Thermal Analysis of Fin Modelling for Cooling of Electronic System

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Abstract – Cooling of any heat generated device could be complete either by active ways or passive pays. Passive ways are the natural method of cooling like fin while active ways are spraying of the coolant. Passive ways of cooling are cheaper and also performs well. Fins also recognized as extended surface are the most convenient method of passive or natural cooling. Present paper describe on the evaluation of the work conducted by the researcher on the numerical modelling of the fin. Circular fins with 5mm and 10mm length has been fitted over a base plate and the heat remove analysis has been conducted. From the study it has been found that the fin increases the heat transfer from the system where it has been fixed by raising the surface area presented for the releasing of heat. They also increases the intensity of the fluid flow near the heat generated device which further increases the heat dissipation rate. Study also reveals that the increasing the length of the extruded surface enhance the heat dissipation rate.

Index Terms – Thermal analysis, Fin Modelling, Cooling, Electronic system.

1. INTRODUCTION

In engine, burning of air fuel mixture occur inside the cylinder and lots of heat produced in the moving and stationary parts of engine, if cooling mechanism are not provided to the engine it can damages the parts of engine. Heavy vehicles like four wheeler uses liquid cooling system while 2 wheeler engine uses air cooling system. Air cooling arrangement has some benefits for example lighter weight, easy maintenance and lesser space requirement. Air cooling is done by extended surfaces (fins) supplied at the outer surface of engine cylinder to release the heat. This is why the investigation of fin is essential.

The rate of heat transfer from a surface at a temperature T_s to the surounding medium at T_∞ is given by Newtons law of cooling as

$$Q_{conv} = h\,A\,(T_s - T_\infty)$$

Where,

A_s =Heat transfer area

h = Convective heat dissipation coefficient.

T_s = Surface temperature.

T_∞= Atmospheric temperature.

There are two methods to raise the speed of heat dissipation

- To amplify the speed of heat dissipation area A_s
- To enlarge the convection heat dissipation coefficient h. h may be increasing by the installation of a pump or fan, but this approach practically is not achievable.

The approach is to increase the surface area by attaching the extended surfaces called fins. Fins fabricated from extremely conductive materials like aluminium. Finned surfaces are produced by enlarging, welding or covering a slim metal sheet on any outside. Fins enlarge heat dissipation from a surface by revealing a big area to convection and radiations. Finned surfaces are ordinarily utilized as a fraction of practice to improve heat transfer, and they regularly expand the velocity of heat dissipation from a surface a few fold. The car radiator is an instance of an extruded surface. The firmly pressed slim metal sheets appended to the warm water tubes expand the surface area for convection and accordingly the rate of convection heat transfer from the tubes to the surroundings ordinarily.

Fin Assumption

- Steady state one dimensional conduction Model.
- No Heat sources or sinks within the fin.
- Thermal conductivity constant and uniform in all directions.
- Heat dissipation coefficient steady and consistent over fin faces.
- Surrounding temperature steady and consistent.
- Base temperature steady and consistent over fin bottom.
- Fin thickness much lesser than fin height.
- Heat flow off fin proportional to temperature excess.

Hear transfer is power in transportation that happens by reason of a temperature gradient or difference. This temperature difference is thought of as a primary force that creates heat to flow. Heat dissipation happens by three basic processes or modes, conduction or diffusion, convection, radiation

Conduction Heat Transfer

Heat transfer performs from high active particles of substance comes in contact with the less active particles of substances. In Conduction, heat exchange can simply occur in solid , liquid or gases state. In air and fluids, heat transmit is because of the attraction and movement of the molecules or atoms during random motion. In solids, conduction process starts because of the combinations of shaking of the atoms or molecules in a solid lattice crystal and the energy transfer by free electrons. A chilled canned drink stay in a hot room temperature due to heat flow from the room to the drink through the aluminium canned may by conduction. The speed of heat dissipation during a mode based on the geometry thickness and material, in addition to on the temperature difference across the medium.

Fourier's law of heat transfer in solids

The time of heat movement during a flat partition is directly proportional to the product of temperature difference across the wall and the region of heat transmit, and is inversely proportional to the width of the wall.

$$\text{Rate of heat conduction} \propto \frac{\text{Area } \times \text{Temperature difference}}{\text{Thickness}}$$

$$q'' = -k\frac{\partial T}{\partial x}$$

q'' = Heat flux W/m^2.

k = Thermal conductivity of the material, ability of a material to conduct heat. W/m-K

∂T = Temperature Difference K.

