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Paper Authors

***B. MAHESH, **A. RADHA KRISHNA.**

* DVR College of Engineering and Technology.

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MODELLING AND THERMAL ANALYSIS OF CERAMIC COATING HEAT SHIELDING SYSTEMS IN AUTOMOBILE VEHICLES

***B. MAHESH, **A. RADHA KRISHNA**

PG Scholar (thermal engineering), DVR College of Engineering and Technology, Hyderabad.

HOD Dept of MECH, DVR College of Engineering and Technology, Hyderabad.

ABSTRACT:

A heat shield is designed to shield a substance from absorbing excessive heat from an outside source by dissipating, reflecting or simply absorbing the heat. Due to the large amounts of heat given off by internal combustion engines, heat shields are used on most engines to protect components and bodywork from heat damage. As well as protection, effective heat shields can give a performance benefit by reducing the under-bonnet temperatures, therefore reducing the intake temperature. Heat shielding is necessary to prevent engine heat from damaging heat-sensitive components. The majority of older cars use simple steel heat shielding to reduce thermal radiation and convection. It is now most common for modern cars are to use aluminium heat shielding which has a lower density, can be easily formed and does not corrode in the same way as steel. Higher performance vehicles are beginning to use ceramic heat shielding as this can withstand far higher temperatures as well as further reductions in heat transfer. In this study, firstly, thermal analysis done on engine protect Heat shielding system, made of aluminium silicon alloy and steel alloys and MgO–ZrO2 material. the results of Heat shielding systems materials are compared with each other. The effects of materials on the thermal behaviours of the Heat shielding systems are done. It has been shown that the maximum and min temperature of the Heat shielding systems. Temperatures, radiation, convection, Thermal analysis done by the ansys software. Model Design done by the catia software.

Keywords: heat shielding system design, Temperature, Thermal analysis, aluminium silicon alloy, steel alloys, MgO–ZrO2 materials, ansys.

1. INTRODUCTION

1.1 Heat shield

A heat shield is designed to shield a substance from absorbing excessive heat from an outside source by dissipating, reflecting or simply absorbing the heat. It is often used as a form of exhaust heat management. Due to the large amounts of heat given off by internal combustion engines, heat shields are used on most engines to protect components and bodywork from heat damage. As well as protection, effective heat shields can give a performance benefit by reducing the under-bonnet temperatures, therefore reducing the intake temperature. Heat shields vary widely in price, but most are easy to fit, usually by stainless steel clips or high temperature tape. There are two main types of automotive heat shield: The rigid heat shield has, until recently, been made from solid steel, but is now often made from aluminium. Some high-end rigid heat shields are made out of aluminium sheet or other composites, with a ceramic thermal barrier coating to improve the heat insulation. The flexible heat shield is normally made from thin aluminium sheeting, sold either flat or in a roll, and is bent by hand, by the fitter. High performance flexible heat shields sometimes include extras, such as ceramic insulation applied via plasma spraying. These latest products are commonplace in top-end motorsports such as Formula -1 car.Textile heat shields used for various components such as the exhaust, turbo, DPF, or other exhaust component. As a result, a heat shield is often fitted by both amateur and professional personnel during a phase of engine tuning. Heat shields are also used to cool engine mount vents. When a vehicle is at higher speed there is enough ram air to cool the under hood engine compartment, but when the vehicle is moving at lower speeds or climbing a gradient there is a need of insulating the engine heat to get transferred to other parts around it, e.g. Engine Mounts. With the help of proper thermal analysis and use of heat shields, the engine mount vents can be optimized for the best performances. The management of heat is becoming complex with the growing number of temperature-sensitive and sophisticated components in modern vehicles that have to be protected from heat. The demand of heat shielding technology has been increasing along with the number of applications in automotive industry. Minimal cooling air flows, tightly packed components, engine encapsulation, exhaust gas turbochargers and catalytic converter technology result in high temperatures within the area of the underbody, in the engine compartment and across the exhaust system. Heat shielding systems help engine and exhaust systems to function safely and reliably and contribute to enhanced driving comfort and environmental protection..

1.2 Problem statement

To absorb the excessive heat from an outside source by either dissipating, reflecting the heat. It is often used as a form of exhaust heat management. Due to the large amounts of heat given off by internal combustion engines, heat shields are used on most engines to protect components and bodywork from heat damage.

