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Research Paper

HEAT TRANSFER ANALYSIS OF 1-USER SERVER THROUGH CFD

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With rapid growth of electronic technology, devices are capable of processing more data within a stipulated period of time. Example of such high-density applications are the internet/intranet, networking, data centres and Voice over IP has resulted in the rapid rise of the super slim 1-User rack-mounted chassis solution. The reliability of electronic components is affected critically by the temperature at which they operates. The continuous increase of power densities in electronic packages and the simultaneous drive to reduce the size and weight of electronic products have led to an increased importance on thermal management issues in electronic industry. Cooling of electronic components is enhanced by the use of heat sinks. The present analysis deals with better thermal management of 1-User server with optimum design of heat sink, enhancement of air flow and heat sink with embedded heat pipe. Heat transfer and air flow simulations are carried by Icepack, commercial CFD software.

Keywords: Computational Fluid Dynamics, Heat Transfer Analysis, 1-User server

INTRODUCTION

The growing prerequisites for high density applications emphasize the critical need to pack as much processing power into as small a footprint as possible and considering EMI/EMC effects Timothy Dake *et al*. and Archambeault *et al*. This make the thermal management as a critical issue in the design process of micro electronics. The performance of the electronic device is directly related to the operating temperature; therefore it is a crucial issue to maintain the electronics at acceptable temperature levels. Heat sink provides a suitable solution to the cooling problem of micro electronic devices. R Steinbrecar *et al.* showed that heat sink with low air circulation is not suitable for electronic

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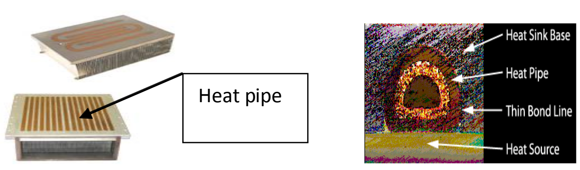
enclosure, as the thermal power density is above 700 W R Steinbrecar *et al.*

In the present paper, investigations are carried out on thermal management of 1-User server, by using Optimization of base heat sink, ducting with blowers, ducting with double axial fans and embedded heat pipe in heat sink and ducting with blower.

Working Principle of Heat Pipe

A heat pipe is a two-phase (liquid-vapor) device that provides a very high unidirectional thermal conductance for the efficient transport of heat along its length. It consists of a vacuum-tight container lined with a wicking structure on its inner surfaces and filled with a working fluid, which exists in both liquid and vapor states within the container as shown in Figure 1. The working fluid absorbs heat and evaporates at the hot locations of container, carries the heat by physically flowing as a gas through the vapor core to the cooler parts of the container, liberates heat and condenses into a liquid and returns through the wick to the hot regions, thus completing a thermodynamic cycle. The temperature differences between the hot and the cold regions within the vapor core of the heat pipe depends only on the pressure drop that the vapor experiences as it flows through the vapor core. This temperature drop is quite small, giving the heat pipe an effective thermal conductance

Figure 1: Heatpipe Constructions in the Embedded Heatpipe

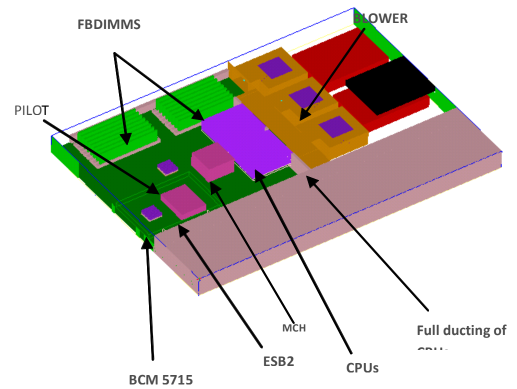


significantly greater than that of copper. The wicking structure enhances evaporative heat transfer at the evaporator and provides the motive force to return the liquid phase back from the condenser to the evaporator by capillary action when gravity cannot be utilized to return the liquid.

CFD MODEL AND BOUNDARY CONDITIONS

Thermal modelling is one of the major challenges in the design of high power density electronic devices cooling. The 1.72" height of the 1-U provides both the solution and the challenge as shown in Figure 2.

