

Structural Analysis of Pressurised Canister

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ABSTRACT: In this paper a canister (container) was designed and analyzed which is used for transportation and storage of missile. The canister is made of composite shell structure stiffened with rectangular ribs on the interior surface. An opening is provided on the canister at the rear end to insert the missile. Canister protects the missile from external heat, dust and moisture. Therefore canister plays an important role for missile. It was identified several causes of disturbances which damages the canister such as internal load, stacking load and lifting loads. Efforts have been made to design and optimize the canister for these loads. Detailed finite element stress analysis is carried out to determine the static response of the designed composite missile canister structure under mechanical loads. ANSYS package has been employed to perform the structural analysis.

KEYWORDS: Canister shell, Stress Analysis, Stacking Loads, Lifting Loads, Stability.

I. INTRODUCTION

A missile is an object which is forcibly propelled at a target, either by hand or any form of a mechanical weapon. Missile is a weapon that is self-propelled after leaving the launched device, usually with the intent of striking some distant object. Missile is a weapon designed to deliver an explosive warhead with great accuracy at high speed. Missiles are sturdy, well-constructed machines. But, because of their size, weight, and bulk, they are not that easy to handle. Most of the missile damage is unfortunately a result of carelessness and poor handling practices. Therefore we use containers, canisters, and handling equipment for maximum missile safety with minimum handling by personnel.

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 onsite 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.

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 center of the container panels and cracking and delamination near the stiffener panel interface. Nondestructive 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 [6] 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.

II. PROBLEM STATEMENT AND METHODOLOGY

Definition: There are several loads which acts on the canister when in use. It was identified several causes of disturbances which damages the canister such as internal load, stacking load and lifting loads. These loads will deform canister. If the canister is deformed then missile which is inside the canister will also get damaged, therefore canister must be designed such that it should able to withstand all the loads acting on the canister without damaging the missile.

Scope of Work: The canister is used for transportation, storage and launching of missile. Material used for canister is fiber reinforced composite, i.e., E-glass/epoxy, It is used because of its unique properties like high strength, low density and easy to manufacturing etc. The missile is placed on the bulk head which supports the weight of the missile and arrestors made of mild steel are used to locate the missile in the canister. Nitrogen gas is filled in the canister to maintain low temperature for the sensors of the missile. Fill port, vent port and pressure gauges are used for filling nitrogen gas. The pressure of the nitrogen gas in the canister is 0.01Mpa or 0.1bar or 0.1Ksc. Lifting hooks (temporary) made of forged alloy steel are provided to facilitate lifting of the canister of the missile. Fiber arrangement plays major role in carrying the loads. Fiber arrangement (layer orientation) to optimize resistance to loads: (i) ± 45 degree plies give buckling stability and carry shear, (ii) 0 degree plies give column stability and carry tension or compression. and (iii) ± 90 degree plies carry transverse loads. The parameters are Thickness of the canister = 3.5 mm, No. of layers = 5, Layer orientation = -90^0 , -45^0 , 0^0 , 45^0 , 90^0 , Weight of the canister = 128 kg (approximately), (i) Nitrogen is filled in the canister with 0.1bar pressure. (2) While transporting the missiles, it is necessary to place the canister one over the other. So, the canister should withstand for the one more canister weight. That means, 128 kg is applied on the top of the canister. (3) Temporary hooks are provided to lift the canister. While lifting the canister, gravitational force will act downwards. The canister is subjected to various types of loads, like pressure load, stacking load and lifting load etc. It

is recommended to analyze the canister before the manufacturing, to avoid the failure after manufacturing. ANSYS package has been employed to perform the structural analysis of a canister.

Methodology: The design of the canister is carried out and analyzed for displacement and stress variation when different loads acting on it. The objective of this work is to obtain maximum static deflection, maximum vonmises stress and maximum stress variation for different load cases. Methodology is a systematic approach for realization of total task. It consists of the following

Study of component: The study of component is the most important and the first step for the designer. The component drawings are carefully scrutinized to extract the maximum possible information. The important information available is the critical dimension of the canister.**Geometric model of component:** Geometric modelling of components is done by considering all the critical dimensions.**Selection of materials:** A canister is made of a composite material. Therefore E-glass/epoxy is selected as canister material for its good mechanical properties.**Modelling of the component:** 3-D modelling of the entire canister is modelled in the solidworks/unigraphics software. **Analysis:** Structural analysis of the canister is carried using ANSYS software to determine the total deformation and the stress induced in the canister for different load casing acting on the canister.

