Analysis of CPU cooling using liquid with different type of heat sinks

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Abstract

In the present study a mini-square heat sink is investigated with different geometries. Four mini-square heat sinks with two different material types and two different geometries are fabricated from copper and aluminum with the cube size is 50 mm. The de-ionized water is used as a cooling liquid. Effect of material type of heat sink and run condition of PC on the CPU temperature are considered. The liquid cooling in mini -square heat sink is compared with the other cooling techniques. The result of this study are expected to lead to guidelines that will allow the design of the cooling system with improved heat transfer performance of the electronic equipments.
Keywords: *Liquid cooling, Heat sink, cooling of CPU.*

1. Introduction:

The Central Processing Unit (CPU) generates great amount of undesirable heat in modern computing systems. The CPU is responsible for processing most of the data in the systems and is often referred to as a computer's central processor or simply processor. As we know data is processed in the system, and because of this heat is generated. Once heat thresholds are exceeded, CPUs are placed at risk of malfunction or permanent damage.

In order to ensure reliable operation, the personal computer (PC) or electronic devices must be operated in allowable temperature ranges. The exceeding maximum allowable temperature is a serious problem for these devices. Therefore, in order to keep the operating temperature constant, the cooling system must dissipate generated heat higher than or equal to the generated heat of these devices. There are many techniques to dissipate the generated heat. The development of mini and micro-components has been introduced as one of the techniques.

Due to the limitation of air-cooling and small physical size of the electronic devices, the development of mini and micro-components has been rapidly increased especially in the medical engineering, electronic engineering and other fields. Liquid based cooling of electronics is an obvious choice due to their superior thermo physical properties compared with air.

In recent years, attention is now focused on liquid cooling techniques because of their higher heat transfer coefficient rate associated with liquids. Generally two methods have been employed in order to optimize the performance of liquid cooling systems. The first method is to modify the heat sink geometry using ordinary coolants while the second method involves the modification of thermo physical properties of ordinary fluids in an effort to enhance their heat transfer performance.

Today, the most common used method for thermal management of computer chips is air cooling, where the heat is transported from the chip to a directly adjacent metal block, then transported either through solid metal or through heat pipes to a heat sink, from where the heat is transferred to the surrounding air. With water cooling, water in tubes transfer the heat from the block to the fins. Thus, the water in water cooling replaces copper rather than air.

2. Literature Review:

The project aims to find the optimum design for cooling of CPU. In this project an attempt has been made to study the various types of heat sinks and cooling liquids are used. Over the last decade, driven by the rapidly increasing heat dissipation predicament involving microprocessors, numerous investigations have been conducted. Peles, Kosar, Mishra, Kuo and Schneider [1] investigates forced convective heat transfer in a micro heat sink. Lui, Xu and Chen [2] done an experimental study on liquid flow and heat transfer of a heat sink. Tullius and Bayazitoglu [3] studied how optimization is done with different fin geometries so more fins are placed in mini-channels. Chen, Zhang and Li [4] has done experiment study on heat transfer performance of porous heat sink. Shabgard, Allen, Sharifi, Benn, Faghri and Bergman [5] presented theoretical study on challenges for a heat sink. Naphon and Khonseur [6] studied convective heat transfer and pressure drop in micro-channel heat sink. Naphon and Wiriyasart [7] experimentally investigated use of thermoelectric for CPU. Naphon, klangchart and Wongwises [8] presented a numerical study on the heat transfer and flow in mini-fin heat sink. Nazari, Karami and Ashouri [9] compared experimentally the thermal performance of different cooling fluids. Shefeie, Abouali, jafarpur and Ahmadi [10] done numerical study on heat transfer performance with micro pin-fin structure. Hasan [11] investigated the flow and heat transfer properties for heat sink with nanofluid. Jajja, W. Ali, H. Ali and A. Ali [12] has done experimental study on effect of fin spacing. Al-Damook, Kapur, Summers and Thompson [13] presented computational and experimental investigation of air flows through perforated pin heat sink. Whelan, Kempers and Robinson [14] done analysis of jet array impingement water block and a remote heat exchanger. Khonsue [15] experimentally investigate liquid cooling system with thermoelectric. Haghighi, Utomo, Ghanbarpour, Zavareh, Poth, Khodabandeh, Pacek and Palm [16] has done experimental study on convective heat transfer of nanofluids in turbulent flow. Naphon and Wongwises [17] investigated jet liquid impingement heat transfer for CPU.

