ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Transient Thermal Analysis of Fins with Varying Holes on Engine Cylinder for Improvement of Efficiency

Vuppu Venkata Srikanth
(18HN1D2109)
Adarsh College Of Engineering
Department Of Mechanical Engineering
Chebrolu, E.G.Dist , A.P. , India

Mr.G.V.S. Srinivas, M.Tech.,
Assistant Professor
Adarsh College Of Engineering
Department Of Mechanical Engineering
Chebrolu, E.G.Dist , A.P. , India

ABSTRACT:

Engine cylinder is one of the major component in automobiles. Generally it is subjected to high temperatures and thermal stresses. To overcome his cooling is to be done. For this to happen, heat transfer rate should be more and efficient. Therefore, fins are provided on engine cylinder. To study the heat dissipation, thermal analysis should be performed on the cylinder fins. In this project, an invisible working fluid (air) is used to increase the rate of heat dissipation. By incorporating the fins on the cylinder, which provides more surface area, thereby increase in the dissipation rate.

The main aim of the project is to analyze the thermal properties by varying fins types. To predict the thermal behavior, parametric models of cylinder with fins have been developed. The models are created by the geometric modeling and designed Fins in Rectangular Shape. We have taken three different types of fins, they are fins with zero, one and two holes. Cooling fluid used in this thesis is air. The 3D modeling software used is CATIA. To determine the temperature variation in the cylinder fins, thermal analysis is done in ANSYS software. The temperatures and other thermal quantities are determined by Transient thermal analysis that vary over time. In this project, high thermal conductivity materials such as aluminum alloy 46200 was used to build cylinder fins.

1.INTRODUCTION:

The internal combustion engine is an engine, in an exceedingly combustion chamber the combustion of a fuel occurs with an oxidation. The expansion of the high-pressure and high-temperature gases obtained by combustion applies direct force to pistons, turbine blades, and on a nozzle in an internal combustion Engine. In order to generating useful mechanical energy, the component over a distance are moved by this force.

1.1 NECESSITY OF COOLING SYSTEM IN IC ENGINES:

All the heat produced by the combustion of fuel in the engine cylinders is not converted into useful power at the crankshaft. A typical distribution for the fuel energy is given below:
Useful work at the crank shaft = 25%
Loss to the cylinder's walls = 30%
Loss in exhaust gases = 35%
Loss in friction = 10%

It is seen that the number of warmth given to the cylinder walls is considerable and if this heat isn't off from the cylinders it'd lead to the resignation of the charge. additionally, the lubricant would also burn away, thereby causing the seizing of the piston. Excess heating will damage the cylinder material.

Cite this article as: Vuppu Venkata Srikanth & G.V.S. Srinivas "Transient Thermal Analysis of Fins with Varying Holes on Engine Cylinder for Improvement of Efficiency", International Journal & Magazine of Engineering, Technology, Management and Research (IJMETMR), ISSN 2348-4845, Volume 7 Issue 9, September 2020, Page 22-32.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Keeping the above factors visible, it's observed that suitable means must be provided to dissipate the surplus heat from the cylinder walls, so on maintain the temperature below certain limits.
However, cooling beyond optimum limits isn't desirable, because it decreases the general efficiency thanks to the subsequent reasons:
• Thermal efficiency is decreased due to more loss of heat to the cylinder walls.

• The vaporization of fuel is less; this results in fall of combustion efficiency.

• Low temperatures increase the viscosity of lubrication and hence more piston friction is encountered, thus decreasing the mechanical efficiency.

Though more cooling improves the volumetric efficiency, yet the factors mentioned above result in the decrease of overall efficiency.

Thus, it may be observed that only sufficient cooling is desirable and any deviation from the optimum limits will result in the deterioration of the engine performance.

1.2 METHODS OF COOLING
Various methods used for cooling of automobile engines are:

1. Air Cooling 2. Water cooling

1.2.1 AIR-COOLING
Cars and trucks using direct air cooling (without an intermediate liquid) were built over an extended period beginning with the appearance of mass produced passenger cars and ending with alittle and customarily unrecognized technical change. Before World War II, water cooled cars and trucks routinely overheated while climbing mountain roads, creating geysers of boiling cooling water. This was considered normal, and at the time, most noted mountain roads had auto repair shops to minister to overheating engines.

