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Analysis on Base Plates of CPU for Improving Heat Dissipation Characteristics

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Abstract:

Experimental and theoretical studies of the thermal performance of a variety of heat sinks with different base plates for enhancing heat dissipation rates in CPU have been undertaken. The parameters such as fin pitch, fin thickness, base plate thickness, and base plate materials are optimized for improving the thermal performance. The thermal model of the computer system with a single cut plate-fin heat sink design and other fin geometry design is created using Gambit (for preprocessing) and the simulation is carried out using Fluent (for solver execution and post processing). The experimental results of some simple geometry heat sinks have been compared to those predicted by a commercially available computational fluid dynamics code fluent.

In this research work the fin thickness is varied from 3mm to 5mm and also the fin pitch is varied from 1.5mm to 3.5mm. The aluminum, copper and carbon carbon composite (ccc) materials are used as base plate of heat sink. The base plate thickness of 2.5mm and 5mm are used. Although the performance of heat sink, the temperature of heat sink at center need to be predicted. The best heat sink geometry is selected and modified in order to reduce maximum temperature distribution and hot spots of heat sink at center by varying fin pitch, fin thickness, base plate thickness and changing the base plate materials. In this study a complete computer chassis with different base plate heat sinks has to be investigated and the performances of the heat sinks are compared.

1. Introduction:

Microelectronic devices such as transistors, capacitors, inductors, transformers and resistors are the building blocks of all electronic equipment. For such electronics to function, a passage of electrical current is required. A portion of this energy is dissipated as heat due to inefficiencies in a device or the nonzero resistance to electrical current. The heat dissipation in transistors is due to switching, dynamic short circuit and leakage power dissipations. During the same period, the transistor size has been reduced and transistor density of the chip has been increased. Although a few transistors in early electronic circuits do not generate much heat, a few million of those, on almost the same footprint, generate a significant amount of heat.

All semiconductor devices dissipate heat as a byproduct of normal operation. Prior to fourth-generation processors, these devices have been able to dissipate heat via the integrated circuit package in most personal computer applications. The fifth-generation processors use sub-micron, CMOS VLSI integrated circuit technology to support superscalar processor architecture like the AMD-K5 processor, which has integrated more than 3 million transistors on a single semiconductor die. The performance levels of electronic systems such as computers are increasing rapidly, while keeping the temperatures of heat sources under control has been a challenge. All electronic equipments depend on the flow and control of electrical current to perform a variety of functions. Whenever electrical current flows through a resistive element, heat is generated.

The heat dissipation is one of the most critical aspects to be considered in order to maintain the continuous operation. One of the challenging aspects for improving the heat sink performance is the effective utilization of relatively large air-cooled fin surface areas when heat is being transferred from a relatively small heat source (CPU) with high heat flux. When the heat loads are small, thermal conduction through aluminum plates is sufficient to spread the heat into finned heat sinks for convection from the fins into the air. Kim and Lee (1996) mention two important fundamental reasons why cooling technology will always be important in the design of the electronic equipment:

- All electronic devices are undergoing an irreversible process which results in heat generation that must be removed in order to maintain continuous operation.

- The reliability and performance of electronic devices are temperature dependent. Thereby lowering the temperature better reliability and performance has been found.

LITERATURE REVIEW:

