# ANALYSIS OF THE HEAT SINK OF A TAIL LAMP USING FINITE ELEMENT METHOD

RAVINDER KHATRI
Department of Mechanical Engineering, Manav Rachna College of Engineering, Faridabad 121007 Haryana INDIA

## ABSTRACT

The automotive industry today requires the change in design, lower cost and advanced features to enhance the demand of an automobile. With the invention of new designs and using the analysis methods the designers today can predict the performance of an automobile. For a tail lamp the thermal analysis has been performed on the heat sink of a tail lamp. A heat sink used in tail lamp functions to dissipate the heat generated due to continuous use of lamp. The analysis has been performed in two steps. A CATIA model of a tail lamp has been generated in the first step which is in a while imported in the HYPERMESH. Later in the analysis meshing is done on the model with the help of HYPERMESHING and after applying boundary conditions the solution report file and graph can be plotted. These report file and graphs helps in detecting the new boundary conditions validation by comparing the graph result with the standard result of 80W street lamp and 56W tail lamp. Hence the validation of the result can be shown via a comparison table.

**Keywords:** Heat sink, Tail lamp, Meshing, Finite element method, CATIA.

## 1 INTRODUCTION

With the growth of the economy the demand for new innovative products within the desired cost brackets has increased tremendously as customers these days look for higher aesthetic values along with the required functionality, which have made the manufacturers to come up not only with new designs faster but also with more design variants as this is possible only if new designs can be created faster and analyzed accurately. There are several analysis methodologies proposed by engineers for different applications but we have to find the most suitable method for particular application within the specific boundary conditionsto avoid repetitive work which leads to higher costs and lowers the morale of the designer to innovate new designs as well as their risk taking capability will be hampered. For this we have to develop analysis methods which can help us determine the impact of the change in working conditions, dimensions and other parameters on the product. This paper presents a finite element method (FEM) to analyze the temperature distribution over the heat sink of a tail lamp of the vehicle. For this purpose the thermal stress analysis using FE method has been described. The FE and CAD programs have been used for this analysis. The fem method used for thermal analysis has been performed with the help of Hypermesh software. Since in Hypermesh we could not design the complex geometry of the tail lamp hence the designing work has been done with the help of CATIA software which is designing software. Hypermesh has worked as a preprocessor for the analysis. The preprocessor (Hypermesh) must have the capability to import properly the cad model from the CATIA software with the higher reliability and clean manner. Tetrahedral elements are used for proper 3D meshing. Hypermesh also works as the postprocessor.

In the following section the thermal analysis procedure described in detail. In section 2 the CAD file has been imported into the hypermesh and the various meshing techniques are discussed in this section. 3D tetrahedral mesh has generated from the triangular surface meshing which are applied on different surfaces on heat sink. Loads and boundary conditions are applied in the load collector. Then the model is translated into input file for hypermesh. In section 3 the result of the thermal analysis of the heat sink of a tail lamp has been presented using the postprocessor. The result temperature was compared with the standard results for its validation in section 4. The results and comparison are shown with the help of a table and the conclusion has achieved depending upon this comparison.

## 2 PROBLEM FORMULATION

These days the automotive industry is growing at a rapid rate. This tends to improvement in design as well as decrease in cost which results in requirement of the proper analysis of the designed work. The new design will be more complex as compared to the original. In a tail lamp of a bike basically there are four parts. The lens is bonded with the reflector and the reflector is attached with the heat sink. Lens is also connected to the housing and this housing contains the reflector and heat sink. The reflector is generally made of Acrylonitrile Butadiene Styrene (ABS) and lens is made of Acrylic which is a form of glass. Housing is made of Nylon and heat sink is made up of aluminum. All these parts are shown in fig. 1.