3. Objectives and Scope:

The primary objective is to find suitable heat sink for cooling of CPU. And for validating CFD or same type of software package will be used for analysis purpose.

4. Methodology:

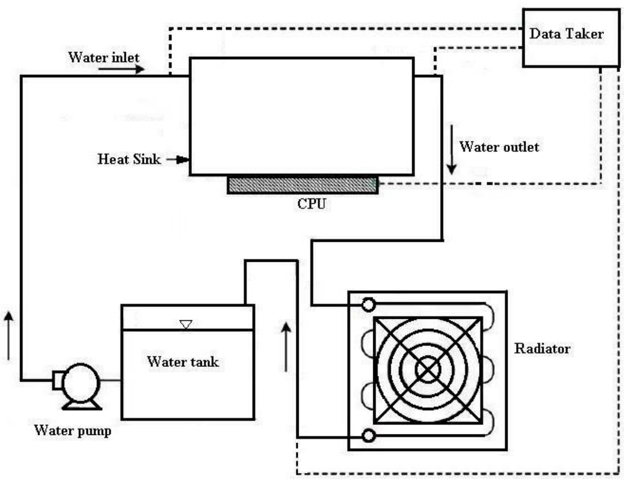

Fig.1 Diagram of proposed set-up

A schematic diagram of the experimental set up is shown in figure above. The test setup consist of a set of PC, cooling de-ionized water loop and data acquisition system. The test section and connections of the piping's are designed such that parts can be replaced or repaired easily. The close-loop of de-ionized water have a storage tank, pump and a radiator. The cooling de-ionized water is cooled by atmospheric air. After the temperature of the water is reached to the desired temperature, the water is pumped out of the storage tank and is passed through CPU and returned to the storage tank through radiator. The test sections will fabricated from the blocks of copper and aluminum.

De-ionized water will be used as coolant. The de-ionized water pumped in to the mini-square heat sink. The inlet temperature of coolant water before entering the cooling section will be kept nearly constant of 25-30 °C. Experiments will conduct with various heat sinks, material type of heat sinks and run condition of PC. The supplied load into the CPU was adjusted to achieve the desired level by setting run condition of PC. 3 run load conditions are applied - ideal, medium load, high load. The temperatures at each position recorded in the specific period time. Data collection was carried out using a data acquisition system.

After conducting the experiment the data will be fed to the software like ANSYS or COMSOL or CFD or similar software package having thermal boundary conditions for validating the values are correct which I will get from experiment.

5. Experimentation:

Computer CPU loading condition for experiment is conducted on room temperature of 24-27 °C in period of 2 hours. The cooling water is cooled at room temperature by radiator using of external fan over it.

Load condition	Temp. range (°C)
Ideal	24-31
Medium	42-50
High	62-70

Table1.Temperature range at different load conditions.

Flow rate of cooling fluid is kept constant. Different temperature of processor and cooling fluid coming outside from heat sink is measured.

This experiment is done on two different type of heat sink which are made of two different materials.

6. Geometry Preparation:

As heat sink is going to be attached to processor of CPU size of heat sink is limited to 50 mm x 50 mm. Thickness of heat sink can be varied as in vertical direction there is no restriction. Part drawing is made in Catia software. For geometry of heat sinks two type of shapes are selected.

1)Zigzag

2)Helix.

And there is an extra part as top cap for covering cube form the top side so fluids will not come out. There is a slot for keeping a tempered glass to look inside. Base body and top cap will fitted through threaded screws. For that holes are made at top. For fitting on processor chip there are also holes at the base.

Geometry models are made in CATIA and are shown below.

