ISSN 2348 – 7968

“Numerical and Experimental Investigation on Thermal Behavior of Exhaust Heat Shield”

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ABSTRACT

Large amount of heat given off by internal combustion engines, heat shields are used on most of the automotives to protect components and bodywork from heat damage as well as protection from high temperature to the surrounding beings. Typically heat shields are made of solid steel and aluminum, recent introduction composite are also introduced as heat shield, but it totally depends on the application. In this project the three main concepts of heat transfer, i.e. conduction, convection and radiation is used to find the heat transfer happening in the exhaust heat shield. An attempt to optimization is made. The Project mainly focuses on thermal behavior of the exhaust heat shield

Thermal Analysis will be carried out with the boundary condition fora realistic working condition, Experimental test is carried out by using the prototype for a prescribed condition (more than room temperature) and the same thing is simulated by using the simulation software.

***Keywords* -** Catia, Hyper mesh, Nastran/Abaqus.

I. INTRODUCTION

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 passes 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.

A block that keeps the substance from immersing high temperature imperativeness from an outside source by holding and scrambling or essentially mirroring that hotness. High temperature shields are typically used to shield parts of a contraption from hotness delivered by its essentialness source, as in detaching the hotel of an auto from its motor. Various space contraption diffuse high temperature made by disintegration with the atmosphere upon reentry using hotness shields that diminish and vaporize, scattering the essentialness go into the air [2].

A high temperature shield is planned to shield some bit of supplies from holding excessive hotness from an outside source by either scattering, reflecting or basically fascinating the hotness [3].

Three vital physical properties choose how well high temperature shields limit: reflectivity, emissivity, and conductivity. High temperature shields work fundamentally by reflecting hotness plummeting and a long way from (or go into) the exhaust structure [4].

1.1 Objective of the Paper

The prime objectives of the project are,

• To check the dynamic stability of the heat shield
• To check heat transfer in the heat shield
• To demonstrate the heat transfer in the heat shield by building a small prototype.

 Dynamic Stability:

The dynamic stability is found by analyzing the component, by conducting modal analysis in FEM package.

II. Design of Heat shields

- A high temperature shield is intended to shield some piece of supplies from retaining unnecessary hotness from an outside source by scattering, reflecting or just engrossing the hotness.

- Hotness shields are intended to shield a segment from engrossing inordinate high temperature either by dispersing, reflecting or basically retaining the high temperature. In an auto fueled by an inward burning motor, the fumes framework from the motor ventilation system to the tailpipe is the greatest maker of hotness after the motor itself.
- The surfaces of the parts that really convey the fumes gasses can achieve temperatures up to around 900°C. Since depletes regularly pass close essential (and thermally touchy) segments, it is particularly critical to shield the delicate parts and modules from hotness douse, additionally to forestall nearby overheating of the auto body.

There are three 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 (0.03 to 0.1 mm aluminum foil or 0.2 to 0.5 mm aluminum sheet).

2.1 Design criteria

Based on what condition the heat shields are designed will be the first question arises in the mind of the designer. Below shown figure 2.1 gives the complete overview on The design criteria used to design the heat shield.

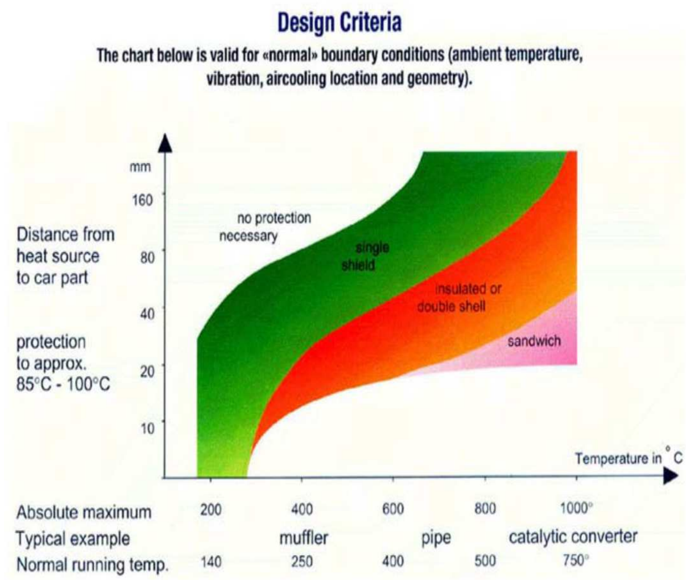

Fig2.1: Design criteria for heat shield.

