ISSN (O): 2393-8609

International Journal of Aerospace and Mechanical Engineering

Volume 3 – No.6, December 2016

TRANSIENT THERMAL ANALYSIS ON RE-ENTRY VEHICLE NOSE CONE WITH TPS MATERIALS

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Abstract:

The term nose cone is used to refer to the forward most section of a rocket, guided missile or aircraft. The cone is shaped to offer minimum aerodynamic resistance. Nose cones are also designed for travel in and under water and in high speed land vehicles. On a rocket vehicle it consists of a chamber or chambers in which a satellite, instruments, animals, plants, or auxiliary equipment may be carried, and an outer surface built to withstand high temperatures generated by aerodynamic heating. Much of the fundamental research related to hypersonic flight was done towards creating viable nose cone designs for the atmospheric re-entry of spacecraft and ICBM re-entry vehicles. In a satellite vehicle, the nose cone may become the satellite itself after separating from the final stage of the rocket or it may be used to shield the satellite until orbital speed is accomplished, then separating from the satellite.

Keywords

Hafmium Diboride; Zirconium Diboride; Nose cone; Re-entry Vehicle; TPS

1. INTRODUCTION

Heat transfer describes the exchange of thermal energy, between physical systems depending on the temperature and pressure, by dissipating heat. Systems which are not isolated may decrease in entropy. Most objects emit infrared thermal radiation near room temperature. The fundamental modes of heat transfer are conduction or diffusion, convection, advection and radiation. The exchange of kinetic energy of particles through the boundary between two systems is at a different temperature from another body or its surroundings. Heat transfer always occurs from a region of high temperature to another region of lower temperature. Heat transfer changes the internal energy of both systems involved according to the First Law of Thermodynamics.

The Second Law of Thermodynamics defines the concept of thermodynamic entropy, by measurable heat transfer. Thermal equilibrium is reached when all involved bodies and the surroundings reach the same temperature. Thermal expansion is the tendency of matter to change in volume in response to a change in temperature. Heat transfer is a process function (or path function), as opposed to functions of state; therefore, the amount of heat transferred in a thermodynamic process that changes the state of a system depends on how that process occurs, not only the net difference between the initial and final states of the process.

Thermodynamic and mechanical heat transfer is calculated with the heat transfer coefficient, the proportionality between the heat flux and the thermodynamic driving force for the flow of heat. Heat flux is a quantitative, vectorial representation of the heat flow through a surface. In engineering contexts, the term heat is taken as synonymous to thermal energy. This usage has its origin in the historical interpretation of heat as a fluid (caloric) that can be transferred by various causes, and that is also common in the language of laymen and everyday life. The transport equations for thermal energy (Fourier's law), mechanical momentum (Newton's law for fluids), and mass transfer (Fick's laws of diffusion) are similar, and analogies among these three transport processes have been developed to facilitate prediction of conversion from any one to the others.

Thermal engineering concerns the generation, use, conversion, and exchange of heat transfer. As such, heat transfer is involved in almost every sector of the economy. Heat transfer is classified into various mechanisms, such as thermal conduction, thermal convection, thermal radiation, and transfer of energy by phase changes.

2. MECHANISMS

The fundamental modes of heat transfer are:

A. Advection

Advection is the transport mechanism of a fluid substance or conserved property from one location to another, depending on motion and momentum.

By transferring matter, energy—including thermal energy—is moved by the physical transfer of a hot or cold object from one place to another. This can be as simple as placing hot water in a bottle and heating a bed, or the movement of an iceberg in changing ocean currents. A practical example is thermal hydraulics. This can be described by the formula:

$$Q= v.\rho.C_p.\Delta T$$

where Q is heat flux (W/m²), ρ is density (kg/m³), cp is heat capacity at constant pressure (J/(kg*K)), ΔT is the change in temperature (K), v is velocity (m/s).

B. Conduction

The transfer of energy between objects that are in physical contact. Thermal conductivity is the property of a material to conduct heat and evaluated primarily in terms of Fourier's Law for heat conduction.

On a microscopic scale, heat conduction occurs as hot, rapidly moving or vibrating atoms and molecules interact with neighbouring atoms and molecules, transferring some of their energy (heat) to these neighbouring particles. In other words, heat is transferred by conduction when adjacent atoms vibrate against one another, or as

ISSN (O): 2393-8609

International Journal of Aerospace and Mechanical Engineering

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electrons move from one atom to another. Conduction is the most significant means of heat transfer within a solid or between solid objects in thermal contact. Fluids—especially gases—are less conductive. Thermal contact conductance is the study of heat conduction between solid bodies in contact.

Steady state conduction (see Fourier's law) is a form of conduction that happens when the temperature difference driving the conduction is constant, so that after an equilibration time, the spatial distribution of temperatures in the conducting object does not change any further. In steady state conduction, the amount of heat entering a section is equal to amount of heat coming out.

Transient conduction occurs when the temperature within an object changes as a function of time. Analysis of transient systems is more complex and often calls for the application of approximation theories or numerical analysis by computer.

C. Convection

The transfer of energy between an object and its environment, due to fluid motion. The average temperature, is a reference for evaluating properties related to convective heat transfer.

The flow of fluid may be forced by external processes, or sometimes (in gravitational fields) by buoyancy forces caused when thermal energy expands the fluid (for example in a fire plume), thus influencing its own transfer. The latter process is often called "natural convection". All convective processes also move heat partly by diffusion, as well. Another form of convection is forced convection. In this case the fluid is forced to flow by use of a pump, fan or other mechanical means.

