixture with suitable materials in this process here 3 types of fixtures (L-type, T-type, Cube type fixture) were designing with the help of cad tool solid worksand analyzing with 2 different materials (Al-2024, az31b) by using Ansys workbench, in this process both static and dynamic loading conditions applied on each material/ object, finally thesis can be concluded with optimum model with optimum material, and discussing their advantages and disadvantages and limitations by showing suitable graphs and tables.

Results to be calculated:

Displacement, stress, strain, safety factor (static analysis)

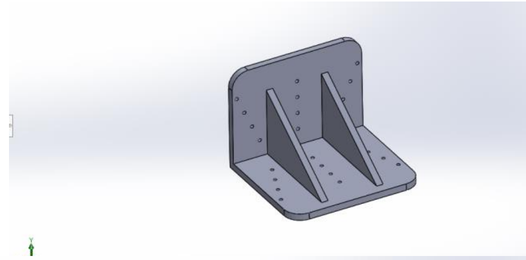
recurrence of nature values for 6 modes are here by each mode shape considering to be object degrees of freedom (dynamic analysis)

MODELLING

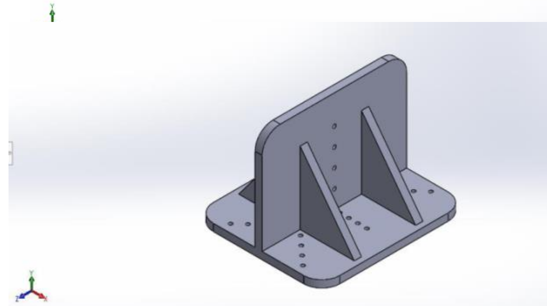
Three types of fixture models was modeled using the software solid works during the design optimization process. Today, the entire design process, from simulation to analysis, prototyping and manufacturing is entirely dependent on remedies for computer-aided engineering Solid modeling is a user-friendly and flexible programme. software that can perform a wide range of tasks, despite their complexity, with ease.

Various sizes and shapes are considered in this job when modelling a vibration fixture. Distinct vibrations have different material characteristics and geometric configurations. fixtures with plate hole patterns are shown in the diagrams below.

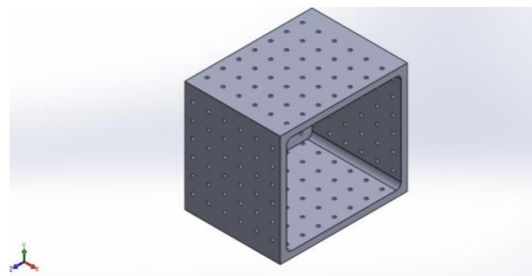
Case 1 :
L - Shape fixture
Dimensions of horizontal plate
400×300×200mm
Dimension of vertical plate
400×350×20mm



Case 2 :
T-shape fixture
Dimensions of horizontal plate 400×350×20mm
Dimensions of vertical plate
400×300×20m

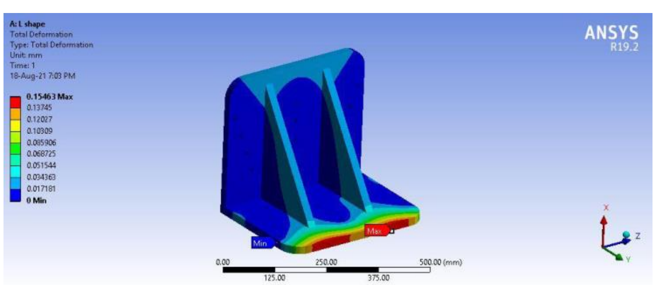


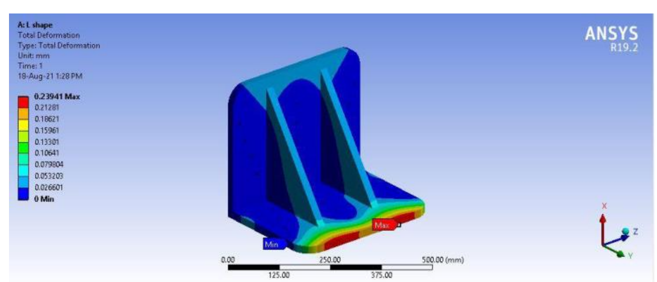
Case 3:
Cube shape fixture
Dimensions
400×350×300mm ,Shell of 20mm



