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Development and Calibration of Thermal Simulation Model for Electronic Control Units

Master's Thesis

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10. CONCLUSION

The main task of the thesis was to develop and calibrate a thermal simulation method for automotive electronics. The simulation method should help to evaluate the feasibility of the concept in the early phase of development project. The expected outcome of the simulation is to define maximum temperature rise at important locations within delta of ± 5 ˚C when compared to measurement results. Based on the temperature rise data, one could estimate if the expected lifetime of the electronics could be met with a given concept or additional cooling features are required. An additional outcome of the work was comparison of two softwares - Creo Parametric and Star-CCM+. The aim to was to find out if Creo Parametric could be used in Stoneridge for such simulation or more advanced CFD software like StarCCM+ should be bought. An external company FS Dynamics was used a consulting partner during the work.

A physics based simulation model with simplified geometry was created to mimic the actual product in Creo Parametric. A simplified PCB model was created and conduction values of materials were calculated equivalent to the complex structure of panel. Out of 400 electrical components on the board 24 with significant power load of ≥0.02 W were modelled (in total 4.82W). Boundary conditions of a normal room without forced air flow were applied to the model. When copying the model from Creo to StarCCM+, data for fluid dynamics and radiation effect was added to the model.

In order to verify the simulation results an experiment was carried out measuring the temperature rise of the actual product while working. Product was placed on a rack where similar conditions to the simulation were created. The product was set to work in maximum power load condition. 12 thermocouples were attached to the product and data was logged via data acquisition device to LabView software. The estimation of maximum error of the measurement is ± 4.1°C. While testing the product, images with thermal camera were captured in order to compare to the fringe contours of the simulations.

After first round of simulations, analysis and consultation with FS Dynamics, it was decided that the model could be improved with more accurate simplifications to mimic the actual product. The adjustments concentrated on the points with the largest delta values.

After the adjustments, simulations were run again. The improvements had a positive effect on the result. The average absolute delta of Creo simulation had decreased from 5.5 ˚C to 2.6 ˚C. The average absolute delta of Star simulation had decreased from 6.8 ˚C to 2.6 ˚C. The maximum temperature on the board was estimated in right location with a delta of 1.8 ˚C in Creo and 0.7 ˚C in Star. The maximum delta had decreased from 19.4 ˚C to 7.5 ˚C in Creo and from 12.6 ˚C to 9.2 ˚C in Star. When comparing to the desired accuracy of the simulation, both Creo and Star analyse had at 10 points out of 12 within absolute delta of 5 ˚C. With both softwares 83% of the measurements points were within the expected ±5 ˚C range. The Star simulation had 75% and the Creo simulation had 83% of the simulation points within the range of measurement error (±4.1 ˚C).

To summarise the comparison of Creo and StarCCM+ results, the effect of fluid dynamics is reduced since the product had no ventilation to ambient environment. The author expects the Creo model to have a much larger delta if the product`s casing had ventilation slots to ambient air. The effect of radiation was compensated with higher convection rate applied to the Creo simulation. The author`s recommendation to Stoneridge is that the Creo software could be used for thermal simulation of closed casing products in natural convection conditions. For simulating ventilated products or product`s placed in forced convection conditions, a CFD software should be used.

The biggest value of this work for Stoneridge is that the simulations were verified with experiments and by that the trust towards the model was increased. The author also recommends to measure temperature rise at maximum operating temperature of the product (85 ˚C) and compare the results to room temperature measurements. Another future continuation of the work would be to apply model on different ECU products and do similar verification.

The authors judgement for this work is that the results are positively surprising since the author has only a brief experience in thermal engineering. The most difficult part of the work was to build the model in way that it is simple but detailed enough to provide expected accuracy. The verification of theoretical simulations increased the author`s trust in computer simulations. It is most likely that the author will continue to work on this thermal simulation model until all measurement results are within the expected range.