Cooling System of Laptops

Part Ⅰ

Literature Article Review (by Xie JiYu)

The most common way to cool hot components today is by using big stock coolers with air flow, provided by the stock fans that come with the CPU and GPU.

It is necessary to understand how heat transfer across the CPU first. Heat transfer across the CPU mainly has three types. Firstly, conduction, which happens in direct metal-to-metal contact. Secondly, convection, which happens in liquids and gases where hot air in a large room rises, or cold water sinks. And thirdly, radiation.

According to a study (R.Mohan, 2010), the CPU can be modeled as a 2D area which dissipates 80W. The 30mm x 30mm cross sectional area of CPU is taken which is commercially available AMD CPU. The mother board, chipset card are modeled as zero thickness with heat generated uniformly for simplicity. The CPU fan is modeled as a lumped parameter model and does not have blades. SMPS (Switch Mode Power Supply) and few miscellaneous cards are modeled and lots of small electronic components on these cards are not modeled. The governing equation is a time-independent flow equations with turbulence, which viscous dissipation term is omitted.

The continuity Equation: $\nabla(\rho,\ \overline{\nu}) = 0$

The X, Y, Z Momentum Equations: Equation of state

$$\nabla(\rho, u,\ \overline{\nu}) = -\frac{\partial p}{\partial x} + \frac{\partial \tau_{xx}}{\partial x} + \frac{\partial \tau_{yx}}{\partial y} + \frac{\partial \tau_{zx}}{\partial z} + B_x$$

$$\nabla(\rho, v,\ \overline{\nu}) = -\frac{\partial p}{\partial y} + \frac{\partial \tau_{xy}}{\partial x} + \frac{\partial \tau_{yy}}{\partial y} + \frac{\partial \tau_{zy}}{\partial z} + B_y$$

$$\nabla(\rho, w, \bar{v}) = -\frac{\partial p}{\partial z} + \frac{\partial \tau_{xz}}{\partial x} + \frac{\partial \tau_{yz}}{\partial y} + \frac{\partial \tau_{zz}}{\partial z} + B_z$$

The Energy Equation: $\nabla(\rho, h, \bar{v}) = -p\nabla \bar{v} + \nabla(k\nabla T) + \emptyset + S_k$

Equation of state: $P = \rho RT$.

Whereρ is the density, u, v and w are velocity components, $\bar{v}$ is the velocity vector, p is the pressure, B terms are the body forces, h is the total enthalpy andτ terms are the viscous stress components.

Using CFD(Computational Fluid Dynamics), Mohan got pictures below:

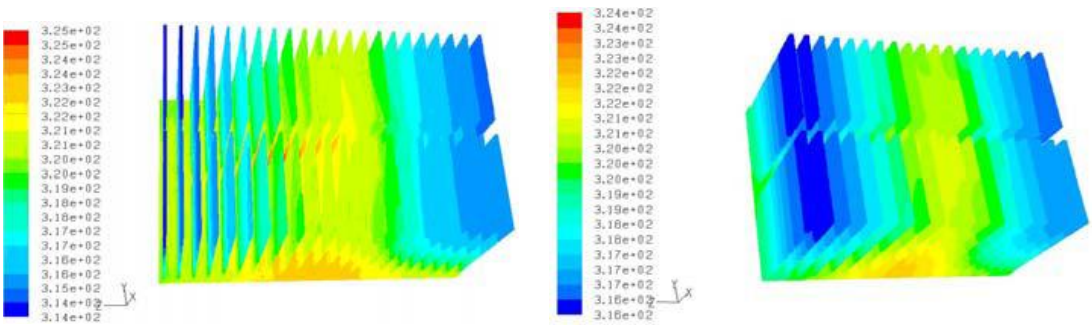

Fig. 1. Plate Heat sink without base plate 0.5mm(left) and 1mm(right) thickness.

