DESIGN OF AN ACTIVE CPU COOLER DESIGN INCOPRATING HEAT SPREADER

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ABSTRACT

This poster designed an active heat sink to cool a silicon CPU that dissipates 130 W of heat. The active CPU cooler is composed of a fan sitting above the heat sink, an aluminum radial heat sink, a copper heat spreader at the base of the heat sink and a copper core inside the heat sink. Various designs with different fin thickness, fin numbers and thermal spreader thickness were studied and the best design was selected. The selected design had 40 fins of 2mm thickness, and a Ø65mm thermal spreader with a thickness of 2mm. Parametric study was done on the selected design to see how the maximum temperature of the CPU varied when the thermal spreader diameter, copper core height and fan speed by the CPU was varied. All the studies conducted proved that the selected design was validated.

INTRODUCTION

In today's high-tech world, chips inside electronic gadgets are getting thinner with more processing power, and hence generating higher amounts of heat energy in a smaller volume. The challenge faced by designers is to effectively cool down the system without compromising on power consumption, noise level and cost efficiency. To dissipate more heat generated through these processors, the fans with high fan speeds and higher mass flow rate can be installed in the assembly of an active heatsink, as shown in Fig. 1. But, increasing the fan speed also increases undesirable vibration, noise level and power consumption of the CPU. Other cooling technologies such as refrigeration and liquid cooling are limited due to complicated integration, limited reliability, and high costs. So it becomes really important to optimize the positioning of the components in the CPU and also the heatsink design. The maximum allowable operating temperature of CPU chip is around 70°C (343K) and its reliability decreases by 10% for every 2°C increase in temperature. In this poster, we would be comparing different heatsink designs, varying the number of fins, fin thickness, height of copper core and rotation speed of the fan for cooling a CPU dissipating 130W heat. Also an optimized heatsink design is presented to dissipate 130W of heat.

DESIGN OF HEAT SINK

Flow Simulation Set-up

The heatsink is to be designed for a silicon chip of 31X31 mm with a base of 35X35 mm. The heatsink has a copper core with a diameter of 30mm. Thin aluminum fins are distributed around the copper core with their number and thickness varying between 20 - 40 and 1 - 3 mm respectively. Design and flow simulations of the heatsink were done in SolidWorks 2016.
The ambient air and initial wall temperature are set as 38°C with the computational domain given below.

X_{max}= 0.095 m	Y_{max} = 0.113 m	Z_{max} = 0.095 m
X_{max}= -0.095 m	Y_{min} = 0.0005 m	Z_{min} = -0.095 m

The mesh is set to automatic with creation of 6 additional control planes, two each in X, Y, Z direction respectively. The solid feature refinement level, tolerance refinement level and tolerance reference criterion is set as 3, 2 and 0.001 m respectively. The rotating region was given an angular velocity of 4400 rpm while comparing different heatsink design set-ups.

COMPARISON OF DIFFERENT HEATSINK DESIGNS

The parameters for comparing different set-ups are number of fins, their thickness and the thickness of the thermal spreader. The flow simulations were done for 20 fins of 1 mm, 2 mm and 3 mm thickness, as shown in Table 1. The number of fins were varied as 20, 30 and 40 in Table 2. The thermal spreader thickness was differed as 5 mm and 2 mm in Table 3. The best design selected based on results of above flow simulations had 40 fins with 2 mm thickness. The thickness of the thermal spreader is taken as 2 mm.

Table 1. The effects of fin thickness with 20 fins

Fin Thickness	1 mm	2 mm	3 mm
Max CPU Temperature (K)	356.04	363.54	352.45

Table 2. Effects of number of fins with a fixed 2 mm thickness:

Number of fins	20	30	40
Max CPU Temperature (K)	363.54	354.74	349.20

Table 3. Effects of thermal spreader thickness with 40 fins of 2 mm thickness

Thermal Spreader Thickness	2 mm	5 mm
Max CPU Temperature (K)	342.49	344.33

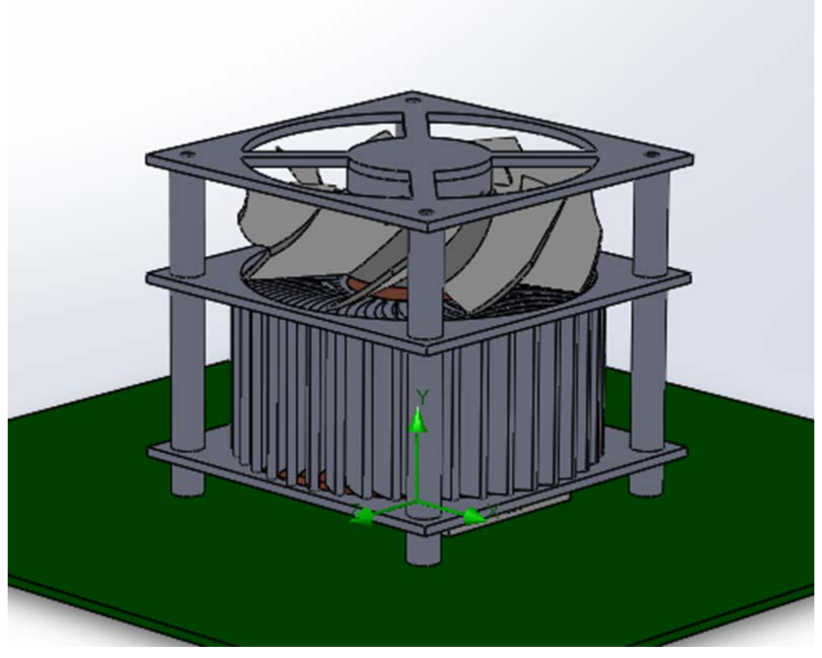

Fig 1: SolidWorks model of selected heatsink

PARAMTERIC STUDY OF OTHER COMPONENTS

1. THERMAL SPREADER DIAMETER

Table 4. The effects of thermal spreader diameter

Thermal Spreader Diameter (mm)	Max CPU Temperature (K)
40	342.39
45	342.20
50	341.89
55	341.62
60	341.70
65	341.38
70	341.11

Parametric study was done to study the effect of thermal spreader diameter on the maximum temperature of CPU. The variation of the temperature of CPU with the change of thermal spreader diameter is represented in the Table 4. From the Table 4 it is clear that, changing the thermal spreader diameter decreases the CPU temperature, but the effect is small.

