International Journal of Progressive Research in Science and Engineering
Volume-1, Issue-5, August-2020
www.ijprse.com

Thermal Analysis of Re-Entry Capsule Over the Heat Shield

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Abstract: This paper deals with the heat or thermal analysis of heat shield within re-entry capsule. The re-entry capsule or space capsule is going to be designed and analysed using two software that is; CATIA & ANSYS. The heat shield material is considered to be having high melting point and high resistance towards heat. Overall comparing all the values with the past used material contours to find a difference and suggest making a new material for advantage of vehicle. Using of ANSYS software, the temperature variations can be found by giving thermal loads.

Key Words: - ***Re-entry capsule, CATIA, ANSYS, Comparing thermal values, Temperature variations by thermal loads.***

I. INTRODUCTION

A Re-entry capsule is the portion of a spacecraft which will be re-entered into the atmosphere. This capsule is made with high sustaining heat capacity and withstanding heavy aerodynamic properties. Mainly it focuses on heat shield because it produces more heat while returning towards atmosphere with huge amount of aerodynamic friction. This friction leads to high melting of material and after that the space capsule is to be landed in the sea or land with the help of inbuilt parachute.

A. Atmospheric Entry:

Atmospheric entry or re-entry denotes that it is going to be reused or re modelling of the material equipments. It is very crucial part of system to work on re-entry. As it produces high amount of friction and heat due to aerodynamic forces, the material tends to lose its stability or factor of safety in sustaining heat. The heat shield design and its material shape and properties are helping capsule to safe re-enter into atmosphere for further operations.

B. Thermal Protection System:

The Space Shuttle has a thermal protection system (TPS) is helping from high amount of heat extraction. Another step of protecting heat as well as sustaining cold, the material in thermal protection system is considered for both cases. Reentry heating produces the melting temperature deeply about 1650^0C. This high amount of heat is protected by TPS which is mainly inbuilt for retraining capsule safe into land. The TPS material is carbon fibre material and a composition of some other withstanding material such as titanium, aluminium, composite tiles and materials. This method has capable of protecting capsule from both cold and heat cases.

Figure.1. Aeroshell

C. Ansys:

Ansys is a analyzing and design making software that was founded in 1970 by John Swanson. Ansys made enormous design and analysis for more projects. It is mostly used for analyzing various contributions to easily found any values and also in animation manner. Thermal analysis is going to do in this project and mostly the parameters used here are configuration of thermal contours. It has not only thermal analysis but also includes vibrational analysis flow analysis dynamic analysis and so on so. Thermal analysis dealt with the branch of material science and physics with various differences in heat and thermal properties. Thermal analysis is also used for the study of heat transfer in different materials and finding various temperature distributions over the flow field area.

II. PROBLEM STATEMENT

The hardest part of this concept is to sustain the atmosphere going up, perform manoeuvres, deliver cargo and then reenter, glide and finally land. The heat shield which is withstanding thermal properties and heat may change due to re-entry friction and causes to burns enormously. The pay load may be varying according to capsule module. The main

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thing is that the capsule heat shield must be attaining high melting point and parachute must be performed at a perfect sequenced manner.

A. *Material Selection:*

Graphene is the material chosen for making of heat shield in reentry capsule in this paper. As it has high melting point at a range of 3000- 5000 k. When it is mixed with composite materials, it increases in strength towards restricting heat in as ablative heat shield. Hence Graphene is best material for capsule.

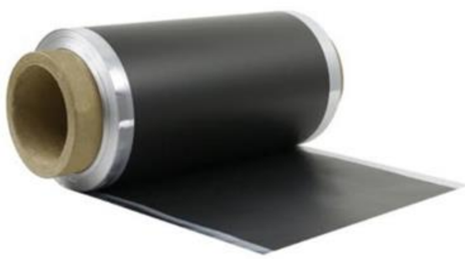

Figure 2.1. Aluminium Coiled Graphene

B. *Material Parameter*:

Table 2.2. Material Parameter

MATERIAL	TEMPERATURE
CARBON FIBRE:	4200^0 CELSIUS
GLASS FIBRE:	846^0 CELCIUS
KEVLAR FIBRE:	500^0 CELCIUS
ALUMNUM:	2470^0CELSIUS
TITANIUM:	3287^0 CELCIUS
STEEL:	2900^0 CELCIUS
NICKEL:	2732^0 CELCIUS
STAINLESS STEEL:	316^0 CELCIUS
COPPER:	2562^0 CELCIUS
GRAPHENE	5000^0 CELCIUS