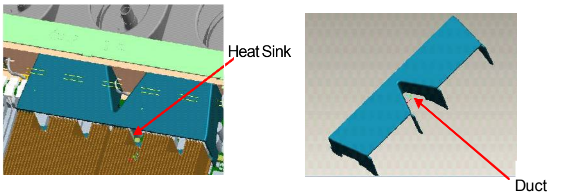
Figure 2: Thermal Model of the 1U Server



The simulations are carried to investigate the air flow and heat transfer dynamics in 1-U Server. Maximum operating ambient temperature of 35 ºC is considered. Mother board is modelled with orthotropic material property of 17 W/mºK in plane and through plane of 0.3 W/ mºK. The compact conduction model is used for CPU modelling. The power dissipation is 120 W. Thermal interface material used is thermal grease (Shin Etsu). PCI cards are modelled as cuboids with flow obstruction as shown in Figure 3. AMB and

RAM in the DIMMs are modelled with respective power dissipation. Flow blockages by cables are modelled as cuboids to take in to the effects of flow obstruction. The blowers are assumed to perform as per the blower curve [5]. Blower power dissipation of each 22.5 W is taken in to account. The total power distribution is 760 W .

Figure 3: CPU Ducting Design



CFD SIMULATIONS

The simulations are carried for four cases. In case (i) simulations are carried for the optimum number of fins, fin thickness and base thickness. The most important parameter in the analysis of forced convection cooling of electronic enclosure is the air flow in the enclosure. The airflow through the enclosure mainly depends upon the pressure drop in the enclosure, fan or blower characteristics, increased flow impedance, reduced acoustic signature and electronic emissions. The simulations are carried for the implications of smaller system sizes and higher static pressures for the optimum duct design. The simulations are carried for baseline heat sink ducting with blower. CPU ducting design is shown in Figure 3.

In case (ii), the simulations are carried for baseline heat sink ducting with blower. In case (iii), The simulations are carried for baseline heat sink ducting with double axial fan. Thermal modelling is done to replace each blower by two double axial fans for more airflow as shown in Figure 4. Modelling assumptions are same as previous one except power dissipation by each fan 30 W is taken into account. In case (iv), the simulations are carried on the baseline heat sink model embedded with heat pipe. Heat pipe is modelled as a orthotropic material (ky=3000 W/ m°K ,kx=Kz=100 W/ m°K) as shown in Figure 5.

Figure 4: Thermal Modelling of Double Axial Fans

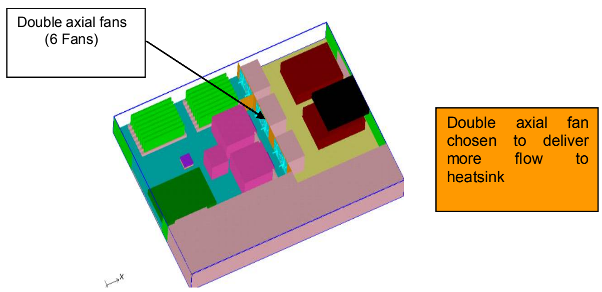
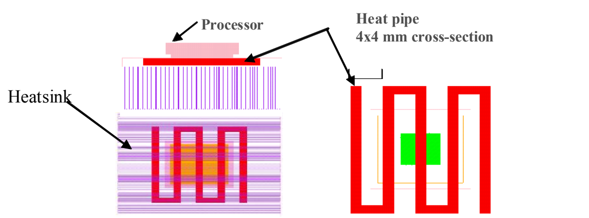


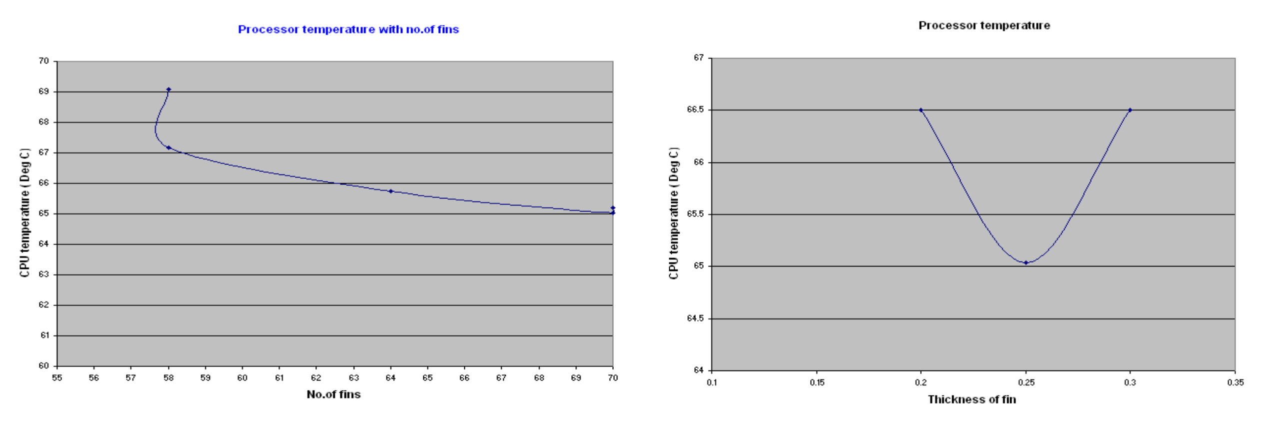
Figure 5: Thermal Model of the Heat Pipe Based Heatsink