Heat shields are planned to shield a section from holding excess high temperature either by scattering, reflecting basically holding the hotness. In an auto controlled by an inward smoldering engine, the exhaust system from the engine ventilation framework to the tailpipe is the best creator of hotness after the engine itself The surfaces of the parts that truly pass on the exhaust gasses can attain to temperatures up to around 900°C. Since drains frequently pass close essential (and thermally sensitive) sections, it is especially basic to shield the fragile parts and modules from high temperature sprinkle, moreover to neutralize neighborhood overheating

1.3 Objective

To protect components and bodywork from heat damage. As well as protection, effective heat shields can give a performance benefit by reducing the under-bonnet temperatures, therefore reducing the intake temperature. Design done by catia software and Analysis done by Ansys.

1.4 Types of Heat Shields

• Single shell heat shields: Single shell hotness shields are utilized for insurance against high temperature wellsprings of generally low temperature, particularly when there is sufficient accessible space.

• Double shell heat shields: These hotness shields made of two aluminum sheets are utilized for moderate temperatures and restricted bundle confinements. For single and twofold shell high temperature shields, aluminum sheets of 0.3 - 1.0 mm thickness are utilized. The sheets may be likewise embellished for expanded firmness.

• Sandwich heat shields: For security against the most astounding temperatures and in instances of serious space constraints, hotness shields in sandwich plans are being utilized. Sandwich hotness shields typically comprise of a solitary transporter sheet (0.3 - 1.0 mm thick aluminum), a protecting center and a cover .The installation of a heat shield is one of the most widely used heat management option due to its cost-effectiveness and ease to fit. In the past, heat shields have usually been made out of aluminized steel. However, nowadays aluminum sheets and foils are generally used, often combined with ceramic thermal barrier coatings or mats of insulating materials.

CHAPTER – 2

LITERATURE REVIEW:

1.Durat et al. (2014)[1] carried out CFD and experimental analysis on thermal performance of exhaust system of a spark ignition engine. An experimental study was carried out to compare the CFD and heat transfer analysis of gas flow in the exhaust pipe. In the experiments the temperatures at inlet and outlet of the exhaust pipe were measured and the study 3-D transient CFD analysis has been performed for the whole exhaust pipe. The results in CFD analysis was in good agreement with those of experimental data. Also, an optimum catalyst location was determined by the CFD analysis performed in transient regime.

2.Ghazikhani et al. (2014)[2] have been researched the exergy recovery from a Direct injection diesel engine. Investigation performed for turbocharged diesel engine at various engine speeds and torques. For this, a double pipe heat exchanger with counter current flow is used in the exhaust of engine. As an important outcome, by increasing the load and engine speed, the recovered exergy increased. The reduction of brake specific fuel consumption (bsfc) due to the use of recovered exergy from exhaust has also been studied in the study. The results show that by using recovered exergy, bsfc decreased approximately 10%.

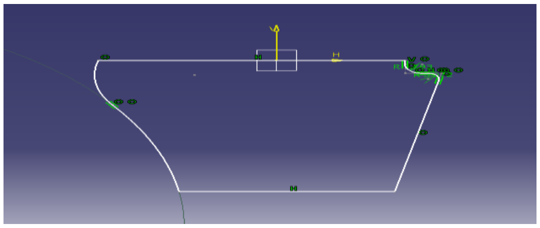
3.Liu et al. (2014)[6] studied the compatibility of automotive exhaust thermoelectric generation system, catalytic converter and muffler. The research work tried to vary the installation position of thermoelectric generator and proposed three different locations. They identified the three positions for installation of thermoelectric generator as (i) location at the end of exhaust system (ii) location between catalytic converter and muffler and (iii) location at upstream of catalytic converter and muffler. Simulation and experiment were developed to compare thermal uniformity and pressure drop characteristics over the three operating cases. From the simulation and experiment, heat exchanger in case (ii) location between catalytic converter and muffler obtained more uniform flow distribution, higher surface temperature and lower back pressure than in other cases.

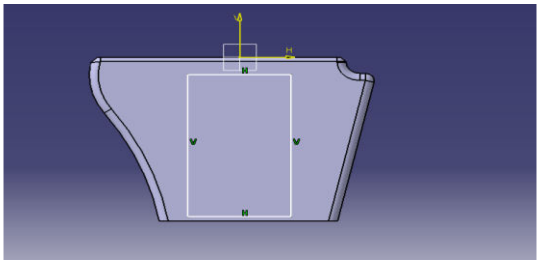
4.Dattatray et al. (2013)[1] studied the thermal analysis for motor bike exhaust silencer for ensuring reduction in hot spot through design improvement. They design the silencer made with hot spot reduction and made improvement in the life of the components of exhaust system. They used high temperature heat resistance powder coating for mufflers of automobile application with enhanced aqueous corrosion, high temperature corrosion . which started from the generation of the hot spotfront end of muffler.