Convective heat transfer, or convection, is the transfer of heat from one place to another by the movement of fluids, a process that is essentially the transfer of heat via mass transfer. Bulk motion of fluid enhances heat transfer in many physical situations, such as (for example) between a solid surface and the fluid. Convection is usually the dominant form of heat transfer in liquids and gases. Although sometimes discussed as a third method of heat transfer, convection is usually used to describe the combined effects of heat conduction within the fluid (diffusion) and heat transference by bulk fluid flow streaming. The process of transport by fluid streaming is known as advection, but pure advection is a term that is generally associated only with mass transport in fluids, such as advection of pebbles in a river. In the case of heat transfer in fluids, where transport by advection in a fluid is always also accompanied by transport via heat diffusion (also known as heat conduction) the process of heat convection is understood to refer to the sum of heat transport by advection and diffusion/conduction.

Free, or natural, convection occurs when bulk fluid motions (steams and currents) are caused by buoyancy forces that result from density variations due to variations of temperature in the fluid. Forced convection is a term used when the streams and currents in the fluid are induced by external means—such as fans, stirrers, and pumps—creating an artificially induced convection current.

D. Convection-cooling:

Convective cooling is sometimes described as Newton's law of cooling:

However, by definition, the validity of Newton's law of cooling requires that the rate of heat loss from convection be a linear function of ("proportional to") the temperature difference that drives heat transfer, and in convective cooling this is sometimes not the case. In general, convection is not linearly dependent on temperature gradients, and in some cases is strongly nonlinear. In these cases, Newton's law does not apply.

1. Forced convection

In forced convection, also called heat advection, fluid movement results from external surface forces such as a fan or pump. Forced convection is typically used to increase the rate of heat exchange. Many types of mixing also utilize forced convection to distribute one substance within another. Forced convection also occurs as a by-product to other processes, such as the action of a propeller in a fluid or aerodynamic heating. Fluid radiator systems, and also heating and cooling of parts of the body by blood circulation, are other familiar examples of forced convection.

Forced convection may happen by natural means, such as when the heat of a fire causes expansion of air and bulk air flow by this means. In microgravity, such flow (which happens in all directions) along with diffusion is the only means by which fires are able to draw in fresh oxygen to maintain themselves. The shock wave that transfers heat and mass out of explosions is also a type of forced convection.

Although forced convection from thermal gas expansion in zero-g does not fuel a fire as well as natural convection in a gravity field, some types of artificial forced convection are far more efficient than free convection, as they are not limited by natural mechanisms. For instance, a convection oven works by forced convection, as a fan which rapidly circulates hot air forces heat into food faster than would naturally happen due to simple heating without the fan.

2. Convection vs. conduction

In a body of fluid that is heated from underneath its container, conduction and convection can be considered to compete for dominance. If heat conduction is too great, fluid moving down by convection is heated by conduction so fast that its downward movement will be stopped due to its buoyancy, while fluid moving up by convection is cooled by conduction so fast that its driving buoyancy will diminish. On the other hand, if heat conduction is very low, a large temperature gradient may be formed and convection might be very strong.

The Rayleigh number (Ra) is a measure determining the relative strength of conduction and convection.

$$Ra = \frac{g\Delta\rho L^3}{\mu\alpha} = \frac{g\beta\Delta T L^3}{\vartheta\alpha}$$

where

- g is acceleration due to gravity,
- ρ is the density with Δρ being the density difference between the lower and upper ends,
- μ is the dynamic viscosity,
- α is the Thermal diffusivity,
- β is the volume thermal expansivity (sometimes denoted α elsewhere),
- T is the temperature,
- ν is the kinematic viscosity, and
- L is characteristic length.

The Rayleigh number can be understood as the ratio between the rate of heat transfer by convection to the rate of heat transfer by

ISSN (O): 2393-8609

International Journal of Aerospace and Mechanical Engineering

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conduction; or, equivalently, the ratio between the corresponding timescales (i.e. conduction timescale divided by convection timescale), up to a numerical factor. This can be seen as follows, where all calculations are up to numerical factors depending on the geometry of the system.

The buoyancy force driving the convection is roughly $g\Delta\rho L^3$, so the corresponding pressure is roughly $g\Delta\rho L$. In steady state, this is cancelled by the shear stress due to viscosity, and therefore roughly equals $\frac{\mu V}{L}=\frac{\mu}{T_{conv}}$, where V is the typical fluid velocity due to convection and T_{conv} the order of its timescale. The conduction timescale, on the other hand, is of the order of $T_{cond}=\frac{L^2}{\alpha}$.

Convection occurs when the Rayleigh number is above 1,000–2,000.

3. Radiation

The transfer of energy from the movement of charged particles within atoms is converted to electromagnetic radiation.

Thermal radiation occurs through a vacuum or any transparent medium (solid or fluid). It is the transfer of energy by means of photons in electromagnetic waves governed by the same laws. Earth's radiation balance depends on the incoming and the outgoing thermal radiation, Earth's energy budget. Anthropogenic perturbations in the climate system, are responsible for a positive radiative forcing which reduces the net long wave radiation loss out to Space.

Thermal radiation is energy emitted by matter as electromagnetic waves, due to the pool of thermal energy in all matter with a temperature above absolute zero. Thermal radiation propagates without the presence of matter through the vacuum of space. The Stefan-Boltzmann equation, which describes the rate of transfer of radiant energy, is as follows for an object in a vacuum :

$$Q = \epsilon\, \sigma T^4$$

For radiative transfer between two objects, the equation is as follows:

$$Q = \epsilon\, \sigma (T_a - T_b)^4$$

where Q is the rate of heat transfer, ε is the emissivity (unity for a black body), σ is the Stefan-Boltzmann constant, and T is the absolute temperature (in Kelvin or Rankine). Radiation is typically only important for very hot objects, or for objects with a large temperature difference.

