Design and Analysis of Composite Rocket Motor Casing

B.Niharika[1], B.Bhaswarup Varma[2]

[1]. Asst. Professor, Dept. of Aeronautical Engineering, MLR Institute of Technology, Hyderabad-500043. India
[2].Student M.Tech Aerospace Engineering, Dept. of Aeronautical Engineering, MLR Institute of Technology, Hyderabad-500043. India
E-mail:grabnihar@gmail.com

Abstract. A solid rocket or a solid-fuel rocket is a rocket engine that uses solid propellants (fuel/oxidizer). The term "solid fuel" in this conte xt is actually erroneous because solid propellant must contain both a fuel and an oxidizer to support combustion. All rockets used some form of solid or powdered propellant up until the 20th century, when liquid rockets and hybrid rockets offered more efficient and controllable alternatives. In this we consider a composite material Carbon/Epo xy and Kevlar/epo xy for a pole relevant in rocket parts .Its length as 10m, interior breadth as 1m, inside weight as 1000psi or 6.894Mpa, engine packaging is outlined and subjected to basic and modular examination. Fundamentally engine packaging is planned in ANSYS apparatus by considering outline contemplations, assist the model is subjected to stack imperatives and weight parameters as in the constant flight and reproduction exa mination will be completed and perceptions are made to know the basic functions ,loads, stress, strain and proficiency of rocket engine packaging. For the Design and Analysis, Simulation Software ANSYS R 18.0 be utilized and results will be summoned. Layer as stress – strain Distribution is acquired, Static Structural Analysis, Modal Analysis will be done and comes about might be closed.

1. Introduction

Every one of the sorts of rocket utilize a few or the other kind of charges until the point that new sorts were presented as half and half and fluid force rockets. Solid rockets are most normally utilized contrasted with different structures fundamentally on the grounds that it is less demanding to construct, maintain and is more dependable comparatively. Solid force rockets can be put away for extensive timeframe and are all the more generally utilized for military purposes. However, their executions attributes are very poor contrasted with fluid charge rockets and consequently are not the favored decision for introductory drive in any of the dispatch vehicle conveying substantial measure of payloads to the external orbits. The principle objective is to deliver an engine packaging by utilizing essential sheet metal and get together by methods for welding. The primary qualities to be considered at the season of engine configuration are the qualities of the sort of engine used, type of materials utilized in view of the yield quality of the plan which is figured and case outline contemplations for

assessments like case loads, deformation, stresses, structural examination etc. Also, the case is intended to fulfill the execution necessities of the motor. A basic strong force rocket engine predominantly comprises of igniters, insulator, grains, nozzle. The grain goes about as the fuel for this situation by touching off upon the sparkles created by the ignitor there by creating vast mass of push through the spout upon combustion. The protector goes about as a separation medium between the grain and the packaging assembly. The gasses went through the spout is of the high weight territory shifting from different Bars

2. Literature Review

Composite materials (additionally called arrangement materials or abbreviated to composites) are materials produced using at least two constituent materials with essentially extraordinary physical or synthetic properties, that when consolidated, deliver a material with qualities unique in relation to the individual segments. The individual parts stay independent and particular inside the completed structure. The new material might be favored for some reasons: basic illustrations incorporate materials which are more grounded, lighter or more affordable when contrasted with customary materials.
ASME Pressure vessel code segment VIII division 2 gives the conditions for the count of shell and vault thickness. Alexander drop created condition for the estimation of least required range of the jolt and the thickness of spine. This approach is called as Schneider approach. NASA SP-8025 has given the insights about the material properties for the different strong rocket engines. In view of these material properties the material is chosen for the strong rocket engine to withstand the weights that will follow up on the engine packaging. NASA has given the points of interest of the strong rocket engine preparatory plan audit and basic investigation of the strong rocket engine industrial facility joint including metallic and non-metallic parts. A basic investigation is performed to confirm the basic trustworthiness of the strong rocket engine at certain working temperature.

NASA has given the strong force execution forecast and examination. In view of this the execution of the strong charge rocket engine the plan is finished by considering the heaps that will follow up on the strong rocket engine packaging. The viability of this procedure is anticipated and surveyed by assessing the response push created through the weight granted energy of the extended fumes gasses Mathematical displaying used to recreate strong rocket ignition chamber inner stream fields is sensibly useful for consistent state and transient stream forecast.

David Heckman in 1988 has investigated that the limited component examination is a to a great degree fine device when utilized accurately. For weight vessels limited component examination gives an extra instrument to use in investigation. In any case, it must be contrasted with other accessible information, not taken as being right since it looks right.