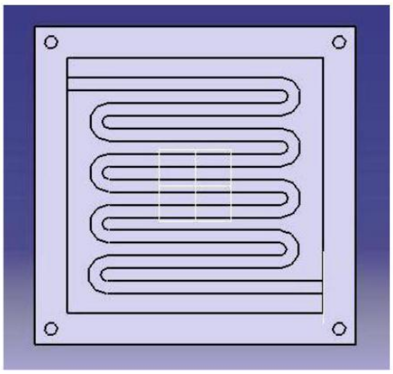

Fig.2 Top view of heat sink 1.

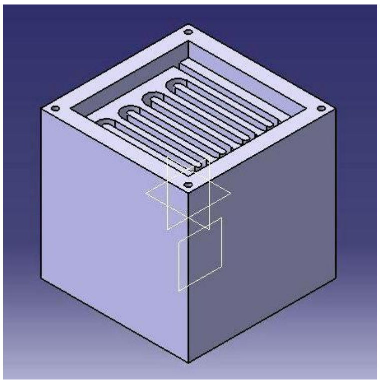

Fig. 3 Isometric view of heat sink 1.

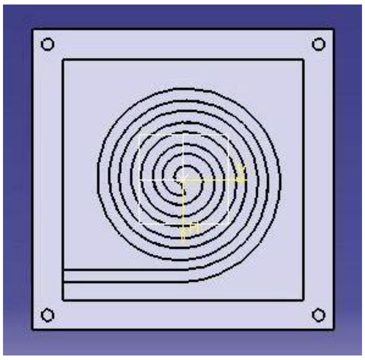

Fig.4 Top view of heat sink 2.

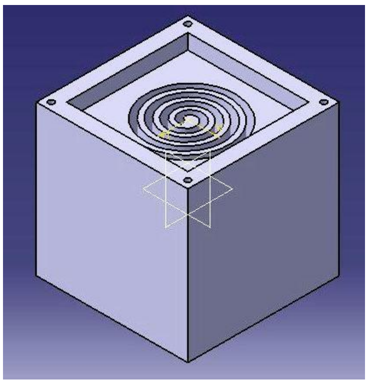

Fig. 5 Isometric view of heat sink 2.

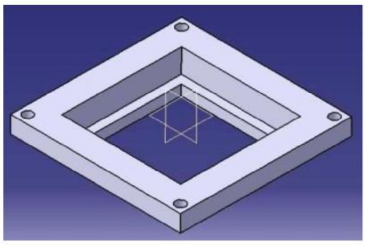

Fig.6 Isometric view of top cap.

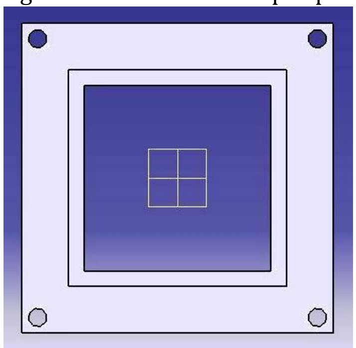

Fig.7 Top view of top cap.

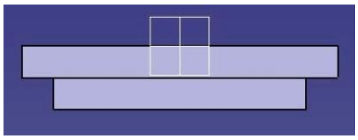

Fig.8 Side view of top cap.

As show in fig. 2 de-ionized water will enter from one side and will come out from the other side of water passage. Similarly for fig. 4 de-ionized water will enter from center of the helix shape and will come out from the other side circulating in circle. For helix a hole is made in the glass so water in pipe will be fitted there.

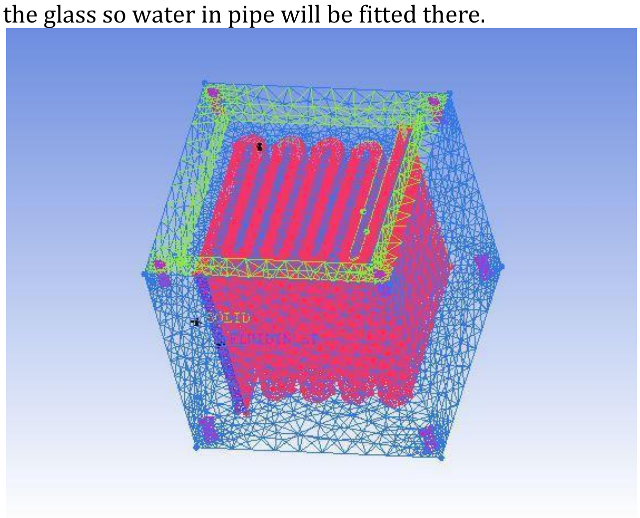

Fig.9 Wire mesh of heat sink 1.

