Diyala Journal of Engineering Sciences

ISSN 1999-8716

Printed in Iraq

First Engineering Scientific Conference
College of Engineering –University of Diyala
22-23 December 2010, pp. 1-11

THE EFFECT OF HEAT SINK FINS LENGTH AND MATERIAL ON ITS PERFORMANCE

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ABSTRACT:-In this paper an investigation of five lengths of three different materials (steel, copper and aluminum) of one quadrate type of heat sink (which commonly used in earlier high performance graphic cards of built-in motherboards) to measure its conductivity and ability of emitting heat when the chipset works at its maximum performance (reaches a temperature of nearly 60^{o} C) and to investigate the relationship between the heat sink length ,material and its performance taking cost into consideration. It's known that for emitting heat, copper came 1st then aluminum and steel in 3rd place, which conform the results, but if we take cost into consideration the aluminum model takes the lead, the results also shows the effect of fins length upon heat sink ability of dissipation heat and it conclude that an aluminum heat sink of 2 -2.5 cm fins length is the best.

Keywords: Investigation, Heat sink, Fins.

INTRODUCTION

During the last 20 years, the electronics cooling industry has made widespread use of Computer added engineering CAE technology for design. Today, it is one of the fastest changing industries, because of rapid hardware advances, ever shorter design cycles, and a constant drive to cut costs and improve unit productivity. Moreover, as computer speed and memory capacity continue to increase, there is a need to remove more heat from computers in the same or less space than before. So due to the increment of clock speed, switching speed and transistor density, the size of the central processing unit chipset becomes smaller but the efficiency is getting higher. This inevitably leads to the **(increase of heat generation rate per volume of the chipset)**. If the heat cannot be removed appropriately, the chipset life can be greatly shorten and the overheat situation can also damage the normal operation of the process [Bar-Cohen, 1999]. A simplest and effective way to improve the chipset heat dispersion is the use of the air cooling fins. In recent years the plate-fin design for the chipset heat dispersion has received considerable attention and many design techniques have been proposed [Bejan and Morega, 1993; Culham and Muzychka, 2000; Krueger and Bar-Cohen, 2001; Shih and Liu, 2004].

THEORY

A dynamic simulation and analysis of the chipset heat sink process was applied to governing equations and boundary conditions .The diagram of the chipset heat sink process to be considered is shown in figure 1 for the shotr one and figure 2 for the longest model (double length).

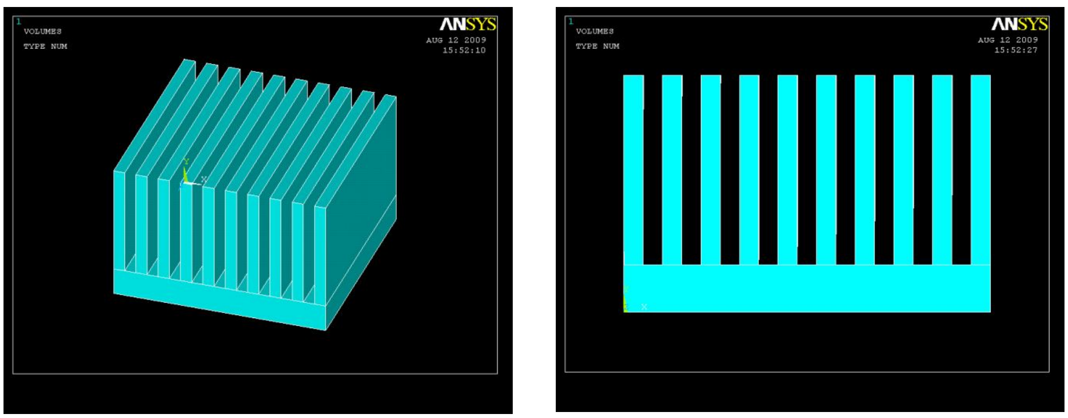


Figure.1 chipset heat sink short model and its cross section.