FINITE ELEMENT ANALYSIS OF FIXTURES

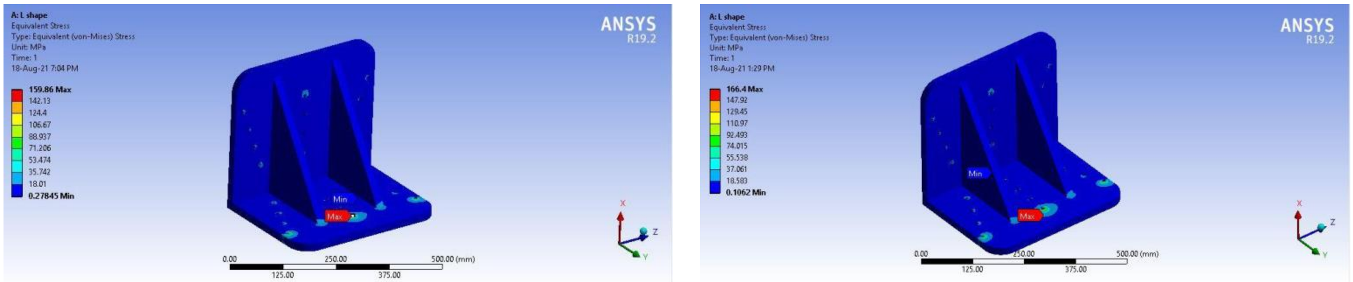
The fixture is analysed using the FEM tool ANSYS. The details of the analysis are summarized in the tables. The boundary conditions- the model is fixed at the mounting hole and Frictionless support is given at the bottom surface of the horizontal base plate. The mesh sensitivity was carried out to refine the mesh to obtain the mesh independent results. Figures illustrate static analysis of various fixtures made of aluminum alloy and magnesium alloy





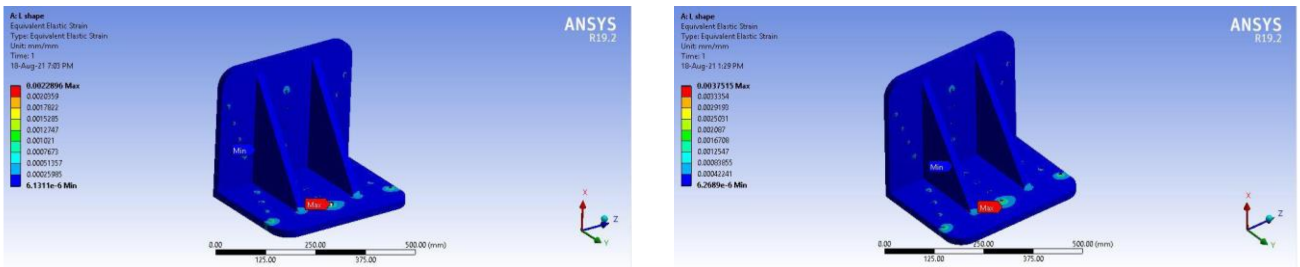
(a) Al alloy of L- shape fixture *(b) L- shape fixture (Mg alloy)*

Figure 5.Deformation of L shaped fixture made of Magnesium Alloy and Aluminum alloy



