Thermal Analysis Of Engine Cylinder Fins By Varying Its Geometry And Material

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Abstract

The Engine cylinder is one of the major automobile components, which is subjected to high temperature variations and thermal stresses. In order to cool the cylinder, fins are provided on the surface of the cylinder to increase the rate of heat transfer. By doing thermal analysis on the engine cylinder fins, it is helpful to know the heat dissipation inside the cylinder.

The principle implemented in the project is to increase the heat dissipation rate by using the invisible working fluid, nothing but air. We know that, by increasing the surface area we can increase the heat dissipation rate, so designing such a large complex engine is very difficult. The main purpose of using these cooling fins is to cool the engine cylinder by air.

The main aim of the project is to analyze the thermal properties by varying geometry, material and thickness of cylinder fins.

Transient thermal analysis determines temperatures and other thermal quantities that vary over time. The variation of temperature distribution over time is of interest in many applications such as in cooling. The accurate thermal simulation could permit critical design parameters to be identified for improved life.

Presently Material used for manufacturing cylinder fin body is **Aluminum Alloy A204** which has thermal conductivity of **110-150W/mk**. We are analyzing the cylinder fins using this material and also using **Aluminum alloy 6061** and **Magnesium alloy** which have higher thermal conductivities.

Keywords: Shape, Material and Geometry of the fin, Transient thermal analysis.

1. Introduction

The internal combustion engine is an engine in which the combustion of a fuel (normally a fossil fuel) occurs with an oxidizer (usually air) in a combustion chamber. In an internal combustion engine, the expansion of the high-temperature and -pressure gases produced by combustion applies direct force to some component of the engine, such as pistons, turbine blades, or a nozzle. This force moves the component over a distance, generating useful mechanical energy.

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 per cent
- Loss to the cylinders walls = 30 per cent
- Loss in exhaust gases = 35 per cent
- Loss in friction = 10 per cent

It is seen that the quantity of heat given to the cylinder walls is considerable and if this heat is not removed from the cylinders it would result in the pre-ignition of the charge. In addition, the lubricant would also burn away, thereby causing the seizing of the piston. Excess heating will also damage the cylinder material.

Keeping the above factors in view, it is observed that suitable means must be provided to dissipate the excess heat from the cylinder walls, so as to maintain the temperature below certain limits.

However, cooling beyond optimum limits is not desirable, because it decreases the overall efficiency due to the following reasons:

1. Thermal efficiency is decreased due to more loss of heat to the cylinder walls.
2. The vaporization of fuel is less; this results in fall of combustion efficiency.
3. 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.

Various methods used for cooling of automobile engines are:

- Air Cooling
- Water cooling

AIR-COOLING

Cars and trucks using direct air cooling (without an intermediate liquid) were built over a long period beginning with the advent of mass produced passenger cars and ending with a small and generally unrecognized technical change.

LIQUID COOLING

Liquid cooling is also employed in maritime vehicles. For vessels, the seawater itself is mostly used for cooling. In some cases, chemical coolants are also employed (in closed systems) or they are mixed with seawater cooling.

Fins have always been used as a passive method of enhancing the convection heat transfer from cylinders. The presence of the solid fins has an effect on both the aerodynamic as well as the thermal characteristics of the flow. The fins tend to obstruct the airflow near the cylinder surface, thus reducing the heat transfer from the cylinder to the surrounding fluid. On the other hand, the fins increase the heat transfer area resulting in an increase in the heat transfer from the cylinder to the surrounding fluid. The net result of these two opposing effects depends on the combination of the number of fins, fin height, and Reynolds number. A.R.A. Khaled [14], modeled and analyzed analytically heat transfer through joint fins systems that are exposed to two different convective media from its both ends and concluded that heat transfer through joint fins is maximized at certain critical length of each portion. Bassam A/K Abu-Hijleh [15-16] investigated numerically the problem of laminar natural and forced convection from a horizontal cylinder with multiple equally spaced high conductivity permeable fins on its outer surface. The heat transfer characteristics of a cylinder with permeable versus solids fins were studied for several combinations of number of fins and fin height over the range of Reynolds number in case of forced convection and Rayleigh number in case of natural convection. Permeable fins provided much higher heat transfer rates compared to more traditional solid fins for a similar cylinder configuration.

In the present work, thermal analysis of a engine cylinder fins has performed numerically by varying its geometry, shape and thickness of the fin i.e., heat fluxes for temperature and thermal analysis values. The geometry of the model is changed for analysis and the results so obtained are consistent with expectations, in the sense that the temperature and heat transfer parameters like effectiveness and efficiency of the fin increase with change in their geometry and thickness of the fin.

1.1. Objectives of the project

The following are the main objectives of the present work:

- To design cylinder with fins for a 150cc engine by varying the geometry such as rectangular, circular and curve shaped (parabolic) and thickness of the fins.
- To determine transient thermal properties of the proposed fin models.
- To identify suitable alloy for the fabrication based on results obtained from finite element analysis and analytical method.

