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The Parameters Affecting On the Design of Spacecraft Payload Transportation Container - A Review

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Abstract: ***This review work aims to found the affecting parameters on the design of any transportation container for different application like space, automobile, chemical industry, and medical etc. Here all factors to be considered in mechanical way. Satellite payloads are special purpose systems which are mounted on a spacecraft structure for space application. Since these payloads are to be assembled to the spacecraft at different location, there is a main requirement of robust transport mechanism. Container for transporting payload should be such that the payload must reach its destination safely and in controlled environment. The payload containers are to be designed for shock loads, vibration loads and thermal isolation from external environment. This transportation container should be able to isolate the payload from vibration, shocks and other environment condition such as humidity and temperature.***

Keywords: Container, Parameters of designing container, Transportation, Analysis, Testing.

1. Introduction

A container is used to store and transport equipment. Often the equipment to be transported is sensitive and fragile. It needs to be protected from all external environment variations, be it mechanical or electrical. Transportation of a space born optical system is an ever-challenging task and needs extreme care at all phases of payload development.

The requirement of transportation can come any time after commencement of integration activity as payload is usually moved from integration lab to various test facilities located at near or far distance. The container has to isolate and protect the payload from all ailing external influences like contamination, vibration, shock, heat etc.

In market so many standard containers are available but some required performance is not achieved and costly so developed a customized container for space application.

2. Literature Review

A container is used to transporting some cargo, payload and goods from one place to another place by safe and protect to all environment condition. Several other parameters have to be kept in mind while designing the container so that the equipment remains inert to any external changes.

Krupa Shanker Singh, A.C. Mathur[1]This paper carried out a design, development and testing of container. Payloads are mounted on a spacecraft structure which is very delicate, complex and special purpose system for the space application. Also, shock and vibration isolator are select for required performance and isolate to environmental conditions. Result of this paper developed a customized container for payload and it's also reused by less cost.

Ahmed HosneyRadwan[2]Discussed about the reusing and recycling material is an important value in sustainable design. Also, explore the container architecture by different opportunities of reusing steel boxes. Case studies from many points of view, like geometrically, architecturally, mechanically, economically and globally.

C.Madan Mohan Reddy[3] This paper analyzed of container chassis by using finite element method to improve the load transport capacity and reduction of failure of chassis with bending by adding stiffeners. Result of analysis in ANSYS are observed the vonmisses stresses are extent up to 37.11% compare to without stiffeners. Also, stress intensity reduced up to 36.23% and deflection reduced by 36.16%.

M. Muni Prabaharan [4]In this paper the author is carried out a static analysis for container drop test by using FEM software and explicit dynamic methods. Thus, the use of explicit finite element method to predict the performance of new products design is replacing the use of physical test. Usually, the drop testis done by high expensive software. This study deals with the simulation of impact test for a new product by using finite element analysis which is reduced the cost because not highly expensive software needed.

T. L. Danabalan[5] This paper relatively discussed safety systems for the satellite transportation. Inspected some delicate space hardware like satellites built with pressurized tanks, sensitive optics, delicate electrical and hazardous chemicals need protection from various environmental hazards during transportation by road and air. These hazards are categorized into mechanical, climatic and electrical hazards. In categorized hazards include shock, vibration and handling loads, temperature, humidity, rain, dust, different pressure, fire, Electro static discharge and RF radiation are electrical hazards.

Keerthi Siva Krishna[6]This paper investigated and optimized the missile container design by using composite material. Developed a suitcase type container Because that have a large contact area at the closing region due to which there was a huge manufacturing complexity. Detailed finite element stress analysis was also done and determined the static response of the existed and modified composite missile container for some load cases.

Pablo E Tapia-González[7]The author investigates and discuss the shock response of the isolators when subjected to pulses of different durations, finding improved isolation performance when compared to an equivalent linear system. Shock and vibration are a source of failures in harsh environments such as military, naval and aerospace applications; thus, the use of vibration isolators is extended. Thus, found shock and vibration isolation is isolate by using wire rope isolator due to nonlinear stiffness behavior and highly damping. Also, the shock response spectrum showing improved shock isolation compared to an equivalent mass spring damper system.

A Chinnamahammad Bhasha[8]In this paper designed to smooth out or damp shock impulse, and dissipate kinetic energy. In a vehicle, it reduces the effect of traveling over rough ground, leading to improved ride quality, and increase in comfort due to substantially reduced amplitude of disturbances. The model is changed with spring thickness and different materials. Conclusion of this research paper optimal stress intensities & maximum displacement values are obtained for the titanium alloy.

Sl. No	parameters	Titanium alloy	Phosphor bronze	Beryllium Copper	Spring steel
1	Maximum displacement (mm)	2.6326	4.9247	4.8582	3.0123
2	Maximum stress intensity (N/mm^2)	36.102	36.5865	36.4637	36.4265

Figure 1: Results of static analysis

Tushar Tandon[9]In this paper analysed the RADAR antenna mounting base with conventional and composite material. Radar antenna structures which are integrated into structures of defence systems are subjected to different loads. Found that composite materials are much superior to conventional materials as far as deformation and maximum stresses are considered.