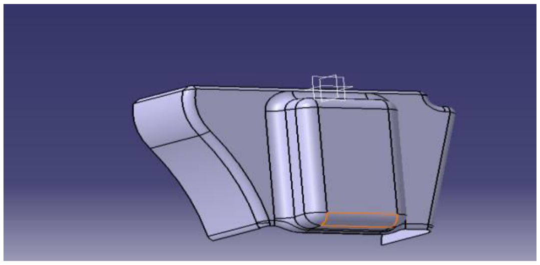
Chapter3

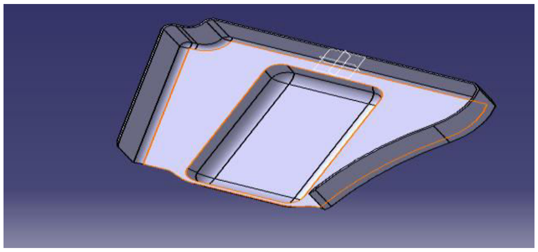
3.1 DESIGN:

CATIA offers a solution to shape design, styling, surfacing workflow and visualization to create, modify, and validate complex innovative shapes from industrial design to Class-A surfacing with the ICEM surfacing technologies. CATIA supports multiple stages of product design whether started from scratch or from 2D sketches. CATIA is able to read and produce STEP format files for reverse engineering and surface reuse









4 Ansys:

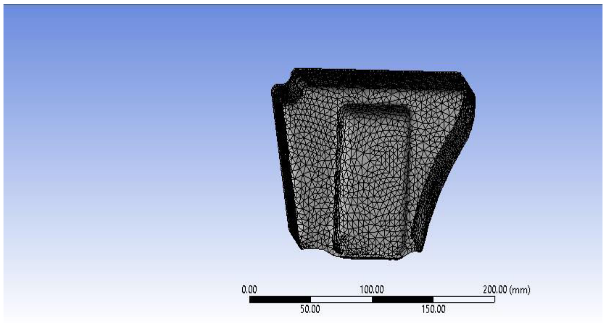
ANSYS is general-purpose finite element analysis software, which enables engineers to perform the following tasks:

1. Build computer models or transfer CAD model of structures, products, components or systems
2. Apply operating loads or other design performance conditions.
3. Study the physical responses such as stress levels, temperatures distributions or the impact of electromagnetic fields.
4. Optimize a design early in the development process to reduce production costs.

5. A typical ANSYS analysis has three distinct steps.

6. Pre Processor (Build the Model).

Mash:



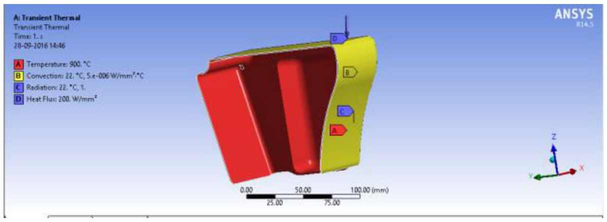
Transient Thermal:

The ANSYS/Mechanical, ANSYS/FLOTRAN, and ANSYS/Thermal products support steady-state thermal analysis. A steady-state thermal analysis calculates the effects of steady thermal loads on a system or component. Engineer/analysts often perform a steady-state analysis before doing a transient thermal analysis, to help establish initial conditions. A transient analysis also can be the last step of a transient thermal analysis, performed after all transient effects have diminished.You can use steady-state thermal analysis to determine temperatures, thermal gradients, heat flow rates, and heat fluxes in an object that are caused by thermal loads that do not vary over time. Such loads include the following:

- Convections
- Radiation
- Heat flow rates
- Heat fluxes (heat flow per unit area)
- Heat generation rates (heat flow per unit volume)
- Constant temperature boundaries.

A steady-state thermal analysis may be either linear, with constant material properties; or nonlinear, with material properties that depend on temperature. The thermal properties of most material do vary with temperature, so the analysis usually is nonlinear. Including radiation effects also makes the analysis nonlinear.