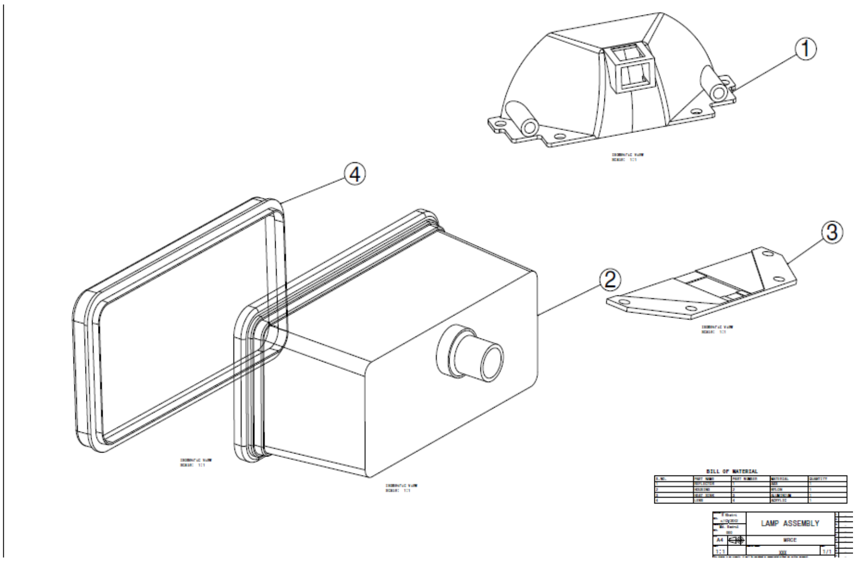


**Figure 1:** Tail lamp geometry for FEA model



## 2.1 Data Preparation

First the analyst has to simplify the geometry and cleanup of the geometry. While the importation of the CAD model into hypermesh some dimensions of the model were missing and some dimensions were overlapping each other. The analyst have to correct all these errors as there is need of proper connectivity of surfaces for proper meshing. Also the analyst has to cleanup the geometry for proper meshing. Also the symmetry check has been performed on the heat sink so as to minimize the analysis time. Unnecessary holes surfaces lines which were out of area of research and have very low impact on meshing has been eliminated for saving time and for quality of meshing. Once geometry simplification has been performed then the major task is of mating the various parts of tail lamp for proper meshing. During designing of a tail lamp the gap between two parts of a tail lamp was provided but during meshing the volume must be enclosed. The CAD file of the CATIA software was converted into the Initial Graphics Exchange Specification (IGES) format and then imported into the hypermesh. After importing the CAD data a surface /Edit/Edge Match is used for geometry simplification and cleanup.

## 2.2 Meshing

Each and every surface of the heat sink is meshed with the triangular elements. These triangular elements converted automatically into tetrahedral meshing when layer by layer mesh has been performed on the heat sink. The analyst has to predict the area where high temperature gradients are expected and a fine mesh is applied to that region and coarse mesh is applied to other surfaces by moving from smaller to larger elements. The element edge length taken is 2 mm. The meshing of the heat sink is shown in fig. 2. Then the equivalence of all nodes has been done. Each and every node must be equivalence. Hypermesh is used for tetrahedral 3D meshing.

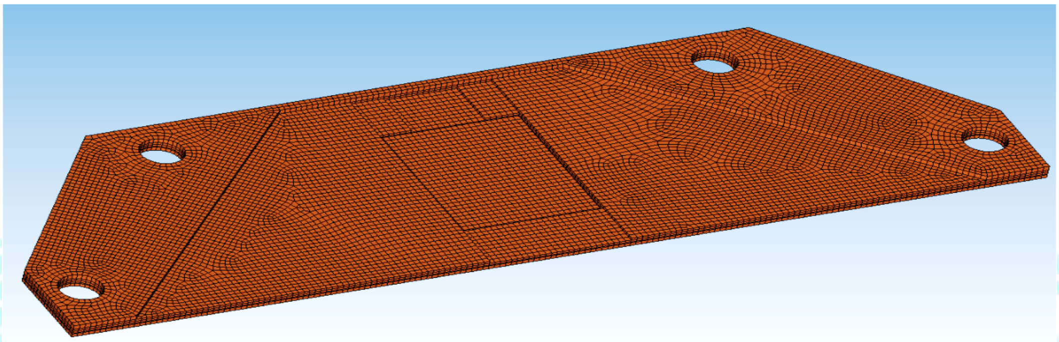

**Figure 2:** Meshing of the heat sink of a tail lamp

## 2.3 Material Properties

The material properties were assigned to different parts of the tail lamp. In hypermesh there are folders which are named as collectors and it contains various parts name material properties of each part and also the load collectors which contains the boundary conditions. The thermal conductivity of each part material are assigned.