2.2 Material selection

The physical properties of aluminum - reflectivity and emissivity, warm conductivity and particular hotness limit - make it to the perfect material for the manufacture of high temperature shields.

- The high reflectivity and low emissivity of the aluminum surface (actually when secured with the regular aluminum oxide film) guarantee that aluminum both assimilates and re-discharges minimal infrared radiation.
- The high warm conductivity of aluminum guarantees that hotness is immediately directed far from potential problem areas in the hotness shield.
- Aluminum has additionally a high particular hotness limit. This implies that the temperature increment in the wake of retaining a given measure of hotness vitality is lower than for some different materials.
- Aluminum sheets and foils are appropriate to fulfill the different assembling and administration necessities of auto high temperature shields. A most critical necessity is a decent formability keeping in mind the end goal to meet the amazing bundle confinements. Hotness shields need to cover the hot segment the extent that this would be possible and as close as could be allowed.
- An alternate critical prerequisite is a great erosion safety. Mugginess and lifted temperatures, pertinent natural variables for hotness shields, emphatically advance consumption impacts. Furthermore, most of the hotness shields are straight forwardly presented to tainting street.

ISSN 2348 – 7968

III. RESULTS AND DISCUSSION.

- Modal Analysis Results
- Heat Transfer Results

Modal analysis, simulation performed at hot condition.

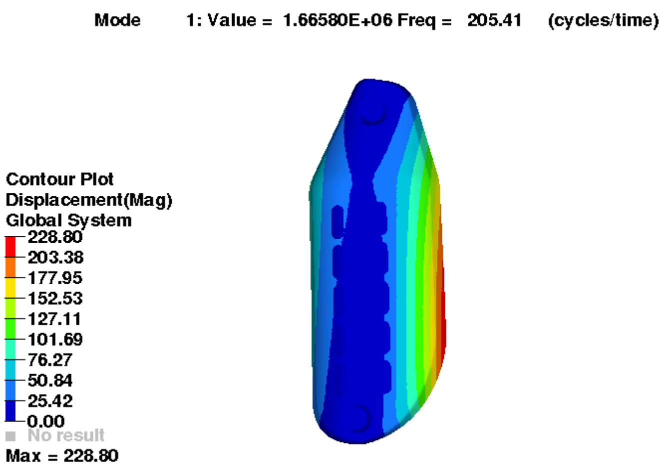

Fig 3.1: Temperature distribution in the heat shield at first mode.

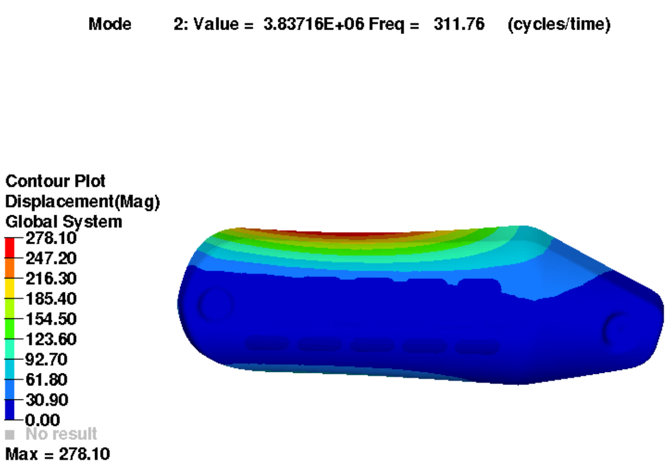

Fig 3.2: Temperature distribution in the heat shield at second mode.