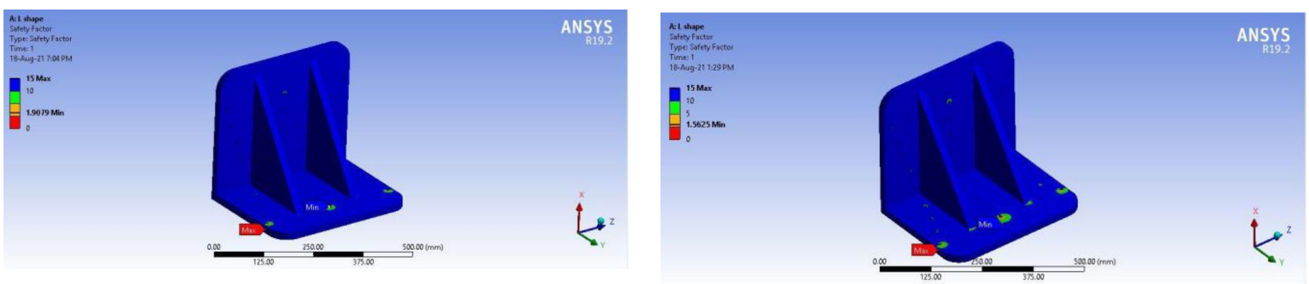
(a).*Al alloy of L- shape fixture* *(b) Mg alloy of L- shape fixture*

Figure 6.Equivalent Stress of L shaped fixture made of Magnesium Alloy and Aluminum alloy



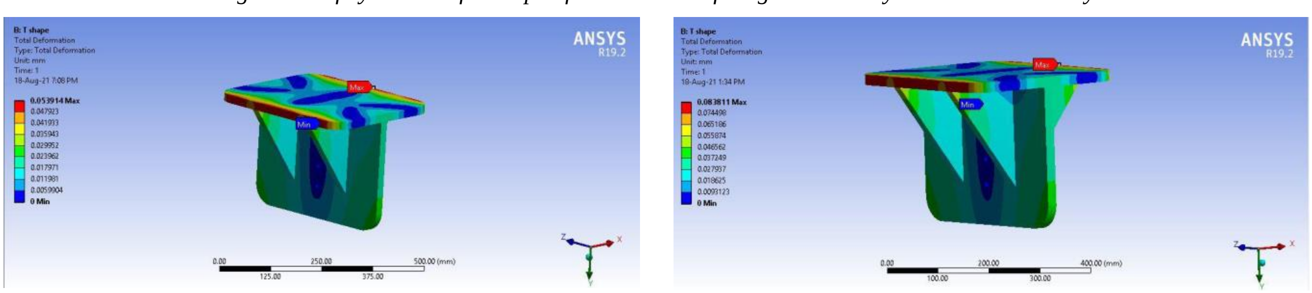
(a) Al alloy of L- shape fixture *(b) Mg alloy of L- shape fixture*

Figure 7.Equivalent Elastic Strain of L-shaped fixtures made of Magnesium Alloy and Aluminum alloy



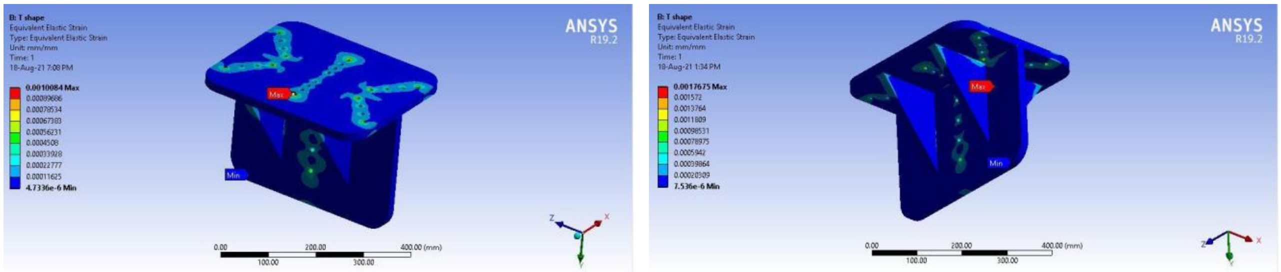
(a) Al alloy of L- shape fixture *(b) Mg alloy of L- shape fixture*

Figure 8.Safety Factor of L shaped fixtures made of Magnesium Alloy and Aluminum alloy



