Steady State Thermal Analysis of Fog Lamp Using Acusolve

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Abstract

This paper deals with the performance study of Steady-State Thermal analysis of FOG LAMP using ALTAIR HYPERWORKS. Preprocessing has been done in HyperMesh and AcuConsole, postprocessing has been done in HyperView. Solving part has been done using AcuSolve, a FEA based general purpose CFD solver by solving three modes of heat transfer viz., CONDUCTION, CONVECTION & RADIATION.

Objective:

The objective is to find the temperature distribution inside the fog lamp, which is responsible for increasing the temperature of the all parts of the lamp. As we know the maximum endurance temperature for the lamp components, and need to verify the sustainability of each part of the lamp by the CFD analysis.

Introduction:

Fog lamp CAD geometry is made for manufacturing, not for analysis, so we need to modify, such a way that we can extract the fluid volumes from the CAD. HyperMesh is the best tool for geometry-cleanup and surface meshing. Challenging work in lamps is to keep it cooler and to make it withstand high temperature condition. Generally, there are two ways to keep lamp cooler, first is by providing vent holes to the lamp, and second is by providing cooling fan and choosing the heat resistant material. In order to analyze fluid flows, flow domains are split into smaller finite number of fluid elements. The governing equations are then discretized and solved on each fluid element. Typically, one of three methods is used to solve the approximate version of the system of equations: finite volumes, finite elements, or finite differences. In the case study here, we have used finite element based CFD solver, AcuSolve.
Process methodology:

1) Meshing:

We have imported geometry into HyperMesh 11.0, after completing geometry cleanup, we have done the surface mesh with TRIA element. Geometry cleanup done on some components of model e.g Bulb holder, reflector etc ... All parts were renamed with respective component names. We need to make our system closed (water-tight geometry). Mesh checks like mesh intersection, duplicate element and penetration were done in HyperMesh and then this surface mesh is exported to AcuConsole using bulk format using CFD user profile. AcuConsole was used to generate volume mesh for all regions except bulb inner volume. A heat flux boundary condition is assigned to bulb surfaces. For capturing the thermal boundary layer of natural convection, boundary layer mesh was created around the bulb surfaces.

2) Physics:

There are different thermal boundary conditions can be assigned to perform conjugate heat transfer problem for lamp. In present study, we are taking physics for our system as mentioned below.

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>PHYSICS PROPERTY</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>BULB</td>
<td>heat flux</td>
<td></td>
</tr>
<tr>
<td>REFLECTOR, LENS, BULB-HOLDER</td>
<td>EMISSIVITY, DENSITY, CONDUCTIVITY, SPECIFIC HEAT</td>
<td></td>
</tr>
<tr>
<td>REFLECTOR, LENS</td>
<td>h</td>
<td>10 W/m²k</td>
</tr>
</tbody>
</table>

To capture outer fluid effect on lamp, we assign heat transfer coefficient values on lens and reflector outer surfaces.

3) Solving and Post Processing:

AcuSolve used for solving the numerical equation and residual visualization has done using AcuProbe. We used HyperView for post processing. Our target is to visualize natural convection inside the fluid region of lamp and the temperature attained by each component.
4) Result:

As per our requirement, we can take out required result from AcuConsole by using 'AcuOut' in AcuConsole the best of this part is, we can take only required solution which can cut our result directory size and we can share only those things which customer demands. Take exported file into HyperView and perform post processing.

Temperature contour plots at different sections are given below:

![Temperature contour plots](image)

*Fig. 1 Temperature contour And Velocity vector Of Inner fluid.*
Fig. 2: Temperature Contour Of reflector and lens.

Max Temp = 432.4 K

Fig. 3: Temperature Contour Of bulb-holder.

Max Temp = 403.4 K
Discussion:

It has been observed that from the temperature contours that simulation temperature of reflector is more than the endurable temperature and rest of the parts have passed the test.

<table>
<thead>
<tr>
<th>Components</th>
<th>Endurable Temperature(k)</th>
<th>Max. Temperature(k)</th>
<th>OK/FAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>REFLECTOR</td>
<td>423</td>
<td>432</td>
<td>FAIL</td>
</tr>
<tr>
<td>BULB HOLDER</td>
<td>423</td>
<td>378</td>
<td>OK</td>
</tr>
<tr>
<td>LENS</td>
<td>413</td>
<td>403</td>
<td>OK</td>
</tr>
</tbody>
</table>

Improvement:

Now we have observed that, inside cooling in the lamp by natural convection is not good. Having only single vent hole, there is only one way for air entry and exit. As we know that hot air is lighter and because of buoyancy effect on fluid, the air will move upward, below mentioned Fig.4 is path line inside the fluid.

As we see from the path line, most of the cold air is trapped down in the lamp, but the bulb is located at the center of the lamp. If we make another vent hole in the lower region i.e. below the bulb, then cold air from outside can easily enter and that sets convection currents, recirculation of air will be far better as compared to present design.
Benefits Summary:

AcuSolve is a fast and accurate CFD solver which does not require time for mesh quality checking as it’s insensitive for mesh topology & mesh quality. AcuConsole is fast powerful tool for volume meshing. With the present success of this project, we are looking forward to use AcuSolve in our different CFD projects.

Future plan:

In the present study, we considered heat transfer to outer air from lamp by assigning heat transfer coefficient. To make our simulation more realistic, we will simulate outer air volume domain around lamp assembly and that will capture natural convection effects with surrounding.

Conclusion:

Since Lens and Housing are walls, the heat transfer across them is more significant. It was also found that the temperature level in some of the common part of the fog lamp was very high, which would lead to sagging and deformation. That’s why the proper cooling of inner parts is main area of focus.

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