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Thermal Analysis of Hatchback Car Roof to control Heat Formation

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Abstract-Thermal comfort is the prime focus of the present work. Simulations are carried over external surface of car roof to determine the Heat Transfer Rate by means of virtual environment with the help of commercial tool. The use of computer software make it possible in time. Numerical methods are employed on three-dimensional vehicle Roof. The present work is carried using the ANSYS and the equations governing Heat flow combined with Cenosphere- magnesium- Cenosphere & Cenosphere-Nimonic-Cenosphere, this three material layer vehicle roof solved by using the appropriate boundary conditions and considering environmental conditions, Few design modifications are made in the form of attachable accessories which have been resulted in reduction of the Heat Transfer. These modification have shown a Heat Transfer Reduction of 40% at a temperature of 50. °C, automatically reducing the work of Air Conditioners allotted to consumes fuels and CO_2 emissions also decreases.

Index Terms- "Automotive Design of Vehicle roof", "Thermal comfort in vehicle cabin"

1. INTRODUCTION

The entire automobile industry is under considerable pressure on increasing customer demands in terms of safety, luxuriousness and performance. The trends lead to fully equipped cars in all classes getting more luxurious and comfortable. At present even small cars often have air conditioning as standard fittings to reduce the temperature in inner body of the car. For that the thermal heat conduction from outside should be minimized. More over we cannot increase the size of the outer car body which results in increasing the weight leads to low performance. Also customer pays increasingly more attention to occupant safety calling for stronger rigid bodies. [1]

Vehicle body weight can be reduced and also the temperature can be reduced by the use of multi-materials structure without increasing the cost. Various light weight automotive bodies have been developed using high strength steels, aluminium alloys. These special materials can provide light weight car bodies. However the high price of these special materials has been one of the main barriers to replace steel. Compare to this materials nimonic 115 having more strength, light weight and low thermal conductivity. Because the increasing number of automobiles has led to various societal and environmental concerns, such as fuel efficiency, emission and global warming. The automobile industry is under considerable pressure to reduce fuel consumption and the emissions of their vehicles.Redusing the weight of the vehicle is one key approach to achieving fuel efficiency, since every 56.69 kg weight reduction results in a gain of 0.09-0.21 km per litre fuel economy. [2]

2. METHODOLOGY

2.1. ***DESIGN IN CATIA:***The fundamental basis for almost all Heat Transfer problems is the Conduction ,Convection, Radiation equations, which define any Steady State Heat Transfer Rate. Theory of thermal behavior in presence of insulating material is studied in this research paper, use of FEM theory with the help of Ansys tool, before that initial design model of Hatchback vehicle roof is mase in Catia software.

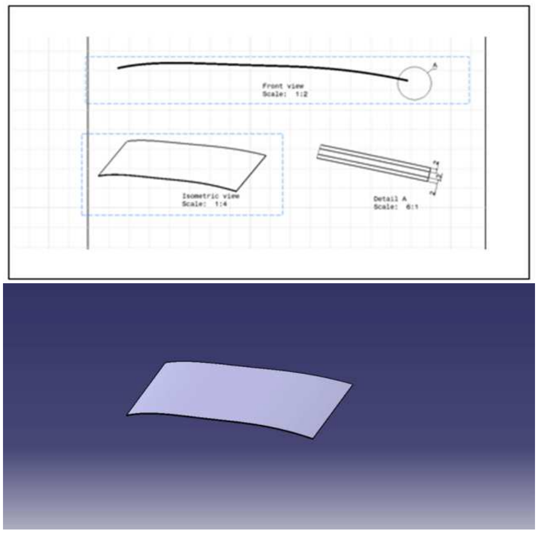


Fig.1Geometrical model of Car Roof in CATIA

CATIA (Computer Aided Three-dimensional Interactive Application) is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Dassault system. The model is designed using catia v5 software. Here taken for analysis one model of roof which contain average dimension of hatchback type body. The average are shown in figure which contain 3 layers, on mid portion the main material and its surrounded by coating materials.

2.2. *Material*

2.2.1 Cenospheres:

Cenospheres are hollow alumino-silicate microspheres from fly ash of power stations; these are valuable industrial product and can be used at creation of functional materials, including filled composites on the basis of inorganic and organic binders. The main preference to use cenospheres as a filler or reinforcement in metal and polymer matrices is that cenospheres is a by-product of coal combustion, available in very large quantities at very low costs. Currently the use of manufactured glass micro spheres has limited applications due mainly to their high cost of production. Therefore, the material costs of composites can be reduced significantly by incorporating cenospheres into the matrices of polymers and metallic alloys. In general, Cenosphere is made up of four main constituents: SiO2, Al2O3, Fe2O3 and CaO.