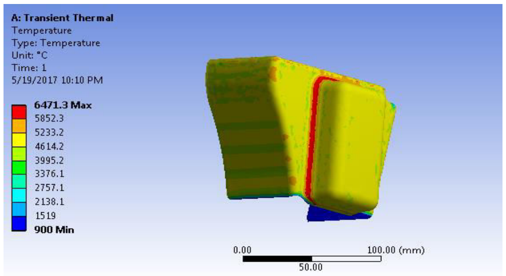
Loads:



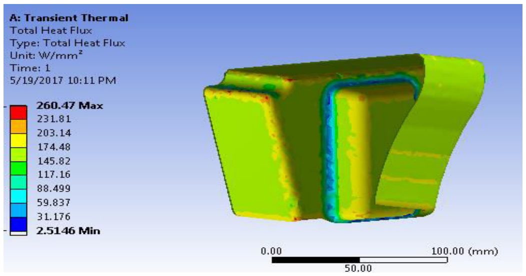
Material Data of steel(1008)

Thermal Conductivity	4.5e-002 W mm^-1 C^-1
Density	7.872e-006 kg mm^-3
Specific Heat	4.81e+005 mJ kg^-1 C^-1

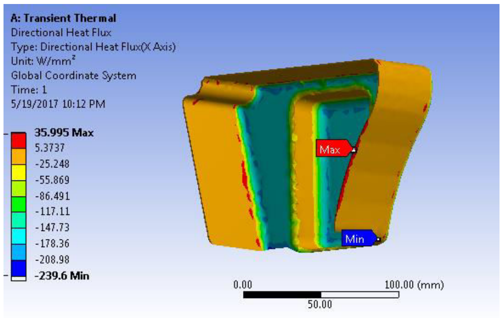
Temperature



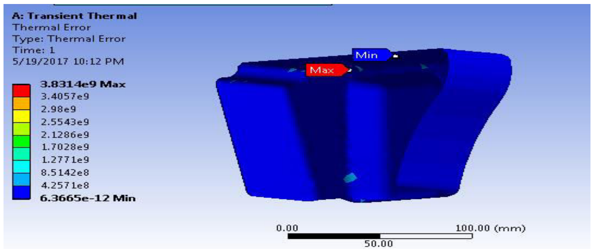
Total Heat Flux



Directional Heat Flux



Thermal Error

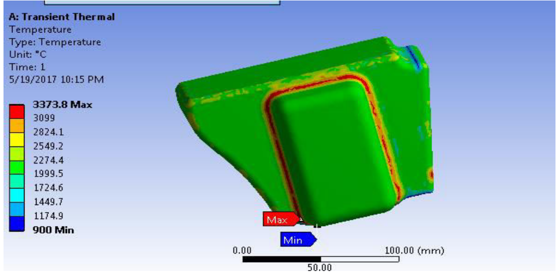


Object Name	Temperature	Total Heat Flux	Directional Heat Flux	Thermal Error
Minimum	900. °C	2.5146 W/mm²	-239.6 W/mm²	6.3665e-012
Maximum	6471.3 °C	260.47 W/mm²	35.995 W/mm²	3.8314e+009

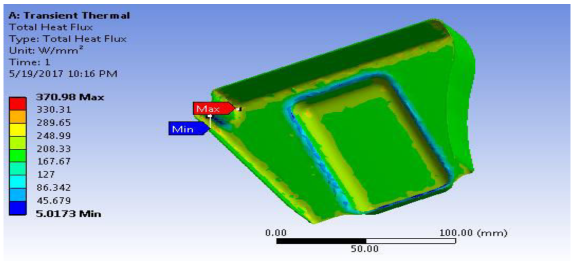
Material Data of aluminium alloy

Density	2.77e-006 kg mm^-3
Coefficient of Thermal Expansion	2.3e-005 C^-1
Specific Heat	8.75e+005 mJ kg^-1 C^-1