Sl. No.	Parameter	Forms
1	Type of Fins	1. Rectangular and 2. Circular
2	Thickness of the fin	1. 3mm, and 2. 2.5 mm
3	Material of the fin	1. Aluminum Alloy A204 2. Aluminum Alloy 6061 3. Magnesium Alloy

2. FINITE ELEMENT MODELLING

The parametric modeling approach uses parameters, dimensions, features, and relationships to capture intended product behavior and create a recipe which enables design automation and the optimization of design and product development processes.

This powerful and rich design approach is used by companies whose product strategy is family-based or platform-driven, where a prescriptive design strategy is critical to the success of the design process by embedding engineering constraints and relationships to quickly optimize the design, or where the resulting geometry may be complex or based upon equations. Pro/ENGINEER provides a complete set of design, analysis and manufacturing capabilities on one, integral, scalable platform. These capabilities include Solid Modeling, Surfacing, Rendering, Data Interoperability, Routed Systems Design, Simulation, Tolerance Analysis, and NC and Tooling Design.

Since the cooling system of the engine uses air, convection boundary is defined on all the outer surfaces (at fins) of the engine assembly.

2.1. Rectangular fin:

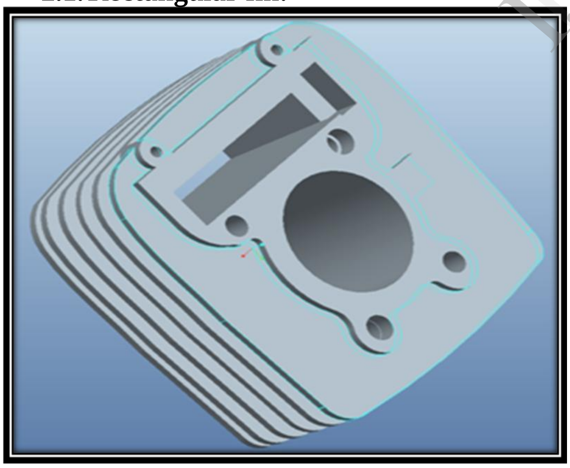

Fig.1. Pro/E model of Rectangular fin (3 mm thickness)

To capture the physics of the problem and to estimate the stresses correctly, the model is finely meshed using solid 187\solid 87 elements.

Total number of elements in the model 243341
Total number of nodes in the model 245267

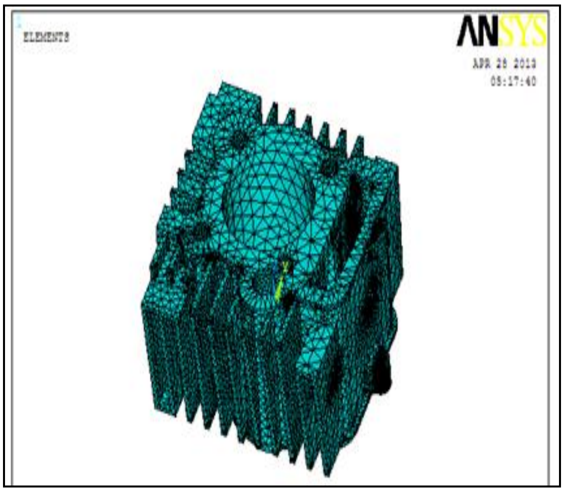

Fig.2. Mesh model of Rectangular fin (3 mm thickness)

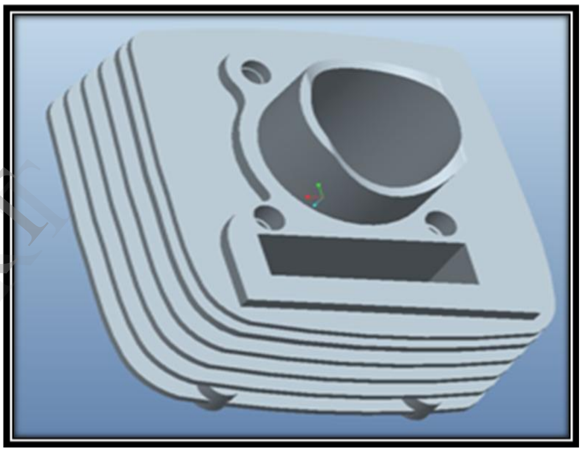

Fig.3. Pro/E model of Rectangular fin (2.5 mm thickness)

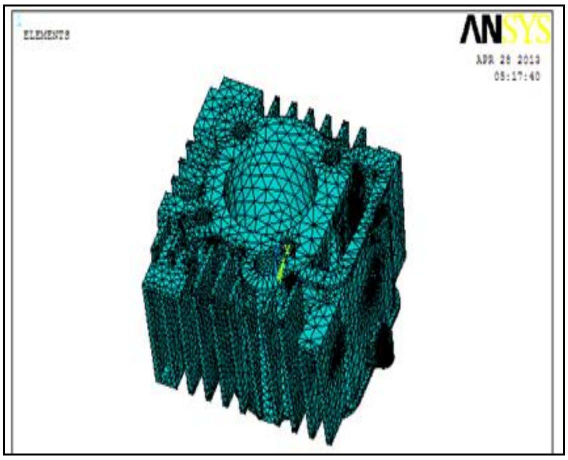

Fig.4. Mesh model of Rectangular fin (2.5 mm thickness)

