Design and optimization of heat sink used in IBM PC to increase Heat transfer rate

Komal Singh Rajput*, Dr. Rohit Rajvaidya[1] & Prof. Prabhash Jain[2]
*M.Tech scholar Department of Mechanical Engineering UIT, BU, Bhopal
[1]Professor, Department of Mechanical Engineering UIT, BU, Bhopal
[2]Professor & Head, Department of Mechanical Engineering UIT, BU, Bhopal

***Abstract* - In the present work the experimental, numerical and analytical studies have been carry out with the purpose of optimization of geometrical fin parameters for heat sink of North Bridge used in personal computer system based on natural convective heat transfer. It has been observed that the perforated heat sink indicates the thermal boundary layer interruption which helps to increase the heat transfer rate. The main objective of this work to deal with deficiency by investigating the effect of heat transfer rate in actual as well as interrupted heat sink. it have been also observed that the interrupted heat sink has less bulky means contained less material which may also lower its manufacturing cost. by using the interrupted design of heat sink it is also revealed that the total heat transfer rate increases from the surface area. results indicates, the proposed design in present work of Northbridge heat sink is giving better performance compared to the actual heat sink.**

***Keywords* - Northbridge heat sink, natural convection, heat transfer rate, thermal Analysis etc.**

1. INTRODUCTION:

In the computer system heat sink is a very important component for cooling purpose of such types of electronics components. heat sink used on all those electronics components where heat is generated it increases the surface area significantly while usually increasing the heat transfer coefficient as well. Hence the total resistance from the electronics element junction to the surroundings is reduced considerably, which reduces the junction temperature within a electronics device. As the result obtaining correct performance characteristics for heat sinks is really important for the purpose of better cooling.

Integrated circuits like CPU and GPU are the main generators of heat in modern computers. Heat transfer rate can be increase by efficient design of heat sink and controlling of operating parameters such as voltage and frequency. but ultimately acceptable performance can only be achieved by managing significant heat generation.

Recent research initiatives has been focused to miniaturization in size and increase of efficiency of micro-chips so on a small chip 105 to 108 components leads to such a high heat generation level of 100W/cm2 that its temperature removal is major concern for safety and reliability of electronic devices. Generation of heat is an irreversible Process and this must be removed in order to maintain the continuous operation of such types of electronics equipments. It has been found that for every 2 ºC temperature rise the reliability of a silicon chip will be decreased by about 10 %. The major cause of an electronic chip failure is due to temperature rise (55%) as against other factors which accounts 20 % vibration, 19 % humidity and 6 % dust[1] as shown in figure 01. it is a great challenge to remove the heat from the electronics chips very effectively. Computer cooling is required to remove the waste heat produced by computer components, to keep components within permissible operating temperature limits.

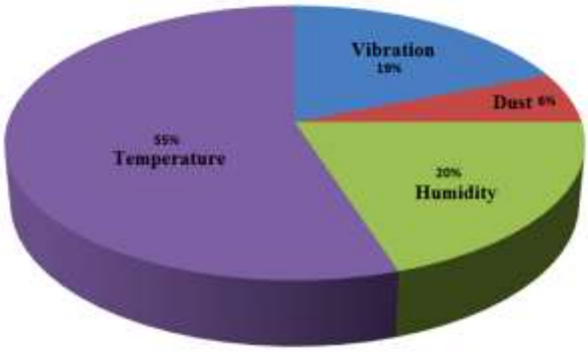

Figure 1: Major Causes of Electronics Failure

2. LITERNATURE REVIEW:

Sasikumar and Balaji et al. [2] numerically contemplated a characteristic convection heat exchange and entropy era from a variety of vertical blades, remaining on a flat channel, with turbulent liquid stream inside. The examination was considered the variety of base temperature along the pipe. One dimensional balance mathematical statement was tackled utilizing second request limited contrast plan.

S. C. Haldar [3] Balances alone contributed little to the aggregate warmth exchange yet they enormously impacted the warmth exchange from the revealed zone of the chamber. Among the different blade parameters, thickness had the best impact on warmth exchange. For meager balances, there exists a blade length, which amplified the rate of warmth exchange. The ideal number and dimensionless length of the balances were gotten as 6 and 0.2 individually when balance thickness was 0.01.

Kundu and Das et al. [4] tended to with the assistance of the Fresenius growing arrangement the temperature profiles of longitudinal balance; spine and annular blade had been resolved diagnostically through a bound together approach. The warm execution of all the three sorts of blade had been examined over an extensive variety of thermo-geometric parameters. It had been watched that the variable warmth exchange coefficient had a solid impact over the balance proficiency.

Dibakar Rakshit and Balaji et al. [5] had explored the conjugate convection from a finned channel with vertical rectangular balances being mounted on outside of the channel. The two dimensional administering mathematical statement, relentless, incompressible, consistent property laminar stream was comprehended for the liquid outside channel. For liquid streaming inside the channel, the stream was thought to be turbulent with constrained convection as the method of warmth exchange.

Inmaculada Arauzo et al [6] tended to a basic scientific methodology for the surmised arrangement of the semi one-dimensional warmth conduction mathematical statement that oversees the temperature variety in annular blades of hyperbolic profile. This balance shape was of amazing significance since its warmth exchange execution is near that of the annular balance of raised allegorical profile, the purported ideal annular balance that is fit for conveying most extreme warmth exchange for a given volume of material.

MD RAKIB HOSSAIN [7] A procedure is presented that allows the simultaneous optimization of heat sink design parameters based on a minimization of the entropy generation associated with thermal resistance and fluid pressure drop. A sensitivity analysis is also carried out to check the influence of bypass configurations, power levels, heat sink materials and the coverage ratio on the optimum dimensions and performance of a heat sink and it is found that any change in these parameters results in a change in the optimized heat sink dimensions and flow conditions associated with the application for optimal heat sink performance.

