PHOENICS Case Study: Electronics
Convective Heat Dissipation within LED Housing

Introduction

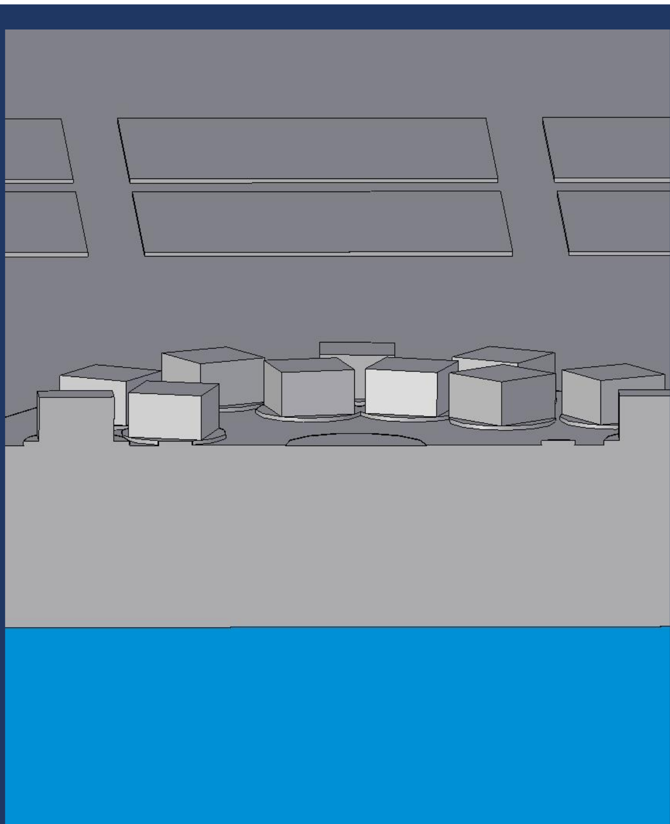
CHAM customer, Stocker Yale, expressed interest in acquiring thermal modelling / analysis software to predict thermals to assist its product design activities. CHAM created an example case to demonstrate the capability of PHOENICS in this capacity.

The products in question were illuminators based on LED chip technology. LED chips are effectively unpackaged semiconductor ICs (~250 cubic microns in volume) and, in Stocker Yale's products, arrays of LED chips are generally mounted on a number of different layers (ceramic PCB, adhesive, metal etc.). The products are cooled by natural or forced convection and, sometimes, by water-cooling. The customer's goal was to determine the "junction" temperature of the LED chips in a product, as this impacts on their reliability.

Description of the piece modelled

The piece is made up of several parts. There are 21 LED die arranged in two circles that are mounted via 'die-attach' adhesive to a gold layer on a ceramic PCB. This ceramic is recessed slightly in an L-shaped bracket, attached via heat-transfer compound, which is then clamped mechanically to an open-ended housing. The model shown is correctly dimensioned but some layers are hard to notice because of the small thicknesses involved.

Not shown are 21 resistor components mounted in three rows much further from the centre of the ceramic. These resistors dissipate ~10mW each but these were disregarded for the purposes of this demonstration example. The main heat sources on the PCB are the LED die and these dissipate 160mW from the top surface. An ambient temperature of 20 degrees is assumed. In this example, cooling is by natural convection.



Stocker Yale LED distribution

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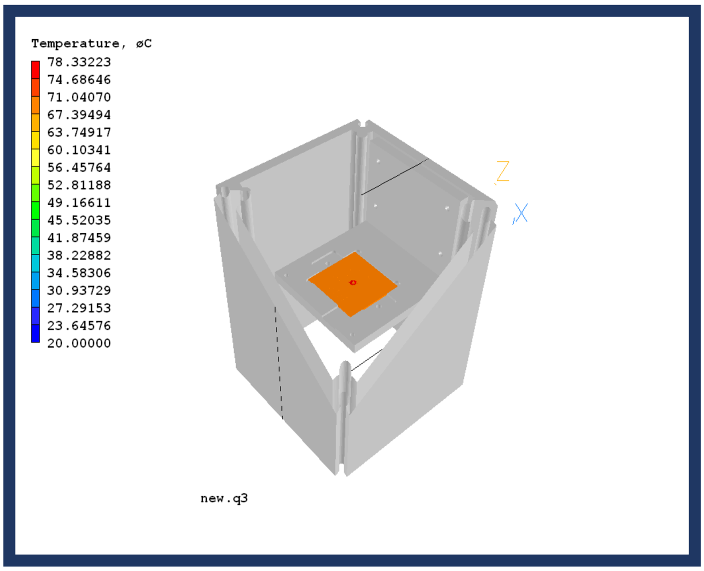
Material Parameters

Part	Thickness	Thermal conductivity
LED	160 um	75 W/mK
Die-attach	15 um	13 W/mK
Gold	8 um	Gold
Ceramic	635 um	26 W/mK
Heat transfer compound	20 um	2.5 W/mK
L-bracket and housing	~of the order of mm	Aluminium