2.2. Circular fin:

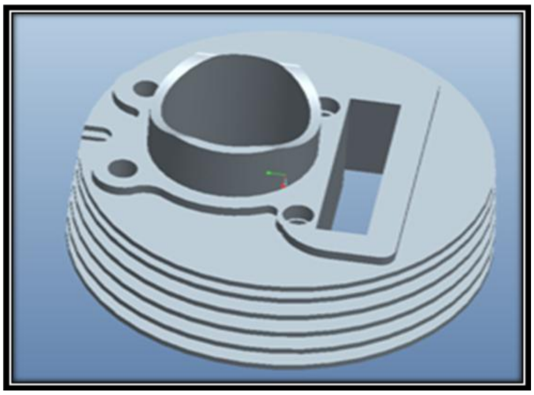

Fig.5. Pro/E model of Circular fin (3 mm thickness)

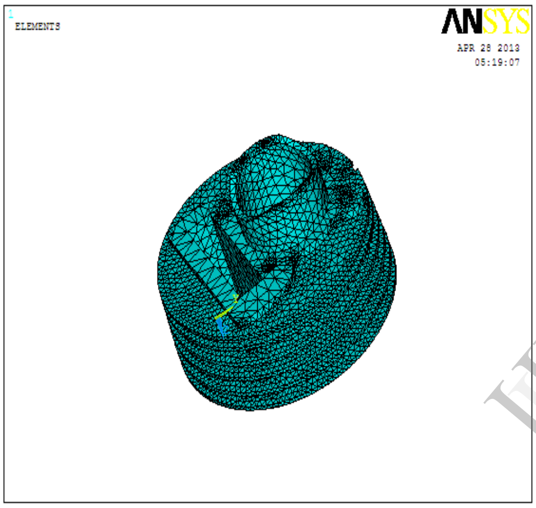

Fig.6. Mesh model of Circular fin (3 mm thickness)

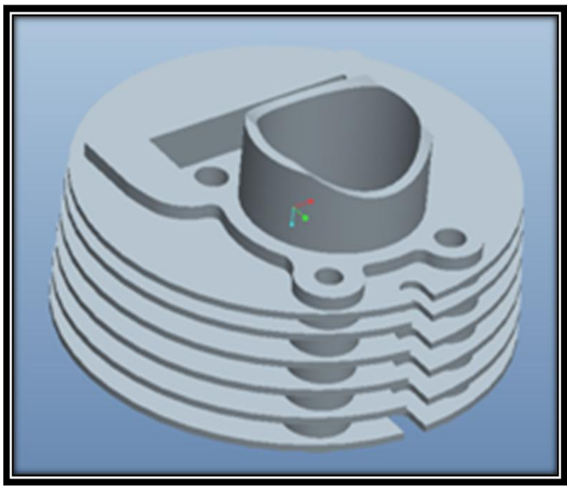

Fig.7. Pro/E model of Circular fin (2.5 mm thickness)

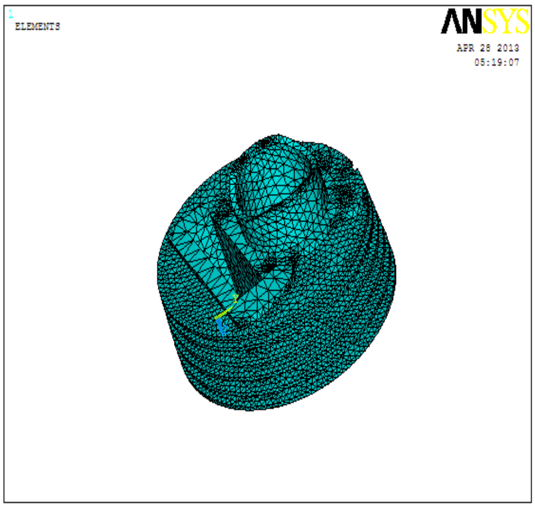

Fig.8. Mesh model of Circular fin (2.5 mm thickness)

3. TRANSIENT THERMAL ANALYSIS

Transient thermal analyses determine temperatures and other thermal quantities that vary over time. The variation of temperature distribution over time is of interest in many applications such as with cooling of electronic packages or a quenching analysis for heat treatment. Also of interest are the temperature distribution results in thermal stresses that can cause failure. In such cases the temperatures from a transient thermal analysis are used as inputs to a structural analysis for thermal stress evaluations.

Many heat transfer applications such as heat treatment problems, electronic package design, nozzles, engine blocks, pressure vessels, fluid-structure interaction problems, and so on involve transient thermal analyses.