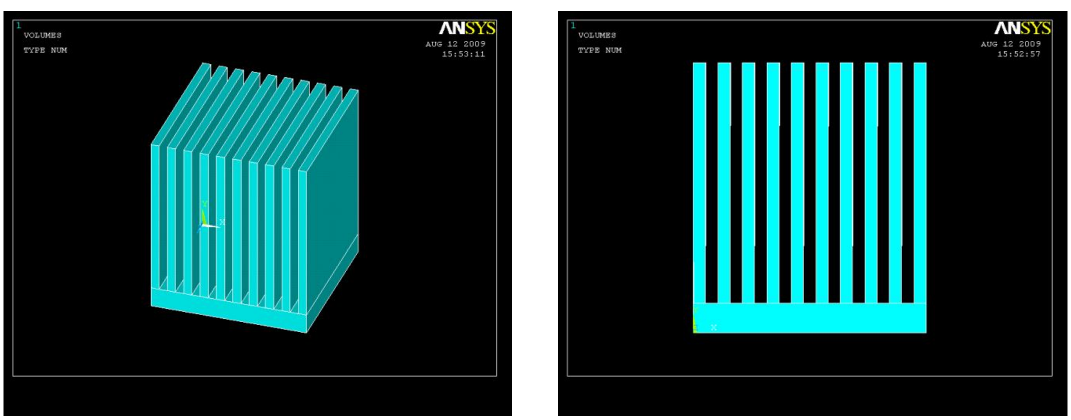


Figure.2 chipset heat sink long (double length) model and its cross section.

The geometric symmetry of the configuration allows one to use the system shown in Figure 1 and 2 for the subsequent numerical study, in order to take the advantages of computational efficiency and to maintain the solution accuracy. For such a chipset heat sink process, heat "travels" from areas of high temperature to areas of lower temperature is governed by the heat equation:

$$\rho C_p \frac{\partial T}{\partial t} - \boldsymbol{n}.(k\nabla T) = Q \qquad (1)$$

Where: ρ is the density, C_p the heat capacity, k the coefficient of heat conduction, which is material dependent, and Q the volume heat source. In (1) the first term represents the energy accumulation, the middle term the difference in the heat flux over the volume, and the last term the volume sink (or source). The boundary conditions are of Neumann type with the outward heat flux, $\boldsymbol{n}\cdot(k\ \nabla T)$, being given as

$$\boldsymbol{n}.(k\nabla T) = h_{eff}(T_{inf} - T) \qquad (2)$$

Here $\boldsymbol{n}$ is the normal vector of the heat flux. In (2), the term h_{eff} $(T_{inf}$ $-T$) is known as Newton's law of cooling, which specifies the heat flux from the surroundings due to forced and/or natural convections, T_{inf} the external or surrounding temperature. It is noted that the radiation heat transfer is neglected here since the temperatures are assumed to be moderate. Also noted is that the heat sink cools down the chipset by directing the dissipated heat from the chipset to the surroundings through heat conduction. This convection heat transfer through is proportional to the difference in temperatures between the heat sink and the surroundings up to a factor known as the heat transfer coefficient h_{eff} . The value of h_{eff} depends on the degree of convection across the surface. That is the higher the convection, the higher the value. Figure 3 simply depicts a 2D view of the model equations and boundary conditions. The outlined area shows a 2D symmetry approximation [1].