3. Transient analysis

A. Hafnium diboride:

Material Data for hafnium diboride

Density	10500 kg m^-3
Thermal Conductivity	62 W m^-1 C^-1
Specific Heat	776.94 J kg^-1 C^-1

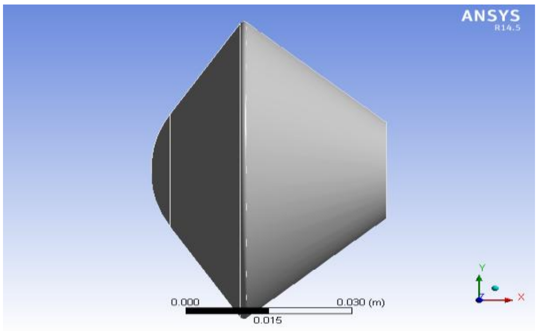

Figure-1: Re-entry capsule physical Geometry

***Geometry*> Model (A4) > Geometry**

Geometry definition

Object Name	*Geometry*
State	Fully Defined
Definition	
Type	DesignModeler
Length Unit	Meters
Display Style	Body Color
Bounding Box	
Length X	4.2291e-002 m
Length Y	7.1565e-002 m
Length Z	7.1565e-002 m
Properties	
Volume	7.8579e-005
Mass	0.82508 kg
Scale Factor	1.
Statistics	
Bodies	1
Active Bodies	1
Nodes	43658
Elements	29035

Mesh

Model (A4) > Mesh

Mesh setup

Object Name	*Mesh*
State	Solved
Sizing	
Minimum Edge Length	7.62e-005 m
Statistics	
Nodes	43658
Elements	29035

Model (A4) > Mesh > Mesh Controls

Object Name	*Body Sizing*	*Refinement*
State	Fully Defined	
Scope		

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Scoping Method	Geometry Selection	
Geometry	1 Body	3 Faces
Definition		
Type	Element Size	
Element Size	5.e-003 m	

Model (A4) > Analysis

Analysis settings

Object Name	*Transient Thermal (A5)*
State	Solved
Definition	
Physics Type	Thermal
Analysis Type	Transient

Model (A4) > Transient Thermal (A5) > Initial Condition

Object Name	*Initial Temperature*
State	Fully Defined
Definition	
Initial Temperature	Uniform Temperature
Initial Temperature Value	22. °C

Model (A4) > Transient Thermal (A5) > Analysis Settings

Object Name	*Analysis Settings*
State	Fully Defined
Step Controls	
Number Of Steps	1.
Current Step Number	1.
Step End Time	500. s
Initial Time Step	5. s
Minimum Time Step	0.5 s
Maximum Time Step	50. s
Time Integration	On
Output Controls	
Calculate Thermal Flux	Yes
Analysis Data Management	
Nonlinear Solution	Yes
Solver Unit System	Mks

Model (A4) > Transient Thermal (A5) > Loads

Loads

Object Name	*Convection*	*Convection 2*	*Temperature*	*Radiation*	*Radiation 2*
State	Fully Defined				
Scope					
Scoping Method	Geometry Selection				
Geometry	3 Faces	1 Face			3 Faces
Definition					
Type	Convection		Temperature	Radiation	
Film Coefficient	190. W/m²·°C (step applied)	10. W/m²·°C (step applied)			
Ambient	3000. °C	2000. °C		2000. °C	3000. °C
Temperature	(step applied)	(step applied)		(step applied)	(step applied)
Suppressed	No				
Magnitude			50. °C (step applied)		
Correlation				To Ambient	
Emissivity				0.9 (step applied)	

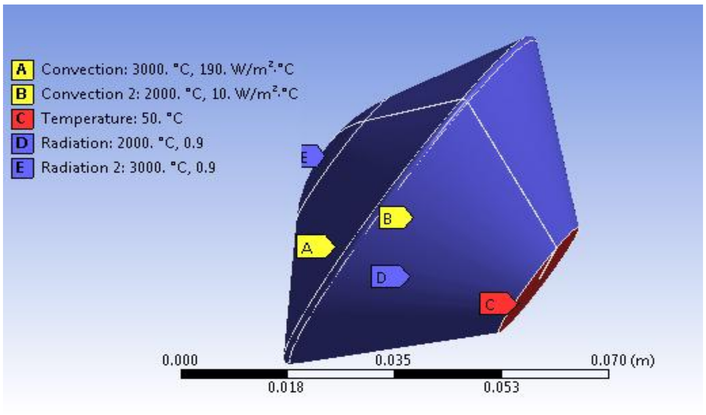

Figure-2: Loads

3.2 Zirconium diboride:

Material Data for Zirconium diboride

Density	6085 kg m^-3
Thermal Conductivity	70 W m^-1 C^-1
Specific Heat	1385 J kg^-1 C^-1

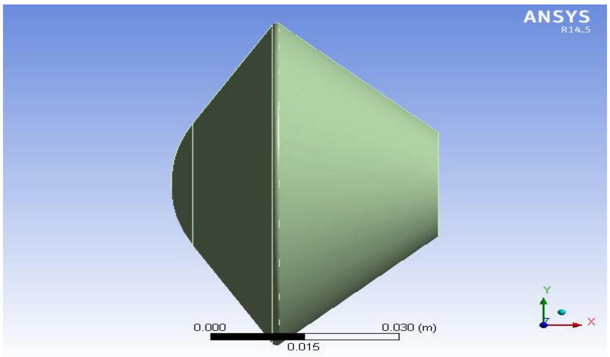

Figure-3: Re-entry capsule physical geometry

Geometry

Model (A4) > Geometry

Geometry definition

Object Name	*Geometry*
State	Fully Defined
Definition	
Type	Design Modeler
Length Unit	Meters
Display Style	Body Color
Bounding Box	
Length X	4.2291e-002 m
Length Y	7.1565e-002 m