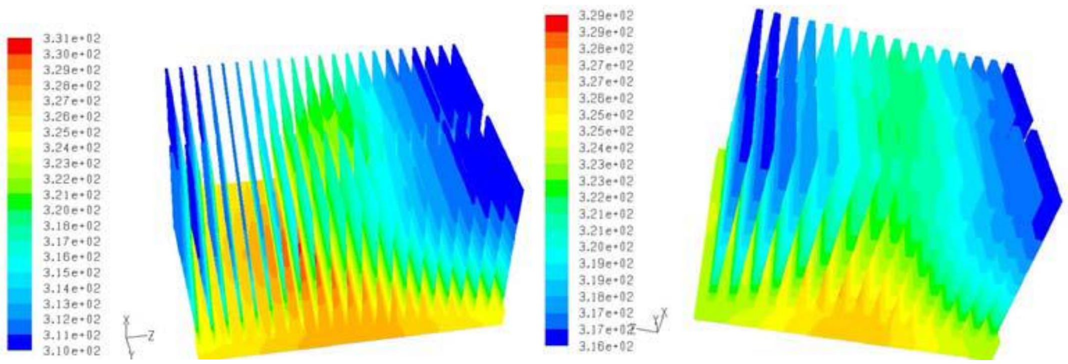

Fig. 2. Plate Heat sink with 2.5mm base plate and 0.5mm(left) and 1.5mm(right) thickness.

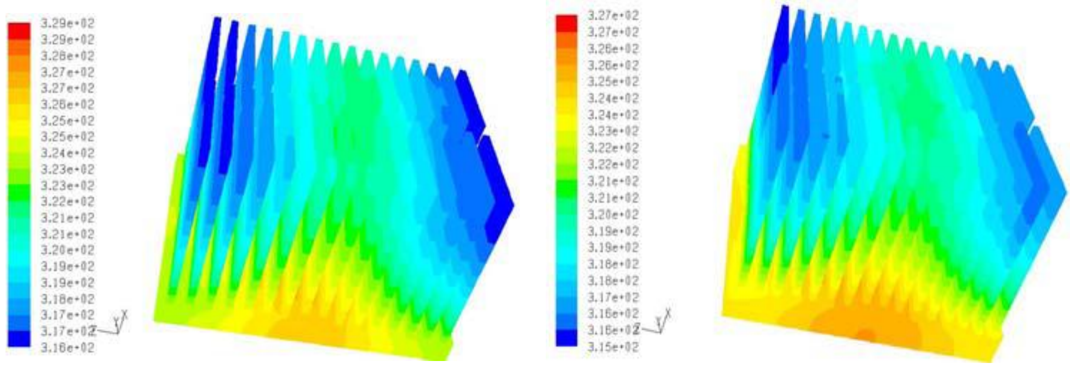

Fig. 3.Plate Heat sink with 2.5mm(left) and 5mm(right) base plate and 1.5mm thickness.

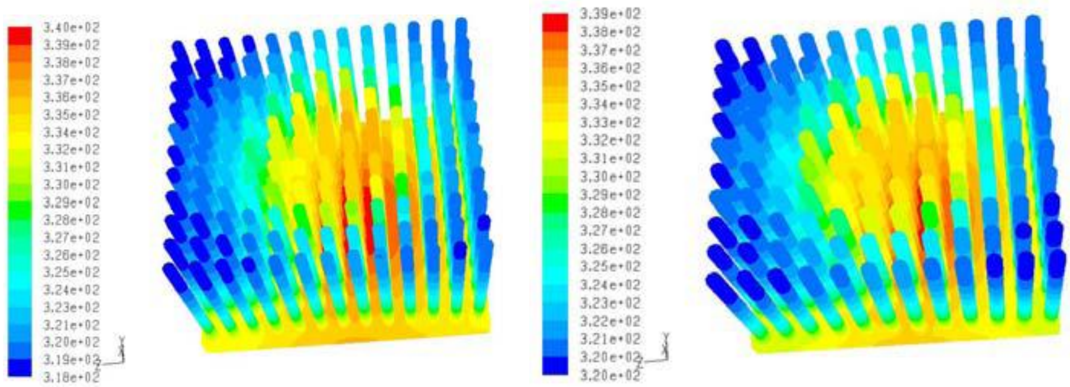

Fig. 4. Cylindrical Heat sink with 2.5mm base plate and 2.5mm(left) and 3mm(right) thickness.

