Analysis of Circumferential Fins by Varying FIN Geometry and Material

D.Tharak[1], K. Harigopal[2], Kappa. Shanmukhi [3]
[1] M.tech Student Gokul Insitute of Science and Technology,
[2] Assistant Professor Gokul Insitute of Science and Technology,
[3] M.Tech Student of Mvgr College of Engineering (a),
Email: *tarakdasai@gmail.com*
kappashanmukhi@gmail.com

ABSTRACT: The current work determines the rate of heat flow from a heating element. Extended surfaces are provided on the element in order to enhance better convection. In this design the fin with different profiles such as rectangle and trapezoidal are analyzed. The study is conducted by considering various materials to obtain optimum material selection to enhance the better flow of heat from the system. The main aim of this work is to study various researches done in past to improve heat transfer rate of cooling fins by changing fin profile and material Used.

*****

INTRODUCTION

Many engineering devices generate heat during their operation. If this generated heat is not dissipated rapidly to its surrounding atmosphere, this may cause rise in temperature of the system components. This cause overheating problems in device and may lead to the failure of component. Fins or extended surfaces are known for enhancing the heat transfer in a system. Liquid-cooling system enhances better heat transfer than air-cooling system. the construction of air cooling system is very simpler. Therefore it is imperative for an air-cooled engine to make use of the fins effectively to obtain uniform temperature in the cylinder periphery. The major heat transfer takes by two modes that is by conduction or by convection. Heat transfer through fin to the surface of the fin takes place through conduction whereas from surface of the fin to the surroundings, it takes place by convection. The amount of conduction, convection, or radiation of an object determines the amount of heat it transfers. Increasing the temperature gradient between the object and the environment, increasing the convection heat transfer coefficient, or increasing the surface area of the object increases the heat transfer. Sometimes it is not feasible or economical to change the first two options. Thus, adding a fin to an object increases the surface area and can sometimes be an economical solution to heat transfer problem.

Necessity for Engine Cooling

1. Engine valves warp (twist) due to overheating.
2. Damage to the materials of cylinder body and piston.
3. Lubricating oil decomposes to form gummy and carbon particles
4. Thermal stresses are set up in the engine parts and Causes distortion (twist or change shape and cracking of components.
5. Pre – ignition occurs (i.e. ignition occurs before it is required to igniter due to the overheating of spark plug.
6. Reduces the strength of the materials used for piston and piston rings.
7. Overheating also reduces the efficiency

2.1 INRODUCTION TO COOLING FINS:

A fin is a surface that extends from an object to increase the rate of heat transfer to or from the environment by increasing convection. The amount of conduction, convection, or radiation of an object determines the amount of heat it transfers. Increasing the temperature difference between the object and the environment, increasing the convection heat transfer coefficient, or increasing the surface area of the object increases the heat transfer. Sometimes it is not economical or it is not feasible to change the first two options. Adding a fin to an object, however, increases the surface area and can sometimes be an economical solution to heat transfer problems. Cooling fins are used in heat exchangers to increase the rate of heat dissipation. To economize in the design, we wish to know the shape of the shape of the fin which uses the least amount of the material for a given rate of heat dissipation. For pure conduction fins, a criterion for the optimum fin problem was proposed by Ernst Schmidt and proved by R.J.Duffin. Recent interest in space vehicle design makes it necessary to investigate the optimum fin shapes under conditions different from that used by Schmidt. Wilkins has obtained for fins radiating heat according to the Stefan-Boltzmann relation to surroundings at absolute zero temperature. LIU has delivered relations for fins with heat generations. The problem thin cooling fins without heat generation under any surrounding conditions of practical interest is formulated as purely mathematical problem suitable for treatment by the calculus of radiation. Euler equations are obtained by formula variation methods sufficient boundary conditions are derived for the functions involved in these equations.