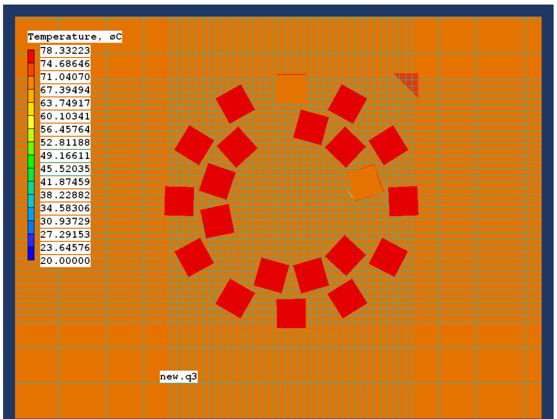
Overall Geometry

A ‘sliced’ view of the geometry, exported from SolidEdge in .STL format, shows the housing and the LED bracket – with the LED’s themselves, grouped in the centre.

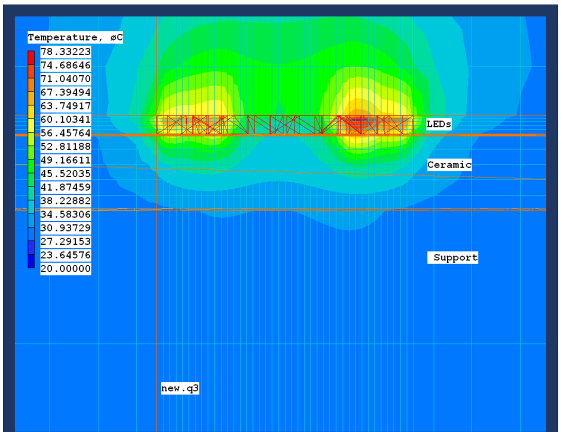


PHOENICS prefers that each part of a multi-part assembly is exported as an individual STL file – so that the user can assign different properties and boundary conditions to each part. As long as these separate STL files contain the true coordinates, they are easily reassembled back into the correct relative positions.

Rather than assign a temperature to the surface of each LED, or group of LED’s, for this example the “IN-FORM” feature was used to block a region for which a temperature release was specified wherever an LED object existed.



Top view of LED’s with overlaying computational mesh



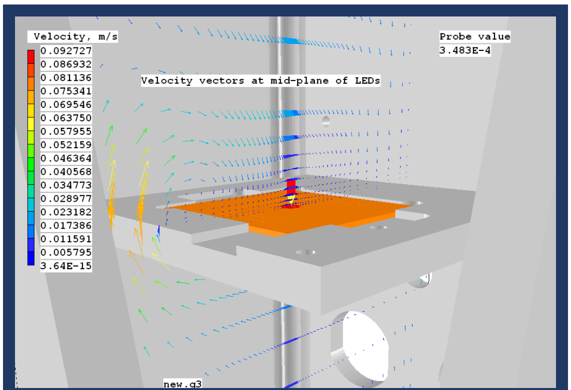
Side view of LED’s, computational mesh, showing temperature release from LED’s

Model Parameters

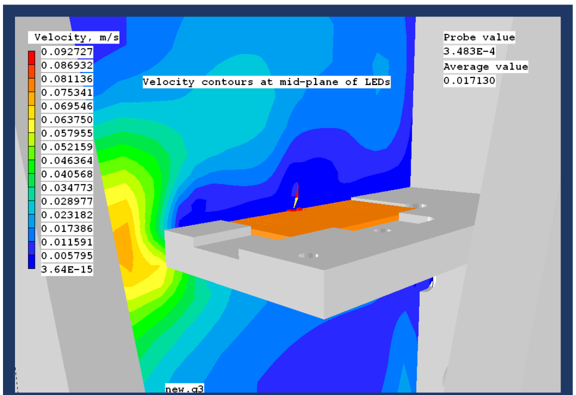
A steady-state analysis was undertaken using the geometry and boundary conditions specified by the customer. Once imported, the case took only a few hours to set up and run. For the final 'production' run, a 45 * 90 * 90 computational grid was used, with the mesh concentrated around the LED heat sources.

Results

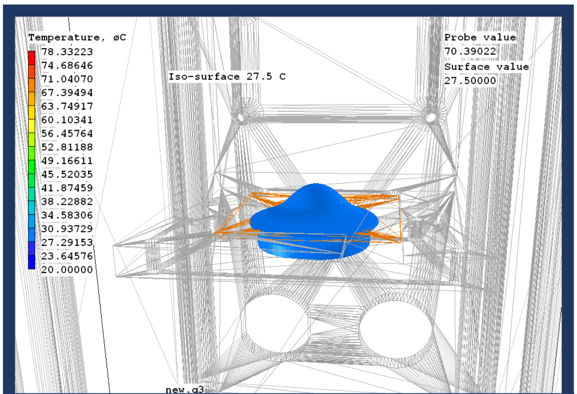
The converged solution time, on a single-processor 3Ghz Windows PC, was 18 hours.