Wen-Lih Chen, Yu-Ching Yang, Haw-Long Lee [8] tackled two dimensional opposite issue of assessing the obscure warmth flux at a pin balance base by the conjugate angle technique. In evaluating forms, no earlier data on the utilitarian type of the obscure amount was required. The precision of the converse investigation was inspected by recreated definite and estimated estimations of temperature at inside areas of the pin balance. The numerical results demonstrated that great estimations on the warmth flux acquired for all the experiments.

The literature study reveals that heat transfer performance was studied for the different shaped fin in different cooling system geometries. The thermal conductivity and convective coefficient alone were taken as the temperature dependent without considering the specific heat capacity of coolant.

3. OBJECTIVE:

There are following objective are to be expected from the present work

1. The primary object of the present work to increase heat transfer rate from the heat source.
2. To predict the heat transfer rate from existing design in computer system with the help of CPUID HWMonitor software.
3. To evaluate the heat transfer rate in Proposed heat sink at Northbridge.
4. To evaluate the heat transfer rate with all new design of heat sink.
5. To optimize the heat sink design from the basis of heat transfer rate.

4. METHODOLOGY:

The present work is categories in two phases, phase one is experimental analysis in which the temperature of existing computer system is recorded with the help of software CPUID HWMonotor. and another phase includes mathematical and thermal analysis of existing as well as new design of Northbridge heat sink.

The heat transfer analysis takes the following assumptions:

1. Conduction heat transfer in the heat sink is one dimensional and is along the x- direction.
2. Heat loss by the convection from the sides of the heat sink at constant ambient temperatureT_∞.
3. The heat sink in the steady state condition.

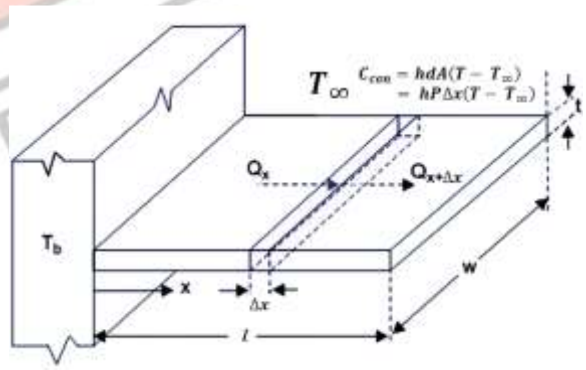

Figure 2: Fin Geometry

From the figure 2 it is cleared that The heat flow is in x-direction and for the purpose of heat transfer analysis the cross sectional area of the fin is taken as function of x. now consider the small volume element of the fin length of dx. An energy balance is performed on this part in which assumed that this part is at constant and uniform temperature of T.

Heat in to the left face = Heat out from the right face + Heat loss by convection

This yield

$$Q_x = Q_{x+\Delta x} + Q_{con} \tag{1}$$

Applying the Taylor series expansion of the first term on the right side of the Equation

The general solution

$$\theta = C_1 e^{-mx} + C_2 e^{mx} \tag{2}$$

Where C_1 and C_2 are constant that can be determined from the boundary conditions.

Heat sink with heat losing at the tip/Heat losing from finite length of the fin

Equation (2) has the general solution given by after applying all boundary conditions

$$Q_{Fin} = \sqrt{hPkA}\,(T_0 - T_\infty)\left[\frac{\tanh\ (ml) + \frac{h}{km}}{1 + \frac{h}{km}\tanh\ (ml)}\right]$$

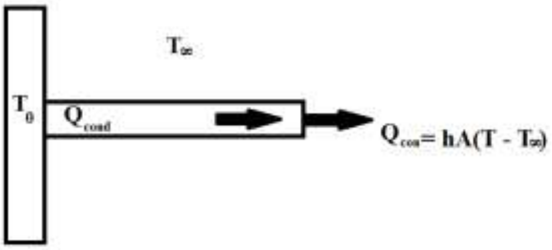

Figure 3: heat transfer by finite length fin

4.1 Experimental temperature record taken by using software CPUID HWMonitor:

For the present work the temperature record is taken by using software CPUID HWMonotor as shown in figure No. 4. This figure explain the temperature value from the computer mother board during the operation, it is cleared from figure that there are three value of temperature showing, current value, minimum value and maximum value achieved by the system during operation of computer system. The computer system is operated on full load such as many heavy programs at the same time was running to check the system performance and it is seen that the temperature has increased and attend about 100º C.

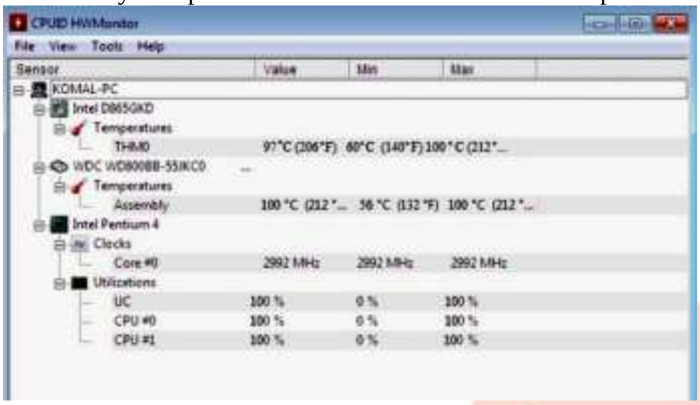

Figure 4: Actual temperature of the current setup taken by using CPUID HWMonitor

Figure 5: Complete Motherboard of IBM PC

Figure 5 shows Northbridge heat sink and Heat pipe is mounted on mother board of present case this Heat sink is usually made of a metal with high thermal conductivity such as aluminium and incorporate fins to increase surface area for better heat tranfer.

