Finite Element Analysis of Vibration Fixture Made of Aluminum and Magnesium Alloys

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Abstract - Vibration is the most important modes of failure in avionic equipment. The avionic equipment fitted into the aircraft has to withstand high vibrations. As vibration equipment cannot be placed directly on the vibration machine shaker table, a mechanic structure called fixture is placed between the equipment and the machine. The avionic equipment under the test has to withstand a random excitation with frequency range of 20 – 2000Hz. In this work designing the fixture that supports the unit and the vibration machine while taking into consideration that its natural frequency does not occur in the excitation range of the unit. These fixtures are generally used for supporting electronic equipment which is used in missiles, fighter aircrafts. The fixture is designed such that its natural frequency does not fall under the frequency range of 20 – 2000Hz. After selecting the suitable design of vibration fixture as per the requirement, it is analyzed by using finite element analysis.

Keywords – vibration fixture, SOLIDWORKS, Finite element analysis

I. Introduction

Avionics are electronic equipment used in aircraft and they demand a great deal of mechanical design skills for achieving sound and reliable products. The use of avionics in the strategic or military applications is rapidly increasing and these equipment's are becoming more and more sophisticated.These factors result in a sharp increase in the failure rates of lea wires, solder joints, cables, castings and other structural members. The main causes of failure of the equipment in the field are environmental parameters like vibrations, shock, dust and temperature that effect the behavior of structure.

In the present work only vibration parameter is considered to test the avionic equipment. The working conditions of the aircraft as per military standards range from 20 to 2000HZ frequency levels. The equipment under test cannot be mounted directly on the vibration machine due to the difference in the pitch of the holes of the unit and the vibration machine. If the natural frequency of the fixture lies in the test range, resonance occurs resulting in amplification of the input, which is undesirable. To ensure proper transmission of input to the avionic equipment, an effective design of the fixture is required.

Figure 1. V875-640 shaker system

Vibration experimentation may require an external exciter to generate the necessary vibration. This is the case in controlled experiments such as product testing where a specified level of vibration is applied to the test object and the resulting response is monitored. A variety of vibration exciters are available, with different capabilities and principles of operation.

A fixture is an intermediate structure, bolted to and driven by a shaker or shock testing machine and some devices under test. The shaker head on a vibration machine usually have some form of a hole pattern that permits the installation of machine screws. These holes can often be used to mount small electric components for vibration testing. Large electronic boxes require some sort of mechanical adapter that will permit the shaker head to transfer the vibration motion to the electronic box. This adapter is commonly known as vibration test fixture.

The vibration test fixture thus acts as interface between the unit and the machine. It is extensions of the armature in the form of very rigid structure that can transfer the required force at the required frequency. Vibration fixtures are available in such a large varieties of sizes and shapes. It is difficult to give general statements, which can be useful for a particular design. Introducing highly damped fixture structure can reduce severe fixture resonance. This can be in the form of laminated structures where energy is dissipated at several fixtures. The reason for why it is desirable to keep the natural frequency of a fixture at least 50% higher than the highest forcing frequency is that, a resonance can magnify acceleration forces

II. FINITE ELEMENT MODELING AND ANALYSIS OF FIXTURE.

In the process of design optimization various fixture models were models using solid works software. The entire process of design to simulation, analysis, prototyping and manufacturing, today is solely depends on end to end computer aided engineering solutions. Solid works is versatile and user friendly software, capable of performing variety of tasks not withstanding its complexity with ease.

In this work, for designing a vibration fixture various sizes and shapes are considered.

Material properties and geometrical configuration of different vibration fixture with hole pattern on the plates are shown in figures 1, 2, 3&4.

***Case1**:*

L-shape fixture

Horizontal plate dimensions 400mm*300mm*30mm

Vertical plate dimensions 400mm*350mm*30mm

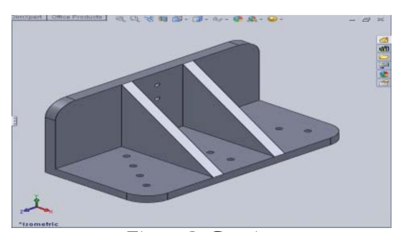

Figure 2. Case1

Case 2:

Inverted T-shaped fixture

Horizontal plate dimensions 600mm*500mm*30mm

Vertical plate dimensions 600mm*350mm*30mm

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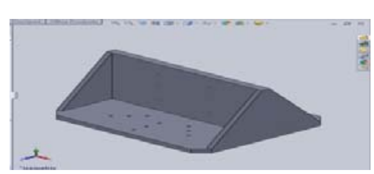


Figure 3. Case2

Case3:
Inverted T-shape with ribs 20mm thickness
Horizontal plate dimensions 600mm*500mm*30mm
Vertical plate dimensions 600mm*350mm*30mm

