ANALYSIS ON SPACE CAPSULE

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Abstract - ***The project describes the Development & Analysis calculations performed on space capsule. These conventional liners and foam bricks can be replaced with insulating material which has good structural properties. This paper presents the coupled field analysis of conventional space capsule using Zirconium Diboride (ZrB2) and Hafnium Diboride (HfB2) as insulating material. The coupled field analysis is carried out using finite element analysis software ANSYS. The analysis resulted that insulating material absorbs the temperatures before reaching the CFRP structure. Finite element analysis tool ANYSIS14.5 will be used to calculate the results for doing stress reaction with gravity & without gravity.***

Key Words: *CATIA V5 R20, Ansys 14.5, Thermal protection system, Shear Stress, Deformation & displacement.*

1. INTRODUCTION

To design and build a space capsule that will survive re-entry through the Earth's atmosphere (or that of another planet) and impact on the surface one should have the knowledge of the forces of gravity and acceleration along with test design trials. Many early spacecraft that orbited the Earth landed on land or water (which is still quite a hard surface if you are travelling at high speed!). The Mercury, Gemini and Apollo spacecraft all landed in the water with the aid of parachutes. The Russian Soyuz spacecraft landed (and still lands) on land with the aid of parachutes and jet firings. The Mars Pathfinder crash landed on the surface of Mars in 1997 with the aid of parachutes and protected by airbags. The Huygens probe to the surface of Saturn's moon Titan (carried on board the Cassini spacecraft) must be able to land safely on land or water because the surface is unknown due Titan's thick clouds.

2. MATERIAL & METHODS

The materials used for this nose cone are the carbon epoxy, hafnium diboride and zirconium diboride when we ompare all these materials the carbon epoxy material can sustain the thermal protection system located in the inner surfaces of the CFRP. A vehicle with less material will heat faster during re-entry.

S.no		Carbon Epoxy composite	Hafnium diboride (Hfb2)	Zirconium diboride (Zrb2)
1	E(N/mm^2)	1.81e5	0.75e5	4.2e5
2	1/m	0.36	0.37	0.34
3	P (kg/mm^3)	1.7e-6	10.5e-6	6.085e-6
4	α ($^0k^{-1}$)	2e-6	7.6E-6	8.3e-6
5	K (W/mm-K)	7e-3	62e-3	70e-3

Table -1: Material Properties

If the design did not contain the stabilizing core, only a skinned geometry would be required. This can be meshed with shell elements, SHELL99 being the most widely used for similar cases analyzing wind turbine blades. The spline model is designed in CATIAV5 and after that the spline model will be imported to ANSYS after importing the spline model the new co-ordinate system should be created for the sake of meshing we are going to use a new co-ordinate system (11-cordinate system) which was created by using the three KP (key points). Because of which the meshing and lay-ups of material will become easier. Important Factors for Design are.

- Deceleration
- Heating
- Accuracy

In order to get uniform strength gear with minimum weight, the The element temperature distribution for a conventional bilinear four node thermal element in local Cartesian coordinates is expressed in the form,

$$T(x,y,t) = [N_1 \quad N_2 \quad N_3 \quad N_4]\begin{Bmatrix} T_1 \\ T_2 \\ T_3 \\ T_4 \end{Bmatrix} = [N_T(x,y)]\{T(t)\}$$

Where Ni and Ti, i = 1, 4 are the element interpolation functions and the time dependent nodal temperatures, respectively. For a rectangular element, the element interpolation functions are defined by,

$$N_1 = \left(1-\frac{x}{a}\right)\left(1-\frac{y}{b}\right) \quad N_2 = \frac{x}{a}\left(1-\frac{y}{b}\right)$$
$$N_3 = \frac{x\,y}{a\,b} \quad N_4 = \left(1-\frac{x}{a}\right)\frac{y}{b}$$