A transient thermal analysis can be either linear or nonlinear. Temperature dependent material properties (thermal conductivity, specific heat or density), or temperature dependent convection coefficients or radiation effects can result in nonlinear analyses that require an iterative procedure to achieve accurate solutions. The thermal properties of most materials do vary with temperature, so the analysis usually is nonlinear

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3.1. Temperature Distribution through the fin for the material (Aluminum Alloy A204)

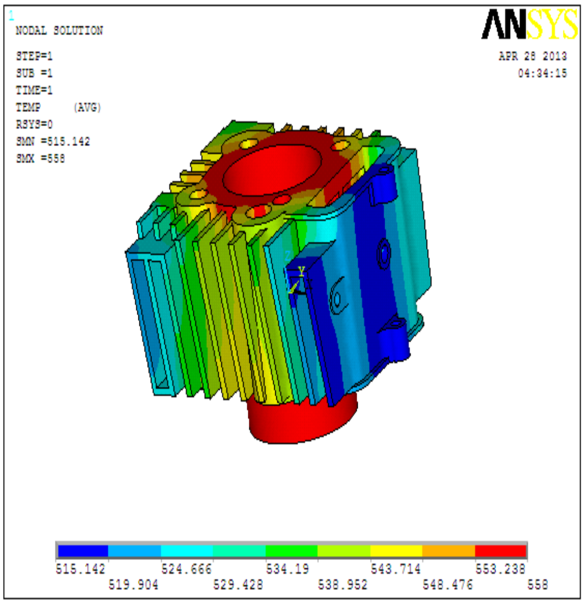

Fig.9.Temperature distribution through Rectangular fin (3mm thickness)

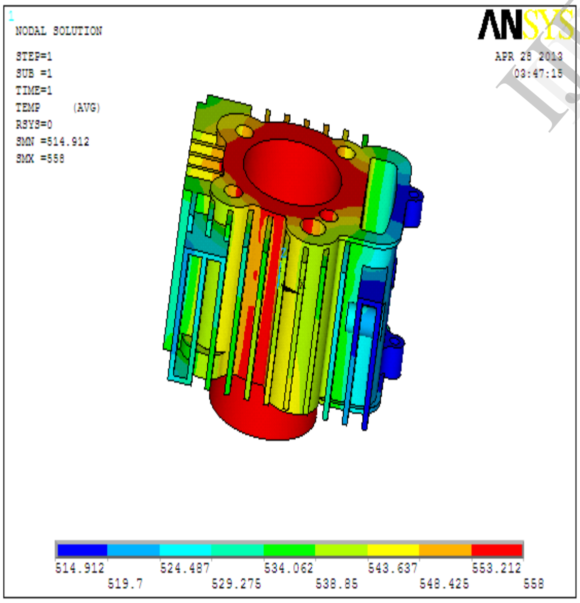

Fig.10.Temperature distribution through Rectangular fin (2.5mm thickness)

3.2. Temperature Distribution through the fin for the material (Aluminum Alloy 6061)

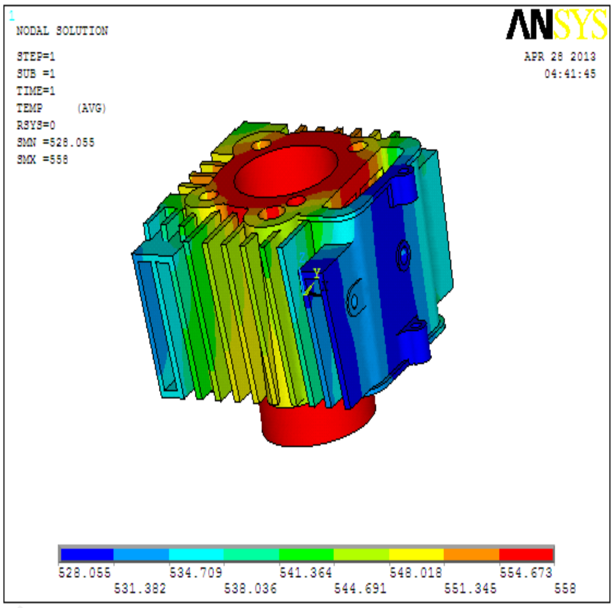

Fig.11.Temperature distribution through Rectangular fin (3mm thickness)

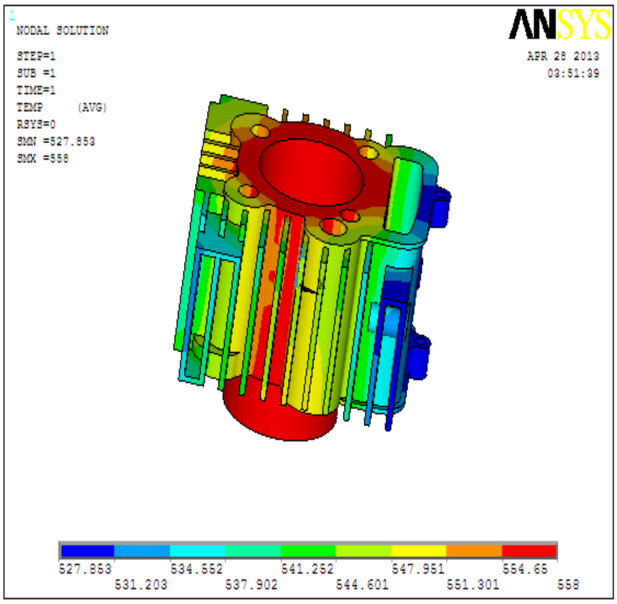

Fig.12.Temperature distribution through Rectangular fin (2.5mm thickness)