## 2.4 Loads and Boundary Conditions

In any finite element problem the boundary conditions must be specified. The boundary conditions are stored in load collector folder in hypermesh and there are various boundary conditions which are as follows:

- Surface temperature difference
- Thermal conductivity of heat sink
- Bulb heat loads

# 3 ANALYSIS

For testing the accuracy of the model the tail lamp was modeled and thermal analysis performed on the heat. The result from the analysis is validated by comparison of result with the experimental data. The first step is to run a thermal analysis for the heat sink. Fig. 3 shows the temperature distribution over the heat sink. The temperature is increasing towards the center of the fixed elements which are surface elements. The temperature is maximum at red colour and minimum at dark blue colour. The maximum temperature observed is 16.1˚C.

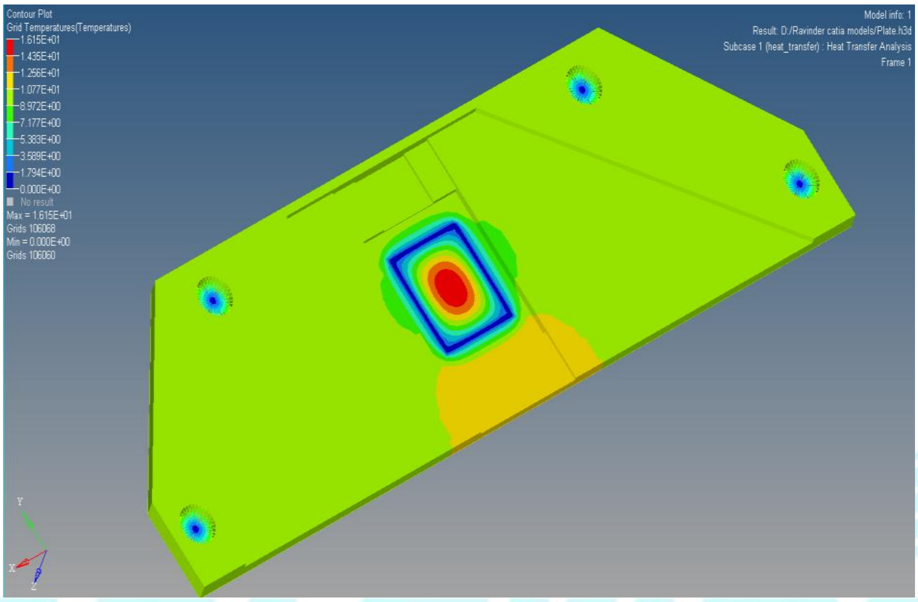


**Figure 3:** Temperature contours in heat sink

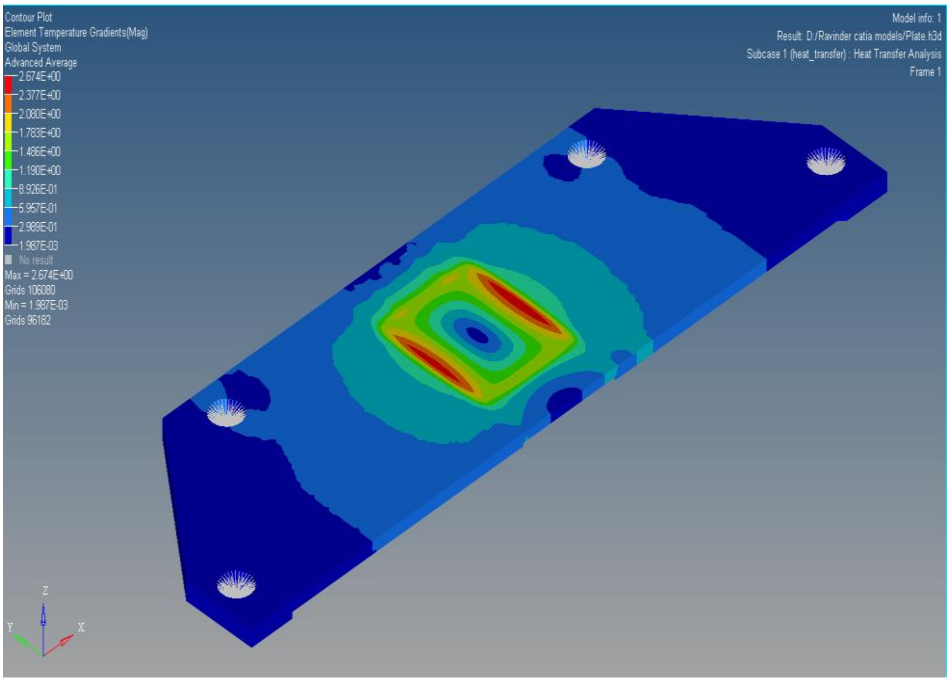


**Figure 4:** Temperature gradient contours in heat sink

The fig. 4 shows temperature gradient contours in heat sink. Here the temperature gradient is minimum at the center of the element flux and the value of temperature gradient is maximum where the thickness in heat sink changes. The value of maximum temperature gradient observed is 2.67˚C.

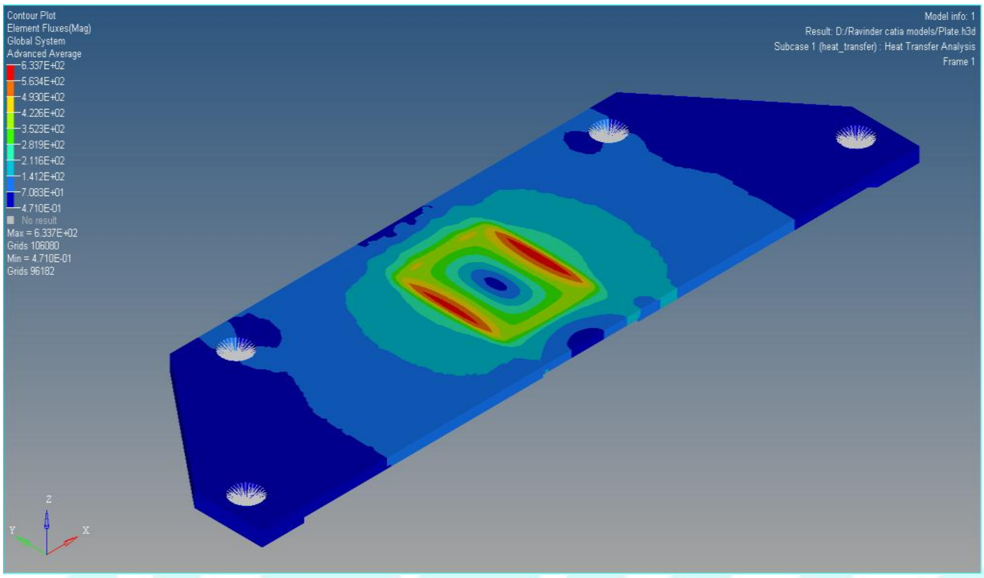