The advantages of using Cenospheres are given as,

1. Cenosphere has a lower density than calcium carbonate and slightly higher than hollow glass. The cost of cenosphere is likely to be much lower than hollow glass. Cenosphere will turn out to be one of the lower cost fillers in terms of the cost per volume.
2. Cenospheres as a filler in Al casting reduces cost, decreases density and increase hardness, stiffness, wear and abrasion resistance. It also improves the maintability, damping capacity, coefficient of friction etc, which are needed in various industries like automotives, aeronautics, etc.
3. The high electrical resistivity, low thermal conductivity and low thermal density of cenospheres may be helpful for making a light weight insulating composite. [3]

2.2.2 Nimonic

Nimonic is a registered trademark of Special Metals Corporation that refers to a family of nickel-based high-temperature low creep super alloys. Nimonic alloys typically consist of more than 50% nickel and 20% chromium with additives such as titanium and aluminium. The main use is in gas turbine components and extremely high performance reciprocating internal combustion engines. The Nimonic family of alloys was first developed in the 1940s by research teams at the Wiggin Works in Hereford, England, in support of the development of the Whittle jet engine. [4]

2.2.3 Magnesium alloy

Magnesium alloys are mixtures of magnesium with other metals (called an alloy), often aluminium, zinc, manganese, silicon, copper, rare earths andzirconium. Magnesium is the lightest structural metal. Magnesium alloys have a hexagonal lattice structure, which affects the fundamental properties of these alloys. Plastic deformation of the hexagonal lattice is more complicated than in cubic latticed metals like aluminum, copper and steel. Therefore magnesium alloys are typically used as cast alloys, but research of wrought alloys has been more extensive since 2003. Cast magnesium alloys are used for many components of modern cars, and magnesium block engines have been used in some high-performance vehicles; die-cast magnesium is also used for camera bodies and components in lenses. [3]

3. IMPLEMENTATION

3.1.1 Geometrical Details and Discretization

The domain was discretized using Ansys Software.The mesh type was tetrahedral with at otalof 648tetrahedral elements. The solution was calculated using fine mesh resulting in 4995 nodes as shownin fig2. Analysis was made using ANSYS V13 subjected boundary conditions. Later the profile was modified from the current profile of Vehicle Roof using software to improve aerodynamic properties of the vehicle roof.

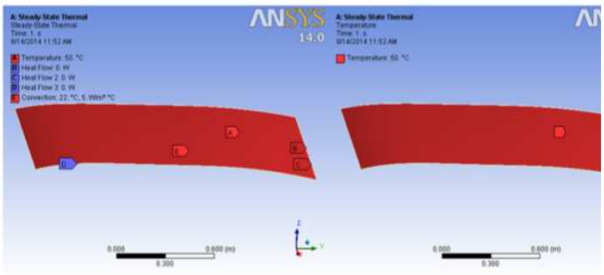
3.1.2 Numerical simulation

In design of vehicle Roof to reduce the heat transfer rate, an understanding of Thermal behaviour is critical which is based on conduction, convection & radiation phenomenon. Armed with this knowledge, materials with lowest thermal conductivities can be used to reduced the heat transfer rate .This information may be obtained experimentally, analytically or numerically. Later this method of analysis was used in different segments of cars to optimize the design, so that, improvement in the fuel-efficiency and other performance parameters was achieved. The core concentration is reducing temperature distribution over roof by using different coating material which contain low thermal conductivity, and hereby taken two main material and four coating material, by considering maximum atmospheric temperature during summer 50*C as temperature input on top of roof, and the roof is surrounded by air which convection property given as input. The environmental Temperature was specified as at 50°C & Steady state Thermal analysis model was imposed.[9]

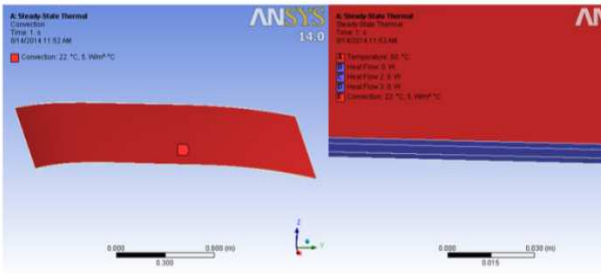
Table1 Boundary conditions:

Boundary	Boundary conditions
Car surface	Free Slip Wall
Inlet	Default Temperature
Outlet	Ambient Temperature
Side walls	Free Slip Wall
Top and bottom surfaces	Free Slip Wall