RESULTS AND DISCUSSION

Case (i): Figure 6 shows the optimal heatsink design within the constraints of the enclosure system and air mover is with a fin count of approximately 70 fins, 4.5 mm base thickness and 0.25 mm fin thickness. Because of space constraints, and chassis strength, EMI/EMC effects vent area is restricted on the rear side. Optimized small vent portion is designed to

Figure 6: Heatsink Optimization Curves



reduce the system back pressure, leads to the augmentation of heat transfer. Simulation results shows that all other components are with in the allowable limit except CPU as shown in the Figures 7 and 8. The further analysis is carried for effective cooling of CPU. The one of the possible methods is to increase air flow.

Case (ii): The increase in air flow is achieved by ducting with blower, one of the possibility to increase air flow and the temperature is brought down to allowable temperature limits. The increase in air flow circulation is shown by velocity vector plot in Figure 9.

Case (iii): The other method to increase the air flow considered is inclusion of double axial fan. The results inferred that all components with double axial fans are thermally with in the allowable limit as shown in Figure 10, increased in air flow is shown by velocity vector plots in Figure 11. The limitation with this cooling system is acoustic and power consumption. Further simulations shows that performance gains achievable with embedded heat pipe construction.

Case (iv): The results shows the decrease in acoustic noise and power consumption with the use of embedded heat pipe in heat sink with minimal flow of air.