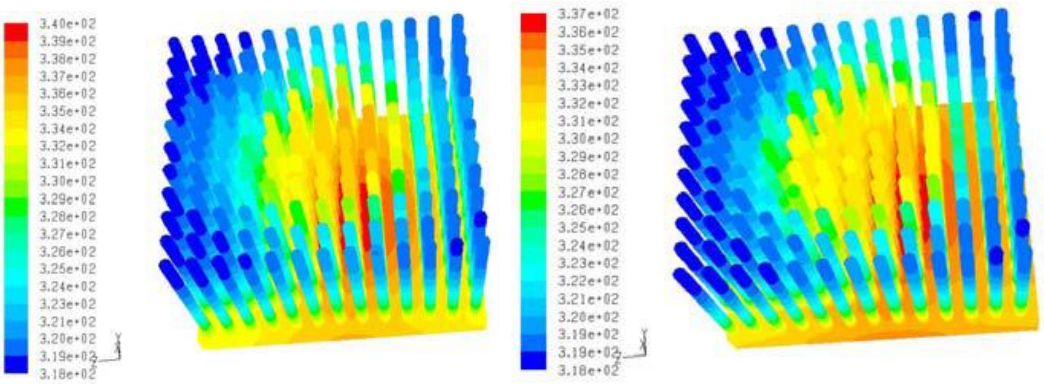

Fig. 5. Cylindrical Heat sink with 2.5mm(left) and 5mm(right) base plate and 2.5mm thickness.

We can learn that by increasing the base plate thickness and changing the material of base plate the performance of heat sink is enhanced. It is also observed that by adding the base plate increases the heat conduction rate instead of increasing the fin height.

In a study (Manish Sharma, 2015), the present design has been modified by using two heat pipes instead of one. In the new suggested design two heat pipes are used with the same evaporator and condenser arrangement.

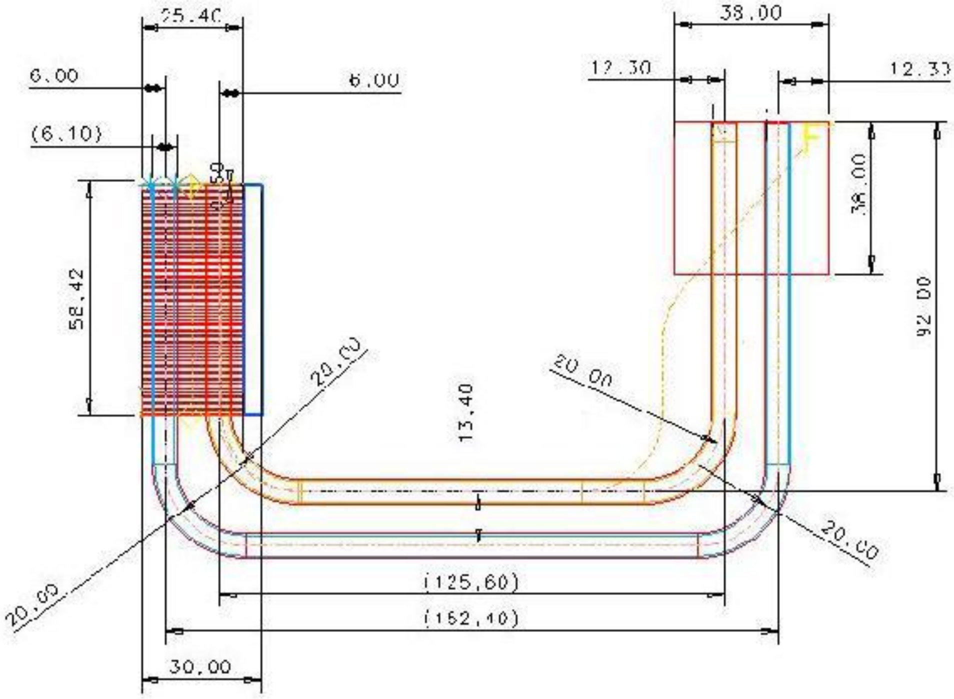

Fig. 6. Dimensional details of new suggested Acer thermal Management system..