∂x = Thickness of wall.

$\frac{\partial T}{\partial x}$= Temperature gradient

Heat is flow towards fall of temperature gradient turns into negative while temperature reduces by rising of width x. The negative indications show that heat movement in the positive x direction.

Convection

In Convection, energy is transfer between solid surfaces to the adjacent gas (atmosphere) or liquid which is in action, and it engages the mutual effects of conduction and fluid motion. Heat transfer by convection based on the velocity of fluid. In the nonexistence of any more fluid motion, Heat remove is by pure conduction due to the nonexistence of fluid motion among a solid plane and the closest fluid. Convection is governed by Newton's law of cooling.

Radiation

Radiation is the energy transfer in the form of waves through space without any medium other than conduction and convection. Conduction and convection require a medium like solid or gas but radiation only happen in space through electromagnetic waves. The velocity of radiation which can be emitted from a outside at an absolute temperature T is governed by the Stefan- Boltzmann law as

$$Q = \sigma A T^4$$

Where, σ =5.670 $\times 10^{-8}$ W/m^2 is the Stefan Boltzmann constant. The black body is ideal surface for emits radiation at maximum rate, and the radiation transferred by a black body is called black body radiation.

Absorptivity α is another important property of a plane, is explained as the division of the radiation energy incident on a surface that is received by the surface. The entire radiation incident on it is absorbed by black body. That is, a blackbody is a perfect absorber (α=1) of radiation.

2. LITERATURE REVIEW

Tarvydas et al[1] in 2013 studied regarding the heat sink modelling and performance for an electronic element. They worked on FEM process on COMSOL software for the thermal modelling of the heat rejection. They studied the result of the meshing processes on the time taken by COMSOL for completed solution of the heat Sink.

Paul et al[2] in 2012 find out optimum solution of Extended Fins in the research of Internal burning of fuel in Engine they found solution for top speed vehicles wider fins supplied improved efficiency. When thickness of fin was raised, the fewer gaps between the extruded surfaces produced in swirls being produced that support in rising the heat dissipation. Results shows a huge number of fins with less width can be selected in high speed vehicles than wide fins with fewer numbers as it assists inducing better turbulence.

Kumbhar et al[3] in 2009 find out the solution of Heat transfer expansion from a horizontal rectangular fin by triangular perforations whose bases parallel and towards the fin base under natural convection has been calculated using ANSYS. They have found solution that the heat removing rate enlarges as evaluate to fins of related dimensions without perforation. The perforation of the fin enhance the heat removing rates at the same time reduces the expenses for fin equipment's also.

Nagarani et al[4] in 2010 analyzed the heat removing rate and potency for circular and elliptical rounded fins for various environmental conditions. Elliptical fin efficiency is over than circular fin. If area constraint is there on one explicit direction whereas the vertical direction is comparatively unlimited oblique fins can be a fine selection. Commonly heat transfer co-efficient depends upon the area, time, run circumstances and fluid properties. If there are changes in ecological conditions, there are transform in heat transfer co-efficient and efficiency also.

Pise et al[5] in 2010 investigated the research to evaluate the speed of heat transfer with solid and pervasive fins. Permeable fins are shaped by adjusting the hard rectangular extruded surfaces with making 3 holes per fins that tilt at one half lengths of the fins of two wheeler engine blocks. Hard and holey fins block are hold in inaccessible chamber and competence of every fin of these blocks were calculated. Engine cylinder block contain solid and holey fins were analyzed for changed inputs. It was found that permeable extruded surfaces block average heat removing velocity develops by about 5.63% and normal heat rejection coefficient 42.3% as evaluated to solid fins with decreasing of cost of the material 30%.

Raju et al[6] in 2012 studied the finest plan of an IC engine cylinder fin array by a binary coded genetic algorithm. This research also consist the result of difference between extruded surfaces on different limitations like whole surface area, heat rejection coefficient and entire heat transfer .The aspect supplies of a single fin and their equivalent collection of these two outlines were also find out. Ultimately the heat rejection during both arrays was compared on their mass basis. An outcome explains the benefit of triangular outline fin array. Heat transfer during triangular extruded surfaces array per unit mass is in excess of that the heat rejection by rectangular fin array. Then the triangular shaped fins are favored than the rectangular shaped fins for automobiles sector, C.P.U., aero-planes, space vehicles etc.