Figure 7: Temperature Experienced on all Components on the Mother Board

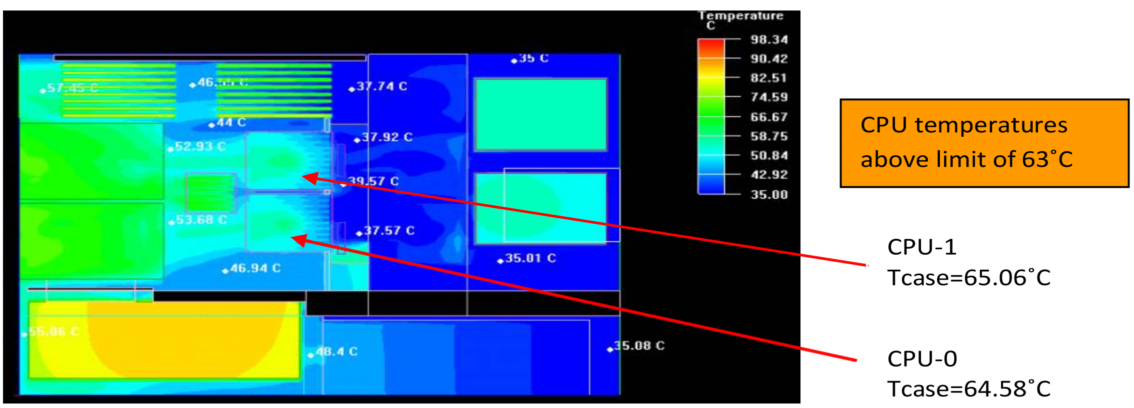


Figure 8: Zoom in Model of the DIMM Section

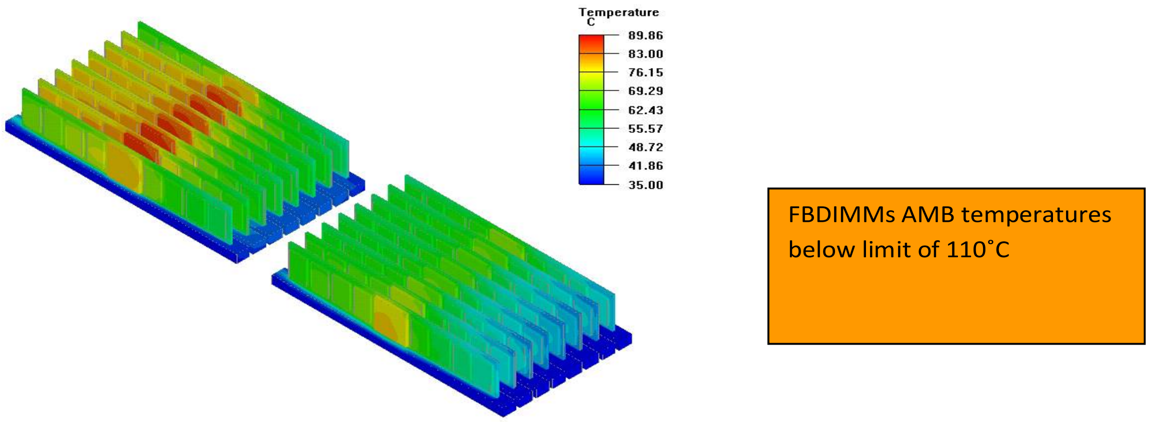


Figure 9: Velocity Vectors in the System (Total CFM ~ 80 CFM)

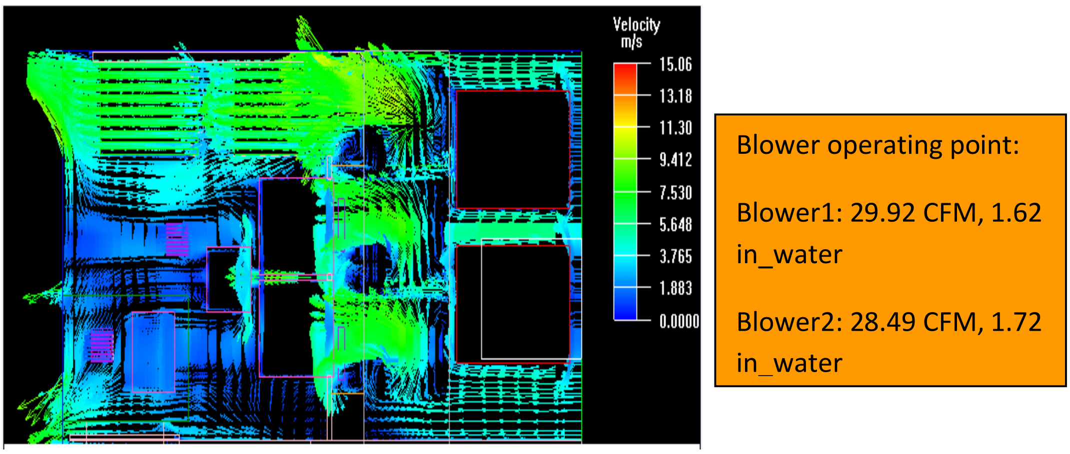


Figure 10: Temperature Contours on All Components

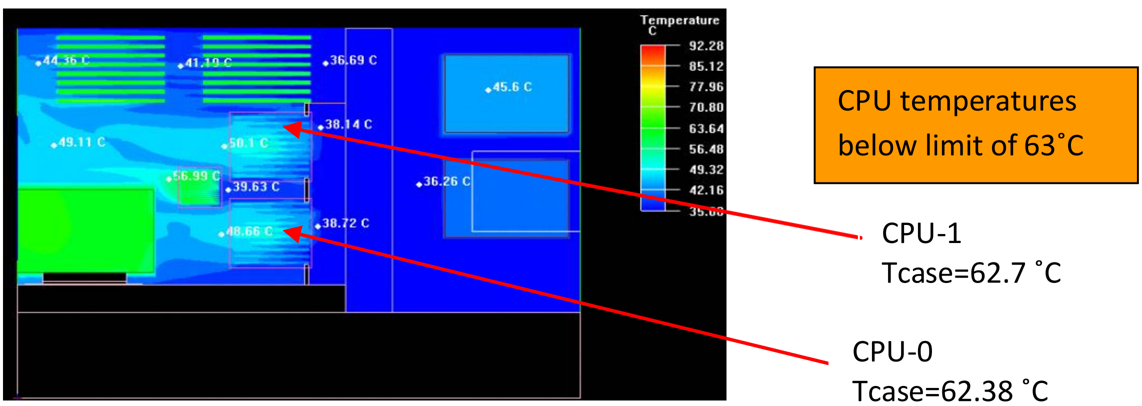
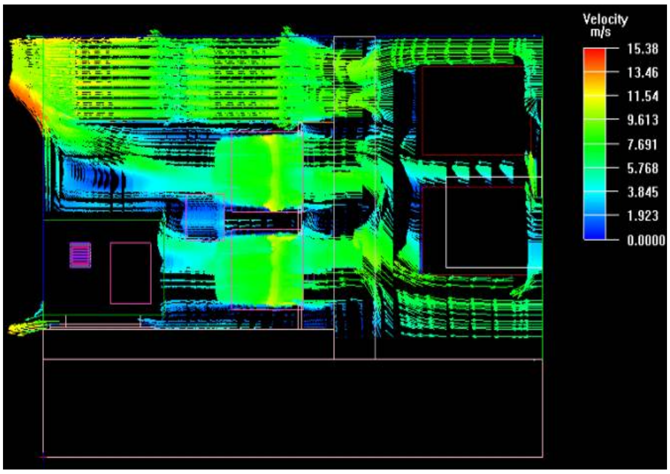