1. Studies on Experimental and Numerical analysis of Heat pipes

Many of the researchers have focused on heat pipe cooling and few of them discussed about liquid cooling for CPU. Zhao and Avedisian (1997) have presented an experimental study of heat transfer from an array of copper plate fins supported by a copper heat pipe and cooled by forced air flow. The results are compared to an identical array of copper fins, but supported by a solid copper rod. The primary variable is the height of the fin stack, while the fin pitch, air flow rate, surface area and fin shape are fixed. The results show that for some conditions, fins of fixed pitch supported by a heat pipe dissipate higher heat transfer rates for the same surface temperature than fin arrays supported by a solid rod. The difference in heat transfer rates decreases as the height of the fin stack decreases. The maximum steady state heat fluxes and total powers have been measured to be 80 W cm^{2} and 800 W, respectively, for the tallest fin stack studied (10.16 cm) for an approach air velocity of 5.9 m s ^{1} and a surface temperature rise above the ambient of 160°. The fin stacks supported by a solid copper rod has dissipated 30 W cm^{2} and 300 W for the same conditions. For the smallest height examined (2.54 cm) no significant advantage has been realized by using a heat pipe to support the fin stack. A simplified analysis is also presented to predict surface temperature for a known heat input for both heat pipe supported and solid rod supported plate fin arrays. Marongiu et al. (1998) have discussed the investigation of micro-heat pipes and other high thermal conductivity materials that has been incorporated into Multi Chip Modules (MCM). The parameters that affect the heat dissipation capabilities such as fin material, fin height, heat pipe configuration and pumping power have been changed and analyzed using Icepak.

An experimental investigation of the thermal performance of a flat plate heat pipe has discussed by Wang and Vafai (2000). The results indicate that the temperature along the heat pipe wall surfaces is quite uniform. The results also indicate that the porous wick of the evaporator section creates the main thermal resistance resulting in the largest temperature drop, which consequently affects the performance of the heat pipe. The idea of the heat pipe time constant is introduced in this work to describe the transient characteristics of the flat plate heat pipe and an empirical correlation for the time constant in terms of input heat flux is presented. Correlations for the maximum temperature rise and maximum temperature difference within the heat pipe are also presented. The experimental results at steady state are compared with the analytical results and found to be in good agreement. This work constitutes the first detailed experimental investigation of a flat plate heat pipe.

Problem Description:

The CFD computational domain of the present desktop computer is shown in Figure 4.1. In the present study, the mainboard, heat sink and all the other components are enclosed in the entire desktop computer chassis. There are many other heat sources in addition to the CPU. Some of them are on the mainboard (e.g., northbridge chip), some of them are attached to the mainboard (e.g., memory modules) and some of them are in the chassis volume (e.g., DVD). The chassis is modeled using standard dimensions (452mm × 438mm × 180mm) of a common ATX chassis by hollow blocks, and internal components are represented as lumped objects. During modeling, all the components inside the chassis are standard sized components and exact**.**

The temperature distributions on modified heat sinks with ccc base plate is shown in figure 4.13. The replacement of the copper base plate into the ccc base plate, the base temperature of heat sinks is changed insignificant value. It could be seen that the base temperature of heat sinks (b to d) is very high compared to other heat sinks. Even though the heat sinks b and c has slots for more air flow, the base temperature is not reduced much compared to heat sink a. While changing the fin geometry from round disc plate to elliptical disc plate, the base temperature of heat sink d is decreased to $8_{\circ}$C compared to heat sinks (a to c). The base temperature of heat sink g is decreased by $1_{\circ}$C compared to heat sink e and also up to $25_{\circ}$C compared to heat sinks (a to d). The base temperature of heat sink f is decreased from $67.27_{\circ}$C to $62.13_{\circ}$C compared to heat sink e.

4.13 Effect of the modified fin geometry heat sinks with base plates on Nusselt number

The Nusselt number of the modified heat sinks is shown in figure

4.14. The Nusselt number difference for the heat sinks a to c is very small.

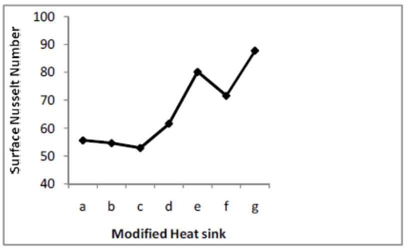

Figure 4.14 Effect of modified heat sink on Nusselt number

When the heat sink design changes from circular to elliptical, the Nusselt number of heat sink d is increased slightly which means that the heat transfer is increased. The Nusselt number of heat sink e is higher than the heat sink f. Hence, top surface temperature of the heat sink is decreased. The Nusselt number g is high compared to all heat sinks. The heat sink g has more heat transfer area, which enhances the heat transfer rate.