BOUNDARY CONDITIONS

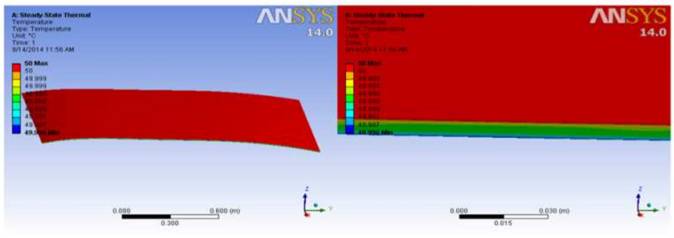


A) OVERALL INPUTS **B) TEMPERATURE INPUT**

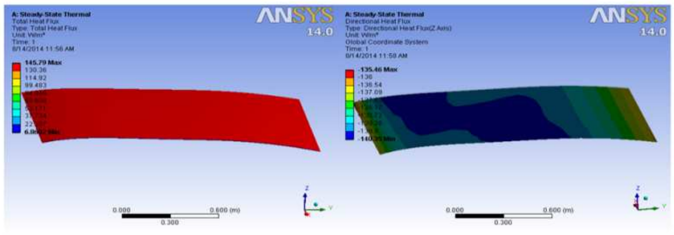


C) CONVECTION **D) INSULATION**

RESULTS FOR FULL MAGNESIUM ALLOY



A) TEMPERATURE DISTRIBUTION **B) CROSS SECTION**



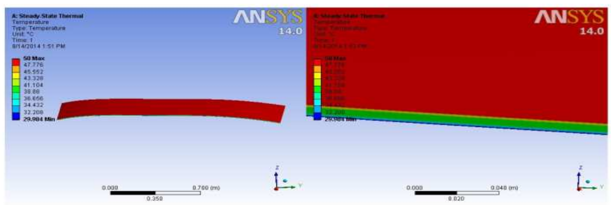
C) HEAT FLUX **D) DIRECTION HEAT FLUX ON Z AXIS**

Cenosphere-Nimonic-Cenosphere
Material Data

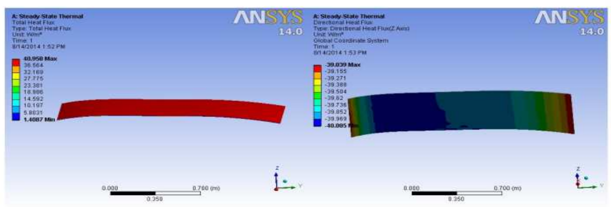
TABLE 5: Nimonic

Thermal Conductivity	10.6 W m^-1 C^-1

RESULTS FOR NIMONIC ALLOY WITH CENOSPHERE COATING



A) TEMPERATURE DISTRIBUTION **B) CROSS SECTION**



C) HEAT FLUX **D) DIRECTION HEAT FLUX ON Z AXIS**

3.1.3 Improvisation

The various material design modifications that we reanalyzed and are detailed in following sections with two approaches of design modifications at the rear end of the model.

Cenosphere-Magneicium-Cenosphere
Material Data

Cenosphere

TABLE 2

Thermal Conductivity	8.e-003 W m^-1 C^-1

Magnesium

TABLE 3

Thermal Conductivity	171 W m^-1 C^-1
Density	1746 kg m^-3
Specific Heat	1013 J kg^-1 C^-1

An Cenosphere -Magnesium- Cenosphere vehicle roof reduces the temperature by 20.02^{o}c. A well-designed vehicle roof will keep the steady temperature transfer rate

4. RESULT & DISCUSSION

Layer 1	Layer 2	Outside temp.	Inside temp.	temp. diff.
MAGNISIUM	CENOSPHER E	50	29.98	20.02
NIMMONIC	CENOSPHER E	50	29.90	20.10

Here we taken two sets of materials, the current one which is used for all automobile body roof material is magnesium alloy. But it has low thermal resistance by comparing nimmonic, and cenosphere material The difference between maximum and minimum temperature distribution for magnesium alloy is 0.004. it is too low reduction in the roof. we need effective value in temperature reduction. Magnesium alloy with cenosphere coating and Nimmonic alloy with cenosphere are 20.02 & 20.10 respectively. From the above values it concludes Magnesium alloy with cenosphere coating and Nimmonic alloy with cenosphere coating is effective in temperature reduction. So these two coatings are preferable to analyze in the next phase as structural analyze

5. CONCLUSION

The main objective is to design a new material for car outer body and to find novel ways to reduce the heat conduction between the surrounding and car cabin.
The material which is found has a unit properties like low weight to volume, high strength compared to conventional materials, Check the performance of the material for its efficiency and analysis the heat flow through the newly designed material. In future it can be adopted for various types of automobiles bodies and other parts.

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