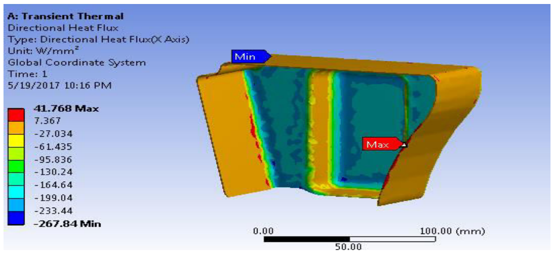
Temperature



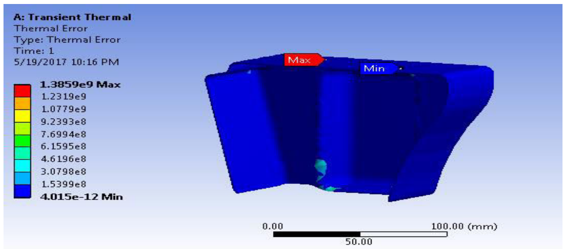
Total Heat Flux



Directional Heat Flux



Thermal Error

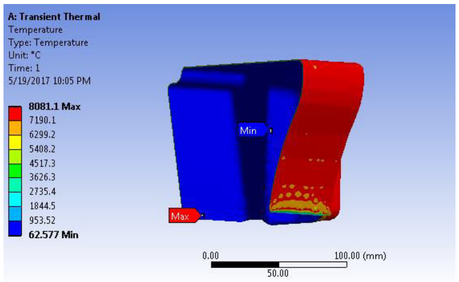


Object Name	*Temperature*	*Total Heat Flux*	*Directional Heat Flux*	*Thermal Error*
Minimum	900. °C	5.0173 W/mm²	-267.84 W/mm²	4.015e-012
Maximum	3373.8 °C	370.98 W/mm²	41.768 W/mm²	1.3859e+009

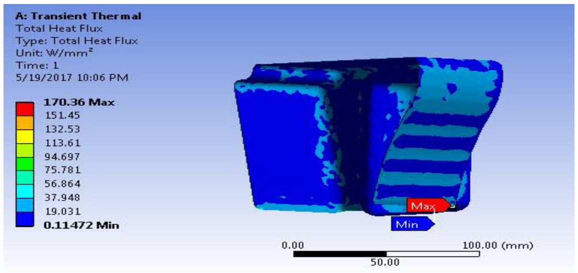
Material Data of zirconium

Density	5.7e-006 kg mm^-3
Thermal Conductivity	3.e-003 W mm^-1 C^-1
Specific Heat	9.e+005 mJ kg^-1 C^-1

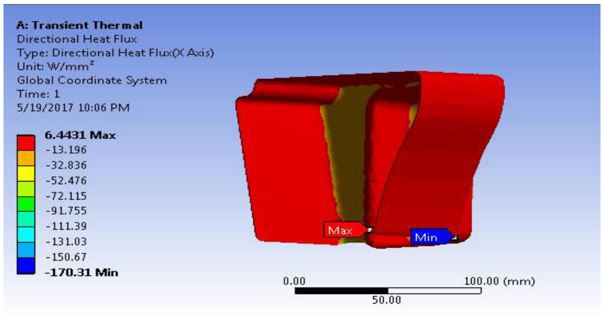
Temperature



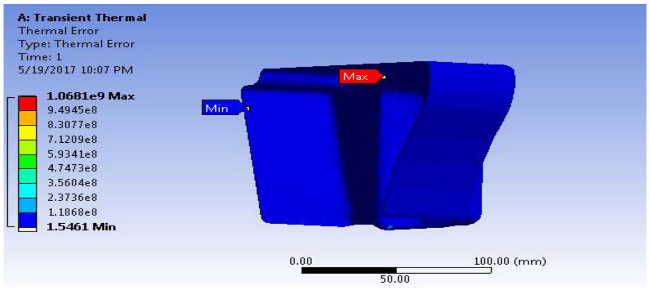
Total Heat Flux



Directional Heat Flux



Thermal Error



Object Name	Temperature	Total Heat Flux	Directional Heat Flux	Thermal Error
Minimum	62.577 °C	0.11472 W/mm^2	-170.31 W/mm^2	1.5461
Maximum	8081.1 °C	170.36 W/mm^2	6.4431 W/mm^2	1.0681e+009

Conclusion:

By observing the above results are obtained from thermal analysis of engine exhaust heat shield using high thermal conductivity and good thermal behaviour of materials like STEEL 1008, Aluminium alloy, Zirconium

- From above results observing high temperature obtained zirconium 8081.1 °C lowest materials is Aluminium alloy 3373.8 °C
- Highest Maximum heat flux obtained Aluminium alloy 370.98 W/mm^2 and lowest is zirconium 170.36 W/mm^2
- Lowest thermal error occurring materials zirconium 1.0681e+009 and highest values is steel 1008 3.8314e+009

Future scope

Today, heat protection (or thermal management) is not seen anymore as an isolated issue. In a total system approach, the applied heat shields are increasingly integrated into multifunctional components. Aluminium alloy, zirconium, steel alloy heat shields will be more and more integrated into innovative solutions for: Engine encapsulations to reduce fuel consumption and polluting emissions while treating noise at its source

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