CATIA drawing is imported into ICEM software where we can clean this geometries and also do meshing of it. ICEM is useful software for mesh. Here unstructured mesh type is used i.e. triangular.

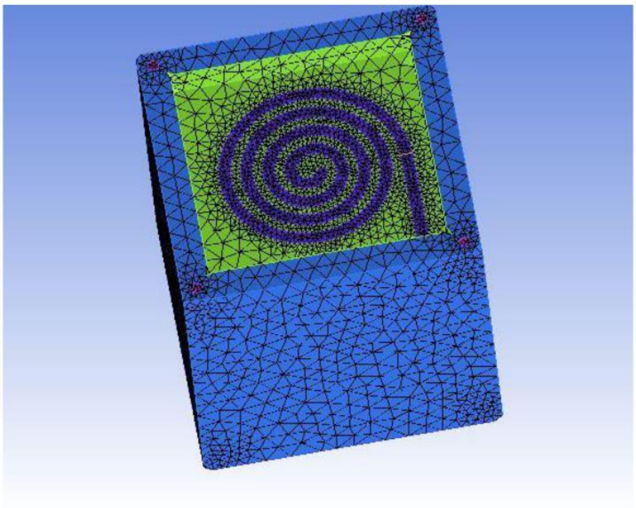

Fig. 10 Surface mesh of heat sink 2.

7. Result:

Temperature distribution is found in CFD post processor software. It is also a sub-part of ANSYS. Mesh file is imported into CFD fluent and boundary conditions are given to geometry.

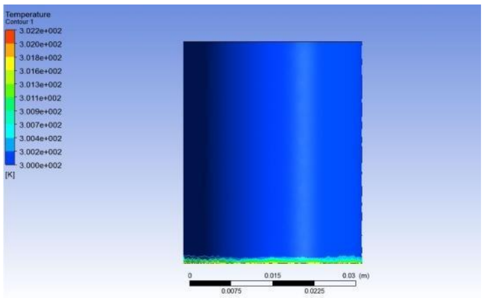

Fig.11 For ideal load condition.

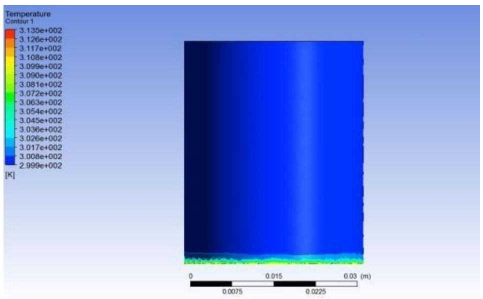

Fig.12 For medium load condition.

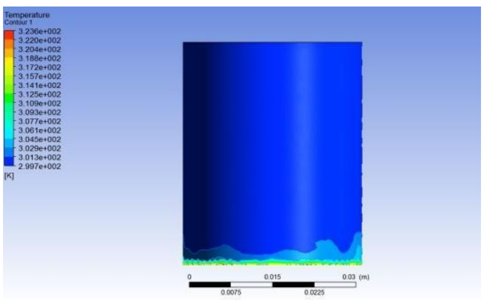

Fig.13 For high load condition.

8. Conclusion:

The analysis work is done on different heat sinks material and run condition of processor. As copper have more heat transfer conductivity than aluminum but it is costly than aluminum. On the base side heat is directly applied form the processor so temperature of base is nearly as high as processor temperature. But as water starts flowing it carried out the heat of sink. Even for high load of processor, heat sink gives good result.

9. References:

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