Patil et al[7] in 2013 find out CFD and investigational research of elliptical shaped fins for heat rejection parameters, heat rejection coefficient and tube effectiveness by artificial convection. The practical analysis is accepted for changed air stream speed with changing heat input. The CFD temperature division for all belongings confirms investigational results. At air moving rate of 3.7 m/s, the heat rejection speed decreases as heat participation increases. Also h is superior at higher than atmospheric temperature and lesser at under atm. Temperature. At air flow rate of 3.7 m/s the effectiveness, enhance as heat input increases.

Magarajan et al[8] in 2012 mathematically studied on heat rejection of I C Engine heat removing by extended surfaces on engine with the help of CFD" tool. [4]In this research, heat rejected of an IC engine fuel burning portion by the cooling fins with six numbers of fins consists pitch of 10 mm and 20 mm are considered numerically with commercially presented CFD tool Ansys Fluent. The IC engine is firstly at 150 and the heat discharge from the cylinder is find out at a wind speed of 0 km/h. It is explained from the CFD consequence which it takes 174.08 seconds (pitch=10mm) and 163.17 s (pitch =20mm) for ethylene glycol domain to achieve temperature of 423 K to 393 K for firstly. The research results explains that the cost of heat rejected by the ethylene glycol through rounded fins of pitch 10mm and 20mm are about 28.5W and 33.90 W.

Wange et al[9] in 2013 conducted experimental and computational investigation of fin array and given that the heat removing coefficient is high in indentation fin array than not including notch fin array. Designing limitations of fin effects on the working of fins, so appropriate collection of geometric parameter, Nitnaware et al[10] in 2015 find out the result of fin designs, coefficient of heat transfer coefficient (h) and material (K) is studied for the heat loss for air cooling of an I.C. engine. Also heat remove per unit mass of fin is higher for conical shape fin than rectangular shape therefore tapering fins are favored over rectangular cross section fins. The speed of heat transfer increases with increase in h, linearly, for small values of h. Aluminium is the better material for designing fins for air-cooled IC engines due to low weight, high rate of heat transfer and lower cost.

Ali et al[11] in 2012 find out the solution to improve heat transmit rate of cooling fins by over changing cylinder block fin form and size or climate condition. Engine time and efficiency can be improved with effective cooling. The cooling system of the air cooled engine is usually reliant on the extruded surface design of the cylinder top and block. The heat moves during the engine elements and convicted to air by the planes of the fins. Inadequate deduction of heat from engine will guide to high thermal stresses and lower engine efficiency. The fin geometry and cross sectional area affects the heat movement capable. In High velocity vehicles wider fins provide improved efficiency. By Increasing fin thickness resulted in swirls being produced which facilitate in growing the heat transfer. Large number of fins with less thickness can be preferred in high speed vehicles than thick fins with less numbers as it helps inducing greater turbulence and hence larger heat transfer.

3. MODELLING AND BOUNDARY CONDITIONS

Two set of geometries have been considered. Both the geometry contains one base plate over which circular fins have been fitted. Both the geometry has 100 numbers of fins. Figure 1 represents the first geometry and figure 2 represents the second geometry. First geometry has 5mm length circular fins and second geometry has 10mm length circular fins. Dimensions of the base plate are length × width 38mm×38mm and 2mm thickness. Distances between the fins in X-direction and Y-direction are 3.5mm. Figure 3 represents the applied boundary conditions. Aluminium has been used in the present analysis. On the base temperature (1100°C) has been applied while on all the other surfaces convective type boundary condition (30 W/m^{2}°C) has been considered.

