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Review Article

Study on Design of a Container with Composite Material

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Abstract: Missiles are sturdy, well-constructed machines. But, because of their size, weight, and bulk, they are not that easy to handle nor are missiles indestructible. Most missile damage is, unfortunately, a result of carelessness and poor handling practices. To reduce the possibility of damage, missiles are shipped, stored and handled with special equipments. Approved containers, canisters, and handling equipments provide maximum missile safety with minimum handling by personnel. In this paper review on design of a container which is used for transportation and storage of missile. The Missile container is made of composite shell structure stiffened with rectangular ribs on the interior surface. The opening to insert the missile is given at the rear end, which has very small contact area at the closing region.

Keywords: Review, Design, Storage Container, Composite Material

1. Introduction

Missile is an object capable of being projected, usually with the intent of striking some distant object. More particularly, a missile is usually a weapon that is self-propelled after leaving the launching device. In other words, missile is a rocket-propelled weapon designed to deliver an explosive warhead with great accuracy at high speed.

There are different and specialized types of containers, canisters, and handling equipments in the ordnance field. Many are designed for a single purpose or use and cannot be interchanged with comparable items. The containers, canisters, and handling equipments used to deliver missiles to a ship.

A container is used for shipping and storage. The containers are similar, differing mostly in size and weight. Missile containers are large, rectangular aluminum boxes used for the shipment and storage of missiles. Missile containers are identified by a mark number.

2. Composite Material

The use of a combination of different materials, which result in superior products, started in antiquity and has been used continuously down to the present day. In early history mud bricks were reinforced with straw to build houses; more recently man-made stone was reinforced with steel bars (reinforced concrete) to build modern buildings, and bridges, etc, and now composites of matrix reinforced with fibers are used to build airframe structures. Modern composites owe much to glass fiber-polyester composites developed since the 1940's, to wood working over the past centuries, and to nature over millions of years. Numerous examples of composites exist in nature, such as bamboo, which is a filamentary composite. Through the years, wood has been a commonly used natural composite whose properties with and against the grain vary significantly. Such directional or isotropic properties have been mastered by design approaches, which make advantage of the superior properties while suppressing the undesirable ones through the use of lamination. Plywood's, for example, are made with a number of lamina. Such a stacking arrangement is necessary in order to prevent warping. In the language of modern composites, this is referred to as the symmetric lay-up or zero extension-flexure coupling (orthotropic).

Composite materials, often shortened to composites or called composition materials, are engineered or naturally occurring materials made from two or more constituent materials with significantly different physical or chemical properties which remain separate and distinct at the macroscopic or microscopic scale within the finished structure. The advantages of composite materials are that, if well designed, they usually exhibit the best qualities of their components or constituents and often some qualities that neither constituent possesses. Some of the properties that can be improved by forming a composite material are

- High Strength-to-Weight ratio
- High stiffness
- High corrosion resistance
- High wear resistance
- Attractiveness
- High fatigue life
- Temperature independent behavior
- Thermal insulation
- Acoustical insulation

Naturally, neither all of above properties can be improved at the same time nor is there usually any requirement to do so. In fact, some of the properties are in conflict with one another, e.g., thermal insulation versus thermal conductivity. The objective is merely to create a material that has only the characteristics needed to perform the required task as per the design.

Classification of Composites

Composite materials are commonly classified at following two distinct levels:

- The first level of classification is usually made with respect to the matrix constituent. The major composite classes include Organic Matrix Composites (OMCs), Metal Matrix Composites (MMCs) and Ceramic Matrix Composites (CMCs). The term organic matrix composite is generally assumed to include two classes of composites, namely Polymer Matrix Composites (PMCs) and carbon matrix composites commonly referred to as carbon-carbon composites.
- The second level of classification refers to the reinforcement form - fiber reinforced composites, laminar composites and particulate composites. Fiber Reinforced composites (FRP) can be further divided into those containing discontinuous or continuous fibers.

3. Review

Dorothy S. Ng [1], has written in a book “Structural Analysis of Storage Container”, performed the structural analysis to evaluate the storage container against a rare, short duration event. An accidental free drop of a container may occur in a combination of two events: a rare, short-duration earthquake concurrent with an operation of raising the storage rack to a maximum height that the crane is capable of. This hypothetical free drop may occur only to the container in the uppermost shelf of the storage rack.

The analyses were the structural evaluation of the storage container to determine the material containment integrity of the storage container after the accident. The evaluation was performed simulating a free drop from the storage rack, with a maximum load in the container, striking / an unyielding surface in the worst orientation.

The analyses revealed that, in the very unlikely event of a container drop, the integrity of the hermetic seal of the storage container could be compromised due to plastic deformation of the lid and mating flange. Simple engineering and administrative controls can prevent that from occurring.

Serena, Joseph M [2] had presented a paper on “An On-Site Demilitarization Container for Unexploded Ordnance” and explained about design development, fabrication and analysis of the container. And also presented design techniques. At many of these sites, ordnance has been discovered very close to schools, homes, and other inhabited and privately owned facilities. The removal of ordnance presents some hazards from the effects of an explosion, including blast overpressures and fragment projectiles. Both people and their property must be protected from these effects. Currently, all munitions must be buried before on-site detonation, or transported to a remote site for demolition.