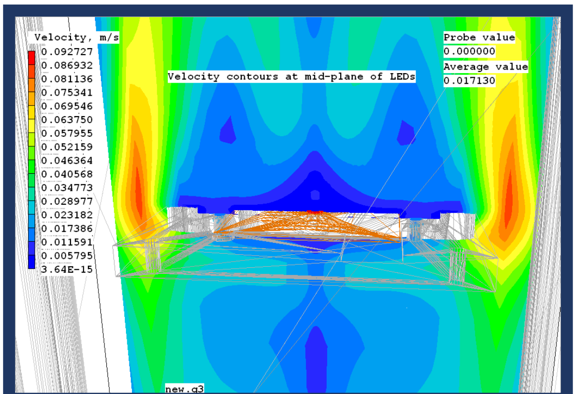
Velocity vectors at mid-plane of LED's



Velocity contours at mid-plane of LED's



Temperature Iso-surface at 27.5 ºC



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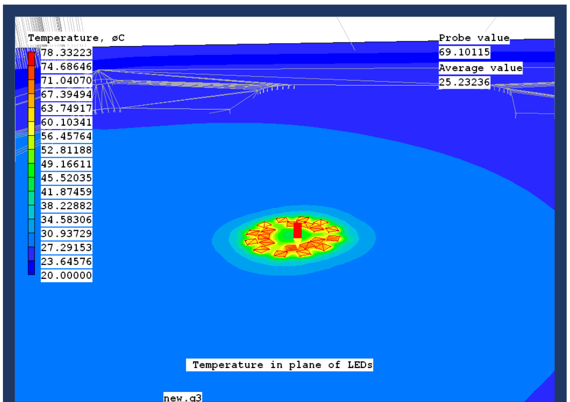
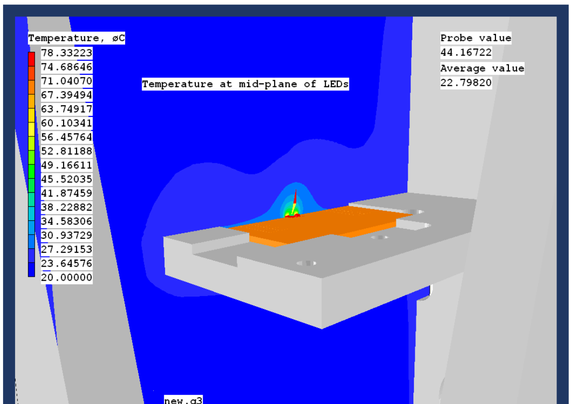
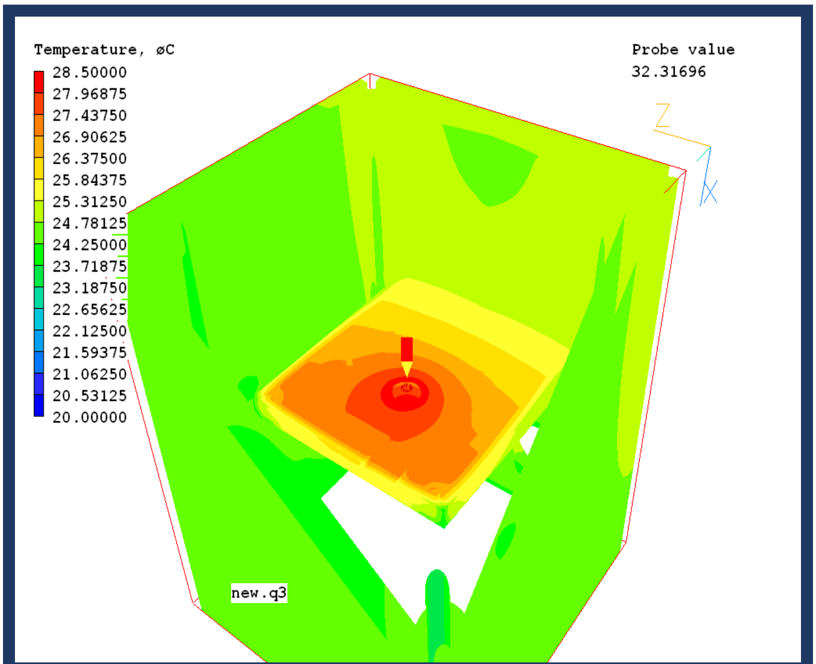


Temperature in plane of LEDs



Temperature at mid-plane of LEDs

The solution showed that the peak temperature reached was 78ºC, 58ºC above ambient. This was in line with the client's expected value of around 50ºC above ambient.



Surface Temperature of casing

The casing temperature rose by around 5ºC, and the bracket supporting the LEDs rose by 8-9ºC.

The flowrate induced by the buoyant flow was 0.119 gm/s with an average exit velocity of 0.0275m/s.

The case can be readily extended to include the 21 resistors, presently ignored within the demonstration study. Modifying the case to introduce other factors, such as forced convection, is an equally straightforward matter.

For further details about this, and other studies undertaken using PHOENICS, please contact CHAM via email at sales@cham.co.uk or use the contact details shown below.