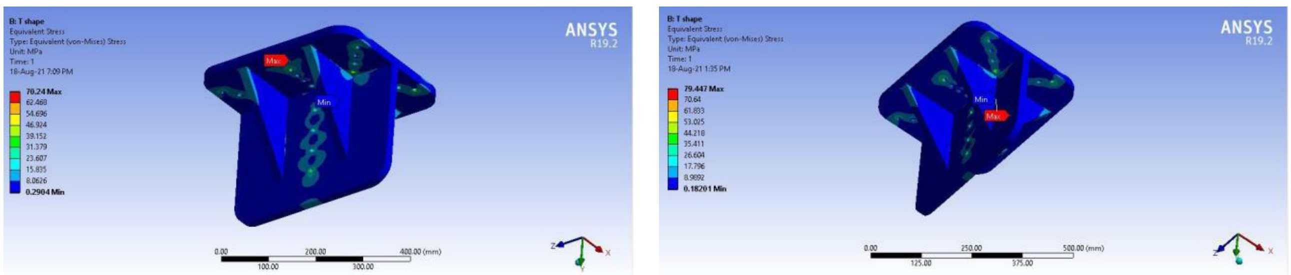
(a) Al alloy of T- shape fixture *(b) Mg alloy of T- shape fixture*

Figure 9.Deformation of T shaped fixtures made of Magnesium Alloy and Aluminum alloy



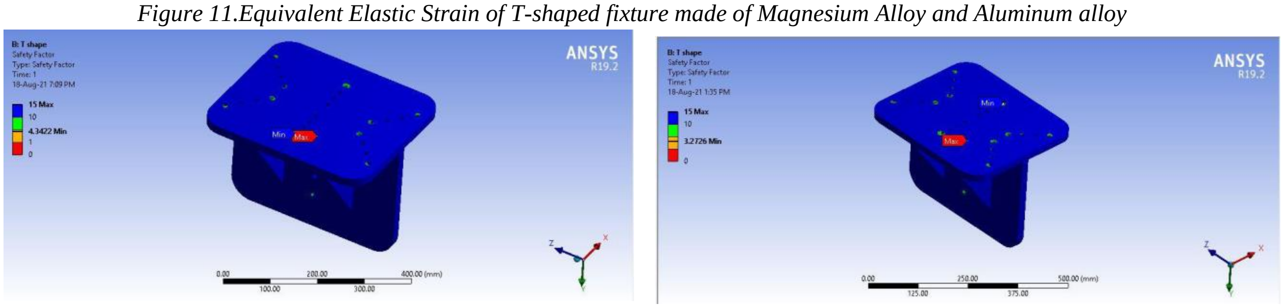
(a) Al alloy of T- shape fixture *(b) Mg alloy of T- shape fixture*

Figure 10. Equivalent Stress of T shaped Fixtures made of Magnesium Alloy and Aluminum Alloy



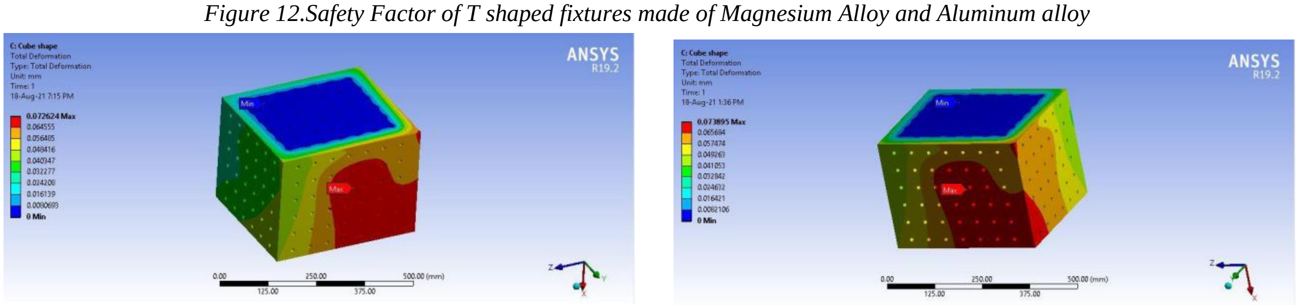
(a) Al alloy of T- shape fixture *(b) Mg alloy of T- shape fixture*

Figure 11.Equivalent Elastic Strain of T-shaped fixture made of Magnesium Alloy and Aluminum alloy