Where 'a' and 'b' are the element dimensions in the x and y directions. With these element interpolation functions, an element temperature distribution varies bi-linearly. Finite element (F.E.) formulations for nonlinear, transient thermal problems can be derived from the governing heat conduction equation with radiation boundary conditions by the method of weighted residuals (Reference 6). In general, the element temperature T(x,y,t) and temperature gradients are expressed in the form

$$T = [N_T]\{T(t)\}_e$$
$$\begin{Bmatrix} \frac{\partial T}{\partial x} \\ \frac{\partial T}{\partial y} \end{Bmatrix} = [B_T]\{T(t)\}_e$$

Where denotes a vector of element nodal temperatures as a function of time. For simplicity, conduction with only specified surface heating and radiation heat transfer will be considered. Finite element thermal analyses for other heat loads such as internal heat generation and surface convection are presented in References 1-2. For transient thermal analysis the equations for a typical element are

$$[c]_e\{\dot{T}\}_e + [K_c]_e\{T\}_e + [K_r]_e\{T\}_e = \{Q_q\}_e + \{Q_r\}_e$$

Type	Units
Force	N
Moment	N-mm
Stress	MPa
Displacement	mm

Table- 2: Units

The designing of re-entry vehicle manly depends on

- Vehicle size and shape
- Thermal protection systems(TPS)

Vehicle size & shape
we'll continue to assume we're dealing only with non-lifting vehicles.
Thermal protection systems(TPS)
We'll at three approaches to TPS

- Heat sinks
- Ablation
- Radiative cooling

3. Results & Discussions

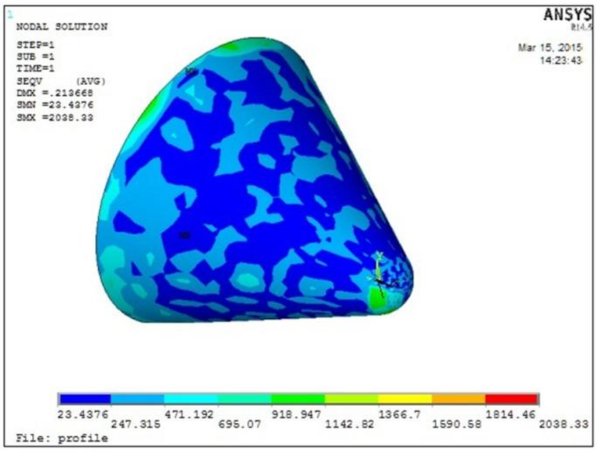

Fig -1: Von-mises stress with gravity

The above reactions are the von-mises stress on the nose cone structure when the gravity is applied here the von mises stress is distributed on the whole body of the nose cone structure the failure section will be less affected in red colour the whole body is protected i.e.., the forces applied on the nose cone structure will be distributed failure area will be less on the nose cone structure. The above reactions are when the gravity is applied on the nose cone structure.

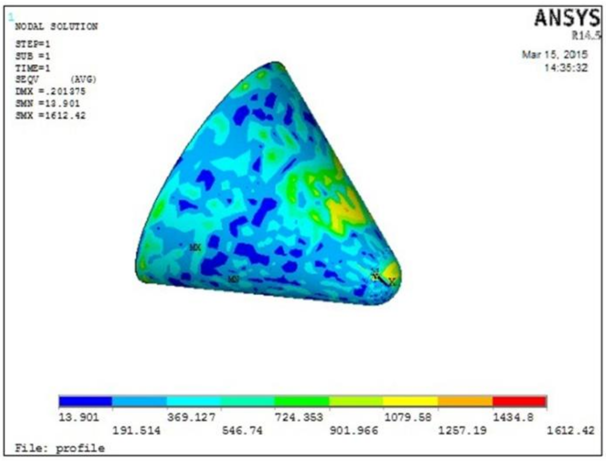

Fig -2: Von-mises stress without gravity

The above reaction is obtained when the gravity is not applied on the nose cone structure the legend table shows the comparison between gravity applied and not applied on the nose cone structure with gravity the von mises stress blue color value- 23.4376, without gravity –13.901 by applying gravity the von mises stress isstable on the nose cone structure.