Auto Club Suisse (ACS) maintains historical monuments thereto era on the Susten Pass where two radiator refill stations remain. A Spherical bottom watering can be hanging next to a water spigot and a cast meta; plaque have those instructions. The spherical bottom was intended to stay it from being set down and, therefore, be useless round the house, in spite of which it absolutely was stolen, because the picture shows.

During that period, European firms such as air-cooled diesel trucks are built by Magirus-Deutz, air-cooled farm tractors are built by Porsche, and air-cooled passenger cars became famous such as Volkswagen. In the USA, Franklin built air-cooled engines.

The Czechoslovakia based company Tata is known for their big size air cooled V8 car engines, Tata engineer Julius Mackerle published a book on it. During the extremely cold and hot environmental weather temperatures, air-cooled engines are better, you can see water-cooled engines are stuck in freezing conditions that air-cooled engines starting and running in those conditions and continue working when water-cooled ones start producing steam jets properly in freezing condition.

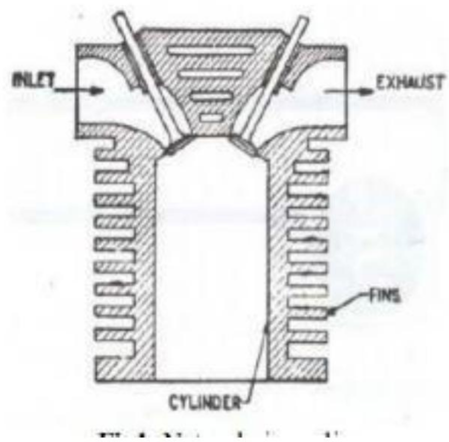

Fig.1.1. AIR COOLING

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

In an engine, the larger parts were exposed to the atmospheric air. During the motion of a vehicle, upon impingement by air at a certain velocity, it sweeps the heat from the engine. Due to natural convection the heat carried away by air, therefore this termed as natural air-cooling. Almost all the two-wheelers were cooled naturally by air.

As the temperature reduction could be a function of frontal cross- sectional area of the engine, therefore there exists a necessity to enlarge this area. An engine with enlarge area will becomes bulky and successively also will reduce the ability by weight ratio. Hence, as another arrangement, fins are constructed to spice up the frontal cross-sectional area of the engine. Fins (or ribs) are sharp projections provided on the surfaces of block and plate. They increase the outer contact area between a cylinder and therefore the air. Fins are, generally, casted integrally with the cylinder. they will even be mounted on the cylinder.

1.2.2 LIQUID COOLING

A Liquid cooling system works by passing a liquid coolant through chambers in the engine block and heads. As the coolant flows through these chambers, it picks up heat from the engine. The radiator within the front of the car are wont to through a heated fluid from the rubber hose. The heated fluid is flowing through the skinny tubes within the radiator, the air stream entering the engine compartment from the grill ahead of the car is employed to cool down the recent air.

Once the fluid is cooled, it returns to the engine to soak up more heat. The water pump has the job of keeping the fluid moving through this system of plumbing and hidden chambers.

Today, most engines are liquid-cooled.

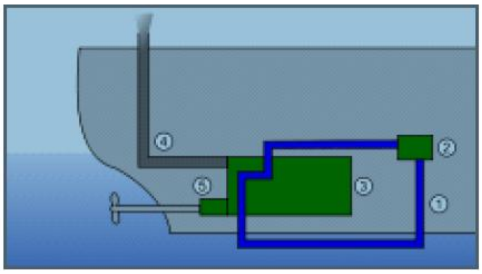

Fig 1.2. A fully closed IC engine cooling system

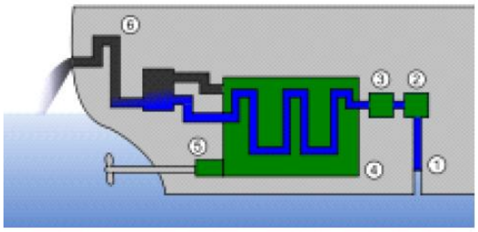

Fig 1.3. Open IC engine cooling system

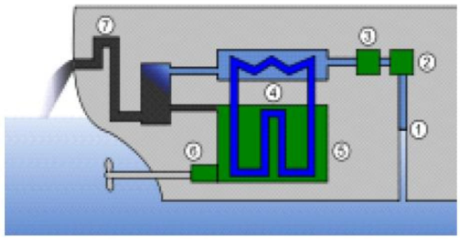

Fig 1.4. Semi closed IC Engine cooling system

1.2.3 FIN EFFICIENCY

Fin efficiency is one of the parameters which make a higher thermal conductivity material important. A fin of a heat sink may be considered to be a flat plate with heat flowing in one end and being dissipated into the surrounding fluid as it travels to the other.[11] As heat flows through the fin, the combination of the thermal resistance of the heat sink impeding the flow and the heat lost due to convection, the temperature of the fin and,