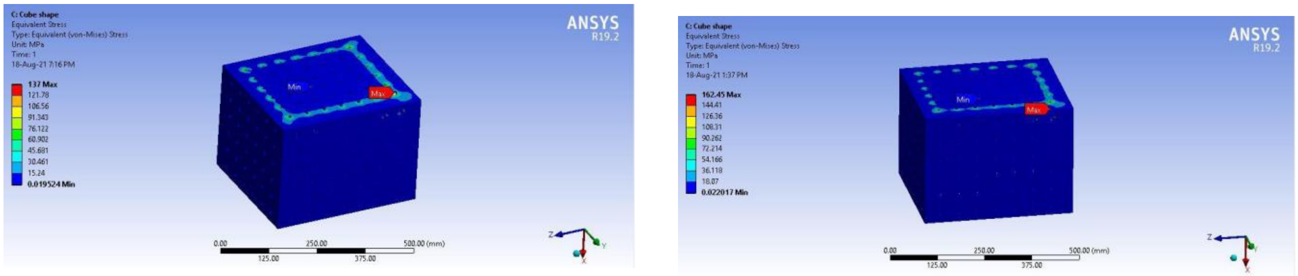
(a) Al alloy of T- shape fixture *(b) Mg alloy of T- shape fixture*

Figure 12.Safety Factor of T shaped fixtures made of Magnesium Alloy and Aluminum alloy



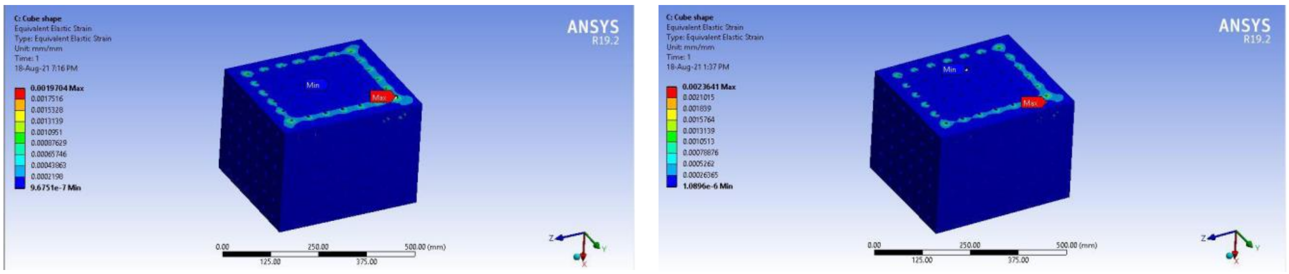
(a) Al alloy of Cube- shape fixture *(b) Mg alloy of Cube- shape fixture*

Figure 13.Deformation of Cube shaped fixtures made of Magnesium Alloy and Aluminum alloy



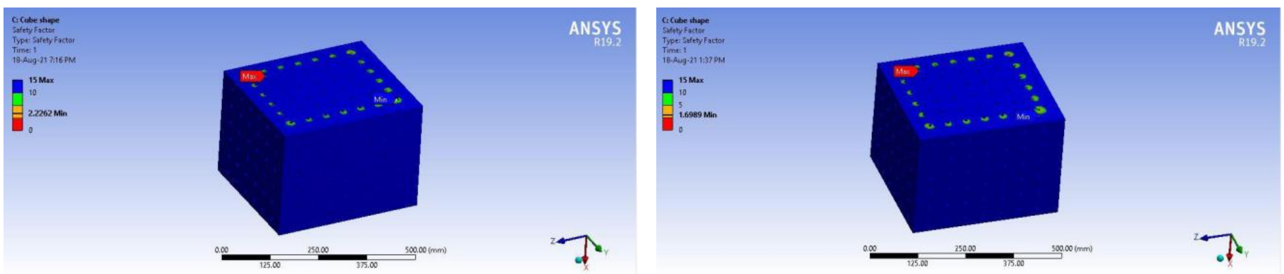
(a) Al alloy of Cube- shape fixture (b) Mg alloy of Cube- shape fixture

Figure 14. Equivalent Stress of Cube shaped fixtures made of Magnesium Alloy and Aluminum alloy