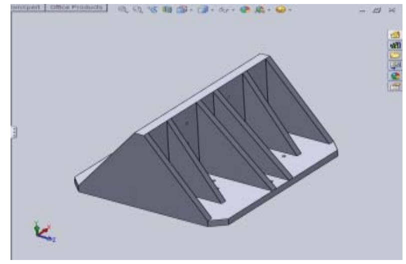
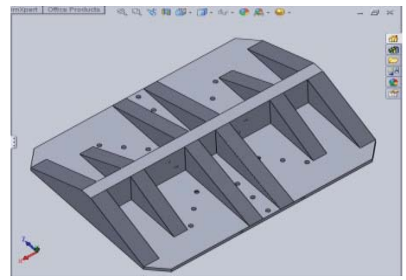


Figure 4. Case3

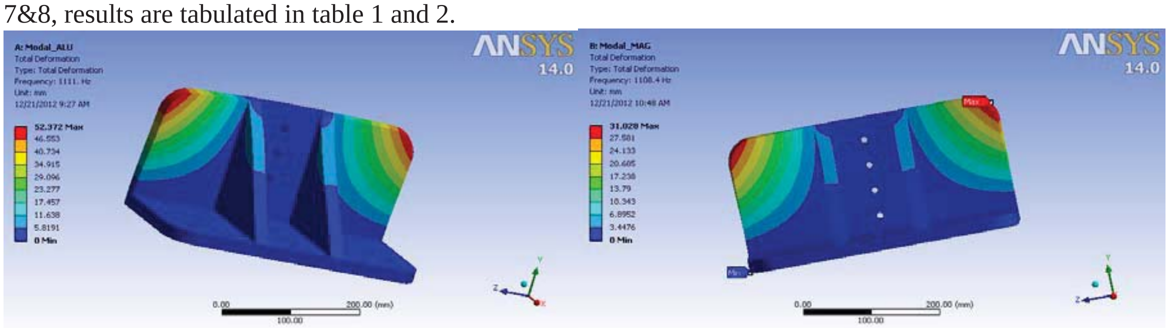


Case4:
Inverted T-shape with ribs of 40mm thickness
Horizontal plate dimensions 600mm*500mm*30mm
Vertical plate dimensions 600mm*350mm*30mm

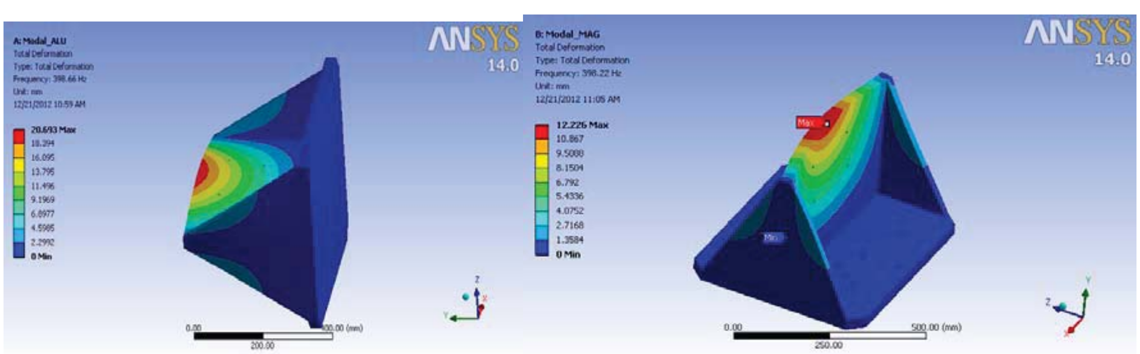
Figure 5.case4

The hole pattern on the plates are as follows
1 M10 hole at the center of the base plate
4 M10 holes on 101mm PCD
8 M10 holes on 203mm PCD
8 M10 holes on 303mm PCD