Huntsville Center has developed a containment structure for use in on-site demolition of unexploded ordnance. This structure is designed to contain the effects of the explosion and limit evacuation to a very small work area. The container uses innovative materials for the containment of fragments and reduction of overpressures. The container will permit onsite detonation of ordnance much more safely and efficiently.

Bob Matthews [3] suggested book “Applied Stress Analysis” and explained the importance of the fiber orientation. He had studied on unidirectional tape as well as woven fabric, which have a significance of better surface finish, higher allowable strength and stiffness, lower raw material cost for unidirectional tape and for woven fabric low fabrication costs, easier forming on contours and corners and also more resistant to surface breakout and delamination.

From these studies he concluded that the fiber should be arranged to optimize resistance to loads, limit number of different angles to expedite manufacturing and for filament winding hoop plies are used.

The orientation of the tailor fiber arrangement explained as +/- 45 degree plies give buckling stability and carry shear, 0 degree plies give column stability and carry tension or compression and 90 degree plies carry transverse loads and reduce Poisson’s effects. Computer codes has been used to optimize fiber arrangement such as PANDA2 for stiffened shell panels, ASTROS for general geometry and membrane loads only and TM1 for curved panels.

Charles P. Haber [4] has written in a book “Dynamic and Structural Analysis of Reusable Shipping & Storage Container for Encapsulated Harpoon Missile” explained about structural analysis of a missile container, which is made up of fiber glass. It was made by the Naval Weapons Handling Laboratory as part of the design study for such container. The subject design incorporates a free breathing fiber glass pod containing the encapsulated weapon. The pod and weapon are suspended from a truss-like outer structure by elastomeric mounts configured in a laterally focalized fashion. The analysis generates isolator parameters which attenuate the handling and transportation shock and vibration environment to safe levels for the weapon and verifies that the structural design concept can sustain the resulting loads.

Cardinal, J. W., et. al [5] had presented a paper on "Nondestructive Analysis of MK 607 Harpoon Missile container" explained about structural failures of the upper shell assembly of MK 607 HARPOON missile storage containers were investigated using analysis and experiment. The two failure modes considered were cracking in the centre of the container panels and cracking and delamination near the stiffener-panel interface. Non-destructive load tests were performed on an actual container for two types of load cases: internal vacuum and externally applied concentrated loads.

Finite element structural analyses were conducted to determine deflections and stresses in the container under these loading conditions. Analytically predicted deflections agreed well with experimentally measured values. The most likely cause of the panel cracking was determined to be the result of the container cover being deflected downward onto the missile support saddle bolts. This study does not identify a cause for the cracking and delamination occurring near the stiffener-panel interface implementation of operational procedures which preclude the HARPOON containers from being loaded from the exterior are recommended. Potential benefits resulting from a redesign of the missile support saddle bolt configuration should also be investigated. It is also recommended that the geometry and material properties of the stiffener be defined more precisely to facilitate a more accurate study of its behavior.

Stephen W. Tsai [8] has written a book "Structural Behavior of Composite Materials", analyzed the structural behavior of the FRP composites. The experimental results show that the relations derived are more accurate than existing theories. This study is concerned with the analysis of the structural behavior of composite materials. It is shown that composite materials can be designed to produce a wide range of mechanical properties. Thus, a structural designer now has at his disposal an added dimension in optimum design - the materials optimization.

Two types of composite materials are investigated: the unidirectional fiber-reinforced composite and the laminated anisotropic composite. Analytical relations are derived between the composite material coefficients and the geometric and material parameters of the constituents.

Test specimens made of filament-wound materials are used. The experimental results show that the relations derived in this study are more accurate than existing theories, which include the netting analysis. Reliable data on filament-wound materials, which are now available for the first time, can be used for future investigations of the behavior of filament-wound structures.

M. J Hinton and P. D Soden [9] had suggested a paper "Predicting failure in composite laminates" explained the failure theories for continuous fiber-reinforced-polymer composite materials. He compared the predictive capabilities against experimental data.

This Special Edition of Composites Science and Technology is dedicated to the subject of failure theories for continuous fiber reinforced-polymer composite materials (FRPs). The papers were commissioned as a co-ordinate study (referred to as the `failure exercise') aimed at providing a comprehensive description of the foremost failure theories available at the present time, a comparison of their predictive capabilities directly with each other, and a comparison of their predictive capabilities against experimental data.

4. Conclusion

The Missile container is made of composite shell structure stiffened with rectangular ribs on the interior surface. To reduce the possibility of damage, missiles are shipped, stored and handled with approved missile containers. Approved containers, provide maximum missile safety with minimum handling by personnel. This makes the design and manufacturing of missile container a critical importance. It is also identified that the missile container is subjected to internal pressure load, Stacking load, Braking load and lifting load.

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