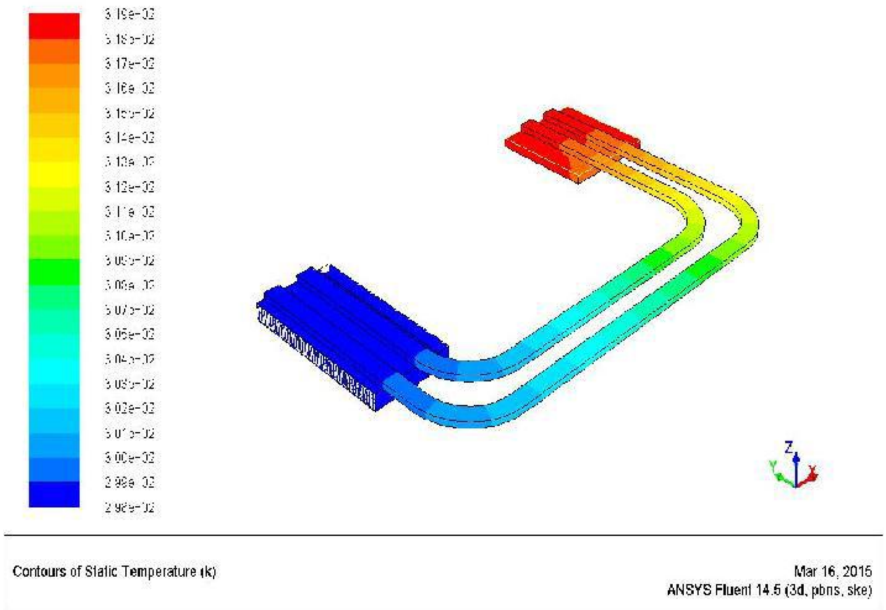

Fig. 7. Static Temperature Contour for existing design.

After modelling of the systems mesh is generated in the ANSYS mesh software. Tetrahedral mesh with element edge length of 1 mm is used for both the systems.

3D CFD analysis of the above models was done in ANSYS fluent using Pressure-based solver. The physical model used was viscous k-ε two equation turbulence model. The material properties are taken as: density of air $\rho = 1.225\,\mathrm{kg}/m^3$ and Viscosity$\nu = 1.7894 * 10^{-5}$ Boundary conditions for the analysis are Pressure $\mathrm{p} = 101325\,\mathrm{Pa}$ as operating condition; Inlet velocity $\mathrm{v} = = 3.47\,\mathrm{m/s}$ and outlet pressure as zero gauge pressure are used. Turbulent intensity = 1% and Hydraulic Dia. = 9.78 mm is used for both inlet and outlet.

Pressure-velocity coupling with SIMPLE scheme is used as the solution method for the analysis. Equations used for momentum, energy, turbulent kinetic energy and turbulent dissipation rate are of second order. Number of iterations performed for obtaining the solution are 2000.

Static temperature contours of the thermal management system of the new suggested design have been presented in figure 8 & 9. The temperature range for existing design is from 298 K to 319 K.