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

therefore, the heat transfer to the fluid, will decrease from the base to the end of the fin. Fin efficiency is defined as the actual heat transferred by the fin, divided by the heat transfer was the fin to be isothermal (hypothetically the fin having infinite thermal conductivity).

These equations are applicable for straight fins:

$$\eta_f = \frac{\tanh(mL_c)}{mL_c}$$

$$mL_c = \sqrt{\frac{2h_f}{kt_f}} L_f$$

1.3 ENGINEERING APPLICATIONS

1.3.1 MICROPROCESSOR COOLING

Heat dissipation is an unavoidable by-product of electronic devices and circuits.[11] In general, the temperature of the device or component will depend on the thermal resistance from the component to the environment, and the heat dissipated by the component. To ensure that the component does not overheat, a thermal engineer seeks to find an efficient heat transfer path from the device to the environment. The heat transfer path may be from the component to a printed circuit board (PCB), to a heat sink, to air flow provided by a fan, but in all instances, eventually to the environment.

Two additional design factors also influence the thermal/mechanical performance of the thermal design:

1. The method by which the heat sink is mounted on a component or processor. This will be discussed under the section *attachment methods*.

2. For each interface between two objects in contact with each other, there will be a temperature drop across the interface. For such composite systems, the temperature drop across the interface may be appreciable.[12] This temperature change may be attributed to what is known as the thermal contact resistance.[12] *Thermal interface materials* (TIM) decrease the thermal contact resistance.

2.Literature Review

Heat engines generate mechanical power by extracting energy from heat flows, much as a water wheel extracts mechanical power from a flow of mass falling through a distance. Engines are inefficient, so more heat energy enters the engine than comes out as mechanical power; the difference is waste heat which must be removed. Internal combustion engines remove waste heat through cool intake air, hot exhaust gases, and explicit engine cooling. Engines with higher efficiency have more energy leave as mechanical motion and less as waste heat. Some waste heat is essential: it guides heat through the engine, much as a water wheel works only if there is some exit velocity (energy) in the waste water to carry it away and make room for more water. Thus, all heat engines need cooling to operate. Cooling is also needed because high temperatures damage engine materials and lubricants. Internal combustion engines burn fuel hotter than the melting temperature of engine materials, and hot enough to set fire to lubricants. Engine cooling removes energy fast enough to keep temperatures low so the engine can survive. Some high-efficiency engines run without explicit cooling and with only accidental heat loss, a design called adiabatic. For example, 10,000 mile-pergallon "cars" for the Shell economy challenge are

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

insulated, both to transfer as much energy as possible from hot gases to mechanical motion, and to reduce reheat losses when restarting. Such engines can achieve high efficiency but compromise power output, duty cycle, engine weight, durability, and emissions.