4.2 Thermal analysis of Northbridge Heat sink: The complete thermal analysis in the present work is follow three major steps. Preprocessor, solutions and post processor. Preprocessor involve CAD geometry, Meshing and Boundary conditions.

4.2.1 CAD Modeling: For geometry construction the length and width of North Bridge heat sink is taken as 40 mm x 40 mm, the maximum height is 23 mm, there are total 12 walls in the Northbridge with end walls are 2 mm thick and rest of all are 1 mm thick, the gap between two consecutive walls is 2.4 mm.

4.2.2 Meshing: After completing the CAD geometry of Northbridge heat sink is imported in ANSYS workbench for further thermal analysis and the next step is meshing. The mesh created in this work is shown in figure No. 7. The total Node is generated is 725388 and total elements is 143600.

4.2.3 Defining Material Properties & Boundary condition: for any kind of analysis material property are the main things which must be defined before moving further analysis. The material properties of the present case are as: Density: 2770 Kg/m^3, Coefficient of thermal Expansion: 2.3e-005 ^{o}C^{-1} specific Heat 875 J/Kg-^{o}C

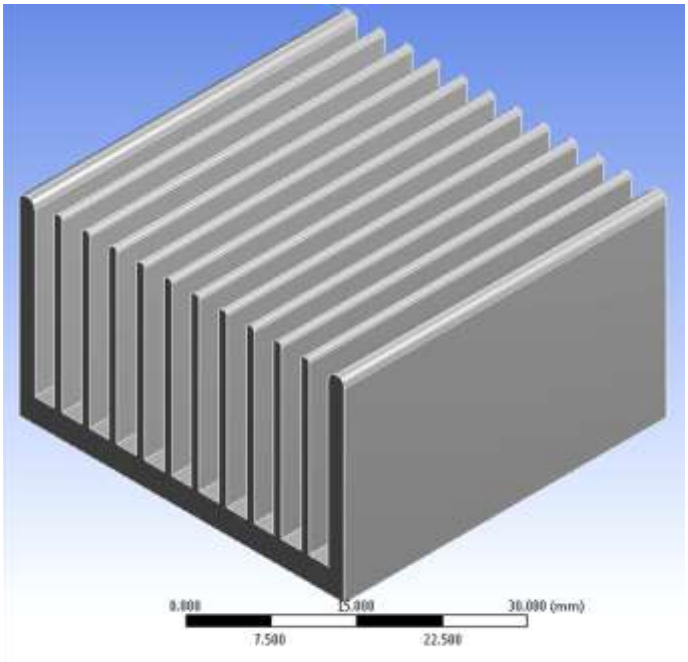

Figure 6: CAD Geometry of actual Northbridge Heat sink

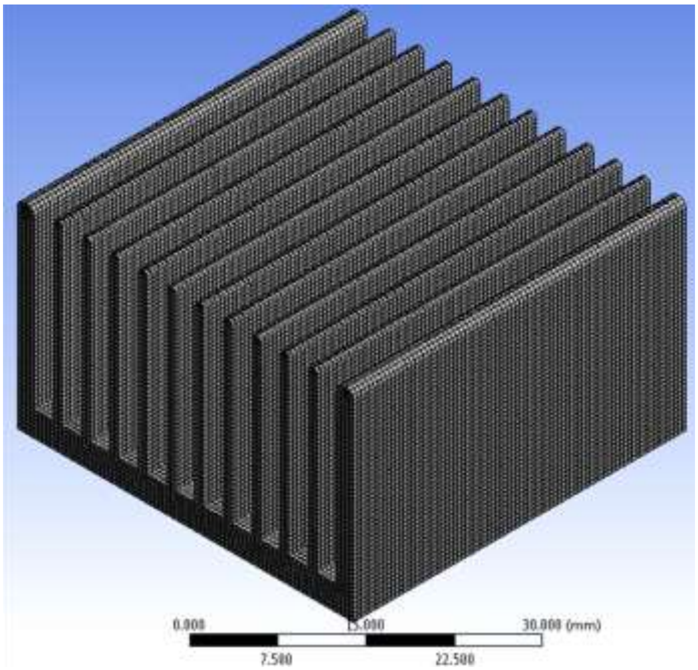

Figure 7: Meshing Total No. of Nodes: 725388 and total No. of Elements: 143600

Boundary condition:

1. The maximum temperature generated at bottom face of the Northbridge heat sink as predicted during the experimental reading.
2. Since this heat sink is situated in closed chamber that is why there is no air flow hence it is assumed that in this closed chamber the normal room temperature air is available and its convective coefficient value is lies between 0 to 25 W/m^2. For the present work the value of convective coefficient is taken as 25W/m^2.
3. The value of conductive coefficient of the material is taken as 235 W/m^{o}C
4. The Mechanical APDL solver is used for present analysis.

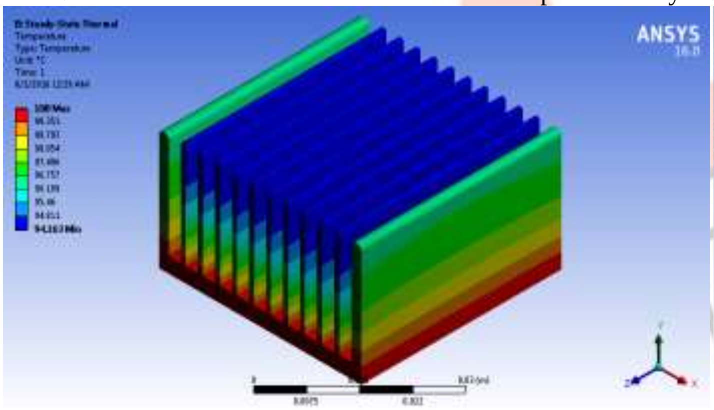

Figure 8: Temperature distribution over Actual Heat sink

The thermal analysis result indicates the temperature distribution of Northbridge continuous heat sink the maximum temperature is 100^{o}C and minimum temperature is 94.163^{o}C.

