FLOW AND THERMAL ANALYSIS OF A COMPUTER CHASSIS USING LIQUID CRYSTAL THERMOGRAPHY AND HOT-WIRE ANEMOMETRY

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THIS THESIS IS DEDICATED TO MY PARENTS,

Luis and Carmen Terrazas:

In Whom I have found unending love and support.

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by

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THESIS

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Executive Summary

This thesis describes the application of three well-established techniques for flow and temperature field characterization: liquid crystal thermography, smoke-wire flow visualization, and hot-wire anemometry. These techniques were used to investigate an alternative computer chassis configuration and compare its flow and temperature distribution to the original production chassis. The alternative configuration involved blocking all chassis orifices (including the vacant vent hole array on the backside of the chassis) with the exception of the original ventilation intake and exhaust. The modification of the chassis provided a means for demonstrating the effectiveness of using these experimental techniques in the electronic enclosure design process.

Full-field temperature measurements were obtained using liquid crystal thermography. This technique was developed as a relatively inexpensive tool used to visualize complex temperature distributions on solid surfaces. Liquid crystals react to changes in temperature by continuously changing color over an active range from 0.5 to 30 degrees Celsius in width. Liquid crystal imaging can easily provide qualitative full-field temperature information. Quantitative temperature information is obtainable by means of a calibration procedure that associates temperature with a measurable scalar that represents the color of the liquid crystal surface. Even though it is an intrusive technique, Hallcrest (1987) considers liquid crystal thermography to be the most suitable technique for measuring temperatures of electronic devices.

Flow field characterization of the chassis was performed using two techniques: smoke-wire flow visualization and hot-wire anemometry. First, a qualitative assessment of the flow structure was obtained using the smoke-wire. Second, the flow was quantified using a constant temperature hot-wire anemometer. The experimental techniques employed in and results obtained from this work are intended to be useful for the improvement of electronics cooling and chassis design practices.

The increasing power and performance of electronic components provide packaging engineers with an unending challenge to re-evaluate their current thermal design practices. The design of electronic enclosures faces a design dilemma between thermal management and electromagnetic interference (EMI) containment. Conventional electronic enclosure design practices are mostly responsive to consumer needs. High temperatures experienced by electronic components inside a computer are a concern for chassis designers. Research in this area using Computational Fluid Dynamics (CFD) software has become attainable with the advancement in computer technology. However, these computer models oftentimes do not account for parameters such as wire and ribbon cable size and location, and hence can yield inaccurate models.

Using the techniques mentioned above, several differences were found in the flow field structure of the original chassis configuration versus the alternative configuration. For example, flow near the vacant vent hole area was measured at ~1 m/sec in the original chassis configuration and ~0.5 m/sec in the alternative chassis. The flow velocity in the area close to the processor-cooling fan was also higher in the original

chassis configuration (~1 m/sec) than in the alternative configuration (~0.7 m/sec). These differences in the flow field structure within the chassis have a direct effect on the temperature of the components. For instance, the temperature of the ICH2 chip in the original chassis configuration was 38 °C, which was 2 °C higher than in the alternative chassis. The average temperature of the audio codec chip was 39.6 °C in the original chassis configuration, an increase of 1.2 °C compared to the same chip in the alternative configuration. The differences in the flow field structures of the two chassis configurations were further identified using a smoke-wire flow visualization technique. Images captured using this technique helped to determine the regions with higher velocity flow and provided a qualitative description of the direction of the flow. Using the smoke-wire, it was determined that the uncovered vent hole array in the original chassis configuration served as a "secondary" ventilation intake. That was not the case for the covered holes of the alternative configuration.

The results presented in this thesis show that these three well-established techniques can be applied to obtain valuable flow and temperature information to be used in the design process of electronic enclosures. Furthermore, the integration of these techniques into current design practices can provide experimental validation for numerical models of the flow and temperature fields within the chassis.

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