(a) Al alloy of Cube- shape fixture (b) Mg alloy of Cube- shape fixture

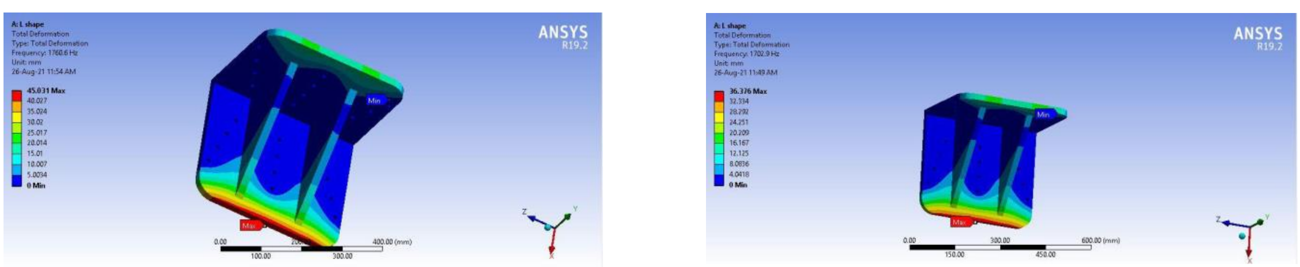
Figure 15. Equivalent Elastic Strain of Cube-shaped fixture made of Magnesium Alloy and Aluminum alloy



(a) Al alloy of Cube- shape fixture (b) Mg alloy of Cube- shape fixture

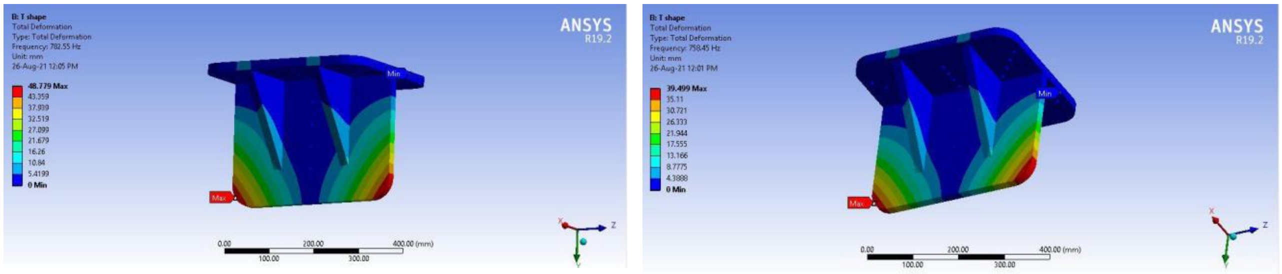
Figure 16. Safety Factor of Cube shaped fixtures made of Magnesium Alloy and Aluminum Alloy

Figures shows modal analysis of various fixtures made of aluminum alloy and magnesium alloy.



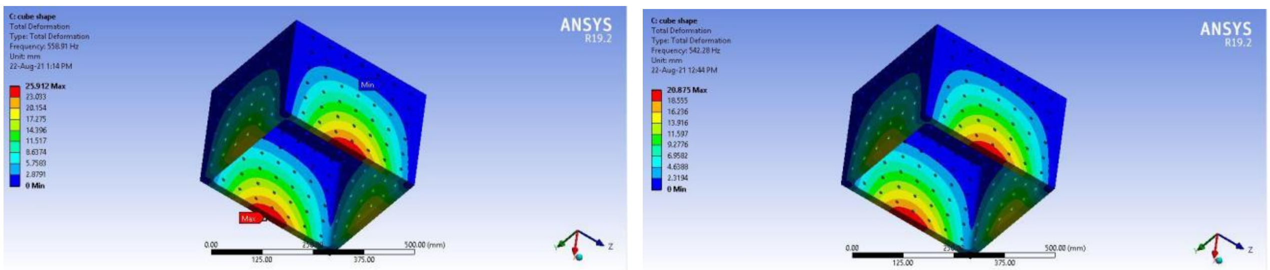
(a) Al alloy of L- shape fixture (b) Mg alloy of L- shape fixture