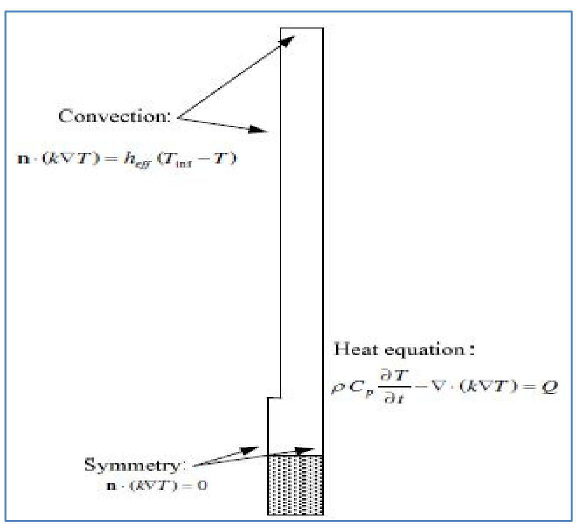


Figure.3 governing equation and boundary conditions**.**

MATHEMATICAL MODEL

Five models of heat sink has been mead by (Ansys Ver.11) the cross-section area of the model is: 3.8cm width by 3.8cm long and 0.5cm height the fin height is 2 , 2.5 , 3 , 3.5 and 4cm respectively with thickness of 0.2cm and depths of 3.8cm. as shown in figure 4.

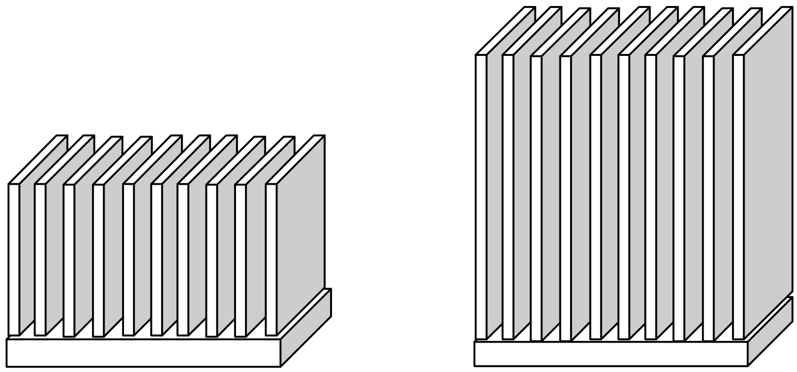


Figure.4 The differences between the short model and the long one

A free volume mesh for the models with Ansys program is made as in figure 5

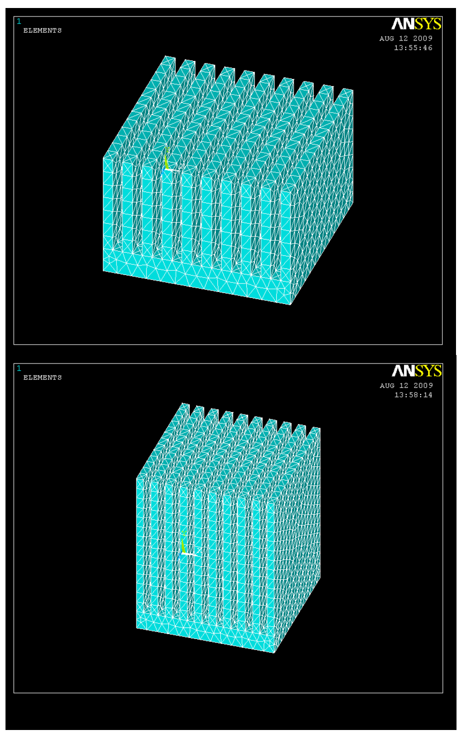


Figure.5 The free volume mesh for the short model and the long one.

Then the five models has been tested for three materials steel , aluminum and copper for the same condition .

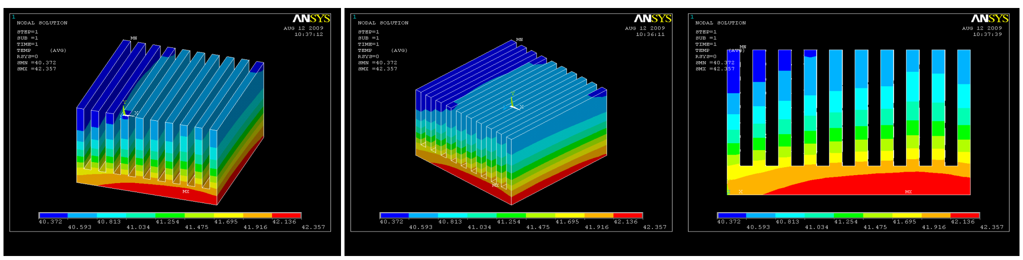
RESULTS

Table 1 shows the minimum and maximum temperature for the five models and three materials.