3. MODELLING

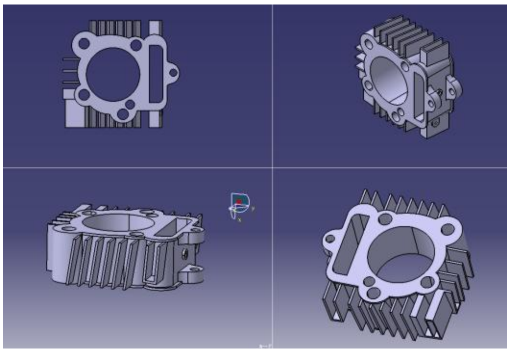

Fig 3.4. CAD model designed in CATIA

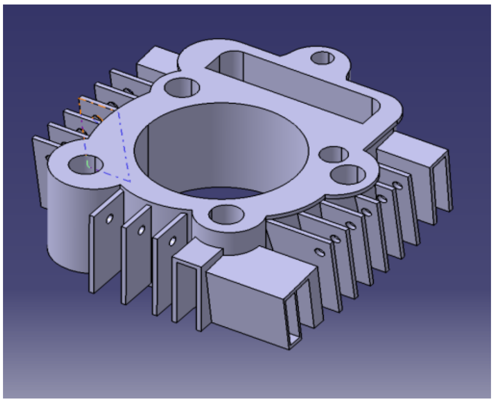

Fig 3.5. Engine block with 1 hole on fins

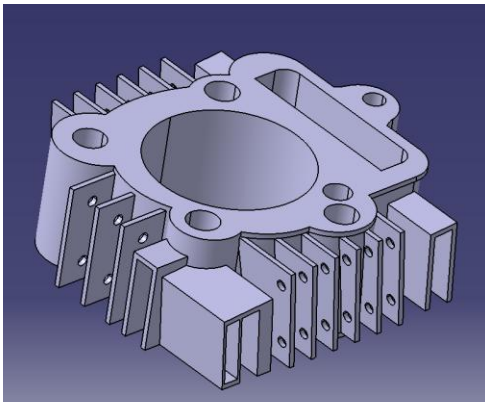

Fig 3.6. Engine block with 2 holes on fins

3.1 ANSYS

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software implements equations that govern the behavior of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated or graphical forms. This type of analysis is typically used for the design and optimization of a system far too complex to analyze by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations. quality through turning.

ANSYS is the standard FEA teaching tool within the Mechanical Engineering Department at many colleges. ANSYS is also used in Civil and Electrical Engineering, as well as the Physics and Chemistry departments.

3.1.1 GENERIC STEPS TO SOLVING ANY PROBLEM IN ANSYS

Like solving any problem analytically, you need to define (1) your solution domain, (2) the physical model, (3) boundary conditions and (4) the physical properties. You then solve the problem and present the results. In numerical methods, the main difference is an extra step called mesh generation. This is the step that divides the complex model into small elements that become solvable in an otherwise too complex situation. Below describe the processes in terminology slightly more attune to the software.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

1. Build Geometry
Construct a two or three dimensional representation of the object to be modelled and tested using the work plane co-ordinate system within ANSYS.

2. Define Material Properties
Now that the part exists, define a library of the necessary materials that compose the object (or project) being modelled. This includes thermal and mechanical properties.

3. Generate Mesh
At this point ANSYS understands the makeup of the part. Now define how the modelled system should be broken down into finite pieces.

4. Apply Loads
Once the system is fully designed, the last task is to burden the system with constraints, such as physical loadings or boundary conditions.

5. Obtain Solution
This is actually a step, because ANSYS needs to understand within what state (steady state, transient… etc.) the problem must be solved.

6. Present the Results
After the solution has been obtained, there are many ways to present ANSYS' results, choose from many options such as tables, graphs, and contour plots.

4.ANALYSIS

4.1 THERMAL ANALYSIS ON ENGINE BLOCK WITH ZERO (0) HOLES ON FINS

By using engine block with zero (0) holes on fine we can analyze the thermal analysis in ANSYS with material as Aluminum Alloy of material properties give below.

4.1.1 ALUMINUM ALLOY MATERIAL PROPERTIES

Thermal Conductivity – 180 w/m*k
Specific Heat – 0.896 J/g °C
Density – 2.7 g/cc

4.1.2 LOADS

Temperature -558 K
Film Coefficient – 0.019 w/m2 K
Bulk Temperature – 313 K

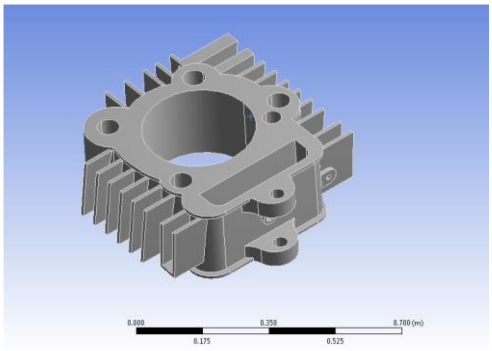

Fig 4.1. CAD model imported into ANSYS.