III. ANALYSIS OF A CANISTER

A canister is a hollow structure which is used for storage, transportation and launching of the missile. The canister is made of composite shell structure stiffened with rectangular ribs on the interior surface. The modelling of the canister is shown IN Fig.1. The canister contains total 236 parts in it. Canister model is represented with the dimensions in different views i.e. front view, side view and rear view. All the parts of canister are modelled and are assembled. The major dimensions i.e. length=4400mm, depth=370mm, height=370mm and thickness=3.5mm. Shell99 is an 8-node, 3-D shell element with six degrees of freedom at each node: translations in the nodal x, y, and z directions and rotations about the nodal x, y, and z axes. The element is defined by eight nodes, average or corner layer thicknesses, layer material direction angles, and orthotropic material properties. Mass21 is a point element having up to six degrees of freedom: translations in the nodal x, y, and z directions and rotations about the nodal x, y, and z axes. A different mass and rotary inertia may be assigned to each coordinate direction. The mass element is defined by a single node. The element coordinate system may be initially parallel to the global cartesian coordinate system or to the nodal coordinate system. The element coordinate system rotates with the nodal coordinate rotations during a large deflection analysis. Shell 99 used for composite canister material. Mass 21 used for canister weight. Total number of layers =5, Thickness of each layer– 0.7mm, Total thickness= 3.5mm. The figure2 shows the meshed model of the canister and Figure3 shows the geometric boundary conditions imposed and loads applied and also deformations induced in the member. By applying the internal pressure of 0.1bar, the nodal displacements are 0.229mm, 0.203mm and 0.014mm in x, y and in z-directions respectively and max stress is 44.81Mpa.

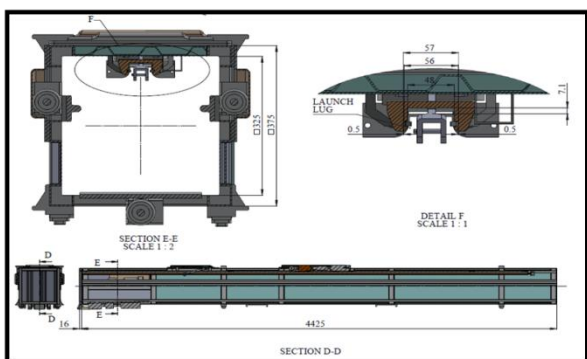


Fig.1: Geometric model of canister

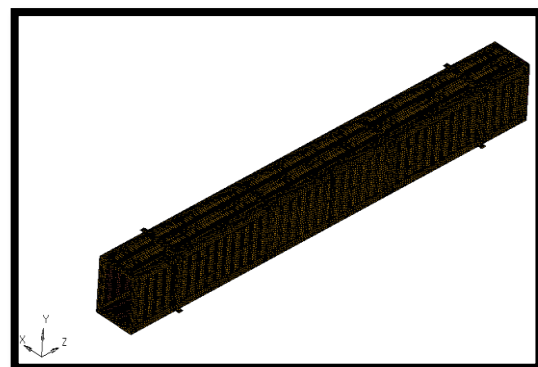


Fig.2 Finite element model of canister

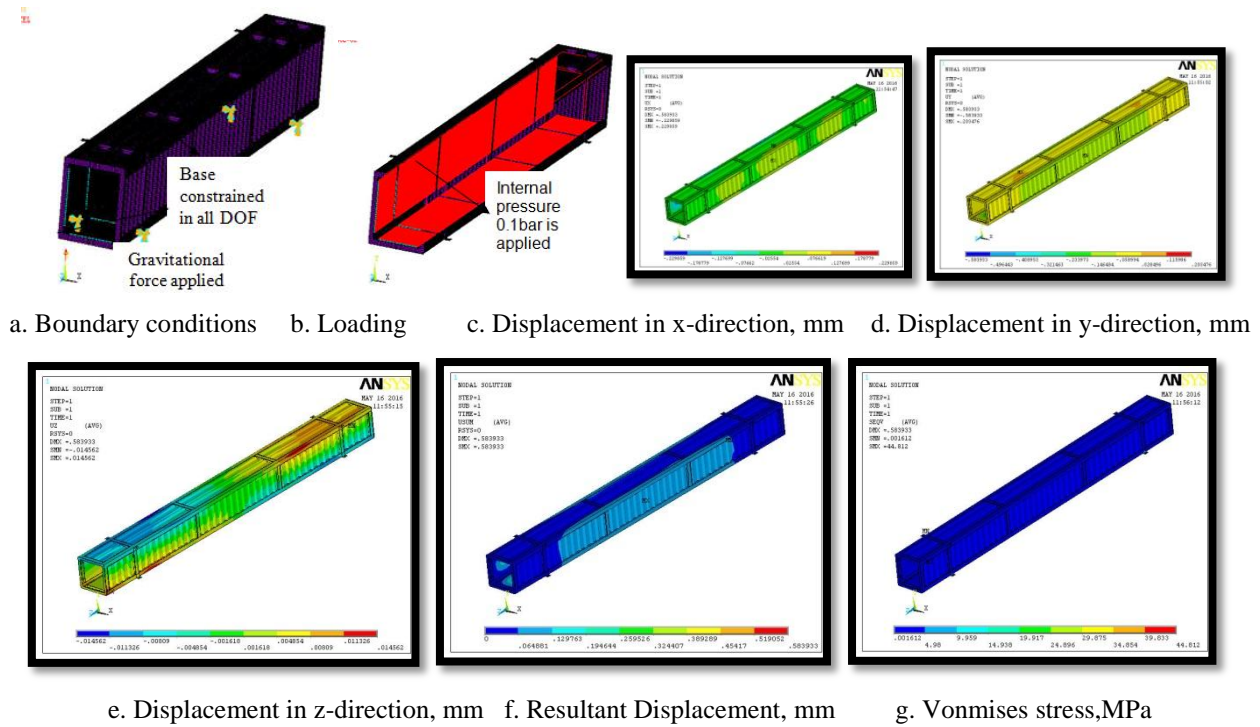
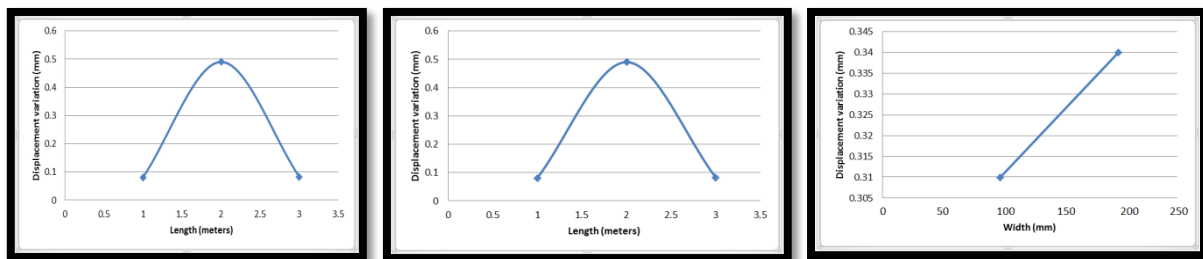