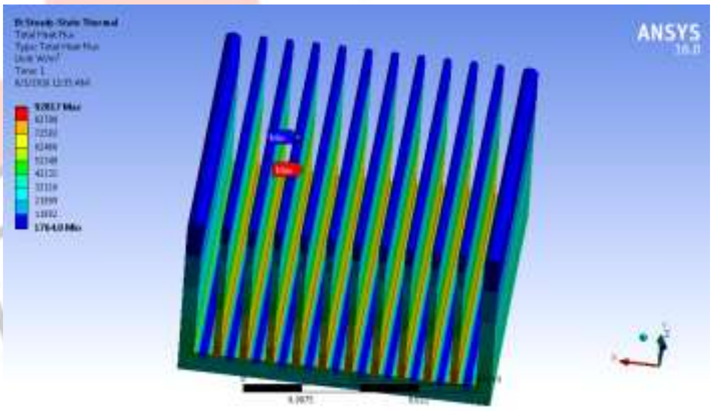

Figure 9: Total heat flux over Actual Heat sink

The result indicates Total heat flux generated on the north bridge continuous heat sink maximum heat flux generated is 92817 W/m^2 and minimum heat flux generated is 1764.8 W/m^2.

4.3 Proposed design-1: After examination of the actual heat sink used in present work does not transfer sufficient heat from the heat point that is why hear some others design have been proposed to transfer maximum heat from the heat point. In this work three optimize design proposed.

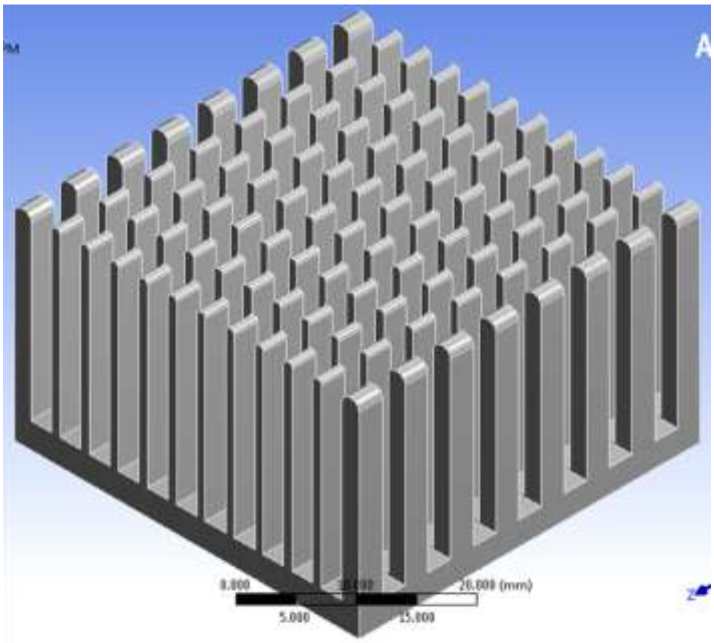

Figure 10: CAD geometry of proposed design-1

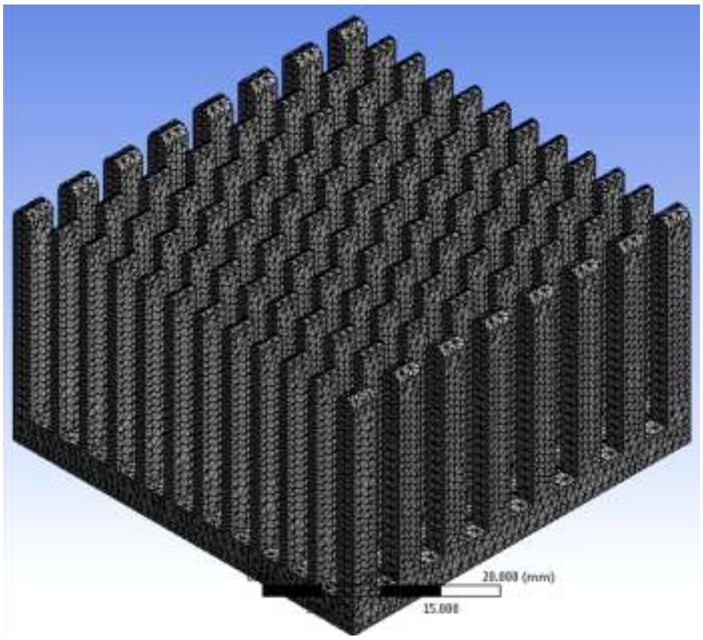

Figure 11: Meshing Total No. of Node: 314605, Total No. of Elements: 167365

CAD Modeling: For geometry construction the length and width of proposed design -1 basic dimensions are same as actual heat sink and proposed design-1 is a discontinuous geometry have been created with 2.66mm gap between two consecutive walls.

Meshing: After completing the CAD geometry of Northbridge heat sink is imported in ANSYS workbench for further thermal analysis and the next step is meshing. The mesh created in this work is shown in figure No. 11. The total Node is generated is 314605 and total elements is 167365.