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Length Z	7.1565e-002 m
Properties	
Volume	7.8579e-005 m³
Mass	0.47815 kg
Scale Factor Value	1.
Statistics	
Bodies	1
Active Bodies	1
Nodes	43658
Elements	29035

Mesh

Model (A4) > Mesh

Mesh setup

Object Name	*Mesh*
State	Solved
Defaults	
Physics Preference	Mechanical
Relevance	0
Sizing	
Minimum Edge Length	7.62e-005 m

Model (A4) > Mesh > Mesh Controls

Object Name	*Body Sizing*	*Refinement*
State	Fully Defined	
Scope		
Scoping Method	Geometry Selection	
Geometry	1 Body	3 Faces
Definition		
Type	Element Size	
Element Size	5.e-003 m	

Model (A4) > Analysis

Analysis settings

Object Name	*Transient Thermal (A5)*
State	Solved
Definition	
Physics Type	Thermal
Analysis Type	Transient

Model (A4) > Transient Thermal (A5) > Initial Condition

Object Name	*Initial Temperature*
State	Fully Defined
Definition	
Initial Temperature	Uniform Temperature
Initial Temperature Value	22. °C

Model (A4) > Transient Thermal (A5) > Analysis Settings

Object Name	*Analysis Settings*
State	Fully Defined
Step Controls	
Number Of Steps	1.
Current Step Number	1.
Step End Time	500. s
Auto Time Stepping	Program Controlled
Initial Time Step	5. s
Minimum Time Step	0.5 s
Maximum Time Step	50. s
Time Integration	On
Output Controls	
Calculate Thermal Flux	Yes
Analysis Data Management	
Solver Unit System	Mks

Model (A4) > Transient Thermal (A5) > Loads

Object Name	*Convection*	*Radiation*	*Convection 2*	*Radiation 2*	*Temperature*
State	Fully Defined				
Scope					
Scoping Method	Geometry Selection				
Geometry	3 Faces		1 Face		
Definition					
Type	Convection	Radiation	Convection	Radiation	Temperature
Film Coefficient	190. W/m²·°C (step applied)		10. W/m²·°C (step applied)		
Ambient Temperature	3000. °C (step applied)		2000. °C (step applied)		
Suppressed	No				
Correlation		To Ambient		To Ambient	
Emissivity		0.9 (step applied)		0.9 (step applied)	
Magnitude					50. °C (step applied)

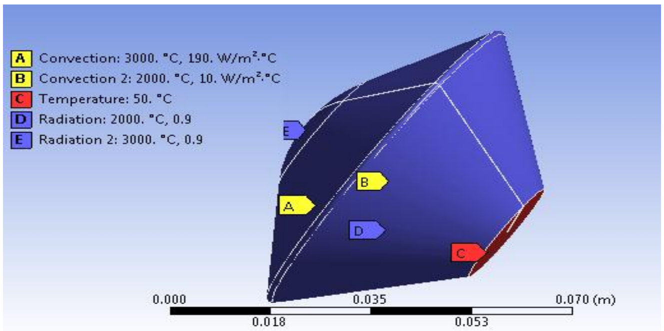

Figure-4: Loads

4. RESULTS AND DISCUSSION

Transient

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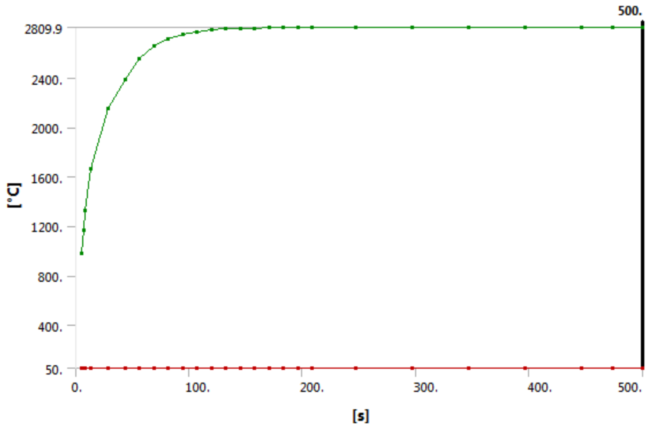
A. Hafnium diboride:

Model (A4) > Transient Thermal (A5) > Solution (A6) > Results

Transient Results for HfB_2

Object Name	*Temperature*	*Total Heat Flux*
State	Solved	
Scope		
Scoping Method	Geometry Selection	
Geometry	All Bodies	
Definition		
Type	Temperature	Total Heat Flux
By	Time	
Display Time	Last	
Calculate Time History	Yes	
Results		
Minimum	50. °C	1.0891e+005 W/m²
Maximum	2809.9 °C	2.3411e+007 W/m²
Minimum Value Over Time		
Minimum	50. °C	10962 W/m²
Maximum	50. °C	4.8748e+005 W/m²
Maximum Value Over Time		
Minimum	976.41 °C	8.7286e+006 W/m²
Maximum	2809.9 °C	2.3411e+007 W/m²
Information		
Time	500. s	
Load Step	1	
Substep	26	
Iteration Number	29	