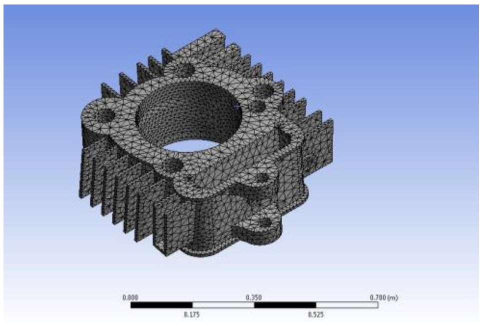

Fig 4.2. Meshed model.

4.1.3 TEMPERATURE

Type : Temperature
Temperature : 558k
No. of faces : 2

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

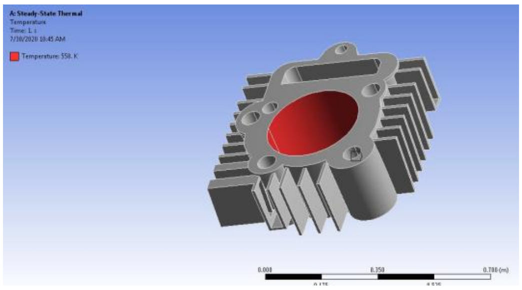

Fig 4.3. load applied faces.

4.1.4 CONVECTION

Type : Convection
Film Coefficient : 0.019 w/m2 K
Bulk Temperature : 313 K
No. of faces : 154

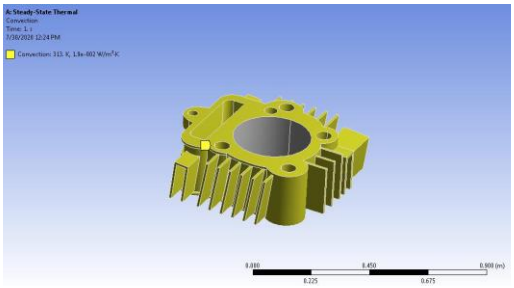

Fig 4.4. Boundary conditions

4.1.5 TEMPERATURE DISTRUBUTION

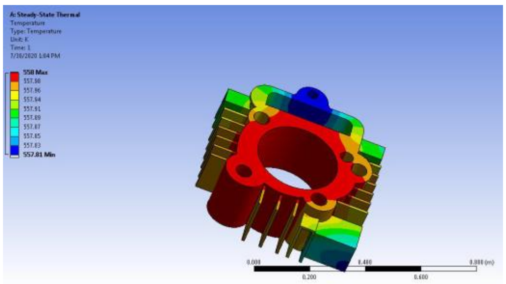

Fig 4.5. Temperature distribution on block

4.1.6 TOTAL HEAT FLUX

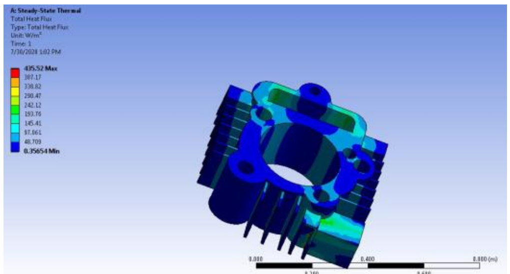

Fig 4.6. Total Heat Flux on Block

4.2 THERMAL ANALYSIS ON ENGINE BLOCK WITH ONE (1) HOLE ON FINS

By using engine block with one (1) hole on fine we can analyze the thermal analysis in ANSYS with material as Aluminum Alloy of material properties give below.