**Figure 5:** Element flux contours in heat sink

Fig. 5 shows element flux contours. The flux is directly proportional to temperature gradient. Hence it follows the same pattern as temperature gradient. The maximum value of heat flux is 633.7 W/mm$^2$.

## 4 RESULT AND DISCUSSION

All the result graphs were generated with the help of hypermesh when the boundary conditions are defined for the finite element method. The load applied in this analysis was 8W as numbers of surface elements are increased and the result will be compared with the standard result of 80W street lamp and 56W street lamp. The comparison table for the results is shown below.

**Table1:** Comparison with street lamp of 80W.

| Sr. No. | Parameters | Experimental Results | FEA Result | Variation |
|---|---|---|---|---|
| 1 | Temperature | 42ºCelsius | 16ºCelsius | 62% |

**Table 2:** Comparison with the 56W tail lamp.

| Sr. No. | Parameters | Experimental Results | FEA Result | Variation |
|---|---|---|---|---|
| 1 | Temperature | 32ºCelcius | 16 ºCelcius | 50% |

## 5 CONCLUSION

- The maximum temperature observed in FE Analysis of the tail lamp is 16.1ºC for the load of 8 W.
- The maximum element temperature gradient is 2.67 ºC/mm.
- The maximum element flux observed is 633.7 $W/mm^2$.
- The results are well in agreement with the similar available experimental results.

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