Model (A4) > Transient Thermal (A5) > Solution (A6) > Temperature



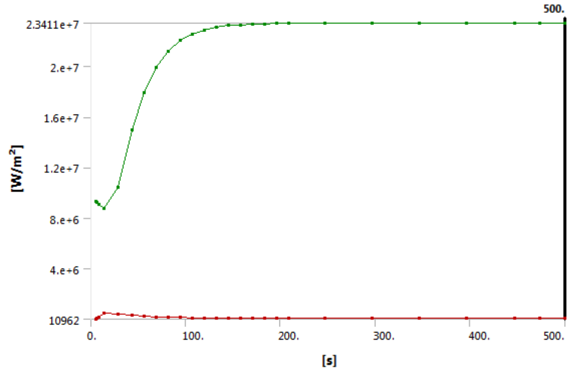
Graph-1: Transient thermal distribution for HfB_2

Model (A4) > Transient Thermal (A5) > Solution (A6) > Temperature

Transient Temperature distribution

Time [s]	Minimum [°C]	Maximum [°C]
5.		976.41
6.6667		1169.7
8.3333	50.	1326.2
13.333		1669.2
28.333		2156.3
43.287		2391.
55.996		2559.3
68.705		2657.9
144.96		2801.8
157.67		2805.
170.37		2806.9
183.08		2808.
195.79		2808.8
208.5		2809.2
246.63		2809.7
296.63		2809.8
346.63		
473.31		2809.9
500.		

Model (A4) > Transient Thermal (A5) >Solution (A6) > Total Heat Flux



Graph-2: Total heat flux for HfB_2

Model (A4) > Transient Thermal (A5) > Solution (A6) > Total Heat Flux for HfB_2

Time [s]	Minimum [W/m²]	Maximum [W/m²]
5.	10962	9.2924e+006
6.6667	1.0057e+005	9.22e+006
8.3333	1.7416e+005	9.1047e+006
13.333	4.8748e+005	8.7286e+006
28.333	3.9445e+005	1.0429e+007
43.287	2.9847e+005	1.4951e+007
55.996	2.3592e+005	1.7881e+007
68.705	1.8791e+005	1.9893e+007
81.413	1.58e+005	2.1207e+007
94.122	1.3929e+005	2.2042e+007
106.83	1.2766e+005	2.2565e+007
119.54	1.2046e+005	2.2889e+007
132.25	1.1601e+005	2.309e+007
144.96	1.1327e+005	2.3213e+007
157.67	1.1159e+005	2.3289e+007
170.37	1.1056e+005	2.3336e+007
183.08	1.0992e+005	2.3365e+007
195.79	1.0953e+005	2.3383e+007
208.5	1.0929e+005	2.3393e+007
246.63	1.0904e+005	2.3405e+007
296.63	1.0895e+005	2.3409e+007

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346.63	1.0892e+005	2.341e+007
396.63	1.0891e+005	
446.63		
473.31		
500.		2.3411e+007