3.3. Temperature Distribution through the fin for the material (Magnesium Alloy)

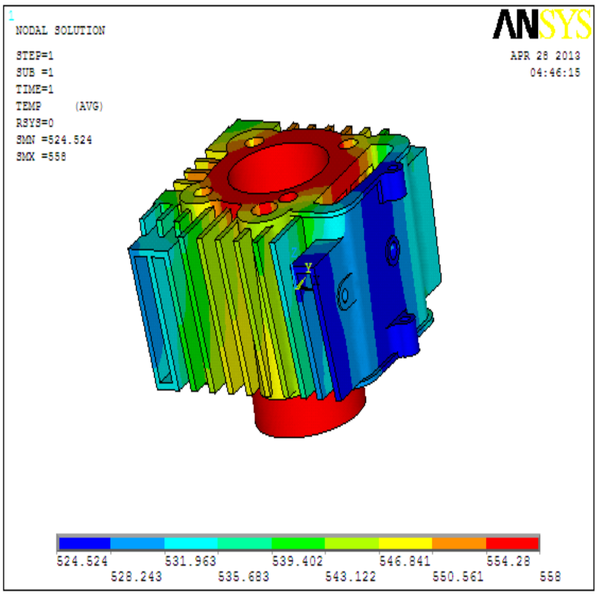

Fig.13.Temperature distribution through Rectangular fin (3mm thickness)

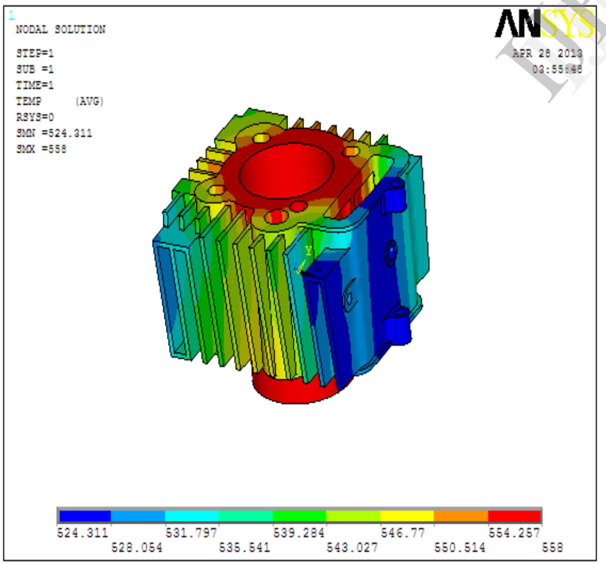

Fig.14.Temperature distribution through Rectangular fin (2.5mm thickness)

3.4. Parametric representation for Temperature Distribution through Rectangular fin:

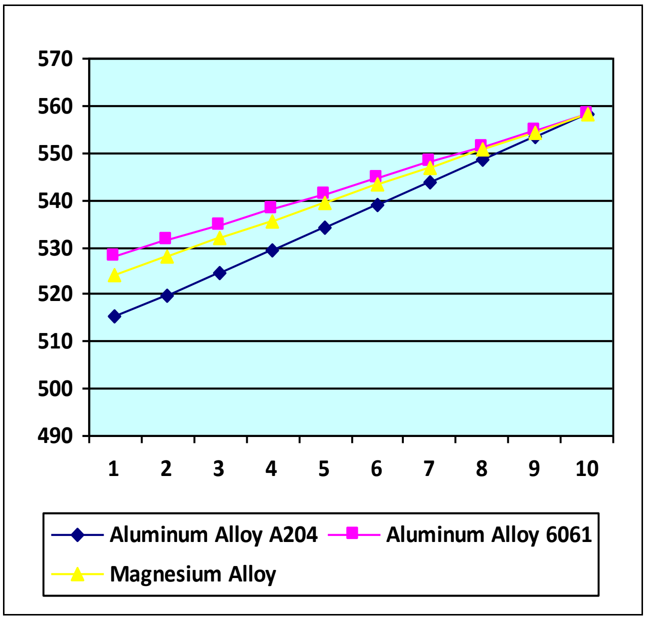

Fig.15. Comparison Graph between all three Materials for Rectangular fin (3mm thickness)