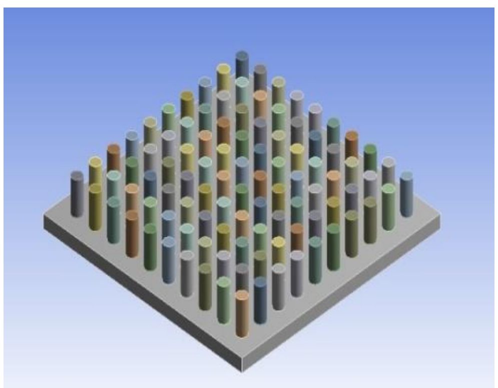

Figure 1: 5mm circular fins

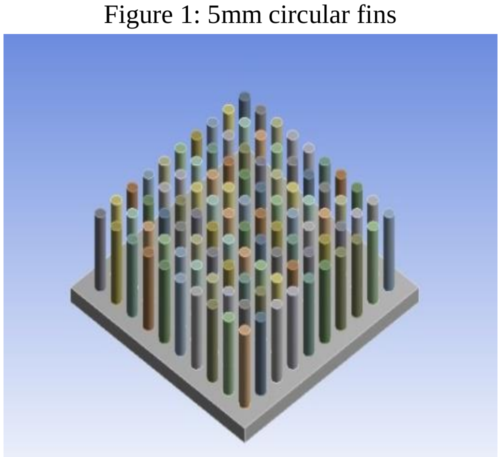

Figure 2: 10mm circular fins

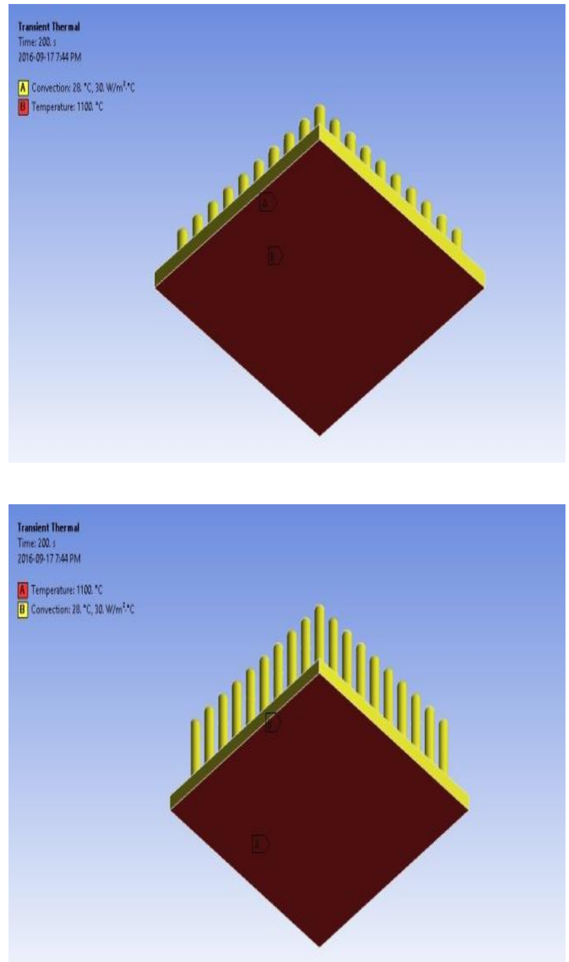

Figure 3: Applied boundary conditions

4. RESULT AND DISCUSSION

Figure 4 and 5 represents the temperature distribution. On the left hand side base plate having 5mm length circular fins and on the right hand side base plate having 10mm length circular fins has been represented. One can observe that the maximum temperature is at the bottom of the base plate and minimum temperature is at the top surfaces of the fins. This concludes that fins helps in increasing the heat transfer by increasing the surface area available for releasing of the heat. It can also be observed that the fins of 10mm length show low temperature at the outer surface when compared with fins of 5mm length. This is because of the larger surface area available because of the increment in the length of the fins. As 100 numbers of fins have been considered in the present work, surface area increases by twice when going from 5mm fin length to 10mm fin length which increases the heat transfer.