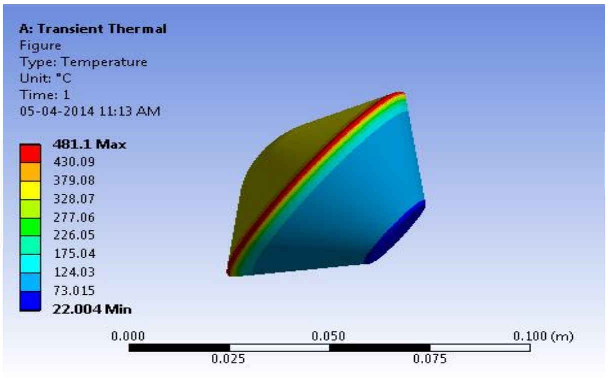

Figure-5: Temperature distribution in 1 sec for HfB_2

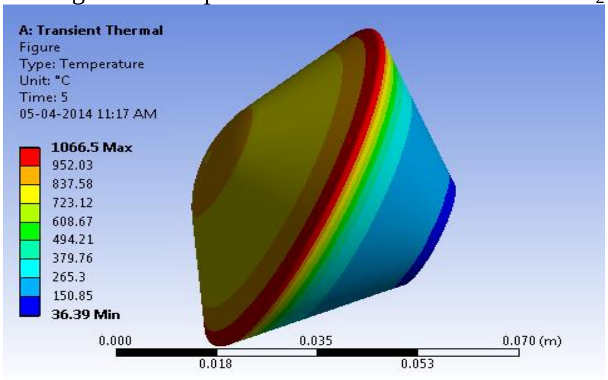

Figure-6: Temperature distribution in 5 sec for HfB_2

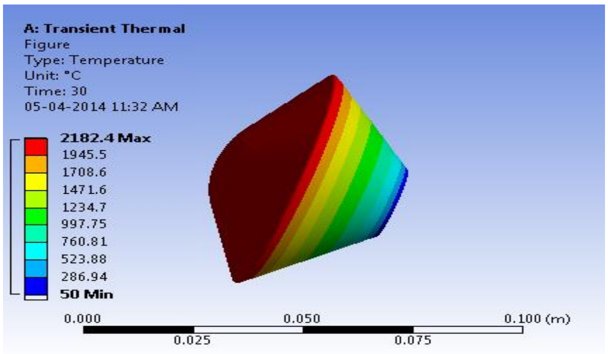

Figure-7: Temperature distribution in 30 sec for HfB_2

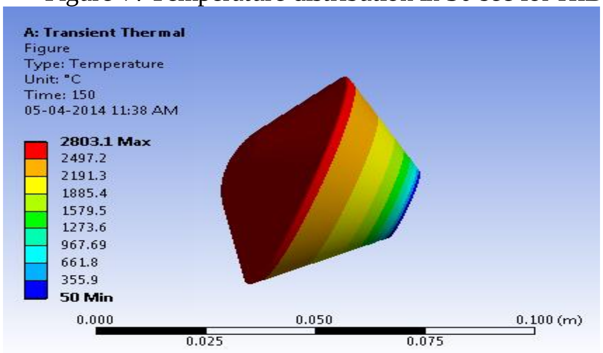

Figure-8: Temperature distribution in 150 sec for HfB_2

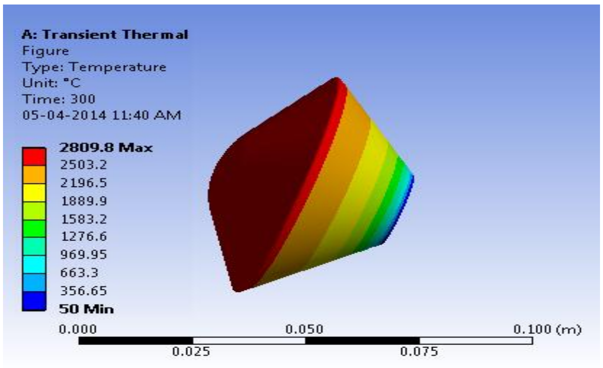

Figure-9: Temperature distribution in 300 sec for HfB_2

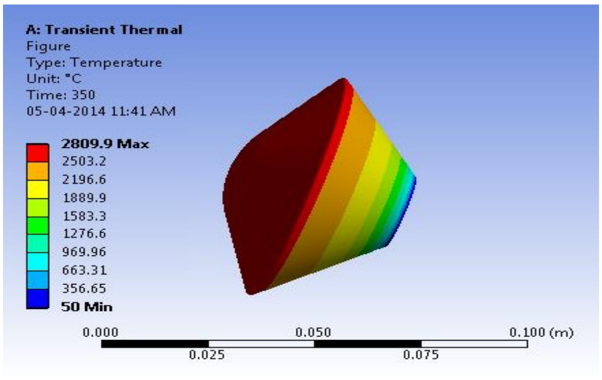

Figure-10: Temperature distribution in 350 sec for HfB_2

Model (A4) > Transient Thermal (A5) > Solution (A6) > Temperature > Figure

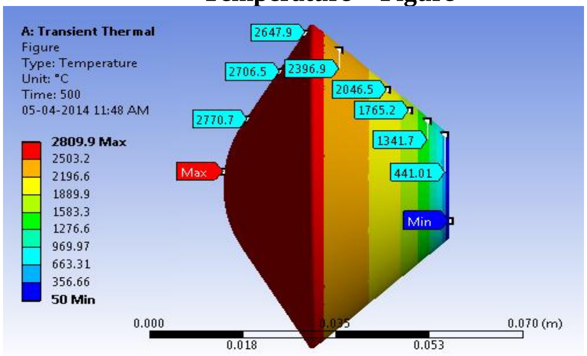

Figure-11: Temperature distribution contour

4.2 Zirconium diboride:

Model (A4) > Transient Thermal (A5) > Solution (A6) > Results for ZrB_2

Object Name	*Temperature*	*Total Heat Flux*
State	Solved	
Scope		
Scoping Method	Geometry Selection	
Geometry	All Bodies	
Definition		
Type	Temperature	Total Heat Flux
By	Time	
Display Time	500. s	Last
Calculate Time History	Yes	
Results		

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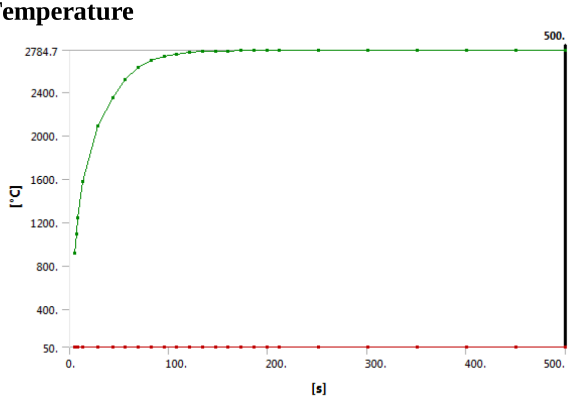
Minimum	50. °C	1.2185e+005 W/m²
Maximum	2784.7 °C	2.5987e+007 W/m²
Minimum Value Over Time		
Minimum	50. °C	2791. W/m²
Maximum	50. °C	4.9246e+005 W/m²
Maximum Value Over Time		
Minimum	910.94 °C	8.8845e+006 W/m²
Maximum	2784.7 °C	2.5987e+007 W/m²
Information		
Time	500. s	
Load Step	1	
Substep	25	
Iteration Number	28	

Model (A4) > Transient Thermal (A5) > Solution (A6) > Temperature



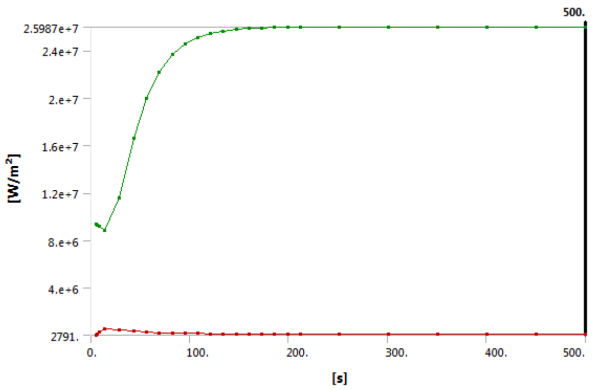
Graph-3: Transient thermal distribution for ZrB_2

Model (A4) > Transient Thermal (A5) > Solution (A6) > Temperature

Transient thermal distribution for ZrB_2

Time [s]	Minimum [°C]	Maximum [°C]
5.		910.94
6.6667		1094.4
8.3333		1244.1
13.333		1578.7
28.333		2087.4
43.333		2343.7
56.284		2519.3
69.235		2625.3
82.186		2688.5
95.137	50	2726.5
108.09		2749.4
121.04		2763.3
133.99		2771.8
146.94		2776.9
159.89		2779.9
172.84		2781.8
185.79		2783.
198.75		2783.6
211.7		2784.1
250.55		2784.5
300.55		2784.6
350.55		
400.55		2784.7
450.55		
500.		