3. Structural Analysis with ANSYS

ANSYS Inc. is a designing recreation programming (PC supported building, of CAE) designer that is headquartered south of Pittsburgh in the South Pointe business stop in Cecil Township, Pennsylvania, United States.
ANSYS offers building recreation arrangement sets in building reenactment that a plan procedure requires. Organizations in a wide assortment of businesses utilize ANSYS programming. The apparatuses put a virtual item through a thorough testing method, (for example, slamming an auto into a block divider, or running for quite a long while on a landing area street) before it turns into a physical question.
ANSYS is a limited component examination programming bundle. Equipped for dissecting a scope of designing applications: Structural, Thermal, Electromagnetic, Fluid Dynamics

3.1 Geometry Creating the Model with Assumed Parameters

The ANSYS workbench organize gives preferable bi-directional relationship over all noteworthy CAD structures, proficient geometry change and creation instruments with ANSYS Design modeler, impelled fitting progressions in ANSYS agreeing, and straightforward move and redo trade of data and results to share between applications. This smart technique is the essential pre
getting ready stage. The objective is to convey a cross segment for commitment to the material science pre-processor. Before a cross area can be made, a closed model solid is required.

3.2 Design Consideration of the model

Solid rocket motor casing model is considered with an Length of 10 m , internal diameter of 1m with an internal pressure applied in 1000 Psi(6890 kpa),and operating pressure is 85psi.

The Layers of the ply are assigned with $90^0/45^0/90$, the thickness of the cylinder is 0.25m

Table 1: Design parameters

Denotations	Carbon Epoxy	Kelvar epoxy
Ex	135Gpa	75Gpa
Ey	10Gpa	6Gpa
μ	0.3	0.34
G	5Gpa	2Gpa
P	1590kg/m^3	103kg/m3
o_{ult}	1432x10^6	1040x10^6pa

3.3 Modeling and Applying Loads on Meshing of cylindrical case

ANSYS is simulation software in which the creating f the model is far easy , and it supports the created models from the CATIA and Other Modeling Tools. Modeling of Rocket Motor Casing which is an axis symmetric. Which is Cut into Half for the better observation.

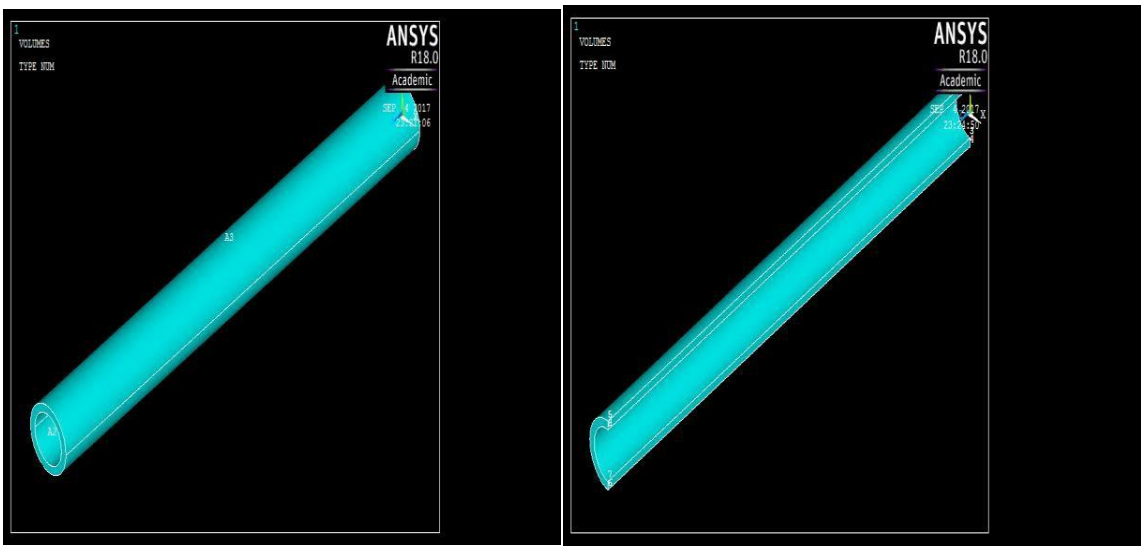

Figure1. Rocket Motor Is Axis Symmetric cut in to half of cylinder modeled in ANSYS

3.4 Meshing of model Rocket Motor Casing.

The main sources of error in a typical FEM solution are discretization errors. discretization error results from transforming the physical system into a finite element model, and can be related to modeling the boundary shape, the boundary conditions, and etc. Formulation error results from the use of the elements that don't precisely describe the behavior of the physical problem. Elements which are used to model physical problems for which they are not suited are sometimes referred to as ill-conditioned or mathematically unsuitable elements.