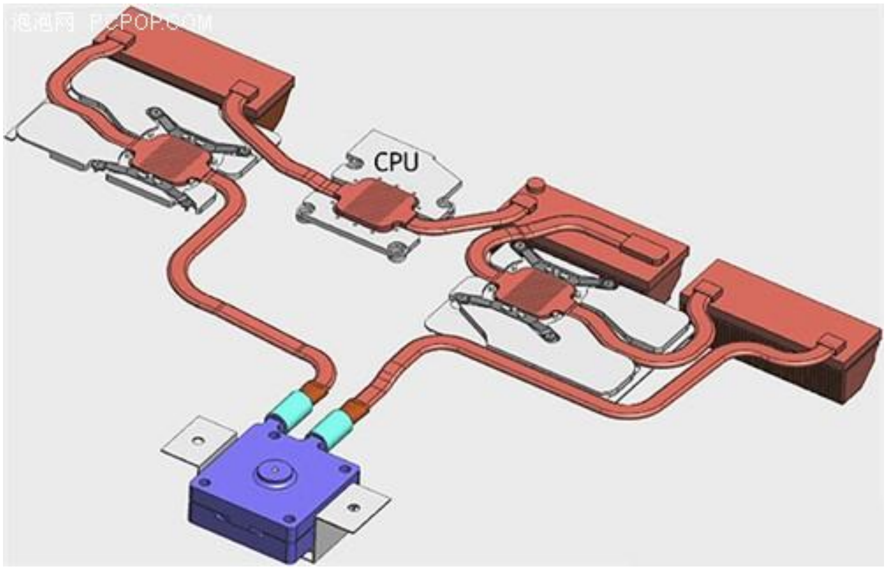

Fig.8. A liquid cooling method of Asetek®

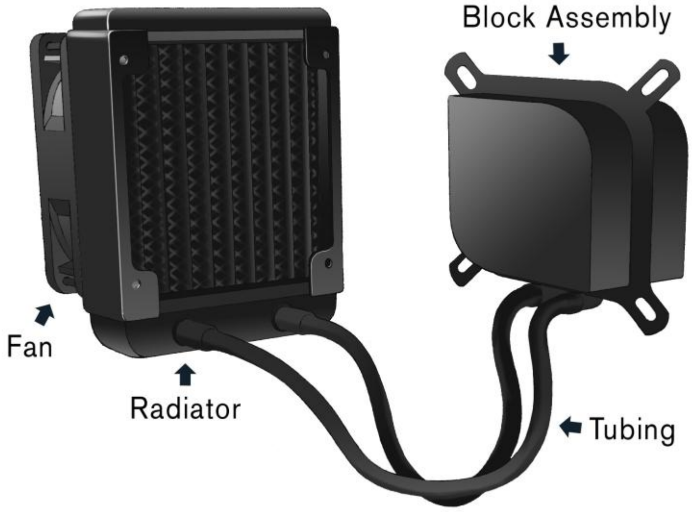

Fig.9. Overview of a factory sealed water cooling system (Thorén and Widell, 2017). These factory sealed systems are constructed from several components: a fan, a radiator, tubing and finally a block assembly, which consists of a water block and a pump.

When computer is running, the fans run at a very high RPM(resolutions per minute) and are quite loud. By installing liquid cooling, devices can get rid of the loud fans, and water is much better at transferring heat from the hot components compared to air. The main advantages of water cooling, compared to conventional air cooling, are that the distance between the heat source and the heatsink can be longer and that the heatsink may be larger than what is possible in a usually restricted space around the heat source. Because liquid cooling radiators provide a huge cooling area, people can use fans at very low speeds, that are practically inaudible, then they can enjoy gaming and everyday desktop work with absolutely no noise coming out of their computer. This study will benefit the design engineers involved in electronic cooling.

Part Ⅱ

Reference

Mohan, R., & Govindarajan, P. (2010). Thermal analysis of cpu with variable heat sink base plate thickness using cfd. *International Journal of the Computer the Internet & Management*, *18*, págs. 27-36.

Sharma, M. (2017). *CFD ANALYSIS OF A LAPTOP THERMAL MANAGEMENT SYSTEM*. 1st ed. [ebook] Available at: http://technicaljournalsonline.com/ijeat/VOL%20VI/IJAET%20VOL%20VI%20ISSUE%20II%20APRIL%20JUNE%202015/IJAETVol%20VI%20Issue%20II%20Article%207.pdf [Accessed 20 May 2017].

Asetek.com. (2017). *Data Center, Server, and PC Liquid Cooling - Asetek*. [online] Available at: http://www.asetek.com/ [Accessed 20 May 2017].

Thorén, J. and Widell, A. (2017). *Development of Liquid Cooling for PCs*. 1st ed. [ebook] Available at: http://publications.lib.chalmers.se/records/fulltext/153096.pdf [Accessed 20 May 2017].