Model (A4) > Transient Thermal (A5) > Solution (A6) > Total Heat Flux



Graph-4: Total heat flux for ZrB_2

Model (A4) > Transient Thermal (A5) > Solution (A6) > Total Heat Flux

Total heat flux for ZrB_2

Time [s]	Minimum [W/m²]	Maximum [W/m²]
5.	2791.	9.3349e+006
6.6667	1.3419e+005	9.2972e+006
8.3333	2.2907e+005	9.2053e+006
13.333	4.9246e+005	8.8845e+006
28.333	4.0748e+005	1.158e+007
43.333	3.1642e+005	1.6659e+007
56.284	2.5279e+005	1.9964e+007
69.235	2.0264e+005	2.2204e+007
82.186	1.7152e+005	2.3647e+007
95.137	1.5223e+005	2.4553e+007
108.09	1.4036e+005	2.5112e+007
121.04	1.3311e+005	2.5455e+007
133.99	1.2869e+005	2.5664e+007
146.94	1.26e+005	2.5791e+007
159.89	1.2437e+005	2.5868e+007
172.84	1.2338e+005	2.5915e+007
185.79	1.2277e+005	2.5943e+007
198.75	1.2241e+005	2.596e+007
211.7	1.2219e+005	2.5971e+007
250.55	1.2197e+005	2.5982e+007
300.55	1.2188e+005	2.5985e+007
350.55	1.2186e+005	
400.55		2.5987e+007
450.55	1.2185e+005	
500.		

ISSN (O): 2393-8609

International Journal of Aerospace and Mechanical Engineering

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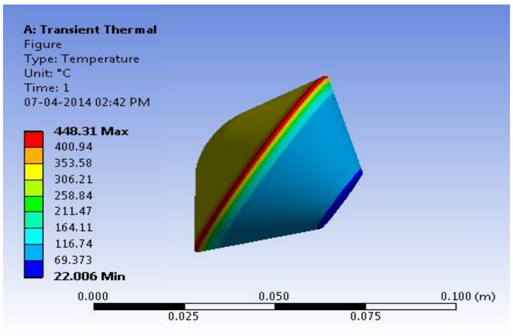

