LED Design Case Study: Down Lighter Thermal Management with Simulation

"LED based lighting is a fast growing market where the product thermal management is critical to the short term and long term success of the product. 6SigmaET allows for the rapid thermal evaluation of different designs."

Norbert Engelberts
Director
ATS Europe, B.V.

- Can simulation accurately predict the junction temperature of an LED-based down lighting system?

- 3x Philips LUXEON K2 cold white LEDs
- 1000 mA forward current
- 9.6 W total power dissipation
- 60,000 hours required life time
- 124 °C life time junction temp limit at 20 °C ambient
- 150 °C max junction temp limit at 40 °C ambient

6SigmaET software

6SigmaET is the first major computational fluid dynamics (CFD) analysis tool for electronics cooling design to be released in the last twelve years. 6SigmaET was developed by the team that introduced CFD analysis to the electronics industry in the late 1990's.

6SigmaET dramatically streamlines the modeling and design optimization processes relative to legacy CFD tools by taking modeling intelligence and automation to the next level.

How Difficult Can LED Lighting Be?

LED lighting can be an effective method to reduce the operating cost of a building. However, unlike traditional lighting solutions, LEDs have a maximum junction temperature of around 100°C whilst other lighting solutions are at around two thousand degrees Celsius. This means that for LED lighting, there needs to be an effective heat transfer path to the ambient air; a thermal design challenge to say the least. A better heat transfer path is normally proportional to the cost of the product. The heat sink performance can be greatly improved by adding a fan, but that adds noise and an extra reliability concern to the product. The challenge is to provide a cooling solution which is just as cost effective whilst satisfying the LED thermal requirements.

How Small Can You Go?

When designing LED cooling solutions, the size of the cooling solution can be directly related to the cost. A bigger heat sink means more weight and more material that has to be paid for. Optimization of a heat sink allows for the best possible performance for a given material cost. Natural convection heat sinks also have the benefit being more reliable than a fan cooled solution without the extra cost of the fan. Could simulation tools be used to accurately predict the junction temperatures of LEDs and reduced hot spots while minimizing the size of the overall lighting product?

future facilities

LED Down Lighter Case Study cont'd

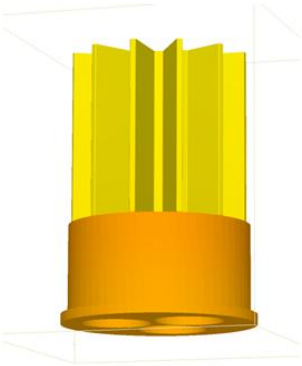
ATS Europe

ATS Europe provides leading-edge thermal management solutions to its European partners. ATS and ATS-Europe engineers have over 100 years of collective thermal management experience, 35 patents, over 70 professional publications, and receive continual requests for technical presentations at international and national conferences. Their engineers from across the globe collaborate to provide next-generation products and custom solutions to meet growing thermal management and packaging needs.

Future Facilities

Future Facilities is a global, full-service organization for thermal design, optimization, troubleshooting and management of Mission Critical Facilities.

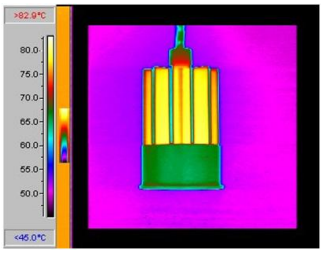
Future Facilities supplies the popular 6SigmaDC suite of electronics cooling and data center software tools for 3D space, power and cooling design, optimization and management.



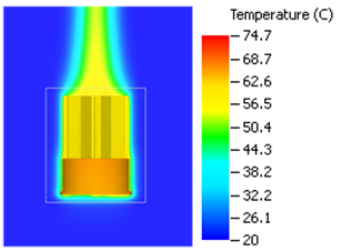
The Solution Options

ATS Europe used Future Facilities' 6SigmaET simulation software to model the thermal performance of the lamp alongside analytical calculations and the eventual experimental measurements. Different configurations of printed circuit boards (PCB) were evaluated using the software. The configurations included FR4 and metal core board configurations. The models predicted that temperature drop across the PCB using the FR4 board configurations would be severe and preclude the use of a natural convection heat sink. After an optimized metal core board configuration was simulated, the heat sink size was determined by analytical methods and performance was confirmed with the software. The heat sink eventually was selected from ATS' standard LED heat sink catalog. The heat sink design was optimized for a natural convection environment and coated with a highly efficient surface finish.

LED thermal test configuration



Measured temperatures



Simulation results from 6SigmaET

The Results

6SigmaET has the modeling capabilities necessary to accurately predict heat transfer and resulting temperature distribution throughout the LED down lighter assembly for a variety of design configurations. In the configuration shown in the figures above, 6SigmaET was able to predict LED junction temperatures within 5% of the experimental values, indicating a high level of confidence in the results obtained.

Parameter	Unit	Analytical	Experimental	6SigmaET
Ambient	°C	20	20	20
Heat sink base	°C	76	71	66
Board	°C	81	78	74
LED junction	°C	110	107	103
Comparison	%	3.5%	Datum	-4.6%

Comparison of results

Services Available

- Software and methodology training
- Technical support
- Software maintenance
- Electronics cooling design consulting services

1 Salamanca Street
London, SE1 7HX
United Kingdom
Phone +44 207 840 9540
www.futurefacilities.com