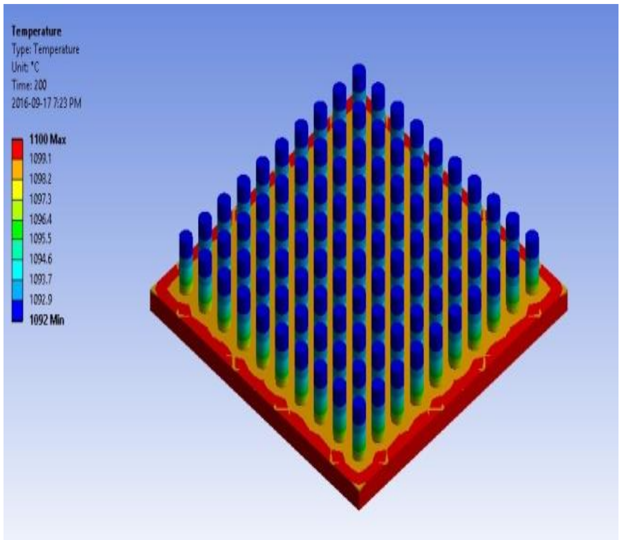

Figure 4: For 5mm length circular fins

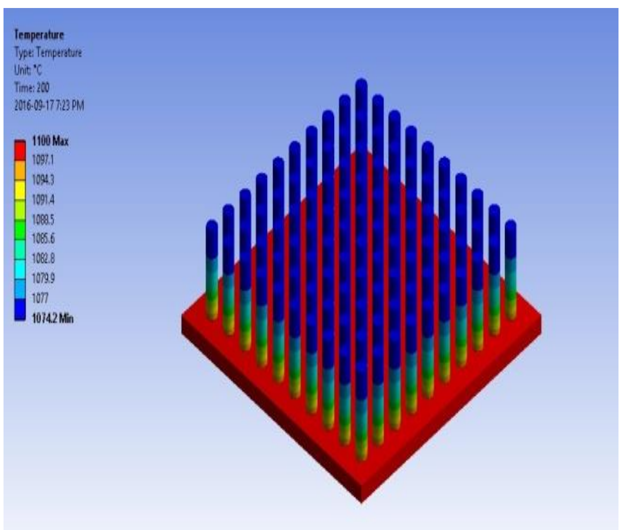

Figure 5: Temperature distribution

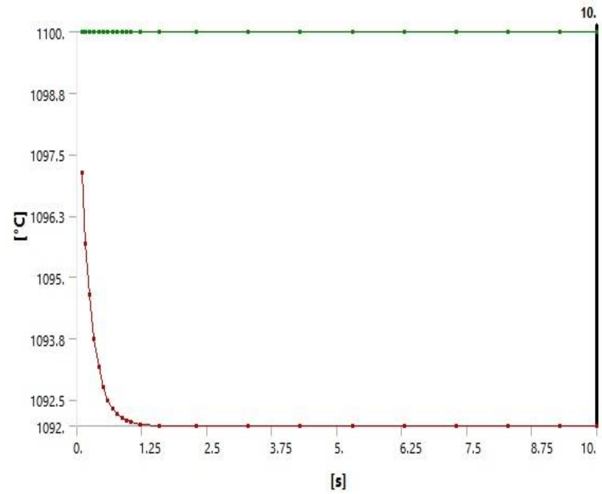

Figure 6: Time-temperature cooling curve for 5mm length circular fins

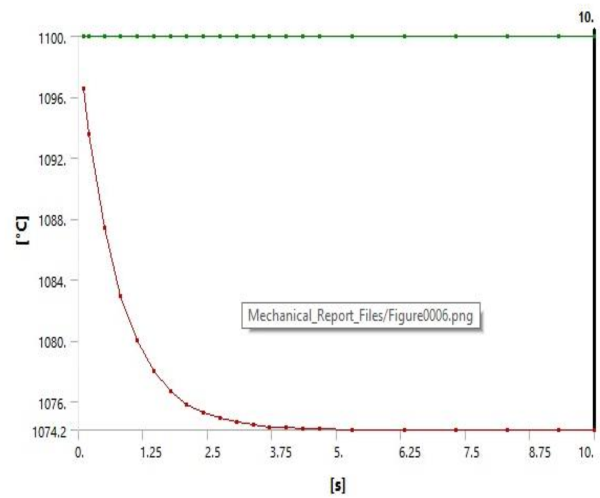

Figure 7: Time-temperature cooling curve for 10mm length circular fins

Figure 6 and 7 represents the time-temperature cooling curve for both types of geometry considered in the present work. Figure on the length side is for 5mm length circular fins while figure on the right hand side is for 10mm length circular fins. On the horizontal axis time has been plotted while on the vertical axis temperature has been plotted. One can easily observed from the time-temperature cooling curve for fins with 10mm length that it shows higher heat transfer rate when compared with time-temperature cooling curve for fins of 5mm length.

5. CONCLUSION

- Cooling of electronic equipment's required for increasing their working life.
- Fins are the best passive way of natural cooling of any heat generated equipment.
- Fins increase the heat transfer rate by increasing the surface area and intensity of flow.
- 10mm length circular fins shows higher heat transfer rate compared to 5mm length circular fins.
- Steeper time-temperature cooling curve has been found for fin with larger length.

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