Fig.3: Boundary conditions and deformations and Stress induced in the canister

Figure4a shows displacement variation graph along length for stacking load. Maximum displacement of 0.5 mm is observed at 2 meters from the starting point in the length of the canister due to both internal pressure of 0.1 bar and stacking load, minimum displacement of 0.08 mm is observed at 1 and 3 meters from the starting point in the length of the canister due to internal pressure of 0.1 bar and stacking load. Figure4b shows the Maximum displacement of 0.17 mm is observed at 200 mm from the starting point in the height of the canister due to both internal pressure of 0.1 bar and stacking load, minimum displacement of 0.14 mm is observed at 100 mm from the starting point in the height of the canister due to internal pressure of 0.1 bar and stacking load. Figure4c shows displacement variation graph along width for stacking load Maximum displacement of 0.34 mm is observed at 200 mm from the starting point in the width of the canister due to internal pressure of 0.1 bar and stacking load.



a. Along length b. Along height, mm c. Along width, mm

Fig.4: Displacement variation in the Canister under pressure and stacking load, mm

Figure5a.shows stress variation graph along length for stacking load Maximum stress variation of 14 Mpa is observed at 2 meters from the starting point in the length of the canister due to internal pressure of 0.1 bar and stacking load, minimum stress variation of 4 Mpa is observed at 1 meter from the starting point in the length of the canister due to internal pressure of 0.1 bar and stacking load. Figure 5b shows stress variation graph along height for stacking load Maximum stress variation of 11 Mpa is observed at 200 mm from the starting point in the height of the canister due to internal pressure of 0.1 bar and stacking load, minimum stress variation of 8 Mpa is observed at 100 mm from the starting point in the height of the canister due to internal pressure of 0.1 bar and stacking load. Figure 5c shows stress variation graph along width for stacking load Maximum stress variation of 6 Mpa is observed at 200 mm from the starting point in the width of the canister due to internal pressure of 0.1 bar and stacking load.

Mpa at 1 meter in length for the internal pressure of 0.1 bar applied. Displacement variations along height is maximum of 0.18 mm at distance of 200 mm in height for lifting load applied. Displacement variations along height is minimum of 0.12mm at 100mm in height for internal pressure of 0.1 bar applied. Stress variations along height is maximum of 11 Mpa at 200 mm in height for the stacking load applied. Stress variations along height is minimum of 7 Mpa at 100 mm in height for the internal pressure of 0.1 bar applied. Displacement variations along width is maximum of 0.6 mm at distance of 200 mm in width for lifting load applied. Displacement variations along width is minimum of 0.2mm at 100mm in width for internal pressure of 0.1 bar applied. Stress variations along width is maximum of 8 Mpa at 200 mm in width for the lifting load applied. Stress variations along width is minimum of 4 Mpa at 100 mm in width for the internal pressure of 0.1 bar applied.

V. CONCLUSION

As per the dimensions and the loads applied the canister is withstanding for the all configurations. The outer shell thickness must be minimum 3.5 mm. The internal pressure inside the canister must be maintained for longer period of time and gases must not leak through gaps. E-glass/epoxy composite material is perfectly suited for canister. Von mises stress of the canister didn't exceed the failure limit. The composite design model considered for the canister is safe.

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