Model is meshed very fine and the loads are applied on it as the walls of the rocket casing are applied with the external forces

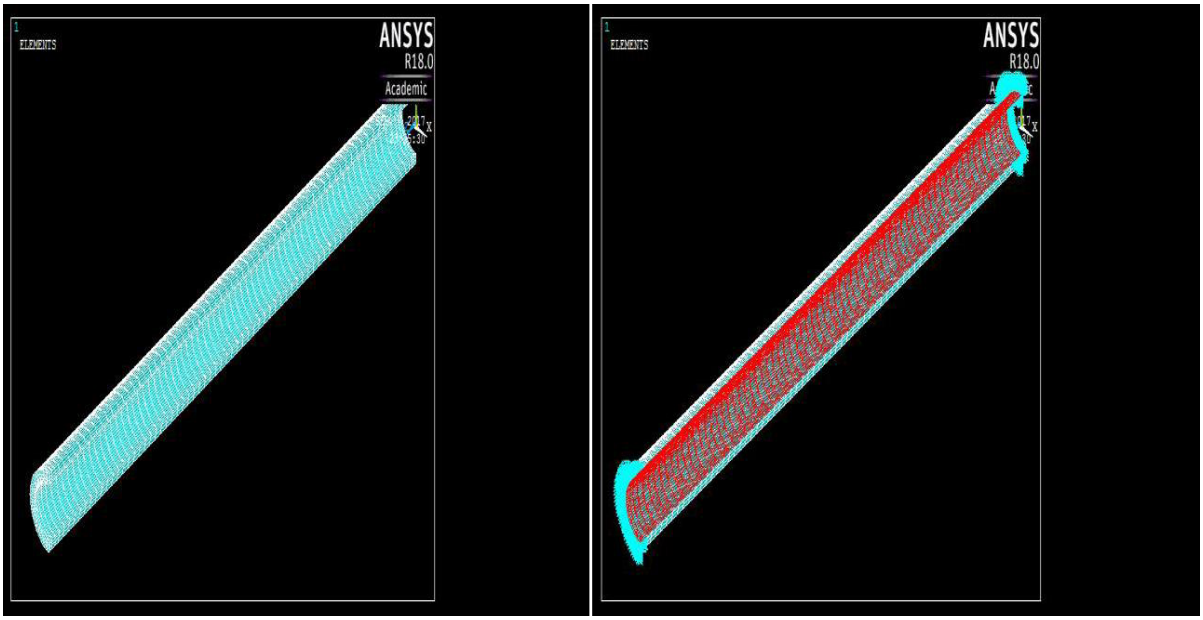

Figure2. Meshed Model of Cut section, All Loads are applied and its Fixed and with an Internal Pressure

3.5 SOLVER INPUTS:

Many numerical schemes are available for solving a fluid flow problem. Based on the physics of the problem, the suitable method is chosen. Here the turbulence model k epsilon used.

a) **Post Processing Results**.

For Carbon Epoxy rocket motor casing:

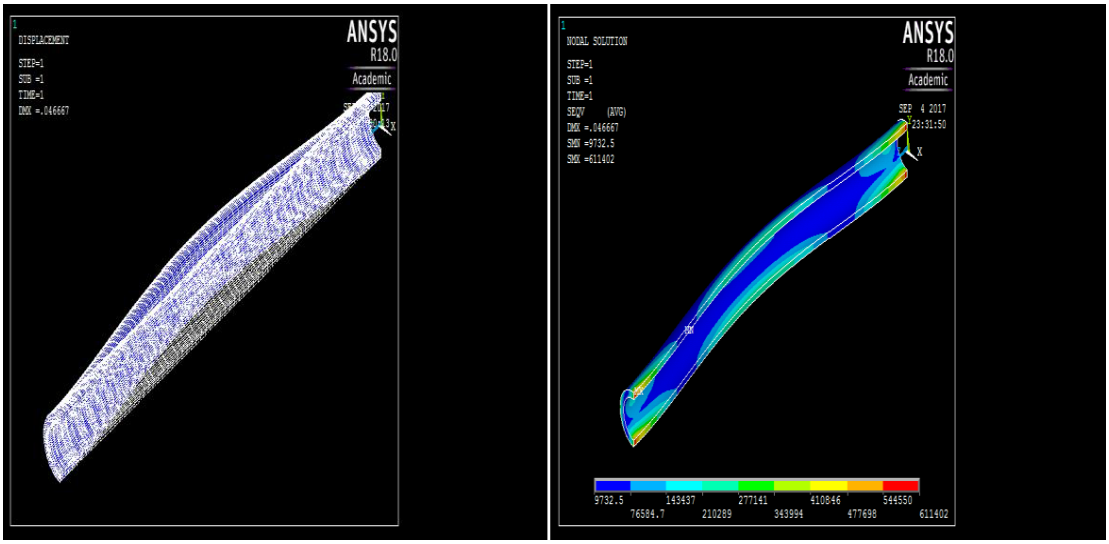

Figure 3. Deformation and maximum stress of carbon epoxy material rocket motor casing