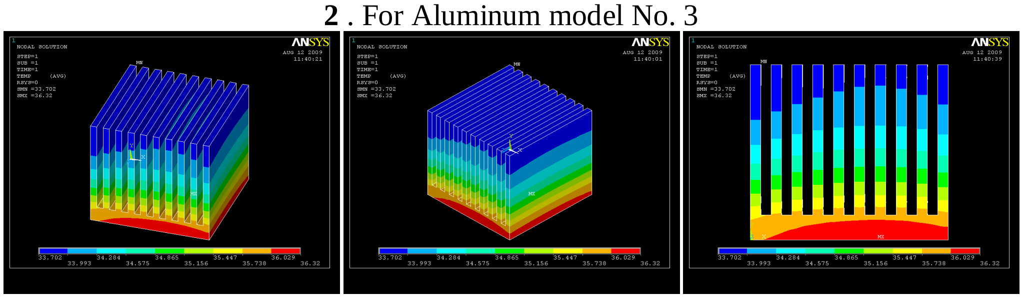
Minimum	Model No.1	Model No.2	Model No.3	Model No.4	Model No.5
Steel	35.975 ^{o}C	31.784 ^{o}C	28.923 ^{o}C	26.763 ^{o}C	25.210 ^{o}C
Aluminum	40.372 ^{o}C	36.344 ^{o}C	33.702 ^{o}C	31.590 ^{o}C	30.069 ^{o}C
Copper	40.751 ^{o}C	36.754 ^{o}C	34.162 ^{o}C	32.088 ^{o}C	30.609 ^{o}C
Maximum	Model No.1	Model No.2	Model No.3	Model No.4	Model No.5
Steel	51.701 ^{o}C	49.151 ^{o}C	48.439 ^{o}C	47.513 ^{o}C	47.220 ^{o}C
Aluminum	42.357 ^{o}C	38.588 ^{o}C	36.320 ^{o}C	34.485 ^{o}C	33.272 ^{o}C
Copper	41.688 ^{o}C	37.815 ^{o}C	35.405 ^{o}C	33.468 ^{o}C	32.142 ^{o}C

And the Ansys diagrams is as shown below:

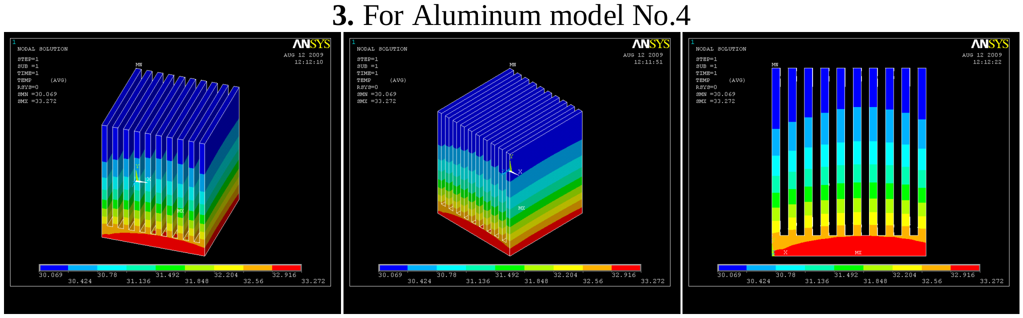
1. For Aluminum model No.1



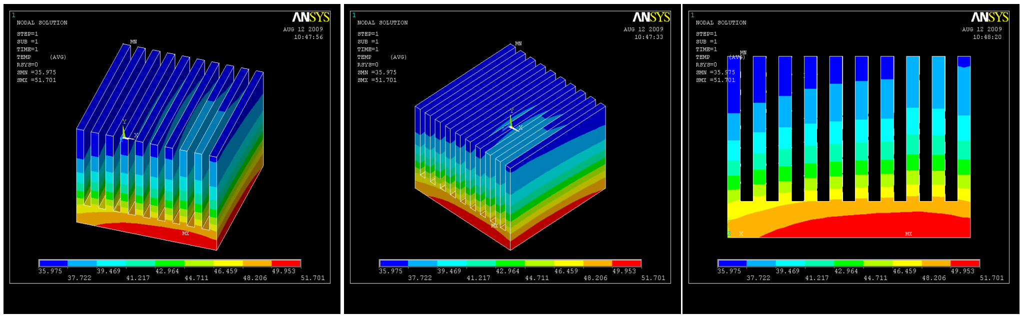
2 . For Aluminum model No. 3



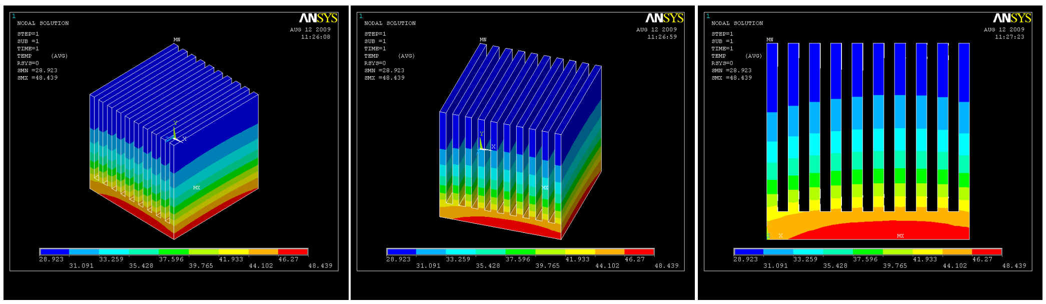
3. For Aluminum model No.4



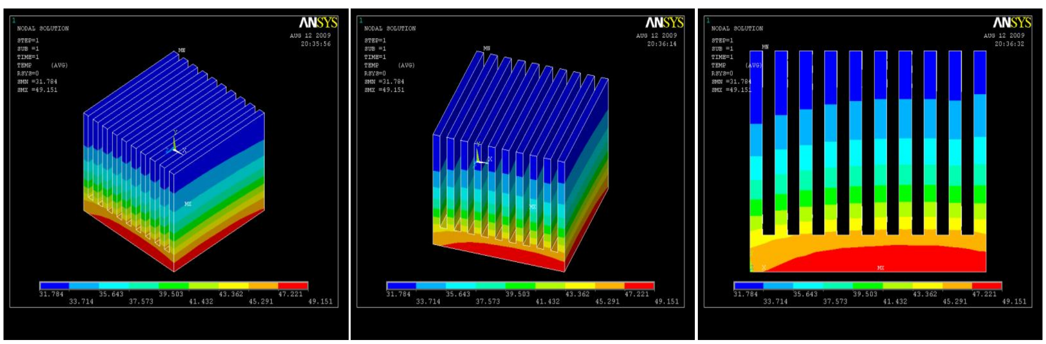
4. For Aluminum model No.5



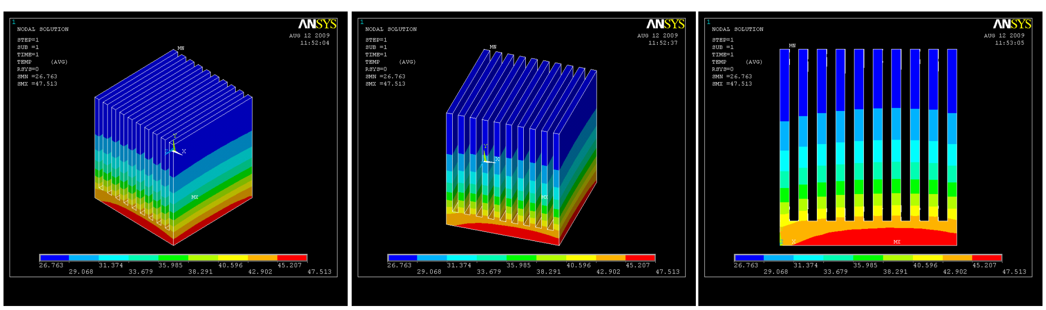
5. For Steel model No.2



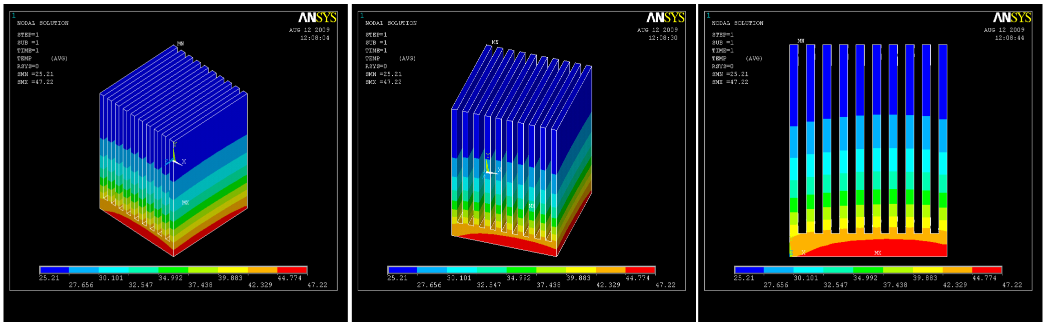
6. For Steel model No.2



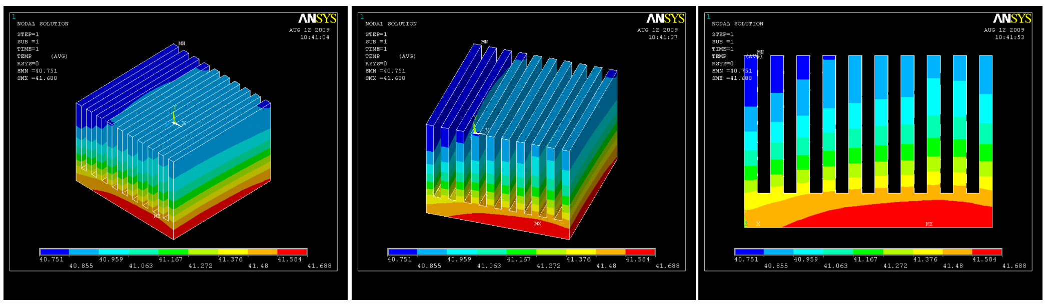
7. For Steel model No.3



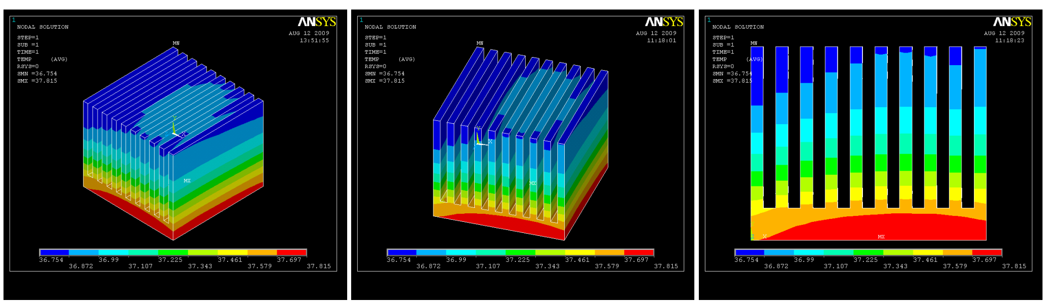
8. For Steel model No.4



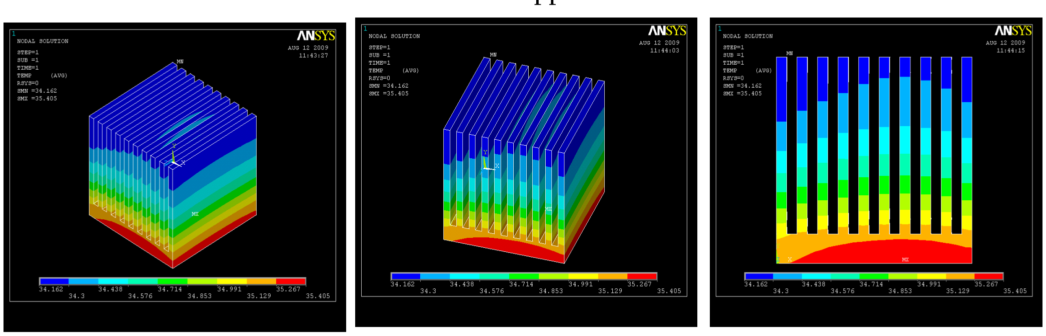
9. For Steel model No.5



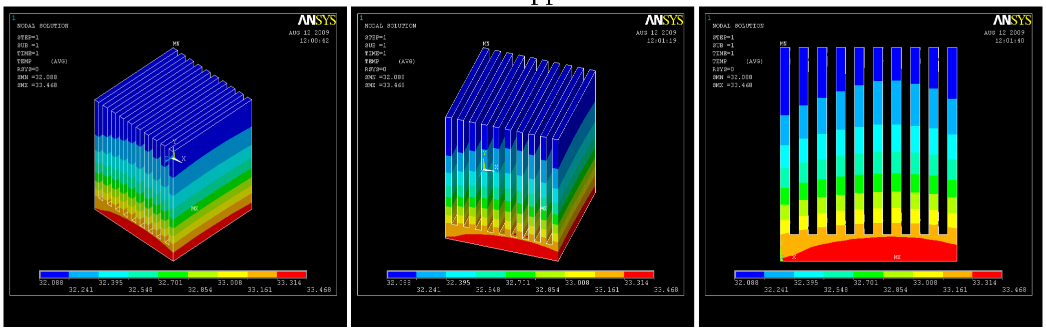
10. For Copper model No.1



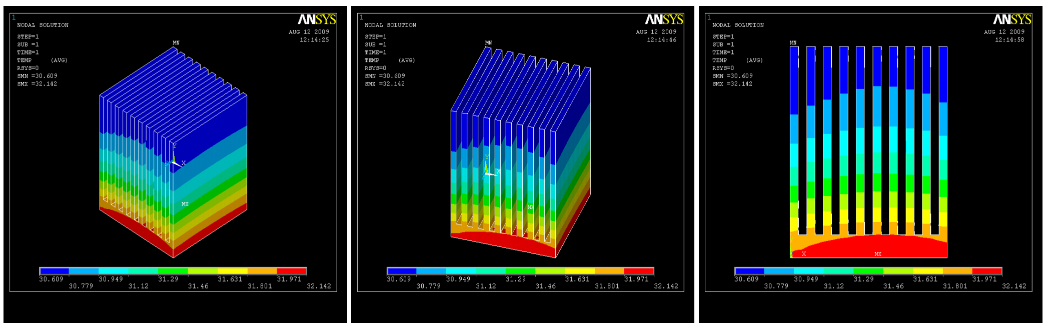