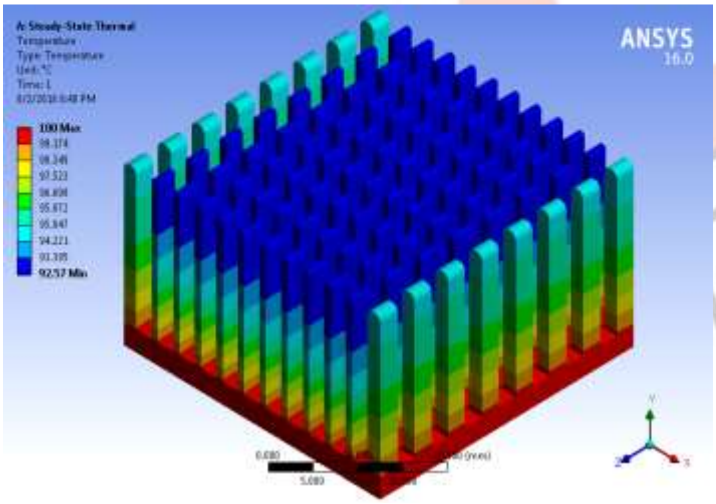

Figure 12: Temperature distribution over proposed design-1

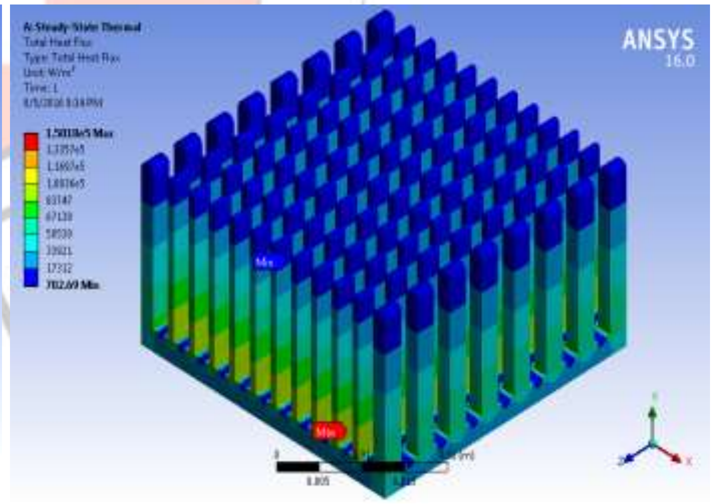

Figure 13: Total heat flux over the proposed design-1

The result of thermal analysis for proposed design-1 indicates the temperature distribution of Northbridge continuous heat sink the maximum temperature is 100°C and minimum temperature is 92.57°C.

Total heat flux generated on the north bridge continuous heat sink maximum heat flux generated is 1.5018e5 W/m^2 and minimum heat flux generated is 702.69 W/m^2.

4.4 Proposed design-2:

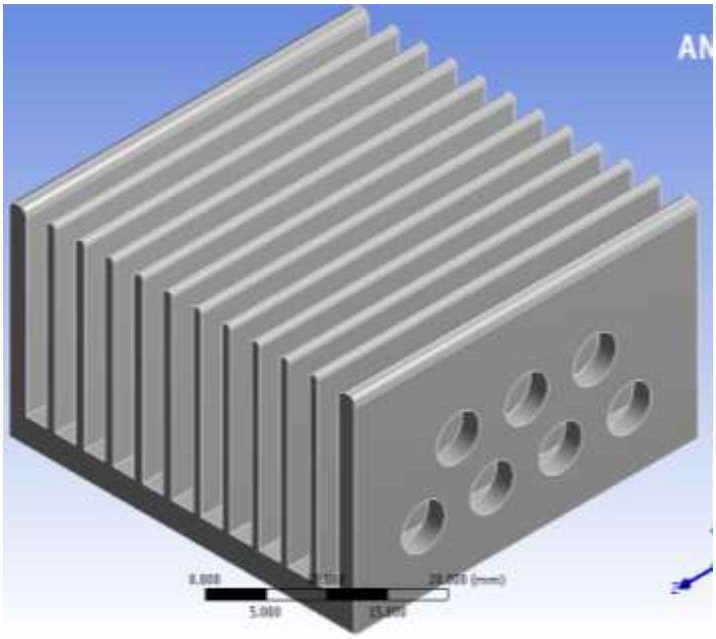

Figure 14: CAD geometry of proposed design-2

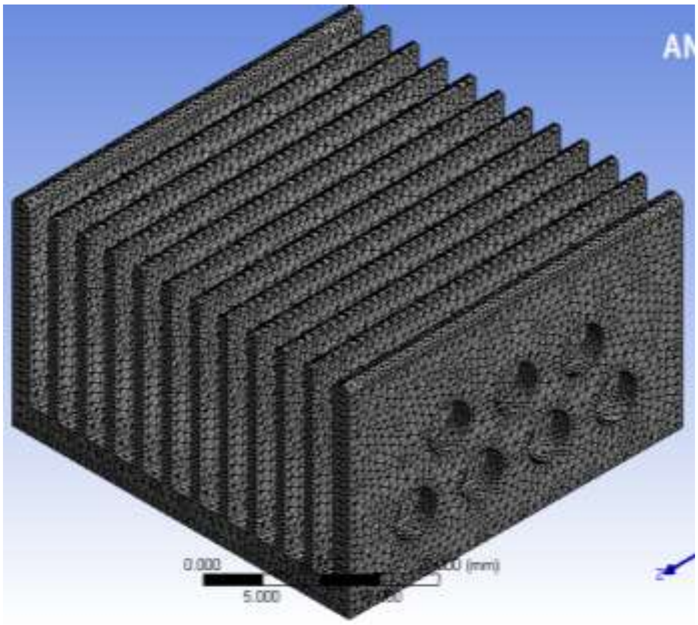

Figure 15: Meshing Total No. of Node 285634 & Total No. of Elements: 153419

CAD Modeling: For geometry construction the length and width of proposed design -2 basic dimensions are same as actual heat sink and there are two rows of circular holes of 3mm diameter in which 4 circular holes in first row situated near to bottom side of the heat sink and 3 circular hole of same diameter at 8 mm above the first row.