Maximum deflection=0.0466m
Maximum stress=6.11GPa
Minimum stress=0.097GPa

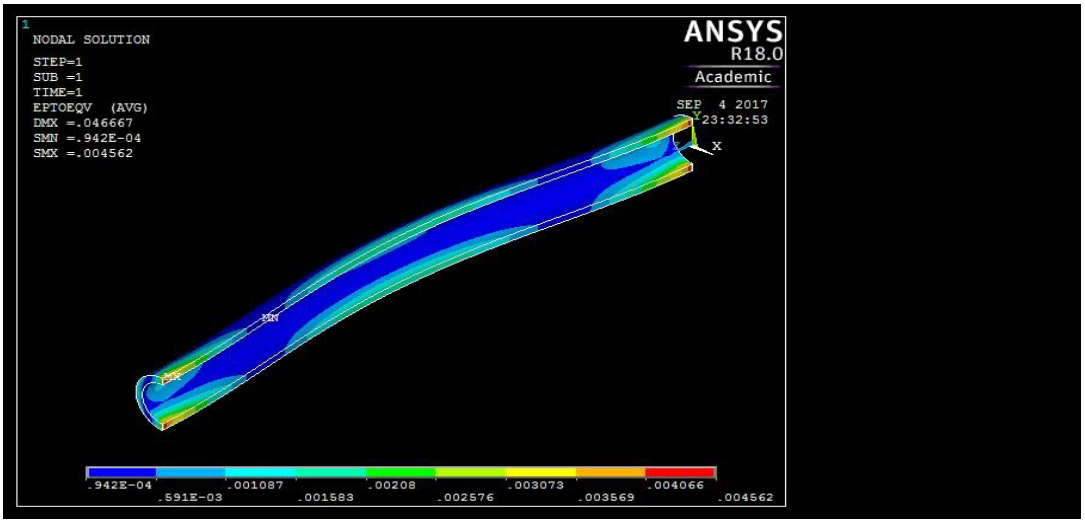

Figure4. Maximum strain of carbon epoxy material rocket motor casing

Maximum deflection=0.0466m
Minimum strain=0.942E-04m
Maximium strain=0.0045m

Result for Kevlar epoxy material rocket motor casing:

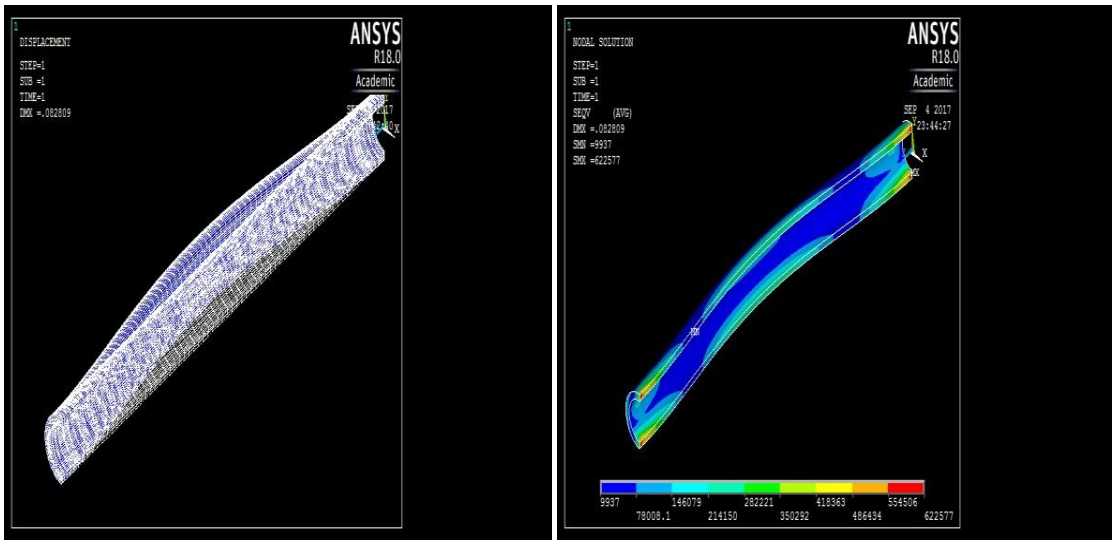

Figure 5. Total deformation and shear stress of Kevlar epoxy material

Total Deformation =0.08280m
Maximum stress=6.2Gpa
Minimum stress=0.09GPA

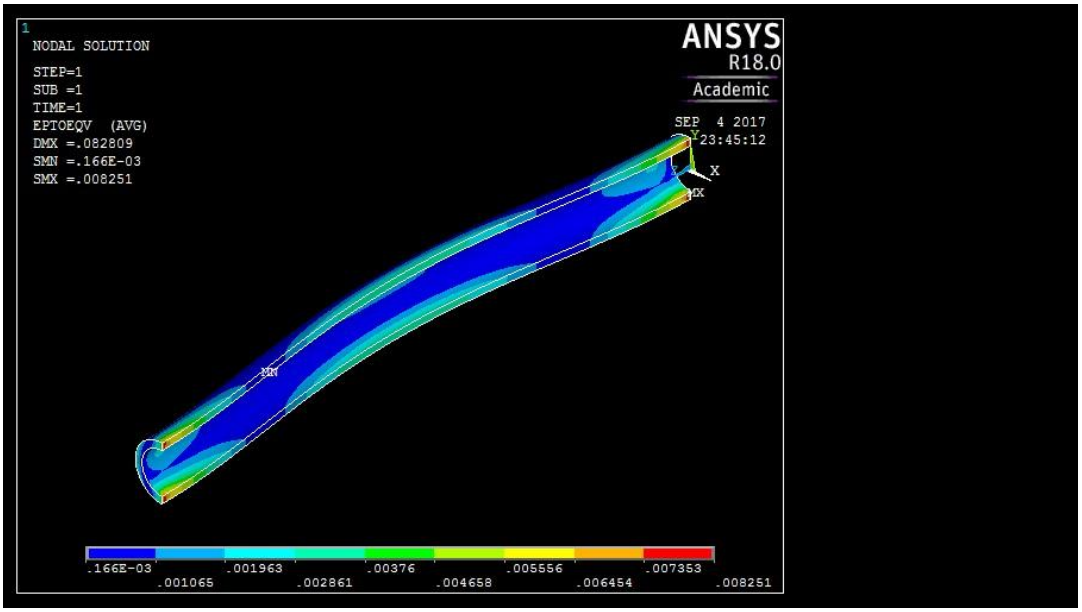

Figure6. Maximum strain of Kevlar epoxy material rocket motor casing

Maximum deflection=0.0828m
Minimum strain=0.166E-04m
Maximum strain=0.008251m

4. Conclusions and future scope :

The following conclusions are drawn from the present work.

- After auxiliary examination of the Rocket engine packaging unmistakably the anxiety created at different areas of the packaging are inside passable constrain and a factor of security of (FOS) 1.5 is gotten by planning the packaging utilizing ASME codes.
- In the wake of watching the anxiety estimations of different materials Carbon epoxy and Kevlar epoxy is having different contrasted with different materials.
- At the point when Internal Pressure is applied the Carbon epoxy material is having the high sustainability of loads then Kevlar epoxy
- So Merging of composite material is best appropriate for rocket engine packaging when relocations taken into thought due to internal pressure which can withstand the deformation then compared to Iso material.
-

4. 1 Future Scope:

1) CFD Analysis for the Solid rocket engine packaging moreover to be performed.
2) Composite Rocket engine packaging can be outlined what's more, contrasted and different materials.
3) Design and Analysis of Solid rocket engine protection should be possible.

5. References

[1] Rocket Propulsion Elements, seventh edition, by Sutton, G.P. and Biblarz, Wiley 2001.

[2] Rocket and Spacecraft Propulsion, second edition, by Turner, M.J.L., Springer 2005.

[3] Strength of Materials, fifth edition, by R.S Kurmi and Gupta.

[4] Design Methods in Solid Rocket Motors, AGARD- lecture series no: 150, AGARD, 1988.

[5] Singh S (2013) Solid rocket motor for experimental sounding rocketsadvances in aerospace science and applications3: 199-208

[6] (1970) NASA SP-8025 Solid rocket motor metal cases (N72-18785)

[7] (2004) ASME (American Society of Mechanical Engineers) codes Section VIII Div.

[8] Dennis Moss Pressure vessel design manual (3rdedn), Gulf professional publishing Burlington USA.

[9] Davanas GE, Jensen DW, Netzer (1996) (eds.) Solid rocket motor design chapter 4 of tactical missile propulsion progress in aeronautics and astronautics AIAA170: 323-379.