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Vibration Environment and the Rockets

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Abstract

Rockets are subjected to vibrations in various operational phases. Source of vibration may be due to air turbulence, propeller noise, engine noise, stage separation, pyro ignition, release mechanism etc. Some of the sections of rocket houses electronic equipments for data acquisition, navigation purposes etc. Any Structure possessing mass and elasticity vibrate under external disturbances. Electronic equipment can be subjected to many different forms of vibration over a wide range of frequencies and acceleration levels. Vibration is usually considered to be an detrimental condition and can produce many different types of failures in electronic equipment. It is always an endeavour to alleviate or minimize the vibration amplitudes. Wide variety of structures and their components are susceptible to vibration as they are subjected to time dependent forces. If the vibration amplitude of structure escalates to the upper levels, the failure of structures takes place. Vibration suppression has greater significance for aero-space structures, which houses sophisticated electronic equipments, as the high vibration amplitudes hinder the performance of such equipments. In this study it is demonstrated that Tuned Mass Dampers (TMDs) placed with individual modal tuning shows satisfactory performance for the structure subjected to wide band harmonic excitation, transient or random excitations.

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Keywords: Vibrations; Tuned mass damper ; modes; finite element

1. Introduction

Many of the structural components at some point during their lifetime are subjected to mechanical vibrations. They must therefore be designed to withstand such conditions without damage. In this study Rocket structural components are considered. Rockets are subjected to vibration in various operational phases due to air turbulence, propeller noise, engine noise, stage separation, pyro ignition, release mechanisms etc.. Many **authors [1-4] have**

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studied the tuned mass dampers for vibration reduction. The concept of tuned mass damper also called vibration TMD is extended to real life structural system. Modal tuning algorithm is implemented and the effectiveness of vibration TMDs for various type of input excitation is studied.

2. Concept of Tuned Mass Damper

Sinusoidal force acting on main spring-mass system causes the structure to go into resonance if the forcing frequency equals the natural frequency of the main mass. The resonance can cause severe problems for vibrating systems. When an absorbing mass-spring system is attached to the main mass and the resonance of the TMD is tuned to match that of the main mass, the motion of the main mass is reduced to zero at its resonance frequency. Thus, the energy of the main mass is apparently absorbed by the tuned mass damper. The motion of the tuned mass damper is finite at this resonance frequency, even though there is no damping in either oscillator. This is because the system has changed from a 1-DOF system to a 2-DOF system and now has two resonance frequencies, neither of which equals the original resonance frequency of the main mass (and also the tuned mass damper). The present study focuses the extending the concept of vibration TMD to real life structural systems.

3. Description of the Structural System

A plate mounted in longitudinal direction of the Rocket is used to house the on-board electronic package box. This plate is termed as mounting plate. The mounting plate with electronic package box is shown in Fig.-1. The basic dimensions and thickness of the mounting plate is shown in Fig.-2. The mass of the mounting plate with TMD is 3.5 kg. The weight of electronic package box is 15 kg.

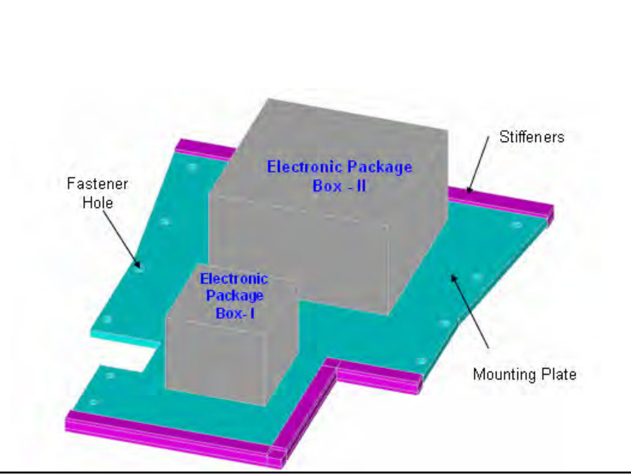

Fig.-1 Mounting plate with electronic package box

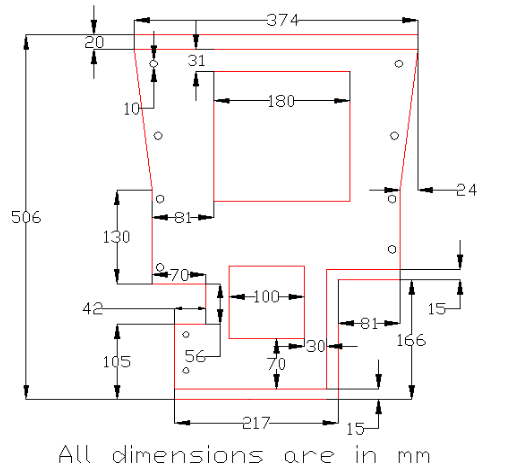

Fig.-2 Dimensioned mounting plat

4. Finite Element Modeling and Free Vibration Characteristics of Bare Plate

The finite element modelling has been carried out using Shell elements available in ANSYS. The Electronic package mass is lumped at 4 fastening locations. The mounting plate is fastened to Rocket through bracket. The fastener locations are considered fixed in finite element model. Fig.-3 shows the finite element mesh and boundary conditions of mounting plate. Free vibration analysis for plate under consideration carried out using finite element method. The first three modes of bare plate are shown in Fig. 4 to Fig.6