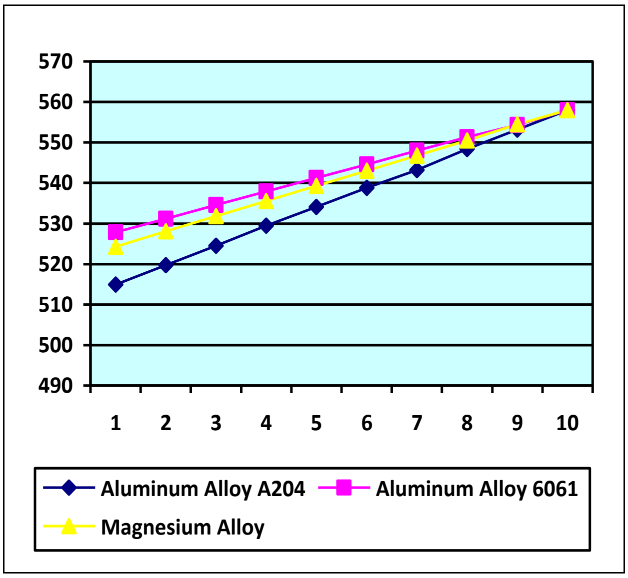

Fig.17. Comparison Graph between all three Materials for Rectangular fin (2.5 mm thickness)

3.5. Temperature Distribution through the fin for the material (Aluminum Alloy A204)

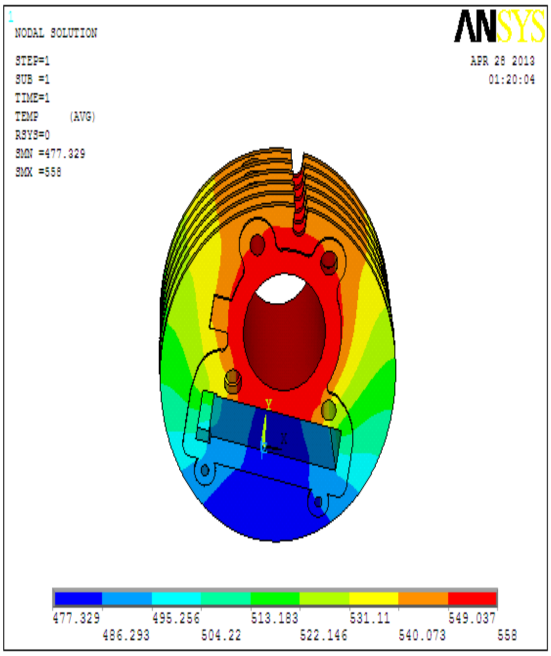

Fig.17.Temperature distribution through Circular fin (3 mm thickness)

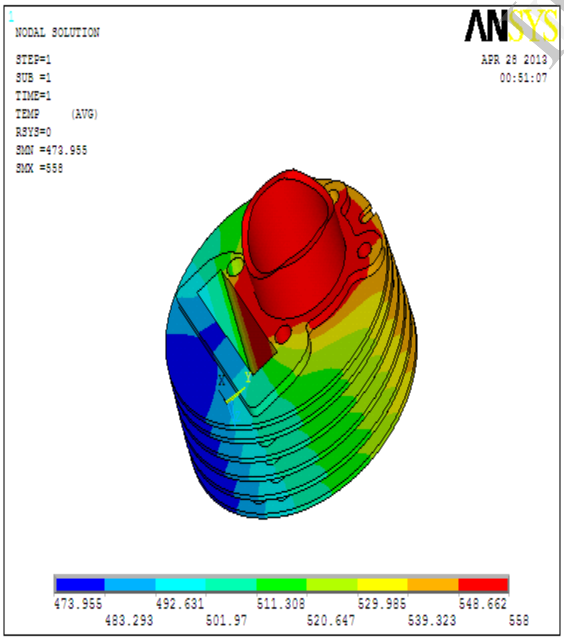

Fig.18.Temperature distribution through Circular fin (2.5 mm thickness)

3.6. Temperature Distribution through the fin for the material (Aluminum Alloy 6061)

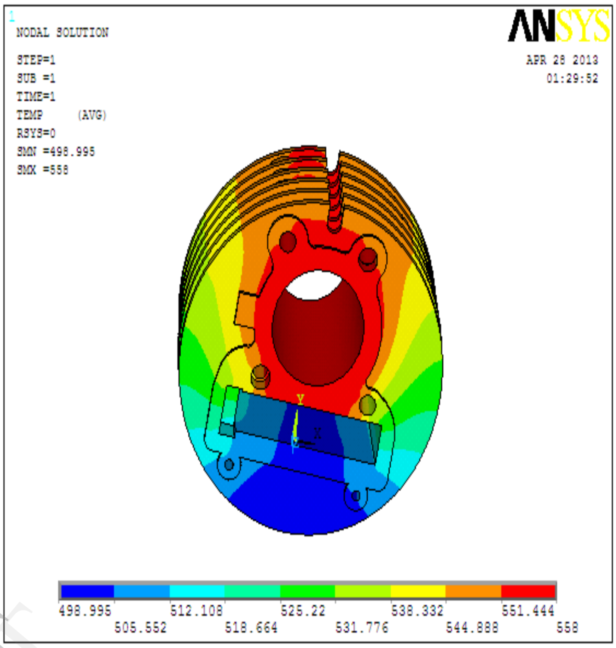

Fig.19.Temperature distribution through Circular fin (3 mm thickness)