Figure 11: Velocity Vectors in the System (Total Flow 112 CFM)



Operating point:

Fan1: 22.47 CFM, 1.44 in_water

Fan2: 21.57 CFM, 1.58 in_water

Fan3: 18.93 CFM, 1.836 in_water

Fan4: 16.22 CFM, 2.04 in_water

Fan5: 18.15 CFM, 1.91 in_water

Fan6: 18.29 CFM, 1.9 in_water

please chk table is not mentioned in the text

Table 1: Summary of Results

S. No.	Component	Allowable Temperature (°C)	Base line	Ducted heatsink with blower	Ducted heatsink with axial fan	Ducted heatsink and embedded heat pipe with blower
1.	CPU-0	Tcase=63	Tcase=82.2	Tcase=64.58	Tcase=62.38	Tcase=61.16
2.	CPU-1	Tcase=63	Tcase=80.1	Tcase=65.06	Tcase=62.7	Tcase=60.21
3.	Blackford MCH	Tcase=105	Tcase=87.7	Tcase=100.5	Tcase=92.28	Tcase=100.5
4.	ESB2	Tcase=105	Tcase=88.1	Tcase=96.2	Tcase=79.92	Tcase=96.2
5.	Pilot	Tcase=75	Tj=108.8	Tj=72.2	Tj=64	Tj=72.2
6.	BCM5715	Tj=110	Tj=98	Tj=74.3	Tj=61.4	Tj=74.3
7.	VRD FETs	Tj=150	Tcase=75.1	Tcase=74.12	Tcase=65.04	Tcase=74.12
8.	VRD Controller	50 ambient	39 ambient	48 ambient	46 ambient	48 ambient
9.	FBDIMM	Tcase=85	-	Tcase=79.1	Tcase=77.5	Tcase=79.1
10.	AMB	Tcase=110	Tcase=75	Tcase=89.8	Tcase=85.2	Tcase=89.8

Note: Tcase = Temperature of the case.

CONCLUSION

The investigations carried in this paper are of optimal heat sink design with optimal air flow and acoustic noise reduction with enhanced heat transfer using CFD analysis by ice pack, commercial CFD software. The salient conclusions are made on the basis of above results:

- Heat sink design is optimized with 70 fins, 4.5 mm base thickness and 0.25 mm fin thickness.
- With the use of ducted and optimized heatsink, components and CPU temperatures have been brought down to 64.58 and 65.06 °C. The components are well within the allowable temperature limit and the CPU is 3 °C more than the allowable limit.
- With the use of double axial fans, all components are thermally safe, but acoustic point of view this option is ignored.
- With the use of embedded heat pipes to the base of the heatsink, temperature has been further reduced by 5 °C, the system and components are within the operating temperature with reduction in acoustic noise.

REFERENCES

1. Archambeault B, Brench C and Ramahi M (2001), *EMI/EMC Computational Modeling Hand Book,* Second Edition, Kluwer Academic Publishers.
2. Steinbrecher R, .Radmehr A, Kelkar K M and Patankar S V (1999), "Use of flow net work modeling (FNM) for the design of Air-cooled server", Advances in electronic packaging, Proceedings of the pacific RIM/ASME Inter Society Electronics and Photonic packaging Conference, Vol. II, pp. 1999-2008.
3. Stephen Scampoli (2009), "Staying Cool with ANSYS Icepak", *ANSYS Advantage*, Vol. III, No. 2, pp. 38-39.
4. Shidore S and Dorsey J (xxxx), "A Proposed Technique for the Modeling of Radial blows in Flowtherm ", Flomerics, Inc.
5. Timothy J Dake and Joseph Majdalani and Susheela Narasimhan (2003), "Design optimizationof a router board using computational fluid dynamics", Proceedings of IPACK'03 International Electronic Packaging Technical Conference and Exhibition, July 6-11, 2003, Maui, Hawaii, USA.