- From the figures 3.11 to 3.2 its shows that the temperature distribution in the heat shield for conduction, convection & radiation and mention there different views. We can see the natural frequency variation from mode 1 to mode 2.

Heat transfer results

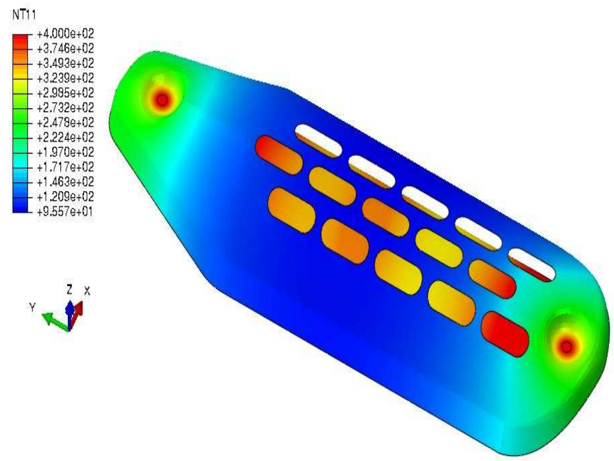

Fig 3.3: First position.

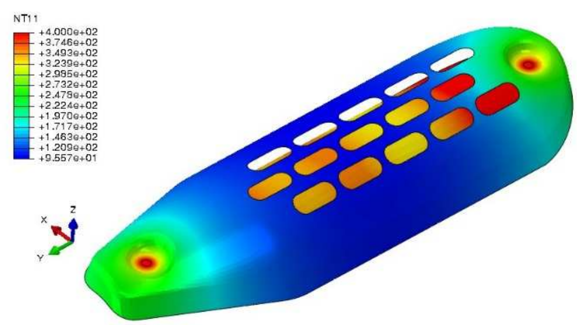

Fig 3.4: Second position

- For the above design heat transfer analysis by considering conduction, convection and radiation and also modal analysis are done to check the structural stability and also thermal stability of the design.
- Modal analysis is performed to check the Eigen vector and Eigen shape. In simple terms to find the mode shape and mode value. Mainly modal analysis is done to check the natural frequency of the component. So that the natural frequency of this component should not match with the any of the component in the system including engine to any other component in the system.

The first three natural frequency of the heat shield is 205.41 Hz, 311.46 Hz, and 373.13 Hz, any component within first three natural frequencies will be failed, so care should be taken the engine frequency or any other component frequency should not match with the heat shield natural frequencies. If at all if it matches the heat shield design to be changed and should assure either natural frequency is less or beyond the natural frequency of any other component.

Heat Transfer Analysis

- There are three modes of heat transfer conduction, convection and radiation. As heat shield is mounted around the exhaust line. It undergoes all three modes of heat transfer i.e conduction, convection and radiation. All three modes of heat transfer is considered in the analysis and executed, the temperature we find around heat shield top shell is ranging from 95° to 145 ° C, at bolting location the temperature ranges from 325° to 395° C.

IV. CONCLUSION

- Heat shields are planned to shield a section from holding excessive high temperature either by scattering, reflecting or 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 of the auto body.
- In this project we mainly concentrated on temperature distribution in the Heat shield for various modes of heat transfers i.e. conduction, convection and radiation. The temperature distribution was also shown through the real time prototype demo. The FEM results exhibit the temperature distribution happening in the heat shield. The FEM results were extracted from ABAQUS a very strong tool for FEM. The FEM results are validated through some real time instruments which in turn build the prototype. The dynamic behavior of the component is found by doing Modal analysis. The natural frequency will be safe enough to fit in to automobile assembly.

V. Scope for future work

In this project we mainly concentrated on temperature distribution in the heat shield, The same can be done by replacing the material with other material property, Cavity can be considered for radiation mode of heat transfer, Optimization can be done for better temperature distribution, Beads can be added in the heat shield to improvise the temperature distribution and dynamic stability of the heat shield.

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