Effect of flow fields around a heat sink and inside a chassis:

The asymmetric temperature distributions are due to the flow obstructions inside the computer chassis around the heat sink. The velocity path lines of flow around heat sink are shown in Figure 4.15. In the top view, the left side of the heat sink is obstructed by the computer chassis wall, whereas on the right side stands the ram cards. The power supply is located at the top. It is modeled as a solid obstruction, so it blocks the flow partially. When the computer chassis is investigated, it is observed that only the upper right part of the heat sink has a free path for the air flow. Therefore, air driven by the CPU fan can travel to that side the effect of which can also be seen in the temperature distributions. On the other sides of the CPU, air returns to the proximity of the heat sink by hitting the wall, the fan sucks the returning relatively hot air and the cooling becomes less efficient at these sides of the heat sink, as can be observed in Figure 4.15. It is also observed from these results that modeling not only the CPU- heat sink assembly but also the whole chassis is important for predicting heat sink performance. To investigate this issue further, everything inside the chassis is fixed and the heat sink model is changed. The mesh is kept the same, to enable the comparison of the results with the detailed chassis model. The model with CPU heat dissipation values also resembles the experimental setup. The air can bounce of the chassis walls and recirculate in the chassis, but the temperature distribution is much more symmetric compared to the detailed whole chassis model. This result reveals that asymmetry in the whole chassis are not only due to chassis walls but also due to the presence of all other components inside the chassis.

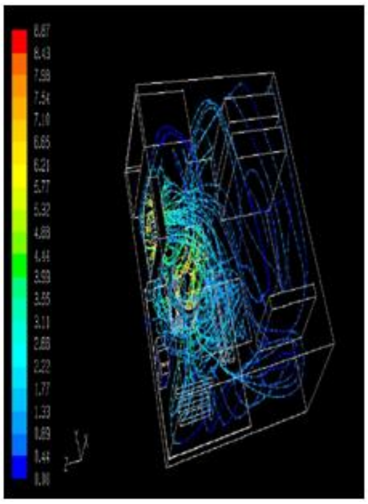

Figure 4.15 Velocity Path lines of flow inside a chassis

CONCLUSION:

In this study, cooling of CPU has been investigated in a complete computer chassis with different base plate heat sinks and the thermal performance characteristics of these heat sinks have been investigated experimentally and numerically at heat load of 100W. The modeling of the study involves several assumptions and simplifications. Since, it is not possible to model all details in the computer chassis, only the critical components are modeled. The influence of the mesh resolution, turbulence model choice, convergence criteria, and discretization schemes are investigated to find the best model with the least computational timing.

The heat sink thermal resistance results are compared with the available experimental results. While the comparison is qualitative, it has been observed that CFD simulation results are in good agreement for the heat sinks. In summary, it was observed that the thermal Analysis of electronic cooling using CFD result in more efficient heat dissipation rate. Here the domain model is identified and computational model is created in preprocessing part. The details of the solver such as boundary conditions, numerical and physical models are discussed. Also the thermal simulation results are obtained and reviewed to make sure of any design change in post processing part. dimensions are obtained by measurement. The various plate fin heat sink is described in chapter 3.2 is modeled with specifications which is used to enhance the heat transfer from the 100 W CPU.

REFERENCES:

1. Abakr, Y.A., Ahmed, M.I. and Ismail, A.F. “CFD Thermal Analysis of a Telecommunication Board”, 4th National Conference on Telecommunication Proceedings, pp. 181-184, 2003.

2. Agarwal, R., Pecht, M., McClusky, F.P., Dishongh, T.J., and Mahjan, “ Electronics packaging materials and their properties”, Boca raton. FL, CRC press, 1999.

3. Ali, A.A. “Design and Analysis of a Compact Two Phase Cooling System for a Laptop Computer”, Georgia Institute of Technology, 2004.

4. Arularasan, R. and Velraj, R. “CFD analysis in a heat sink for cooling electronic devices”, International Journal of the computer, the internet and management, Vol. 6, pp.1-11, 2008.

5. Baughn, J., and Shimizu, S., “Heat transfer measurements from a surface with uniform heat flux and an impinging jet”, ASME Journal of Heat Transfer, Vol.111, pp. 1096-1098, 1989.

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