C. *Design Parameter:*

In 1950, Scientist named Harvey Allen, stated about the design of blunt nose and its properties. In the region of space while returning to atmosphere it travels to about mach 25 and a temperature of 16500 Celsius to 55000 Celsius. Hence a blunt nose is designed for reentry vehicle instead of point nose. To withstand heat, the ablative materials are used and it is designed in a blunt manner. This heat sink absorbs heat and there is insulating tiles made of silica and this is because the silicon cools down very fast. This design makes a great insulator. It deflects the high speed air.

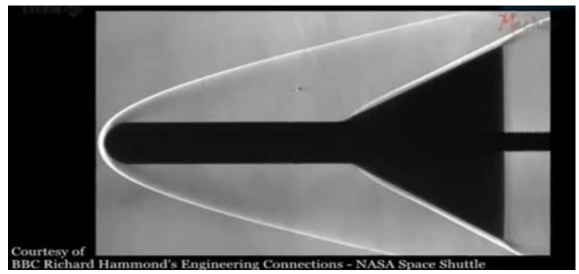

Figure 2.3 Flow Over Blunt Body

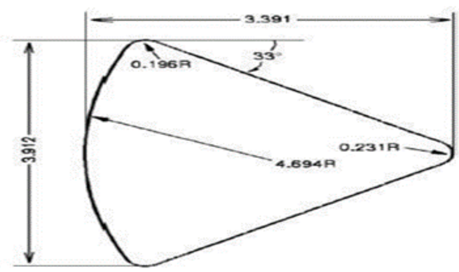

Figure 2.3.1 Dimensions of Capsule

D. *Procedure*

Using of dimensions, creating a 2D model of reentry capsule in CATIA software. The dimensions have been referred and taken from the journals. By projecting into workbench, it converts to 3D. Using drawing or drafting, the model is represented and plotted with dimensions. The modelled design should be saved. This design is then imported in ANSYS software. ANSYS software is an analyzing tool. This is used to do a thermal analysis of capsule at the heat shield. We are using static thermal analysis. It is a heat or thermal analysis. Then clicking on geometry, import the saved model which is design through CATIA. By updating it, the next process will be accessed. That is meshing part and meshing is done for the model to help the analysis part at each nodes and element. Meshing is the process to break the 3D model. Initially select temperature and convection for plotting values. Give the temperature values or heat shield to analyses part. The element or edge or a surface should be selected for applying temperature values. Then the solution part is done by selecting two consequents. One is temperature and the other is heat flux. The total heat flux and the temperature variations

IJPRSE
Progressive Research
International Journal of Progressive Research in Science and Engineering
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can be displayed separately. The blunt shape is used for withstanding ability in heat. The main thing is heat shield which will recover the heat from the surface in the re-enter of atmosphere. Heat shield is located at the end of capsule. The material is choosing as graphene and a combination of composite material. The graphene material is used because it has high thermal conductivity. Using of both CATIA and ANSYS software, the analysis is perfectly done.

III. Conclusion

From the ANSYS design and Graphical analysis, the temperature withstanding ability is high. Some of the material properties are gathered and plotted as graph. The graphical analysis shows that the graphene is the best material. Then using of dimensions the model is designed in CATIA and imported in ANSYS software. Then it is meshed and analyzed for steady state thermal. Due to reenter of atmosphere the speed will be exceed to Mach 25 and the temperature of ablative heat shield goes around 1650^0 Celsius. Hence 1650^0 Celsius is given as temperature for thermal analysis. It is analyzed after some time and displayed as a colorful manner.