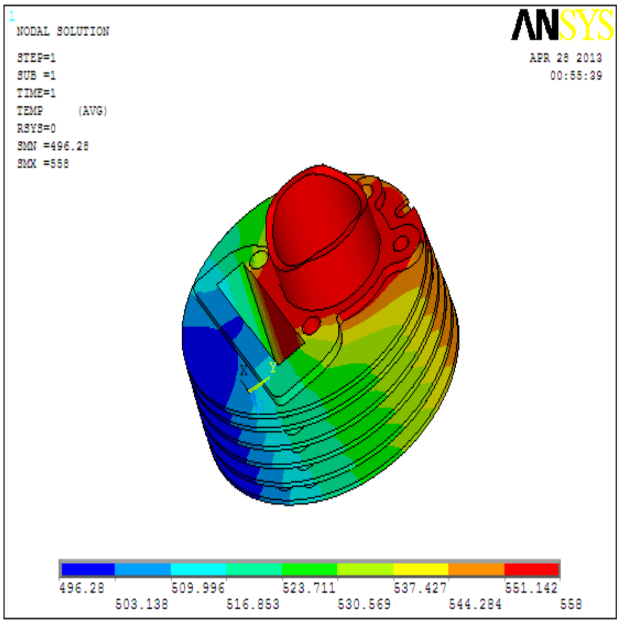

Fig.20.Temperature distribution through Circular fin (2.5 mm thickness)

3.7. Temperature Distribution through the fin for the material (Magnesium Alloy)

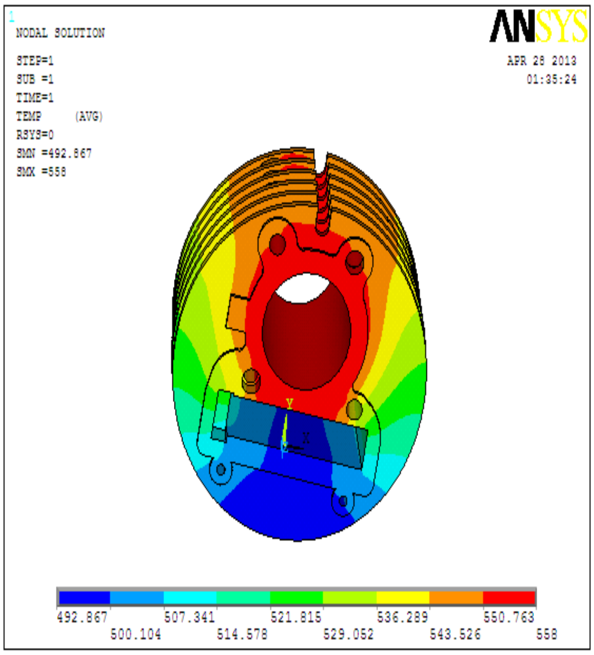

Fig.21.Temperature distribution through Circular fin (3 mm thickness)

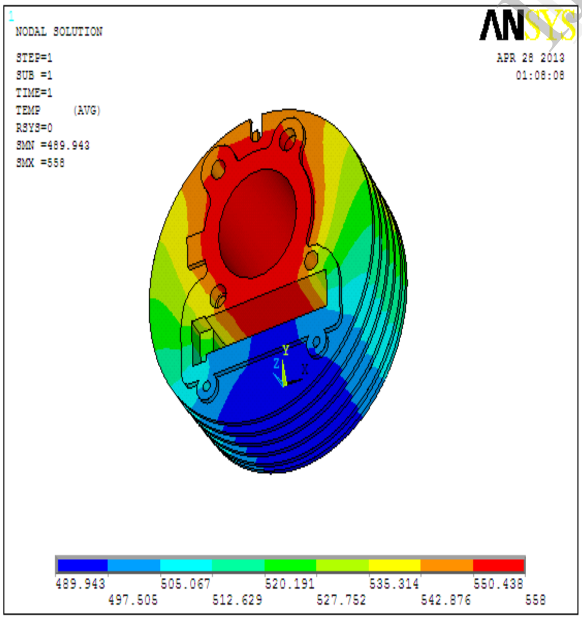

Fig.22.Temperature distribution through Circular fin (2.5 mm thickness)