11. For Copper model no.2



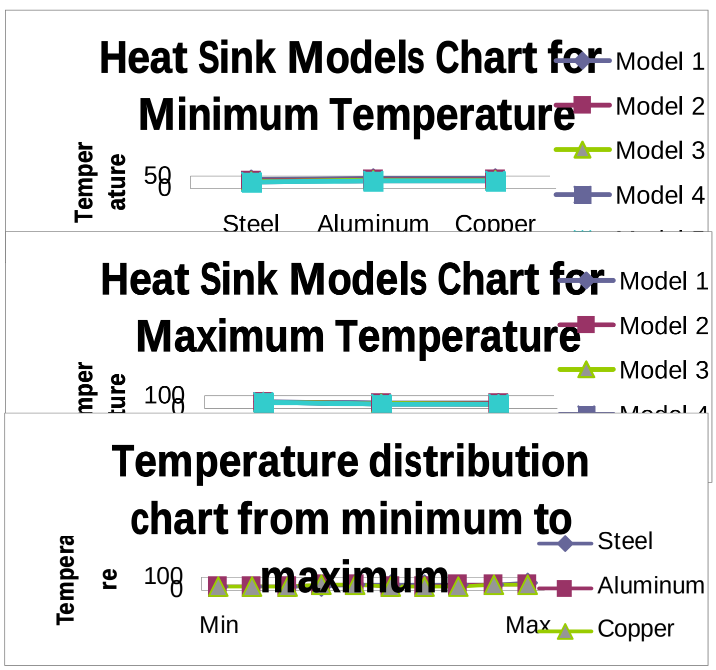
12. For Copper model No.3



13. For Copper model No.4



14. For Copper model No.5



CONCLUSIONS

1. For best cost Model No.1 of Aluminum with dimensions of (3.8 by 3.8 by 0.5cm for the base) and (0.2 by 2cm for fins) is very suitable and also with acceptable performance.
2. For best performance Model No.3 of Copper came at 1st place with dimensions of (3.8 by 3.8 by 0.5cm for the base) and (0.2 by 3cm for fins).
3. Steel models dose not reaches the requirement needed from a suitable heat sink because it emit little heat while the ends of fins is to cooler , the difference in temperature is about 15 ^{o}C degree, while for aluminum 2 ^{o}C and 1 ^{o}C for copper.