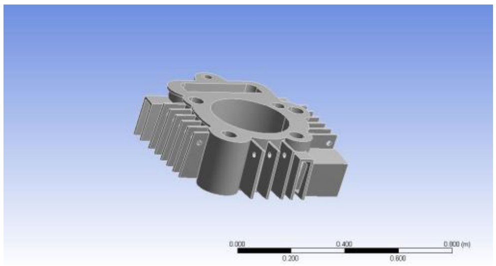

Fig 4.7. CAD model imported into ANSYS

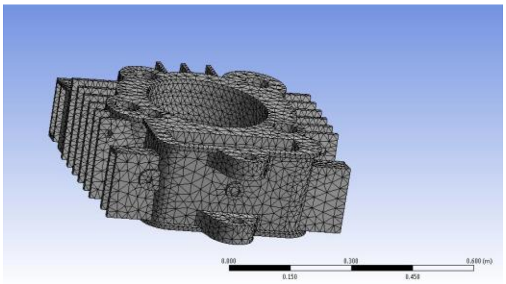

Fig 4.8. Meshed model

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

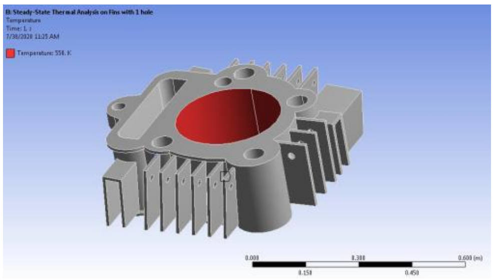

Fig 4.9. Load applied faces

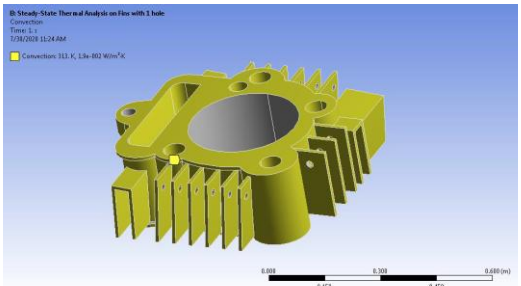

Fig 4.10. Boundary conditions

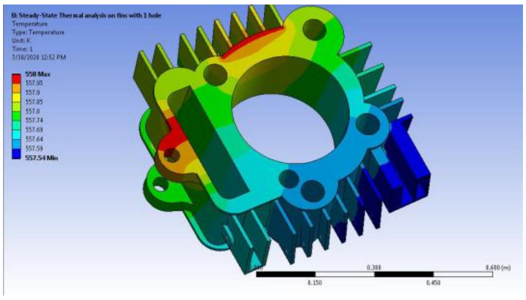

Fig 4.11. Temperature distribution on block with 1 hole fin.

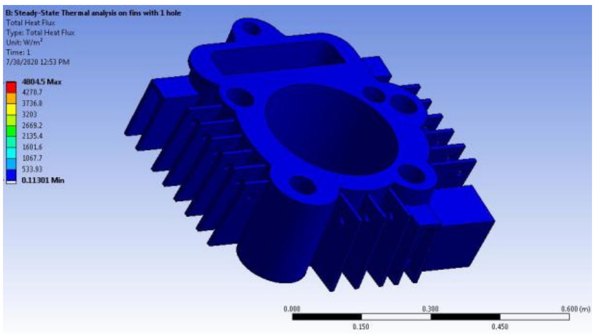

Fig 4.12. Total Heat Flux distribution on Block with 1 hole fin.

4.3 THERMAL ANALYSIS ON ENGINE BLOCK WITH TWO (2) HOLES ON FINS

By using engine block with two (2) holes on fine we can analyze the thermal analysis in ANSYS with material as Aluminum Alloy of material properties give below:

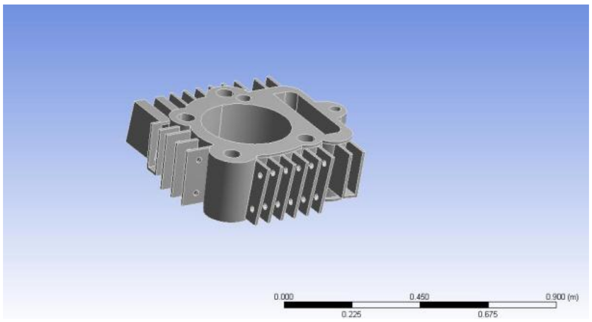

Fig 4.13. CAD model imported into ANSYS.

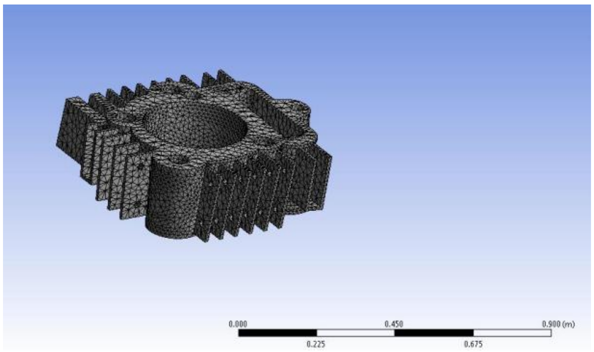

Fig 4.14. Meshed model.