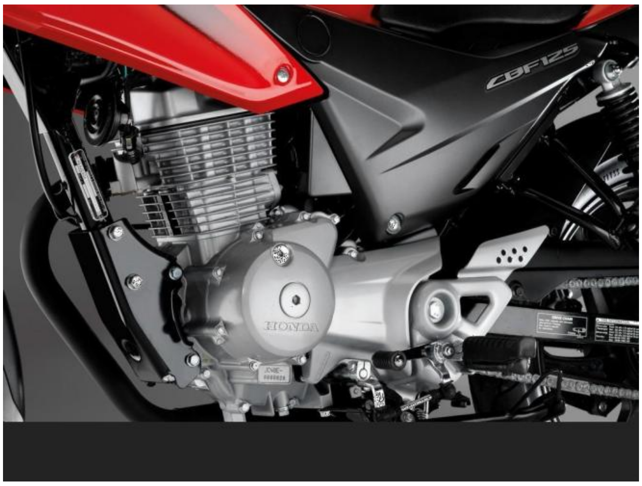


Fig 2.1 Automobile Fin

2.3 TYPES OF FINS:

There are different types of fins and depending upon the application we will be using appropriate fin and here are the different types of fins and their applications.

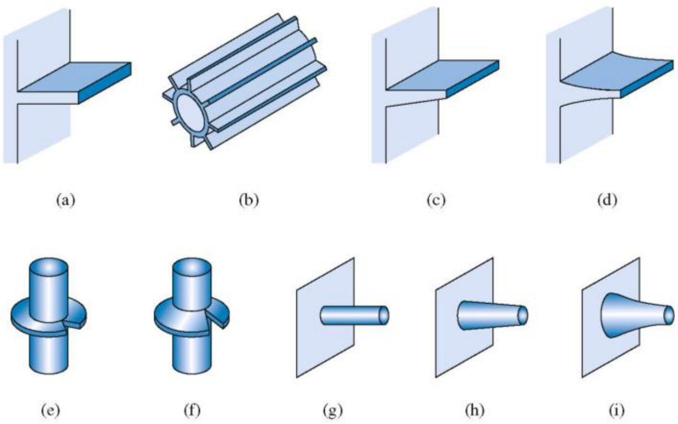


FIGURE 2.20 Schematic diagrams of different types of fins: (a) longitudinal fin of rectangular profile; (b) cylindrical tube with fins of rectangular profile; (c) longitudinal fin of trapezoidal profile; (d) longitudinal fin of parabolic profile; (e) cylindrical tube with radial fin of rectangular profile; (f) cylindrical tube with radial fin of truncated conical profile; (g) cylindrical pin fin; (h) truncated conical spine; (i) parabolic spine.

3 LETERATURE REVIWE

Sampath SS, Sawan Shetty and Chithirai Pon Selvan M analyzed rectangular and triangular fins are considered and temperature distributions at various points on the fin are calculated. An attempt is made to demonstrate the improvements to enhance the maximum heat dissipation from the system using FEA technique and the validation of this is carried out by using governing equations. Results are thus matching with classical equations. By increasing the value of thermal conductivity and film coefficient, it is possible to increase the heat dissipation rate. Different cross-section fins can be used to enhance the heat transfer rate, also with the consideration of dimensionless numbers heat transfer calculations can be carried out. Transient analysis can also be carried out for the same case. Increase in number of fins can also be considered to enhance maximum heat transfer. Heat transfer coefficient can be increased by increasing the surrounding fluid velocity by forced convection. Higher velocities may sometimes lead to lower heat transfer. So it is necessary to maintain optimum fluid velocities around the fins. Overall calculations show that triangular fins dissipate heat more than rectangular fins based on the magnitude of heat transfer rate. It is because of the exposure of the base to the ambient conditions.

P. Sai Chaitanya1, B. Suneela Rani2, K. Vijay Kumar various parameters (i.e., geometry and thickness of the fin) are considered in their study, By reducing the thickness and also by changing the shape of the fin to circular shape from the conventional geometry i.e rectangular, the weight of the fin body reduces thereby increasing the heat transfer rate and efficiency of the fin. They compared the Aluminum alloy 6061 with Aluminum Alloy A204. The results shows, by using circular fin with material Aluminum Alloy 6061 is better since heat transfer rate of the fin is more. By using circular fins the weight of the fin body reduces compared to existing rectangular engine cylinder fin.

4. MODELING

4.1 INTRODUCTION TO CATIA

CATIAV5 is mechanical design software, addressing advanced process centric design requirements of mechanical industry. It is the first of the next generation software. Dassault system software solutions, France. With its feature based design solutions, CATIA proved to be highly productive for mechanical assemblies and drawing generation. CATIA, with its broad range of integrated solution is the leading product development solutions for all manufacturing organization.

