Fujifilm Frontloads Camera Design with FloTHERM®

By Kazuya Mayumi, Optical Device and Electronic Video Product Development Center, Fujifilm Holdings Corporation

Our department focuses on the development of cameras with high performance and high quality, to preserve the culture of photography and to develop imaging technology. The team I belong to develops the elemental technology of such cameras and lenses and supports the business by running simulations. I have been involved in thermal design by predicting temperature with simulation tools ever since the first "X-100" of Fujifilm's X digital camera series. Now simulation technologies are essential for product development today.

Modern digital cameras, like Fujifilm's X-Pro 2 are developed to dissipate the minimum amount of heat as form factors shrink. Excessive heat can increase the size and weight of the cooling solution, preventing miniaturization. It is associated with the concept of poor design by the consumer, as the design can appear to have "regressed" back to an earlier bulkier form factor. It also requires the use of higher-cost parts, adding cost to the product, further reducing its competitiveness.

Heat generated within the camera has to be managed for many diverse reasons, such as the tendency for elevated temperatures to reduce image quality through noise in the Complementary Metal–Oxide–Semiconductor (CMOS) circuitry. The temperature of the chassis must also be limited to avoid the risk of a low temperature burn for the user. For cost reasons, sheet metal parts within the camera can't be replaced with alternatives that spread the heat better if a problem is found in late design or prototyping.

For these reasons considerable care must be taken prior to prototyping. Fujifilm do this by undertaking the following work from the start of development:

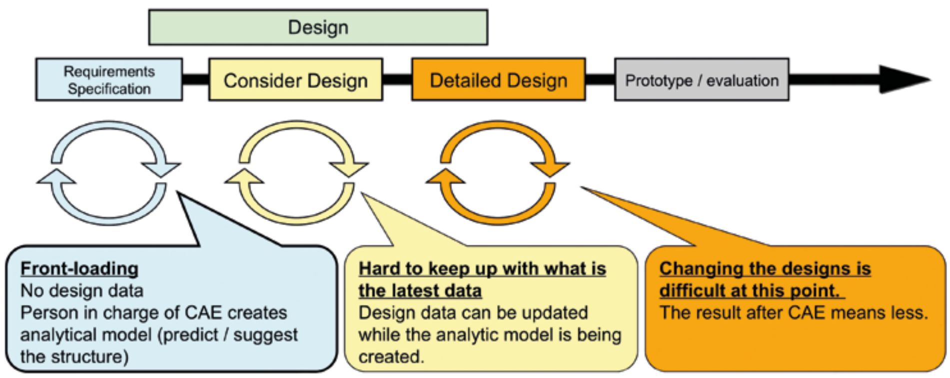

Figure 1. Fujifilm Camera Design Process

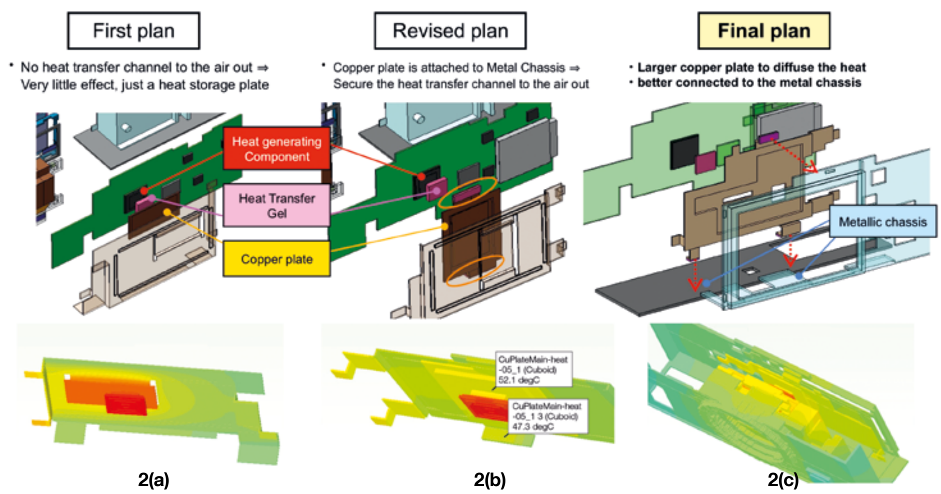

Figure 2. Initial, Intermediate and Final Frontloaded cooling solutions (pre-CAD)

- Present an optimal solution for the structure, as an outcome of thermal simulations on several different design variations,
- Predict the maximum temperature without using any correlations, and
- Complete the study by defining what parts, including their size and number, are needed for the heat dissipating structure.

The process is shown in figure 1: It starts with a simple analysis model built in Mentor Graphics' FloTHERM Electronic Thermal Analysis software. It uses geometry simplified from the CAD model – the exact details of the process Fujifilm considers proprietary.

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"We use FloTHERM to frontload our thermal design. FloTHERM enables us to explore design alternatives early on, design the optimal solution for removing the heat, and provides very good accuracy against the final test results we get for chip, component, and touch temperature on the case."