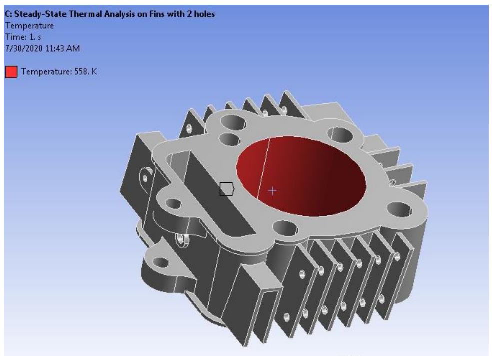

Fig 4.15. Load applied faces.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

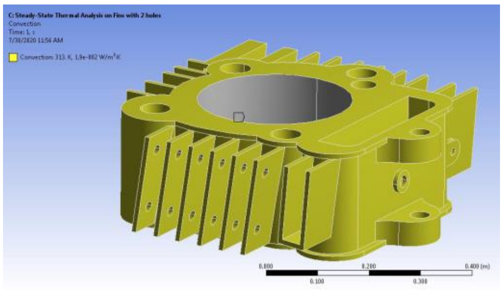

Fig 4.16. Boundary conditions.

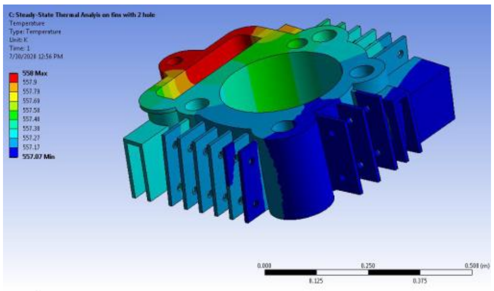

Fig 4.17. Temperature distribution on block with 2 holes fin.

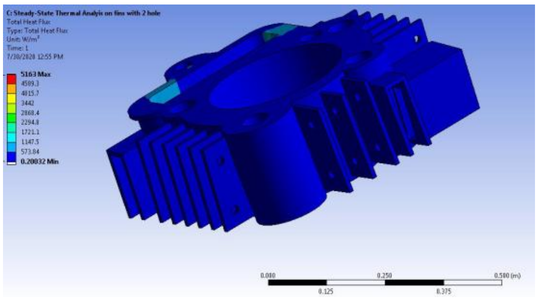

Fig 4.18. Total Heat Flux distribution on Block with 2 holes fin.

5. RESULTS

5.1 TEMPERATURE VS FIN MODELS

Table 5.1. Temperature and total heat flux values of various fin models.

	TEMPERATURE		TOTAL HEAT FLUX	
	Max	Min	Max	Min
Fins with No hole	558	557.81	435.52	0.35654
Fins with 1 hole	558	557.54	4804.5	0.11301
Fins with 2 holes	558	557.07	5163	0.20032

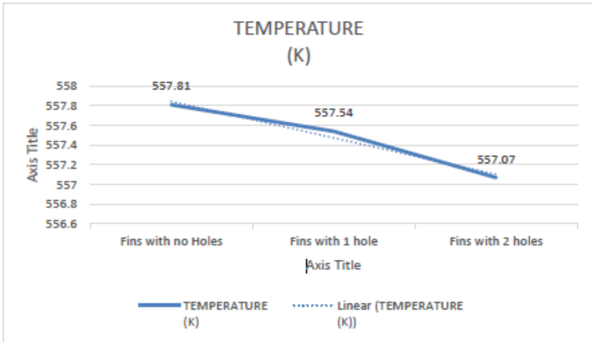

Fig 5.1. Temperature plot vs Fin Models

5.2 TOTAL HEAT FLX VS FIN MODELS

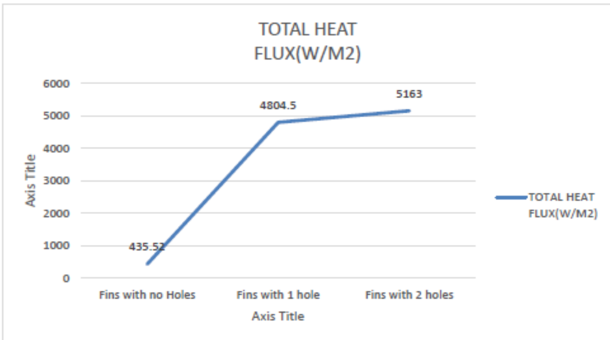

Fig 5.2. Heat Flux vs Fin Models.