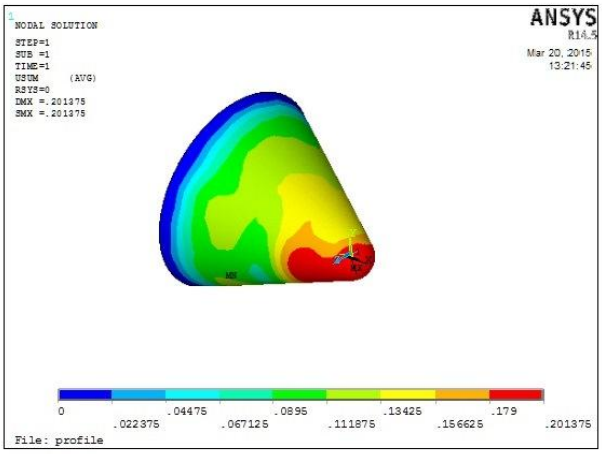

Fig -3: Displacement vector sum without gravity

The thermal and static analysis is done on the space capsule by applying composites. The thermal analysis is done by applying temperature of 2798 k on top layers and temperature 305k on base material. The results obtained in the thermal analysis are applied for the space capsule in structural analysis.

NAME	WITH GRAVITY	WITH OUT GRAVITY
Displacement Vector Sum	.213668	.201375
Displacement- X	.213227	.201313
Displacement -Y	.090811	.076791
Displacement -Z	.069094	.091868
Stress –X	1760.38	1348.18
Stress –Y	1394.64	1255.22
Stress –Z	1801.28	1313.52
Shear stress-XY	585.546	557.94
Shear stress-YZ	578.92	538.872
Shear stress-XZ	429.993	663.773
Von-moises stress	2038.33	16142.12

Table- 3: Comparison Of Results Between With Gravity And Without Gravity

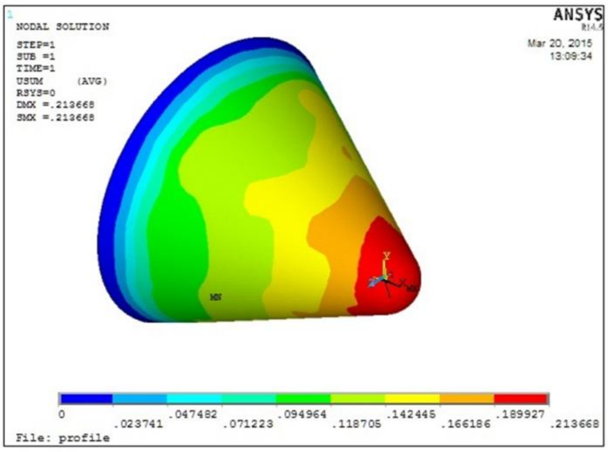

Fig -4: Displacement vector sum with gravity

4. CONCLUSIONS

when we compare to the von mises stresses the failure rate is more to decrease that the thickness of the outer surface of the space cone can be increased then the failure rate can be decreased. The materials used for this nose cone are the carbon epoxy, hafnium diboride and zirconium diboride when we compare all these materials the carbon epoxy material can sustain the thermal protection system located in the inner surfaces of the CFRP.

The future scope of this project is to decrease the stress levels at the outer surface of the nose cone. So, if we compare with the real model of the nose cone with all the supporting systems installed then the stress levels (i.e..,-von-mises stress) can be decreased. The other point is the LS-DYNA model, the space capsule when returns to earth's atmosphere mostly fall into the seas. By applying appropriate material properties those stress levels can be analyzed. This also includes sudden cooling of the highly heated material. Another case will be of the Fluid – Structure and Thermal Interaction.

REFERENCES

[1] [1] [1] Agosh M C "Aerodynamic And Heat Transfer Analysis Over Spherical Blunt Cone"
[2] [2] [2] Chapman, Dean. An Analysis of the Corridor and Guidance Requirements for "Supercircular Entry Into Planetary Atmospheres." NASA TR R-55, 1960.
[3] [3] [3] "A Cooperative Project of the Lunar and Planetary Institute", NASA's Office of Space Science and public libraries "SPACE CAPSULE DESIGN".
[4] [4] [4] J. Muylaert, W. Kordulla, D. Giordano, L. Marraffa, R. Schwane "Aerothermodynamics Analysis Of Space- Vehicle Phenomena"