Figure 17. Modal analysis of L shaped fixtures made of Magnesium alloy and Aluminum alloy



(a). Al alloy of T- shape fixture *(b) Mg alloy of T- shape fixture*

Figure 18. Modal analysis of T shaped fixtures made of Magnesium Alloy and Aluminum alloy



(a) Al alloy of Cube- shape fixture *(b) Mg alloy of Cube- shape fixture*

Figure 19. Modal analysis of Cube shaped fixtures made of Magnesium alloy and Aluminum alloys

RESULTS AND DISCUSION

Table 1: Comparison of Static analysis values of Fixtures made of Aluminum Alloy

Aluminum Alloy	Deformation	Stress	Strain	Safety Factor
L- Shape	0.15463	159.86	0.0022896	1.9079
T-Shape	0.053914	70.24	0.0010084	4.3422
Cube Shape	0.072624	137	0.0019704	2.2262

Table 2: Comparison of Static Analysis values of Fixtures made of Magnesium Alloy

Magnesium Alloy	Deformation	Stress	Strain	Safety Factor
L-Shape	0.2394	166.4	0.0037515	1.5265
T-Shape	0.083811	79.447	0.0017675	3.2726
Cube Shape	0.073895	162.45	0.0023641	1.6989

Table 3: Natural frequencies of fixtures made of Aluminum alloys are compared

Aluminum Alloy	L-Shape	T-Shape	Cube Shape
Mode 1(Hz)	1760.6	782.55	558.91
Mode 2(Hz)	1872.9	810.12	695.95
Mode 3(Hz)	1907.2	1115.9	819.08
Mode 4(Hz)	1961.1	1538.2	1089
Mode 5(Hz)	1973.7	1879.5	1479.3
Mode 6(Hz)	2125.3	1880.5	1675.1

Table 4: Natural frequencies of fixtures made of magnesium alloys are compared

Magnesium Alloy	L-Shape	T-Shape	Cube Shape
Mode 1(Hz)	1702.9	758.48	542.28
Mode 2(Hz)	1815.9	782.43	674.17
Mode 3(Hz)	1843.2	1084.7	793.42
Mode 4(Hz)	1897.1	1495.1	1052.8
Mode 5(Hz)	1909	1817.8	1435
Mode 6(Hz)	2062.2	1828.3	1625

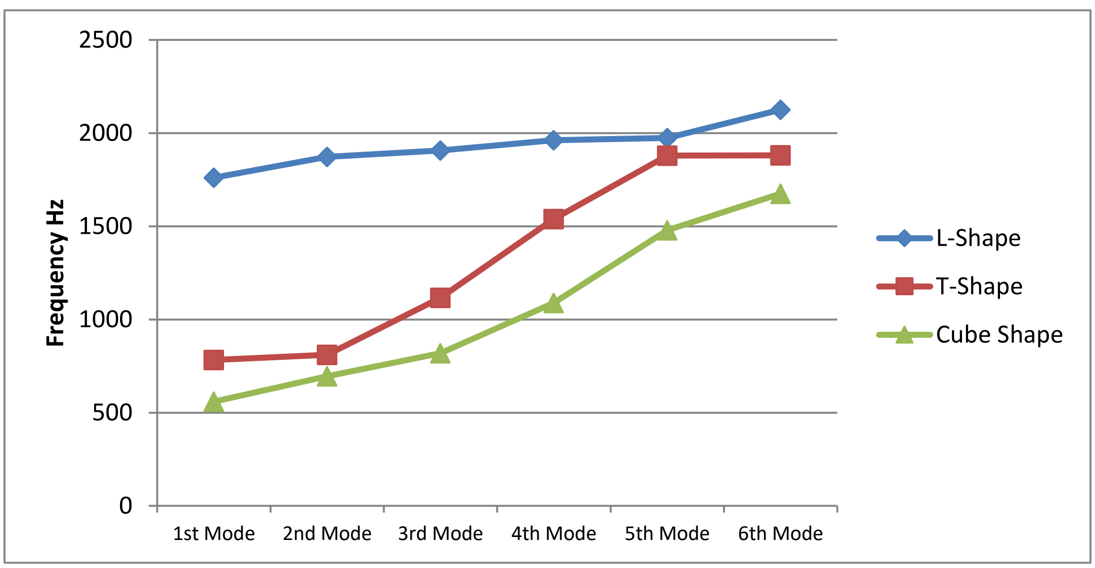


Figure 20. Graph of Frequencies and Mode Shapes for Different Aluminum Alloy Fixtures