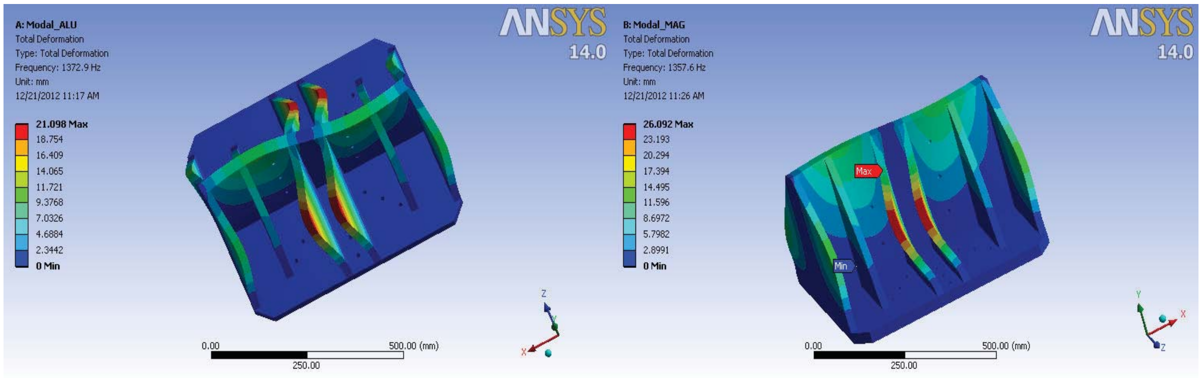
Modal analysis for various fixtures with material aluminum alloy and magnesium alloy are shown in figures 5, 6, 7&8, results are tabulated in table 1 and 2.



(a).L-shape fixture (Al alloy) (b) L-shape fixture (Mg alloy)
Figure 6. Modal analysis of L-shaped fixture made of Aluminum and Magnesium alloys

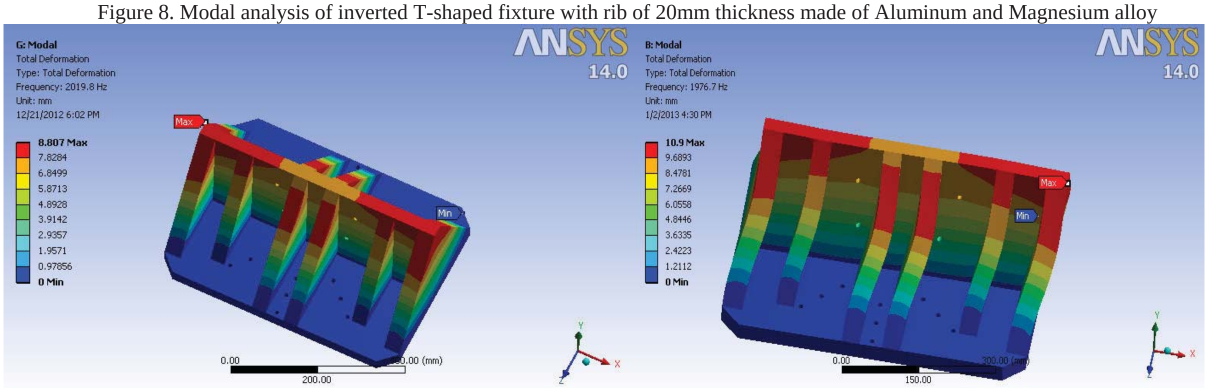


(a)Inverted T-shape (Al alloy) (b) Inverted T-shape (Mg alloy)
Figure 7. Modal analysis of inverted T-shaped fixture made of Aluminum and Magnesium alloy



(a) Inverted T-shape with ribs Of 20mm thickness (Al alloy)   (b) Inverted T-shape with ribs of 20mm thickness (Mg alloy)

Figure 8. Modal analysis of inverted T-shaped fixture with rib of 20mm thickness made of Aluminum and Magnesium alloy



(a) Inverted T-shape with ribs Of 40mm thick (Al alloy)   (b) Inverted T-shape with ribs of 40mm thick (Mg alloy)

Figure 9. Modal analysis of inverted T-shaped fixture with rib of 40mm thickness made of Aluminum and Magnesium alloy

Table1**:** Comparison of natural frequencies of fixtures with made of material aluminum alloy

S.No	Mode	Case1	Case2	Case3	Case4
1	1	1111Hz	398.66Hz	1372.9Hz	2019.8Hz
2	2	1129.7Hz	913.41Hz	1379.4Hz	2386.5Hz
3	3	1280.5Hz	1397.3Hz	1426.5Hz	2492.9Hz
4	4	1350Hz	1515.4Hz	1500.4Hz	2830.4Hz

Table2: Comparison of natural frequencies of fixtures with made of material magnesium alloy**.**

S.No	Mode	Case1	Case2	Case3	Case4
1	1	1108.4Hz	398.22Hz	1357.6Hz	1976.7Hz
2	2	1126.8Hz	909.81Hz	1359.2Hz	2343Hz