6. CONCLUSION

In this analysis, various models of fins are tested for heat transfer rate using ANSYS transient thermal analysis module. Using the knowledge from base paper, fins are developed and tested their heat transfer capacity using the aluminum based alloys. Later, in this thesis holes are incorporated in fins to attain more heat transfer rate.

1. Heat transfer rate is measured in terms in raise in overall temperature.

2. The minimum temperature is obtained for fin with two holes is 557.07 K.

3. The maximum temperature is obtained for fin with no hole is 557.81 K.

4. The minimum heat flux is obtained for fin with no hole is 435.52 W/m2.

5. The maximum heat flux is obtained for fin with two holes is 5163 W/m2.

6. Therefore, the fin with two holes have minimum temperature and maximum heat flux. So, we suggest that fin with two holes are used for better heat transfer rate.

REFERENCES

1. Li and Chao 2009, "Measurement of performance of plate-fin heat sinks with cross flow cooling International Journal of Heat and Mass Transfer" 52 2949–2955.

2. Mehran Ahmadi, Golnoosh Mostafavi, Majid Bahrami 2014, "Natural convection from rectangular interrupted fins". International Journal of Thermal Sciences 82 62-71.

3. Mahmoud R, Al-Dadah DK, Aspinwall SL, Soo H Hemida 2011, "Effect of micro fin geometry on natural convection heat transfer of horizontal microstructures Applied Thermal Engineering". 31 627-633.

4. Qarnia, Heat Transfer by Natural Convection from a Vertical and Horizontal Surfaces Using Vertical Fins Energy and Power Engineering", 85-89.

5. Sabia, heat transfer by fins in cylinder head

6. Gibson, A.H., The Air Cooling of Petrol Engines, Proceedings of the Institute of Automobile Engineers, Vol.XIV (1920), pp.243–275.

7. Biermann, A.E. and Pinkel, B., Heat Transfer from Finned Metal Cylinders in an Air Stream, NACA Report No.488 (1935).

8. Thornhill, D. and May, A., An Experimental Investigation into the Cooling of Finned Metal Cylinders, in a Free Air Stream, SAE Paper 1999-01-3307, (1999).

9. Thornhill, D., Graham, A., Cunnigham, G., Troxier, P. and Meyer, R., Experimental Investigation into the Free Air-Cooling of Air-Cooled Cylinders, SAE Paper 2003-32-0034, (2003).

10. Pai, B.U., Samaga, B.S. and Mahadevan, K., Some Experimental Studies of Heat Transfer from Finned Cylinders of Air-Cooled I.C. Engines, 4th National Heat Mass Transfer Conference, (1977), pp.137–144.

11. Murakami Y., Flow over Fin Surfaces of Fin Tubes, Bulletin of the Faculty of Engineering, Hiroshima University, (in Japanese), Vol.33, No.2 (1985), pp.117–125.

12. Nabemoto, A., Heat Transfer on a Fin of Fin Tube, Bulletin of the Faculty of Engineering, Hiroshima University, (in Japanese), Vol.23, No.2 (1985), pp.127–136.

13. Dong-Kwon Kim," An experimental investigation of compared the thermal performances of two kinds of heat sinks ", pg.95-99.

14. Younus A Cengel, "An experimental investigation of performance of triangular fin parameter", SAE paper 2010-0007.

15. Maciej Jaworski," Experimental and numerical investigation of heat sink with phase change materials for electronics cooling.

16. Sandhya Mirapalli, "Heat Transfer Analysis on a Triangular Fin", in International

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Journal of Engineering Trends and Technology 19(5):279-284 .

17. Mohan, R. & Govindarajan, P. (2011). Experimental and CFD analysis of heat sinks with base plate for CPU cooling. Journal of Mechanical Science and Technology, Springer, Vol. 25, No. 8, pp. 1-10.

18. Goshayeshi H R, "Heat Transfer by Natural Convection from a Vertical and Horizontal Surfaces Using Vertical Fins", in Energy and Power Engineering 01(02):85-89 .

19. Agarwal A, "Numerical investigation of the effects of number of fins on the melting of paraffin wax in cylindrical annulus", in Journal of Enhanced Heat Transfer 23(4).

20. Mostafavi G, Agarwal A, Ahmadi M," Natural convection from rectangular interrupted fins", in International Journal of Thermal Sciences 82(1):62–71.