2. COPPER CORE HEIGHT

Table 5. The effects of copper core height

Copper core Height (mm)	Max CPU Temperature (K)
10	344.45
15	343.35
20	342.15
25	341.82
30	341.47
35	341.71
37	341.27

Parametric study was done to study the effect of the copper core height on the temperature of CPU. The variation of the maximum temperature of CPU with the change in copper height is represented in the Table 5. From the Table 5 it is seen that the temperature decreases initially until 38 mm and then it again increases. Thus, it can be concluded that the CPU core temperature decreases up to a certain limit with increase in copper core height, after that it increase again with core height.

3. FAN SPEED

Table 6. The effects of fan speed

Fan Speed (rad/sec)	Max CPU Temperature (K)
2500	343.40
3000	342.41
3500	341.68
4000	341.40
4400	341.41
4500	341.30

Parametric study was done to study the effect of the fan speed on the temperature of CPU core. The variation of the temperature of CPU core with the change in fan speed is represented in the Table 6. From the Table 6, it is seen that temperature decreases as the speed of fan rotation increases. But, increasing the fan speed also increases the power consumption and the noise generated by the fan, which is undesirable.

4. RESULTS OF VELOCITY AND TEMPERATURE PROFILE

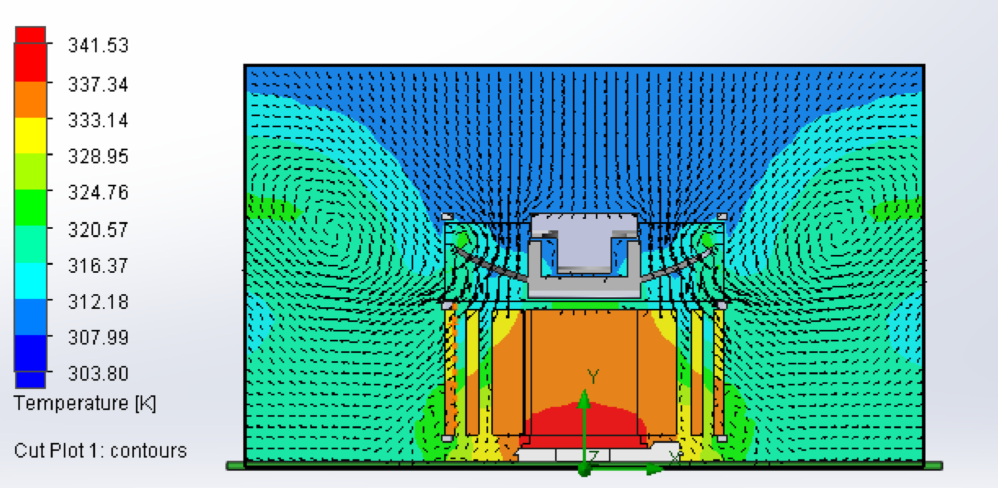

Fig 2: Result of temperature profile of selected heatsink

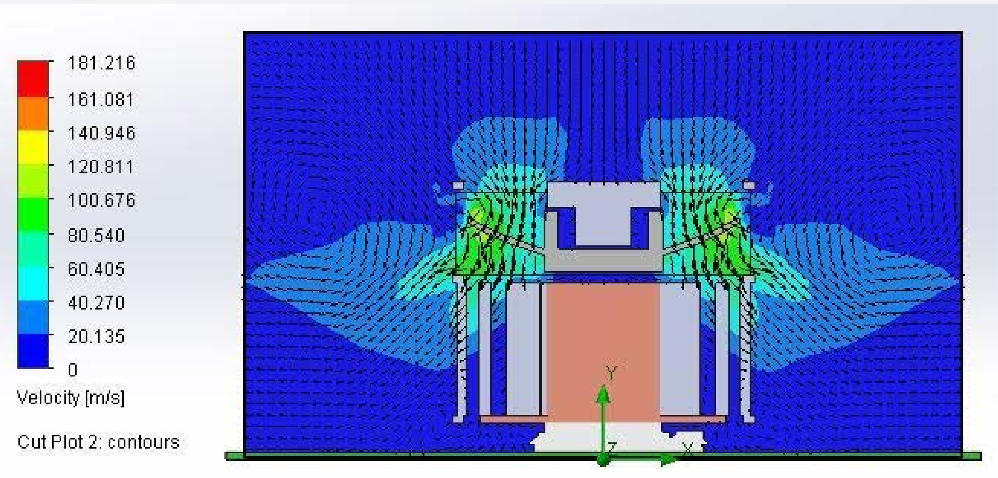

Fig 3: Result of velocity profile of selected heatsink

CONCLUSION

In this poster, study of different characteristics of heatsinks & components were done. We got a better idea of how thickness and diameter of the thermal spreader, number of fins and their thickness, core height and fan speed affect the performance of the heat sink. Only after extensive studies and varying different parameters in a systematic way an optimized design of the heat sink for a certain application can be found out. The results of the parametric studies further confirm the validation of the selected design.