Meshing: The total Node is generated is 285634 and total elements is 153419, it is clear from the mesh geometry the node numbers and element numbers are almost six in digit which show that the mesh is very fine because the result accuracy depends on the mesh quality.

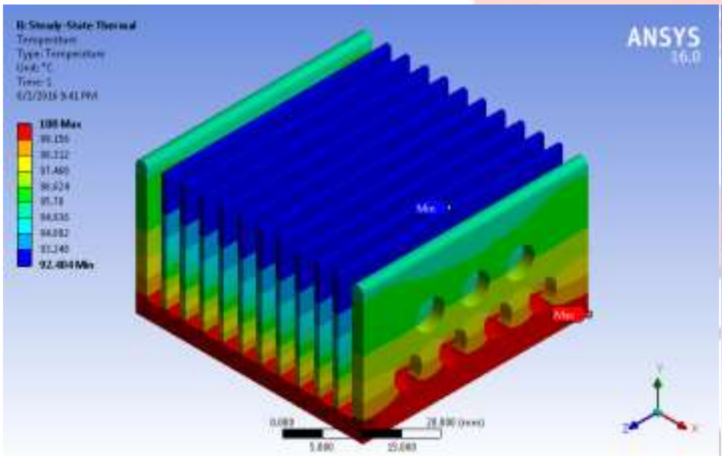

Figure 16: Temperature distribution over proposed design-2

The result of thermal analysis for proposed design-2 indicates the temperature distribution of Northbridge continuous heat sink the maximum temperature is 100ºC and minimum temperature is 92.404ºC as shown in figure 16.

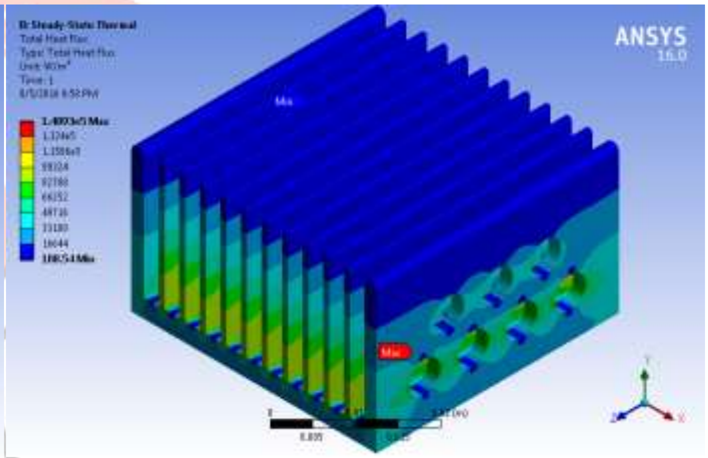

Figure 17: Total heat flux over the proposed design-2

The below result as shown in Figure 17 indicates Total heat flux generated on the north bridge heat sink maximum heat flux generated is 1.4893e5 W/m^2 and minimum heat flux generated is 108.54 W/m^2 .

4.5 Proposed design-3:

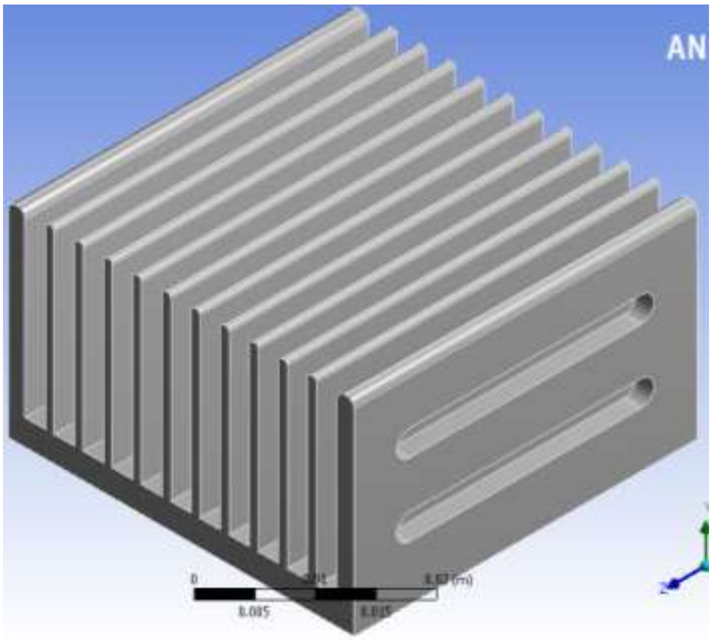

Figure 18: CAD geometry of proposed design-3

4.5.1 CAD Modeling: There are two rows of circular holes of 3mm diameter in which 4 circular holes in first row situated near to bottom side of the heat sink and 3 circular hole of same diameter at 8 mm above the first row.

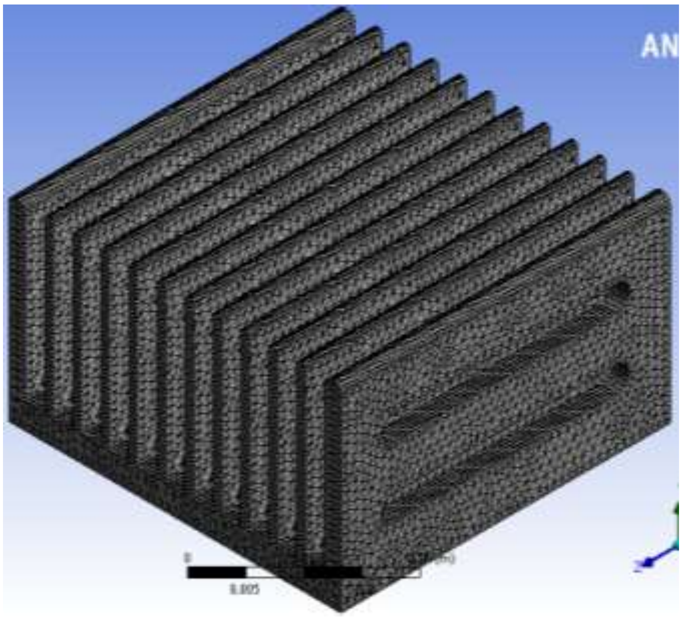

Figure 19: Meshing Total No. of Node: 369413 & Total No. of Elements: 202677

4.5.2 Meshing: The mesh created in this work is shown in figure No. 19. The total Node is generated is 285634 and total elements is 153419.