A. Modelling Design:

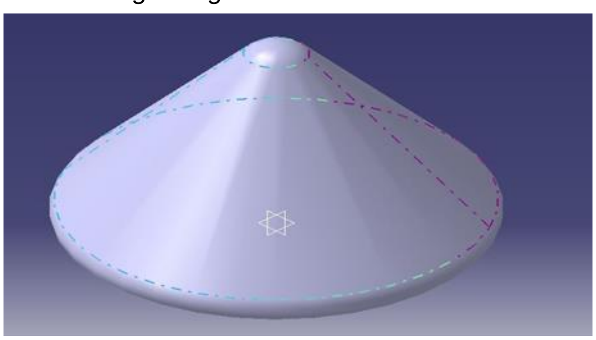

Figure 3.1.1 Catia Design

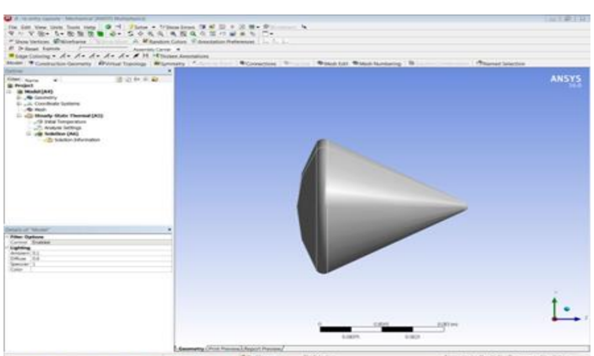

Figure 3.1.2 Imported in Ansys

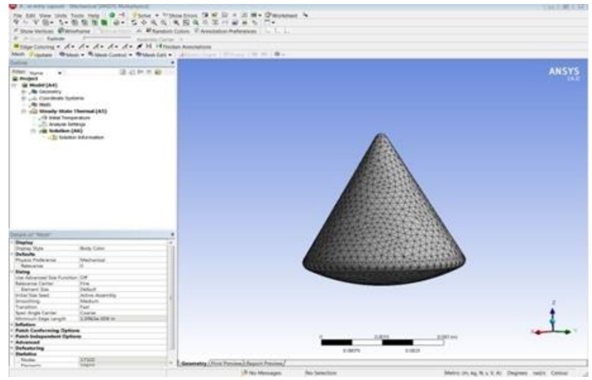

Figure 3.1.3 Meshing of Model

B. Analysing Heat Shield:

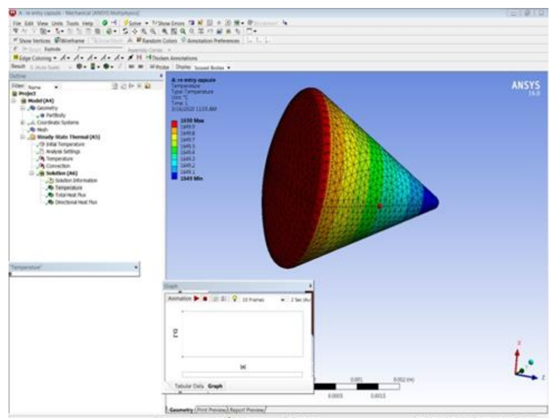

Figure 3.2.1 Temperature Analysis

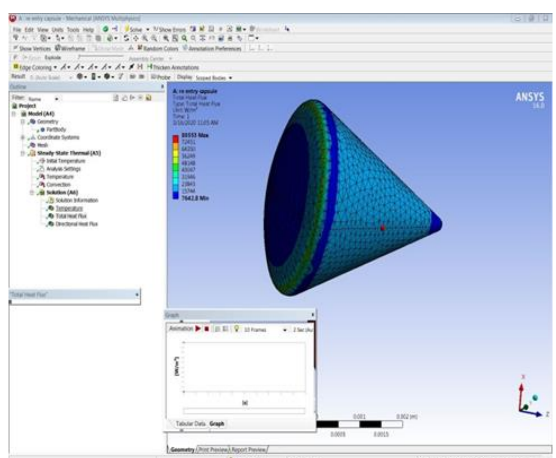

Figure 3.2.2 Analysing Heat Flux

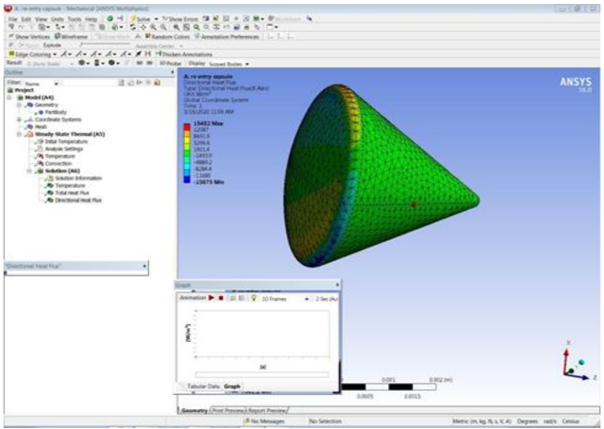

Figure 3.2.3 Analysing Directional Heat Flux Variations

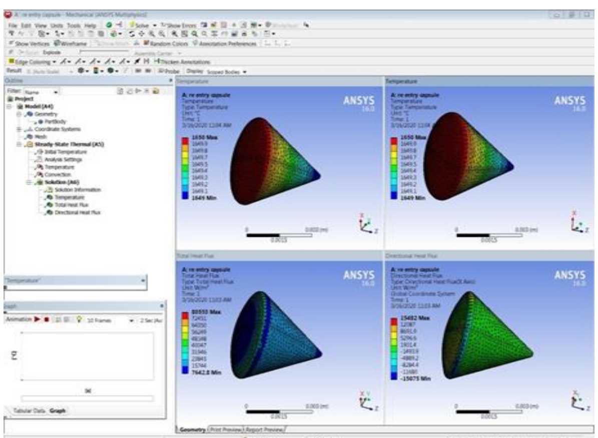

Figure 3.2.4 Multi Sectional View of Thermal Analysis

C. Graphical Analysis:

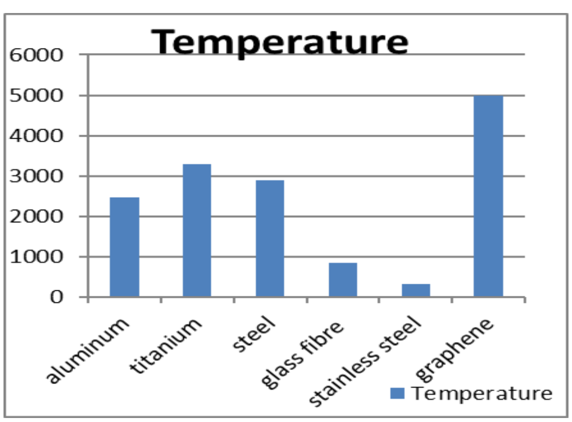

Figure 3.3 Graphical Analysis of Material Temperature

D. Outcome:

The journals are referred for the thermal analyses of re-entry capsule and the design parameters and materials specification are conformed by referring respective journals. The overview of re-entry capsule is design in CATIA. The work plan is the distribution of thermal loads on the heat shield which is a thermal protection system. There are more TPS material in which carbon composite has high withstanding capacity. Metallic fiber is chosen for this project and the metallic fibre materials are tabled with respective to their temperature. Graphene material is choosing for the heat shield. The three view diagram of capsule is recognized and concluded to place an ablative material for the right place of re-entry projection. The high thermal conducting ability is found to be high in graphene material. By Scientist Harvey Allen statement, the blunt nose is the perfect design foundation for oblique shock wave and its flow parameters. The CATIA designed model and the graphical analysis is also figured.

E. Future Work:

The future work or modifications in this project is to change the temperature values and analyses the capsule heat shield. The ablative materials can be changed according to your project. Any other software's are preferred for design and analysis. We can also find fluent flow analysis. We can also find vibrational analysis due to high frictional force. Hence so much of field properties can be applied.

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