Figure-12: Temperature distribution in 1 sec for ZrB_2

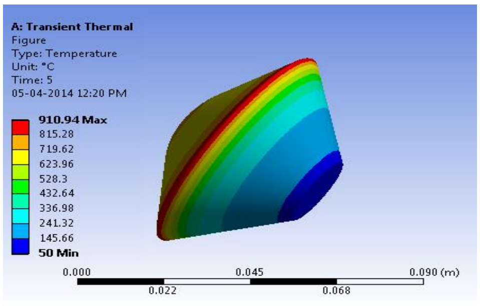

Figure-13: Temperature distribution in 5 sec for ZrB_2

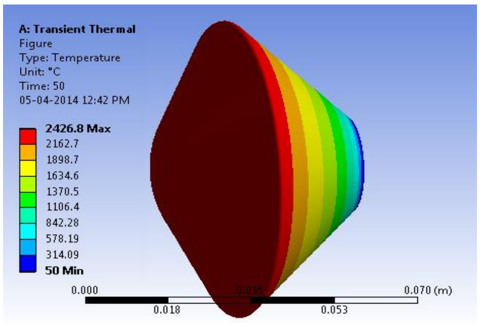

Figure-14: Temperature distribution in 50 sec for ZrB_2

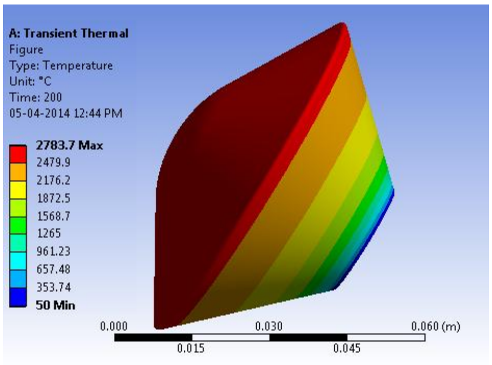

Figure-15: Temperature distribution in 200 sec for ZrB_2

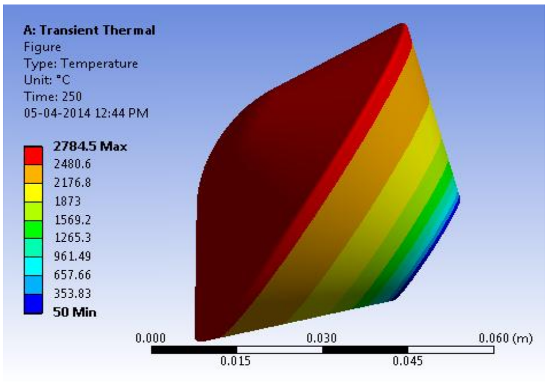

Figure-16: Temperature distribution in 250 sec for ZrB_2

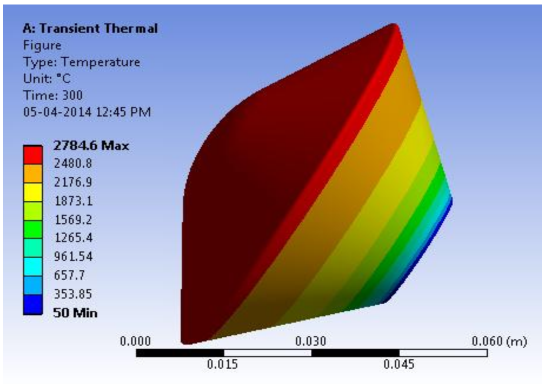

Figure-17: Temperature distribution in 300 sec for ZrB_2

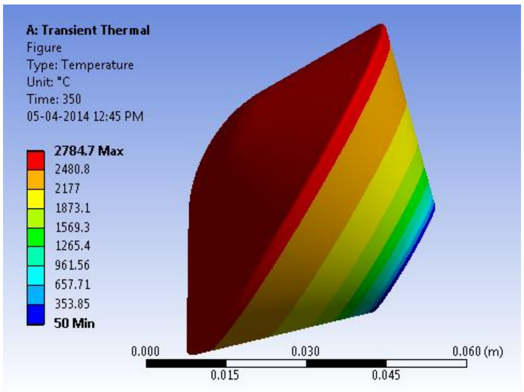

Figure-18: Temperature distribution in 350 sec for ZrB_2

Model (A4) > Transient Thermal (A5) > Solution (A6) > Temperature > Figure

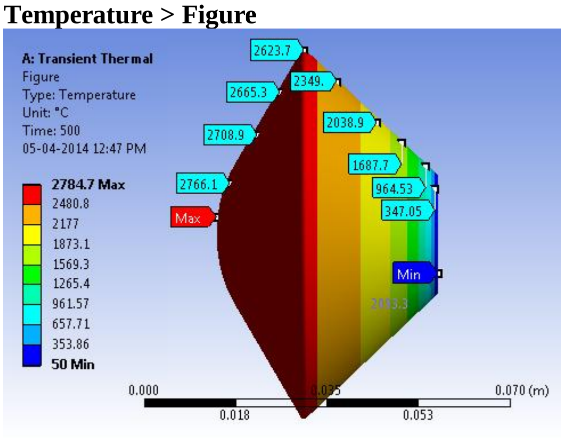

Figure-19: Temperature distribution contours

ISSN (O): 2393-8609

International Journal of Aerospace and Mechanical Engineering

Volume 3 – No.6, December 2016

5. CONCLUSION

Computational solutions for various materials are validated which are fairly in good understanding. For the Hafnium diboride material the temperature distribution is from 2806.9°C to 2809.9°C and the distribution is normal showing the uniformity. For the Zirconium diboride material the temperature distribution is same from 2784.1°C to 2784.7°C shows the resistance of the material in transferring the temperature. From the simulated results the Hafnium diboride material shows the better heat flux values in promising levels than Zirconium diboride material. Similarly the Zirconium diboride material shows better distributed pattern than Hafnium diboride material.

6. FUTURE SCOPE

On addition of various materials like SiC, Si3N4,MoSi2 to the HfB2 and ZrB2 the material properties are modified for better oxidation effect and thermal resistance.

7. REFERENCES

[1] N. R. Deepak, T. Ray, and R. R. Boyce, "Evolutionary algorithm shape optimization of a hypersonic flight experiment nose cone," Journal of Spacecraft and Rockets, vol. 45, no. 3, pp. 428– 437, 2008.

[2] A. K.Noor, S. L. Venneri,D. B. Paul, and M. A.Hopkins, "Structures technology for future aerospace systems," Computers and Structures, vol. 74, no. 5, pp. 507–519, 2000.

[3] W. L. Huang, Ballistic Missiles, China Astronautics Press, Beijing, China, 2006.

[4] E. L. Fleeman, Tactical Missile Design, chapter 4, American Institute of Aeronautics and Astronautics, Inc., 2nd edition, 2006.

[5] M. Y. M. Ahmed and N. Qin, "Recent advances in the aerothermodynamics of spiked hypersonic vehicles," Progress in Aerospace Sciences, vol. 47, no. 6, pp. 425–449, 2011.

[6] J. Ledu and C. Pollak, "Flight testing results on a hypersonic reentry nose cone," Journal of Spacecraft and Rockets, vol. 6, no. 9, pp. 1044–1047, 1969.

[7] L. E. Ericsson, R. A. Guenther, W. R. Stake, and G. S. Olmsted, "Combined effects of nose bluntness and cone angle on unsteady aerodynamics," AIAA Journal, vol. 12, no. 5, pp. 729–732, 1974.

[8] L. E. Ericsson, "Parametric investigations of slender cone nose bluntness effects," Journal of Spacecraft and Rockets, vol. 23, no. 1, pp. 126–128, 1986.

[9] T. C. Lin,W. R. Grabowsky, and K. E. Yelmgren, "The search for optimum configurations for re-entry vehicles," Journal of Spacecraft and Rockets, vol. 21, no. 2, pp. 142–149, 1984.

[10] M. Gauer and A. Paull, "Numerical investigation of a spiked blunt nose cone at hypersonic speeds," Journal of Spacecraft and Rockets, vol. 45, no. 3, pp. 459–471, 2008.

[11] M. Y. M. Ahmed and N. Qin, "Drag Reduction using aerodisks for hypersonic hemispherical bodies," Journal of Spacecraft and Rockets, vol. 47, no. 1, pp. 62–80, 2010.

[12] C. D. Marley and D. W. Riggins, "Numerical study of novel drag reduction techniques for hypersonic blunt bodies," AIAA Journal, vol. 49, no. 9, pp. 1871–1882, 2011.

[13] T J Prasanna Kumar, S Koteswara Rao, S Durga Prasad, Md Faisal, P Anil, "Design Optimization of Can Type Combustor" International Journal of Engineering Research & Technology Vol. 5, no.11, e-ISSN: 2278-0181