4. The idea of making heat sink from mixed material like for example the base from copper and fins from aluminum is great but it's too expensive.
5. The performance of heat sink maybe greatly improved by adding fan over it to suction the hot air out.
6. The shape and design of the heat sink is very important to carry the heat from the chipset to the top of the heat sink yet complex designs came with high cost.

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تأثير معدن وطول زعانف المبدد الحراري على أداءه

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الخلاصة

في هذا البحث تم اختبار خمسة أطوال وثلاثة معادن مختلفة (نحاس ألمنيوم وفولاذ) لمبدد حراري رباعي الشكل(والذي يستخدم بكثرة في تبريد المعالجات الرسومية للوحات الأم ذات المعالجات الرسومية المرفقة) وذلك لحساب موصليته ومدى قابليته على تبديد الحرارة عندما تعمل معالجات الرسوم بقدرتها القصوى (تصل حرارتها إلى حوالي 60 درجة) وكذلك لبحث العلاقة بين طول المبدد ونوعية معدنه وبين أدائه أخذين التكلفة بنظر الاعتبار. من البديهي والمعلوم أن النحاس يأتي في المرتبة الأولى في قابلية تبديد الحرارة ومن ثم الألمنيوم فالفولاذ وقد طابقت النتائج ذلك وعند أخذ الكلفة بنظر الاعتبار يكون الألمنيوم هو الأفضل ، كما دلت النتائج على أن التبديد الحراري يحدث بصورة أسرع مع زيادة طول الزعانف ولكن ضمن حدود معينة تكون بعدها غير مجديه بل تزيد من تكلفة المبدد لذلك وجد البحث أن مبدد حراري من الألمنيوم بطول 2-2.5 سم هو الأكفأ.

الكلمات الدالة : بحث ، مبدد حراري ، زعانف.