CATIA is the best solution capable of addressing the complete product development process, from product concept specification through product in service in a fully integrated associative manner. CATIA mechanical design solutions provide tools to help you implement a sophisticated standard based architectures. This enables collaborative design and offers digital mockups and hybrid designs.

The domain area include

Product design and manufacturing

Drawing enterprise competitiveness
Task presentation
Process improvement

CATIA V5 is totally complaint with Windows presentation standards. CATIA V5 provides a unique two way interoperability with CATIA version 4 data. As an open solution, CATIA includes interfaces with the most commonly used data exchange industry standards.

4.2 CATIA WORK BENCHES:

Sketcher:

In general, the design process starts by identifying the fundamental feature of the part and making a sketch for it. CATIA sketcher tools initially drafts a rough sketch following the shape of the profile

The objects are created are converted into proper sketch by applying geometric constraints and dimensional constraints. These constraints refine the sketch according to a rule. Adding parametric dimensions further control the shape and size of the feature.

Pad, shaft, rib etc., are used as one of the feature creation tools to convert the sketcher entity sketch into a part feature. When there are more numbers of features in the model, the same process may be repeated to make each additional sketch.

Part design:

Many mechanical designs consist of complex assemblies made from many parts. This type of design work can be made easier by part and assembly modeling capabilities that are well integrated.

The CATIA is a 3D parametric solid modeler with both part and assembly modeling abilities.

You can use CATIA to model simple parts and then combine into more complex assemblies.

With CATIA, you can design a part by sketching its component shapes and defining their size, shape, and inter relationships. By successively creating these shapes called features you can construct the part.

The general modeling process for each part.

Plan the part

1. Create the base feature
2. Create the remaining feature
3. Analyze the part
4. Modify the feature as necessary

4.3 BASIC COMMANDS IN PART DRAWING:

PAD:

The pad tool is one of the most widely used tools to create the base features. To create a base feature using this tool, draw the sketch and exit the sketcher work bench. To involve the pad toolbar, choose the down arrow on the right of the pad button in the sketch based features toolbar. The pads toolbar select the sketch and then choose the pad button from the pads toolbar. The pad definition dialog box is displayed. You are prompted to enter the required data to modify the pad. Set the value of depth in length spinner. You can also define the extrusion depth dynamically in the geometry area. You can also create a thin extruded feature using the pad definition dialog box. To create a thin extruded feature, choose the thick check box from the pad definition.

MIRROR:

Mirror command is used to produce the mirror image of required sketcher or model. To create a base feature using this tool, draw the sketch. To involve the mirror toolbar, first we have to draw the axis line about which the object has to be mirrored. After that select the mirror command and select sketcher, then axis.

REVOLVE:

Revolve command is used to produce cylindrical or circular objects. To create a base feature using this tool, draw the sketch and exit the sketcher work bench. Select the revolve command and the sketcher. Then we have to select the axis about which the sketcher is revolved and the select ok.