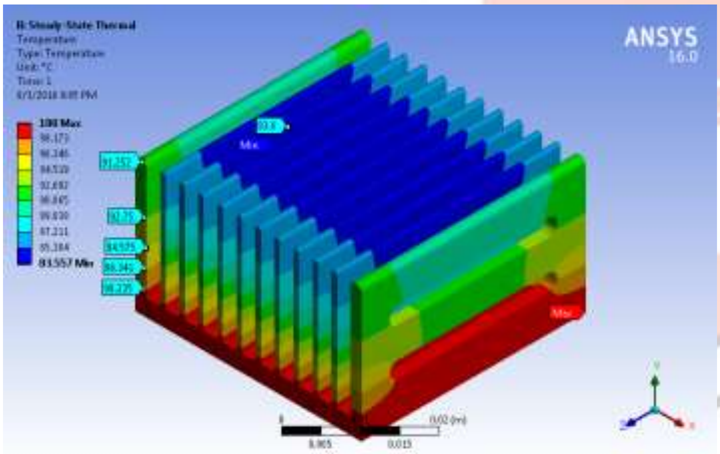

Figure 20: Temperature distribution over proposed design-3

The result of thermal analysis for proposed design-2 indicates the temperature distribution of Northbridge continuous heat sink the maximum temperature is 100°C and minimum temperature is 83.557°C as shown in figure 20 where different color contours show various temperature range during thermal analysis.

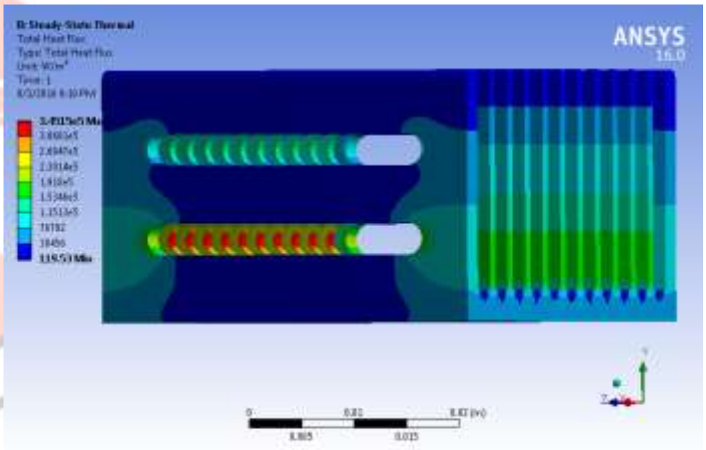

Figure 21: Total heat flux over the proposed design-3

The below result as shown in Figure 21 indicates Total heat flux generated on the north bridge heat sink where maximum heat flux generated is 3.4515e5 W/m^2 and minimum heat flux generated is 119.53 various color contours indicates different value of heat flux range during thermal analysis.

5. RESULT AND DISCUSSION

Thermal analysis ware conducted using ANSYS workbench based on finite volume methodology the effects of different important geometrical parameters on the steady state natural convective heat transfer rate from both continuous and discontinuous fins.