3	3	1660.9Hz	1386.1Hz	1412.7Hz	2446.3Hz
4	4	1885.3Hz	1501.6Hz	1484.9Hz	2769.6Hz

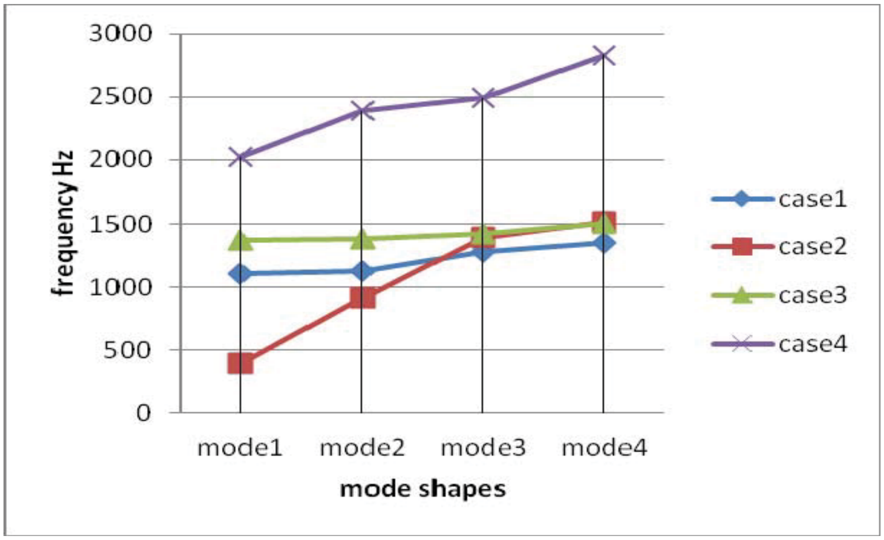


Figure 10. Graph between frequency and mode shapes of different fixtures made of aluminum alloy

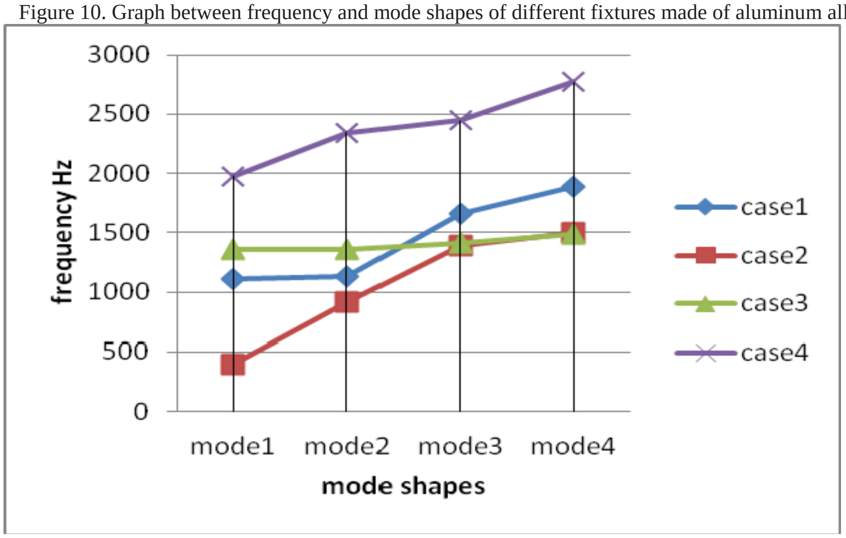


Figure 11. Graph between frequency and mode shapes of different fixtures made of magnesium alloy

III.CONCLUSION

- Modal analysis of L shaped vibration fixture and inverted T shaped fixture is conducted in ANSYS. The models are developed in solid works. The natural frequencies of L shaped fixture made of Al alloy/Mg alloy are greater than the natural frequencies of inverted T shaped fixture made of Al alloy/Mg alloy.
- Modal analysis of vibration fixtures are further extended by attaching ribs of different thickness. Initially inverted T shaped fixture with ribs of 20mm thickness is considered..
- Again inverted T shaped fixture with ribs of 40mm thickness is considered. The fixture is developed in solid works and modeled in ANSYS. From the results tabulated in table 1, it is observed that inverted T shaped vibration fixture made of Al alloy/Mg alloy has yielded natural frequencies that are found to be satisfactory.
- From the comparative results that are shown in tables 1 and 2, it is observed that inverted T shaped fixture with ribs of 40mm thickness and made of either Al alloy or Mg alloy has shown up the values that are quite satisfying

the requirement of natural frequencies greater than 2000 Hz., as per the requirements an optimum design i.e. fixture with base plate 600mm*500mm with thickness 30mm and another plate 600mm*350mm with thickness 30mm placed vertically and ribs thickness 40mm is selected whose natural frequency values for first mode is observed to be 2019Hz.

- From fig 9&10, it is clear that case4 where inverted T-shaped fixture has given better result i.e. beyond 2000Hz.
- Hence of all the fixtures that are modeled and analyzed in ANSYS, inverted T shaped fixture with ribs of 40mm thickness, made of aluminum or magnesium alloy is recommended as the range of natural frequencies obtained in the four modes are beyond the requirement of 2000Hz.

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