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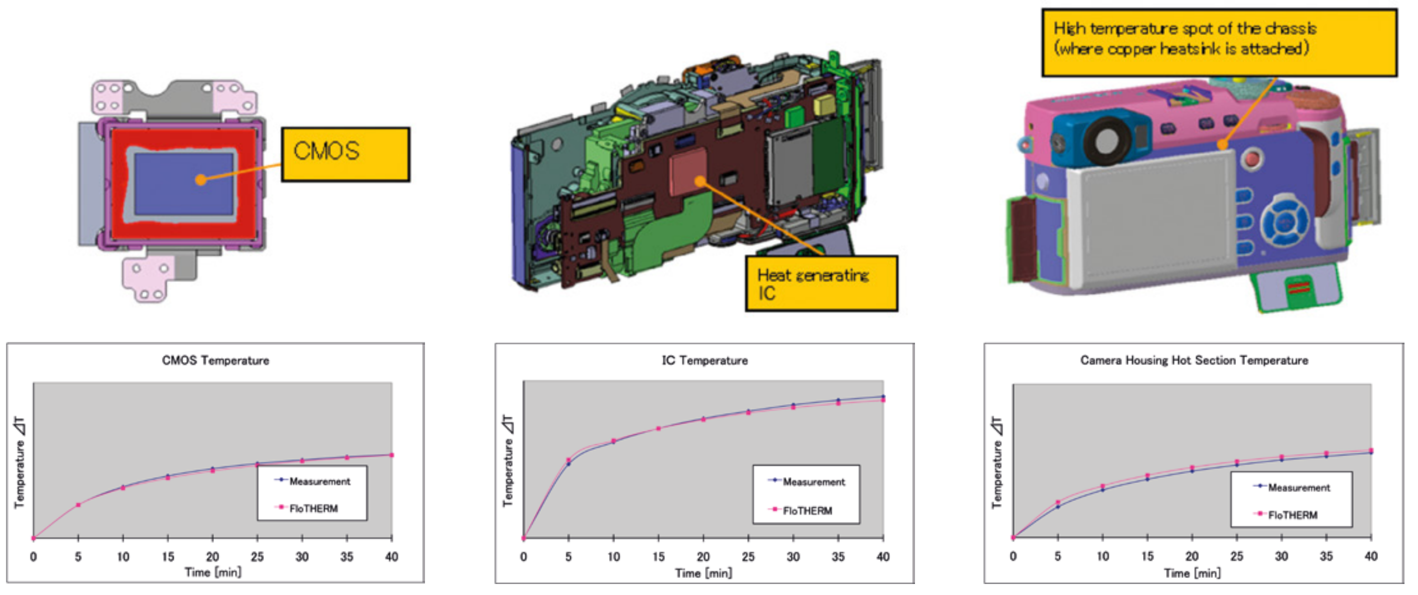

Figure 3. FloTHERM model agreement with test results at different packaging levels.

By keeping this analytical model updated, the effects of changes can be fed back into the design process immediately, frontloading simulation in the development process.

As a case in point, Fujifilm needed to improve thermal performance, introducing a copper heatsink and thermal gel into the product for the first time. In the initial design, shown in figure 2a, along with the FloTHERM result, the copper heatsink just acted as a heat storage device, as there was no heat flow channel to get the heat out. The revised design shown in figure 2b, attached the copper heatsink to the chassis, ensuring that the heat could be transmitted to the air. However, the temperatures were still too high. A final design iteration, shown in figure 2c, increased the size of the copper plate to better diffuse the heat, and additional connections were added to improve heat transport to the chassis.

Using this approach, Fujifilm are able to get highly accurate temperature predictions during the early part of the design process, and use the results of improvements made to the design using FloTHERM to update the CAD model. The predictive accuracy of this analysis model is checked towards the end of the development process once a physical prototype becomes available. The detailed CAD geometry available at this stage is shown in figure 3 for the CMOS chip generating the heat, the component housing the chip, and the hot spot on the camera housing, resulting from this heat source, together with the comparison between measurement on the prototype and the FloTHERM model, which shows excellent agreement at all of these packaging levels.

Using CAD data directly in FloTHERM gives results which are very similar to those shown in figure 3, for the model based on a simplified geometry for the analysis. The import of the CAD geometry is also acceptably fast for use in the design, however this approach is not favored for the simple reason that CAD geometry is not available at the start of the process, so this approach would have the effect of delaying the CFD work until later in the design, when the business benefits of using CFD are less. Whereas the requirements for the cooling solution must be addressed and different options investigated at the outset.

Critical to the design effort is the ability to predict accurate temperature values, not just trends or relative differences. This is because of the thermal limits both on the component's operating temperature, and also the maximum permissible touch temperature of the case. Consequently, it is the responsibility of the CAE engineer to investigate any differences between the simulation result and test data. One source of this discrepancy can be the power values used for the heat sources. It is quite common for electrical engineers to provide power values during design that are conservative, i.e. they over-estimate the likely actual power by say 20% to ensure that the cooling solution will be adequate. However, this makes it impossible to match simulation results to test results, so Fujifilm now ensure that the power estimates that the electrical design team share with the thermal design team are as accurate as possible.

More broadly, Fujifilm consider the ideal role for a CAE engineer is to remain in the background. However, they should be proactive, working to reduce the workload of the designer, and thereby speed the design. CAE engineers should present the results of design optimization and an improved design back to the designer, rather than just reporting back the results of the design iteration they were asked to simulate. Only by optimizing the design process in this way is it possible to perfect the design of the product.

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