3.8. Parametric representation for Temperature Distribution through Circular fin:

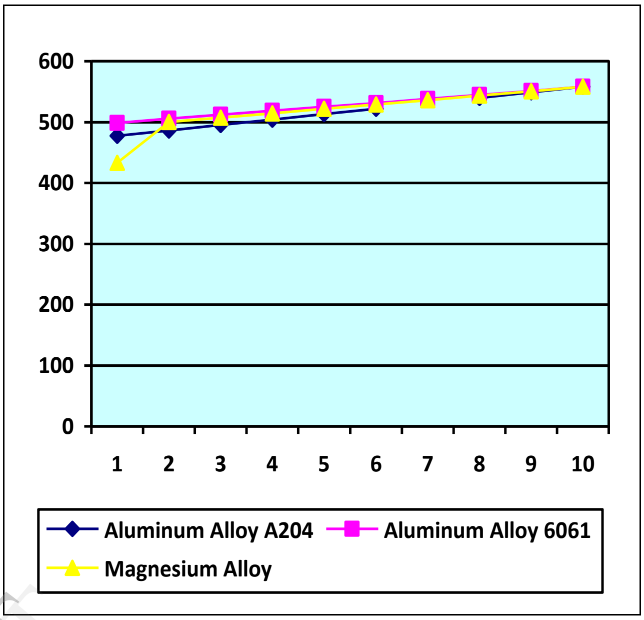

Fig.15. Comparison Graph between all three Materials for Circular fin (3mm thickness)

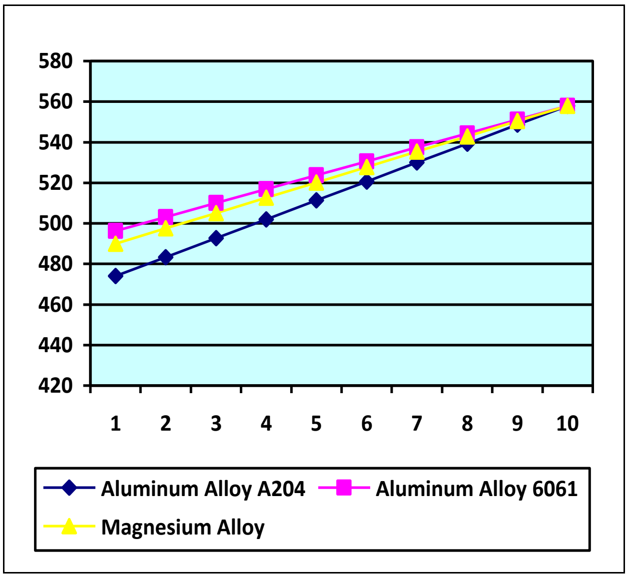

Fig.17. Comparison Graph between all three Materials for Circular fin (2.5 mm thickness)

4. Conclusions:

In present work, a cylinder fin body is modelled and transient thermal analysis is done by using Pro/Engineer and ANSYS. These fins are used for air cooling systems for two wheelers. In present study, Aluminum alloy 6061 and magnesium alloy are used and compared with Aluminum Alloy A204.

The various parameters (i.e., shape and geometry of the fin) are considered in the study, shape (Rectangular and Circular), thickness (3 mm and 2.5 mm)

By reducing the thickness and also by changing the shape of the fin to circular shaped, the weight of the fin body reduces thereby increasing the heat transfer rate and efficiency of the fin. The weight of the fin body is also reduced when Magnesium alloy is used.

The results shows, by using circular fin with material Aluminum Alloy 6061 is better since heat transfer rate, Efficiency and Effectiveness of the fin is more. By using circular fins the weight of the fin body reduces compare to existing engine cylinder fins.

5. References

1. Paul W.Gill, James H. Smith, JR., and Eugene J. Ziurys., 1959, Internal combustion engines-Fundamentals, Oxford & IBH Publishing Company.
2. Dr. Kirpal Singh, 2004, Automobile engineering vol.II, Standard Publishers Distributors, Delhi.
3. Prof. R.B.Gupta, 1998, “Automobile engineering,” Satya Prakashan, Incorporating, Tech India Publications.
4. Wang,Q., Cao,Y., and Chen,G., 1996b “Piston assembly design for improved thermal tribological performance.” Tribology transactions, vol.39 pp.483- 489Compression Ignition Engines, Sadhana Vol. 29, Part 3, pp 275-284.
5. Lienhard, J.H.,IV, and Lienhard,J.H.,V, 2004, A Heat Transfer Textbook Phlogistan, Cambridge, MA.
6. Kern,D.Q., and A.D.Kraus, 1972, “Extended Surface Heat Transfer”, McGraw-Hill Book Company, New York.
7. Gardner, K. A., 1945, “Efficiency of Extended Surfaces,” ASME, J. Heat Transfer, 67, 621-631.
8. Badr, H. M., 1983, “A Theoretical Study of Laminar Mixed Convection Fro a Horizontal Cylinder in a Cross Stream,” Int. J. Heat Mass Transfer, 26, pp. 639-653.
9. Saitoh, T., Sajik, T., and Maruhara, K.,1993, “Benchmark Solutions to Natural Convection Heat Transfer Problem Around a Horizontal Circular Cylinder,” Int. J. Heat Mass Transfer, 36 pp. 1251-1259.
10. Gardner, K. A., 1945, “Efficiency of Extended Surfaces,” ASME, J. Heat Transfer, 67, 621-631