

### Introduction

With the electrification of the automotive industry, new challenges are faced when incorporating new technologies in a tight packaging space. Also, in the consumer products/electronics a strive is seen for ever more compact systems limiting the room for efficient cooling. Code Product Solutions has been a development partner assessing and improving the thermal performance for numerous applications in these markets such as headlights, rearview cameras, EV-chargers, laptop covers, AC-systems, LED applications and PCB-parts. We strive to aid our clients in designing systems that can not only handle all structural loads, but also maintain operating temperatures within scope of material and electronic component specs.

Figure 1 Reflector hot spot temperature before (above) and after (below) flow design updates



#### Thermal performance

In many cases the thermal performance of the product is seen as the final result of the product design. However, often it is the case that for compact or waterproof systems the **thermal performance is critical** and requires special attention to prevent failing the requirements. Simulations give insight early-on in the design process and can assure no surprises are present in the final design phase.



Figure 2 PA6 (right) vs thermal conductive plastic (left) heatsink with mounted LEDs

With our knowledge of analysing these kind of problems, we can accurately predict system temperatures, and find ways to improve flow or heat transfer for better performance. By changing flow behavior, better cooling and distribution of temperatures can be achieved that can mitigate hot-spot temperatures. Also applying heatsinks, coatings or different materials can have profound impact on the thermal performance. The most effective location for applying these measures can be perfectly assessed using simulations.



# Structural behavior

As plastics tend to deform a lot under thermal expansion (compared to metals), a secondary effect can be analysed when doing thermal simulations. Code Product Solutions has much experience with coupling simulations, e.g. using the thermal results and mapping these onto structural mechanical models. Allowing us to predict thermal stress and thermal deformation.



In camera applications for example it can be important that the alignment of the lens stays correct compared to the PCB-sensor. Analyzing the thermal stresses and deformation allows us to give estimates about this already before production of the first prototype.

Figure 3 Multi-layer PCB + single chip in testing environment

#### Predictive engineering

For different applications it has been shown that the simulated values are very close to actual measured values. For example in a headlight application; reflector **hot spot temperature predictions where within 5%** of the measured value. Likewise, the proposed improvements showed mitigation of the failure area (thermal degradation). And resulted in using several grades lower material quality, saving costs.



Figure 4 Temporal prediction of temperature



For PCB + heatsink analysis, simulations have been performed showing temperature over time where offsets within 10% have been achieved. Where effects like radiation, conduction and convection are included.

For a heat exchanger system the life time resulting from cyclic thermal stress was predicted using coupling of flow, thermal and mechanical results. For this application the lifetime in cycles was predicted within 10% of the experimental results. **These simulations can save €100k per test (and time).** 

Besides giving quantitative results, thermal-flow simulations have the unique ability to give insight by allowing to **visualize complete temperature and flow fields,** compared to singular point measurements often obtained by prototype testing. This insight is very valuable for understanding and improving designs.

## **Our** achievements

- Optimise thermal performance reaching 5% accuracy with tests
- Visualize complete temperature and flow fields allowing efficient evaluation of new design performance
- Saving time and costs of testing and tooling