Eklure Basawaraj[10] The author is discussed on the Panels made with composites are used commonly, especially in automotive and aerospace structures due to their high strength/weight and stiffness/ weight ratio. Adjacent impacts by hard body can cause delamination in significant amount, even though the external indication of damage may be a very small surface indentation. Determined (a) Impact damage resistance (contact force-time history), (b) Impact response (Impact displacement-time history), (c) Layer wise stress at specified instance of time, (d) Interlaminar stress, (e) Ply by ply impact damage (onset and growth, nature and extent), (f) Delamination onset by using Abacus/ANSYS. In future found a first ply failure conditions.

Mastura Abdul Rahim[11] In this paper the author studied in different parameters that affecting on a first ply failure. Composite laminates exhibit complex failure behaviour as they are heterogeneous and orthotropic. Each ply or lamina that formed the laminates might yield and rupture at a different stress value. This phenomenon leads to first ply failure (FPF) behaviour which emphasized on the condition where a ply that fails first. This work investigated the influence of three parameters, i.e., material property, aspect ratio, and number of plies, each considered separately, to FPF of the laminates. Analyses were carried out to determine the FPF loads based on the Maximum Stress criterion using commercially available finite element software.

3. Essential aspects of design of payload transportation container

The various guidelines for design of payload transportation container are as below:

- **Elimination from shock & vibration**: The container should protect the payload from the various types of shocks & vibrations coming on the payload during the transit.
- **Cleanliness:** The internal compartment of the container must be clean such that no dust or dirt particles should enter the compartment causing malfunctioning of the payload.
- **Isolation from external environment**: The design of the container should be such that it will isolate the internal compartment must remain isolated from the external environment.
- **Ease of manufacture**: The design of the container should be such that it is easy to manufacture from the easily available raw materials.
- **Easy assembling and dismantling**: The design of the container should be such that the assembly / disassembly of the payload in it should be easy.
- **Provision for various mounting devices**: Sufficient provision should be made for mounting of the various devices, dials & instruments in it.
- **Versatility to transport 3 to 4 different payloads**: It should have mounting and accommodating facility so that it can be used for different payloads.
- **Size optimization**: Its size should be optimized such that it can enter easily in a commercial airplane and no special cargo plane is required.
- **Secure locking of payload**: Payload must get locked securely in the container.
- **Wheels for transportation**: Suitable arrangement should be provided for the wheels so that the container can be easily transported.
- **Locking system for wheels**: Some sort of locking system must be provided to the container wheels so that they remain in locked condition while loading & unloading of the payload.
- **Provision for sight glass**: Suitable provision for the sight glass should be made so that one could monitor the conditions inside.

- **Lifting lugs**: Provision should be made for lifting arrangement so that it can be easily lifted using forklifts.
- **Space for information tags**: Sufficient space for various information, labels, tags, warnings should be made on the outer surface of the container.
- **External & internal aesthetics**: The external & internal design of the container should be aesthetically appealing.

4. Sub-Systems of a container

For accomplishing the above mentioned the requirements a transport container is divided into many sub-systems. A container incorporates all or some of the sub-systems depending on the degree of isolation, the payload requires. The sub-systems are:

- Shock and Vibration Isolation System
- Passive Thermal Control System
- RF & ESD Protection System
- Gaseous nitrogen Purge System
- Passive Dehumidification System
- Pressure Equalization and Rapid Decompression System

5. Conclusion

From above literature review concluded some affecting factors also analyzed data to be considered and finalization model developed by using our requirement transportation container.It is observed that extensive research done on containers and composite structure design and analysis. But not much developed for the space based application of containers. Transporting a composite structure and delicate part of the payload is required extreme care and always safely transporting is challenging task.

Main objective of this is to isolate the all environmental loads and impacts on the structure like temperature, shock, vibration, humidity control etc. By using some different material and isolators through developed a transportation container for the spacecraft payload by use a CAD and FEM software to achieve the mechanical design goals.

Now a day mainly container is made in composite material because light in weight, High strength to weight ratio, Good compressive strength.

Most importing factors is shock and vibration isolation. During road or by air transporting very loads are transferring and some loads are damage or effects on delicate electronic packages, components like PCB, soldering joints, some connectors and these components are highly precisely developed. If we have not properly transported than not achieved our required performance in space application or any other application. Basically, all transporting vehicles are designed properly even passenger's vehicles like bus, bike, car, train etc. Because first mainly requirement of a transportation to one place to another place for transferring some materials, cargos, luggage etc.

It is observed that composite structure is mainly analysed in FEM by ANSYS and HYPERWORKS software. So many techniques are available like static structural, modal analysis, rigid dynamic analysis, explicit dynamic analysis, thermal analysis, impact analysis etc. so easily some design failure criteria and factors are found.

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