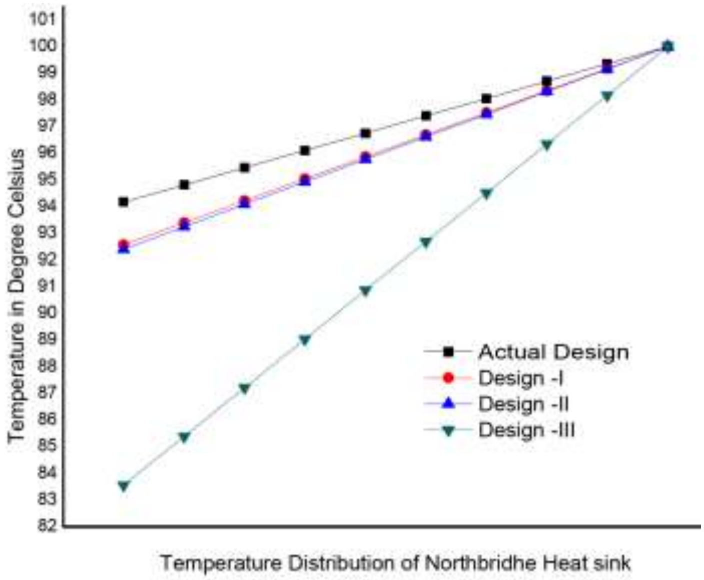

Figure 22: Distribution of Temperature over Northbridge heat sink

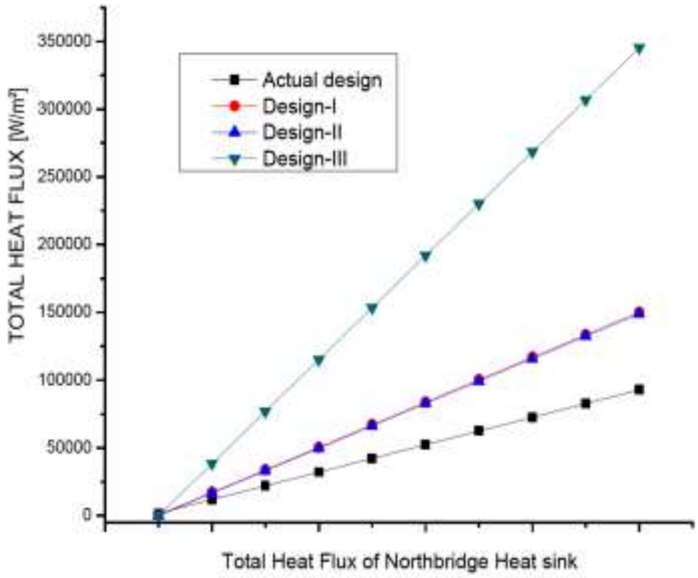

Figure 23 comparative result of Total heat flux

The maximum temperature is 100°C for actual and proposed design but the minimum temperature of actual heat sink are different for different types of proposed design of heat sink, 92.57°C for proposed design-I is 92.57 °C, for proposed design-II is 92.404°C and for proposed design-III is 83.557°C. The comparative result in the form of graph shown in figure 22. Indicating for actual and proposed design of heat sink.

The result of Total heat flux generated on the north bridge heat sink are vary according to heat sink design the value of maximum heat flux generated for actual design is 1.5018e5 W/m^2 and minimum heat flux generated is 702.69 W/m^2 . but for proposed design of heat sink the total heat flux are different then actual design the maximum value of total heat flux are 150180 W/m^2, 148930 W/m^2 and 345150 W/m^2 where minimum value of total heat flux are 702.69 W/m^2 , 108.54 W/m^2 and 119.53 W/m^2. The graphical representation of comparative result of total and directional heat flux is shown in figure 23 & figure 24.

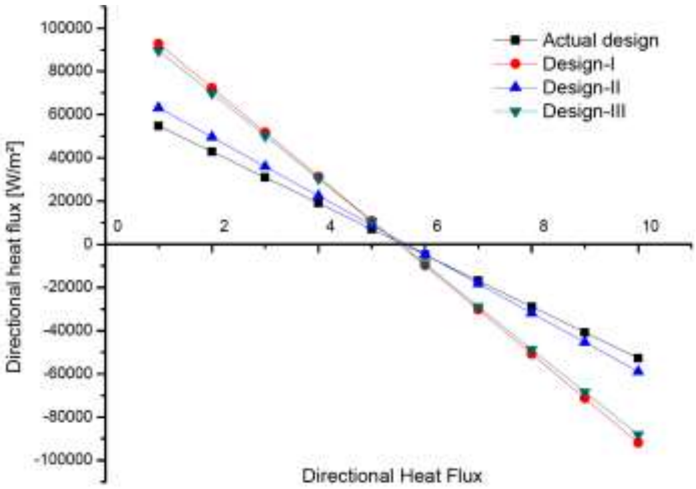

Figure 24 comparative result of Directional heat flux

VI. CONCLUSION:

In the present work Heat sink of the Northbridge used in IBM mother board has been optimized for more heat transfer and less weight using finite element analysis. The heat sink is mounted on the motherboard of IBM PC to dissipate heat. Steady state thermal analysis has been done for four models of Northbridge heat sink in which first heat sink is actual in dimension as mounted on motherboard of IBM PC and rest heat sinks are proposed design for maximum heat transfer rate.

The primary goal of the present work was to enhance the heat transfer rate from Northbridge heat sink designs. In doing so, three optimize design proposed to enhance heat transfer rate from the Northbridge Heat sink. The static thermal analysis has been performed on all four designs and result was conformed to proposed design. The secondary goal was to find a theoretical analysis that would accurately predict both the optimization point for a given space as well as the performance of the solution. The chosen methodology performed accurately predicts the optimization point.

The following observations are made from the thermal analysis of Northbridge heat sink:

1. Since in the present work the heat sink of Northbridge is situated in closed chamber that is why only room temperature air is available for cooling this heat sink.
2. The maximum temperature observed is 100° C in the bottom face of the heat sink.
3. Three New heat sink designs are proposed to increase heat transfer rate from the heat sink and also help to reducing temperatures from this heat sink.
4. Max temperature on the actual Northbridge heat sink is 100 °C and weight of the heat sink is 45.851gram. Minimum temperature is 94.163 °C and maximum total heat flux is 92817W/m^2.
5. Max temperature of the Proposed design-I for Northbridge heat sink is assumed same as actual temperature taken from experimental reading (100 °C) and weight of the of the heat sink is 30.263gram i.e. a mass reduction of 33.99%. Minimum temperature is 92.57 °C and maximum total heat flux is 150180W/m^2.

6. Max temperature of the Proposed design-II for Northbridge heat sink is assumed same as actual temperature taken from experimental reading (100 ^{o}C) and weight of the of the heat sink is 40.521 gram i.e. a mass reduction of 11.62%. Minimum temperature is 92.404 ^{o}C and maximum total heat flux is 148930W/m^2.
7. Max temperature of the Proposed design-III for Northbridge heat sink is assumed same as actual temperature taken from experimental reading (100 ^{o}C) and weight of the of the heat sink is 39.02 gram i.e. a mass reduction of 14.9%. Minimum temperature is 83.557 ^{o}C and maximum total heat flux is 345150W/m^2.

RECOMMENDATION:

It is recommended that perforated heat sink demonstrate an excellent thermal performance. It is observed that the heat flux is increasing and lower temperature is decreasing in proposed design-III .It can also be concluded that the proposed design third of Northbridge heat sink is giving better performance compared to the actual heat sink. hence the design-III of heat sink can be proposed as optimize design.

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