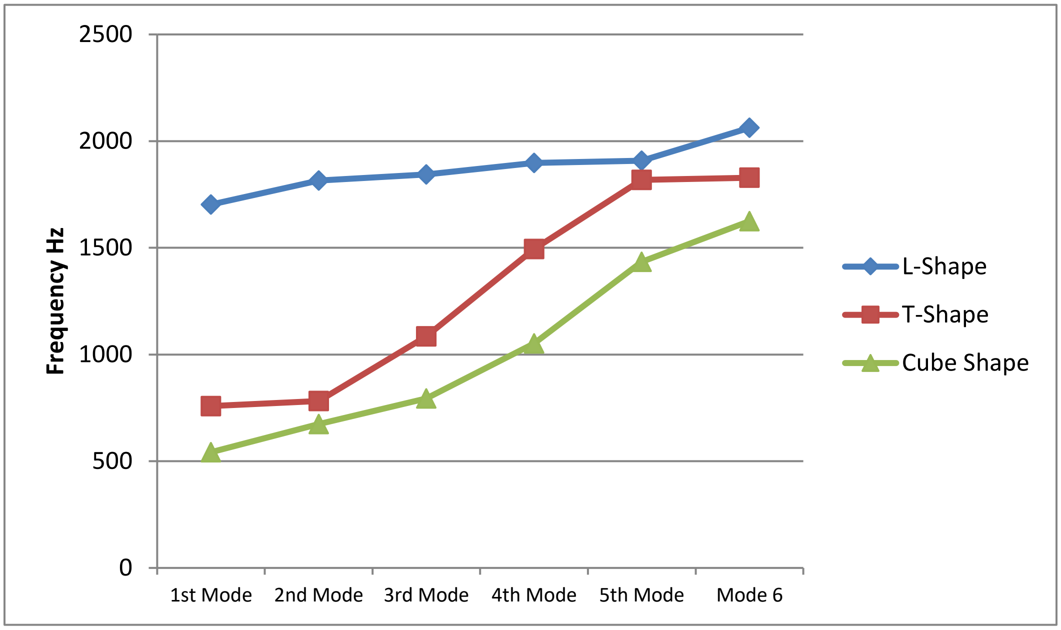


Figure 21. Graph of Frequencies and Mode shapes for Different Magnesium Alloy Fixtures

Conclusion

The main aim of the project is to design a suitable vibration fixture with suitable material, in this process here 3 types of fixtures (Cube, "T" type, "L" type fixtures) were designing with the help of cad tool solid works and analyzing with 2 different materials (Al-2024, az31b) by using Ansys workbench, in this process both static and dynamic loading conditions applied on each material/ object,

From static analysis results it is state that all 3 objects having their individual strength values for each material, in this process T-shaped fixture is having higher strength values compare to other 2 models, and then cube shape vibration fixture has taken 2nd position and then after L shaped has 3rd rank, in terms of their strength values,
But it is not possible to decide a material or object by knowing the static analysis results only, to get more clear comprehension about each object and each material here dynamic analysis is also performed and calculated results like natural frequency values, from dynamic analysis results L-shape object has better results than other 2 models, and then T-shape has 2nd best frequency values, and cube shape has least frequency values in each mode, and there is almost nearly 50% difference is there, so that this cube shape vibration fixture is not suitable for real time applications, and even though it has good static analysis values but poor dynamic analysis values,
Finally thesis can conclude with L-shape vibration fixture with al-2024 material, even though T-shape has good static results than any other model/material, but it has 2nd best dynamic analysis results, so that here L-shape is chosen due to its high range natural frequency range values. And al-2024 is having good strength to weight ratio.

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