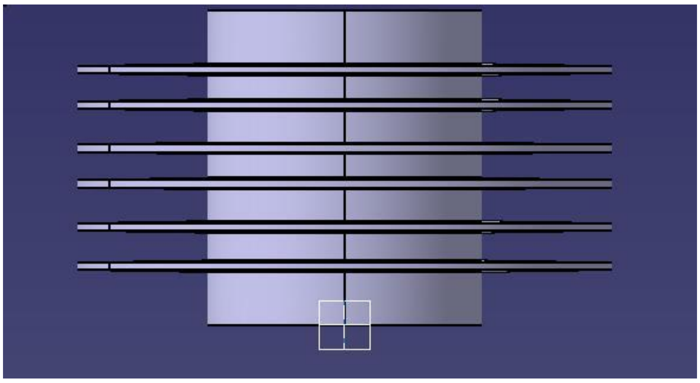


FIG 4.1Circular fins

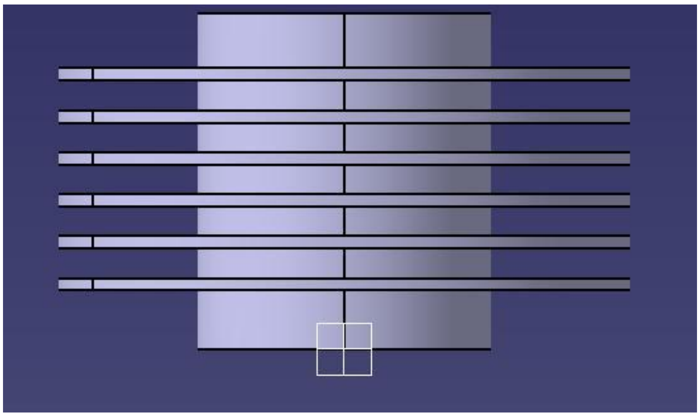


FIG 4.2 Circular fins with trapezoidal fin profile

5.1 INTRODUCTION TO ANSYS:

The rapid advances made in computer hardware and software led to significant developments in finite element analysis software. A number of general purpose finite element analysis software packages with a processor capability and facility for the user to have wide choice of several types of elements, analysis of different types of problems like static, dynamic, material and geometric non-linear, coupled situations, heat transfer, interaction problems etc, and pre and post processing features have been developed. The names of some pf the popular packages are: ABAQUS, ADINA, ANSYS, ASKA, COSMOS, NISA, PAFEC, SAP, SESAM-80 etc.

Basic Stages I Ansys:

- .Pre-processing
- Solution
- .Post-processing

5.2 ADVANTAGES OF ANSYS:

ANSYS finite element analysis software enables engineers to perform the following tasks:

Build computer models or transfer CAD models of structures, products, components or systems.

Apply operating loads or other design performance conditions.

Study physical responses, such as stress levels, temperature distributions or electromagnetic fields.

Optimize a design early in the development process to reduce production costs.

Do prototype testing in environments where it otherwise would be undesirable or impossible (for example biomedical applications).

The ANSYS program has a comprehensive graphical user interface (GUI) that gives users easy, interactive access to program functions and commands.

5.3EXPERIMENTAL PROCEDURE

A. Analysis

Steady state thermal analysis determines temperatures and other thermal quantities that vary over surface. The variation of thermal gradient over the surface is of interest in many applications such as with cooling.

B. Build Geometry

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

C Define Material Properties

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

D. Generate Mesh

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

E. 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.

F. Obtain Solution

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

Design Parameters:

Length of fin (L) = 33mm=0.33m
Thickness y = 3 mm = 0.003 m
K=conductivity of fin material =120W/Mk
h=heat transfer coefficient =100W/m^2K.
Where T=temperature of cylinder head = 600K
Ta=atmospheric temperature=313K

Thermal loads applied:

Temperature = 458 K
Film Coefficient = 25 w/m2 K
Bulk Temperature = 313 K.

6 RESULTS

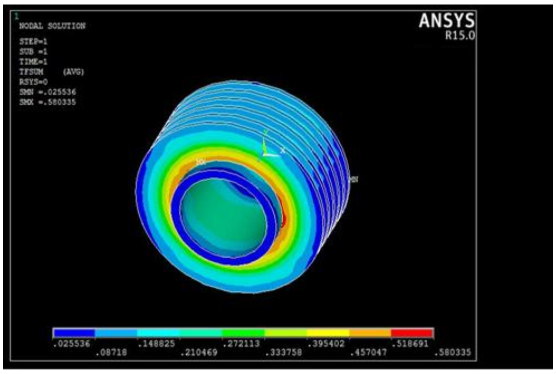


FIG 6.1 Heat flux in rectangular fins for Al204

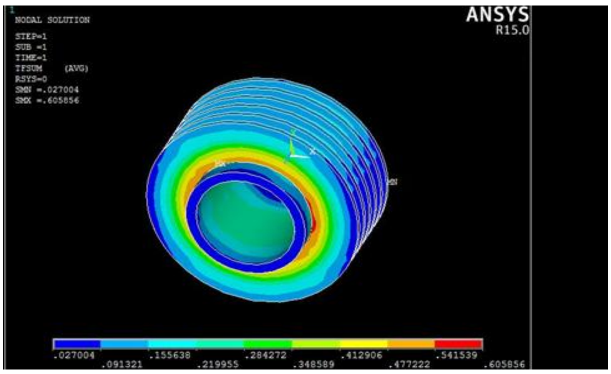


FIG 6.2 Heat flux in rectangular fins for Al6061

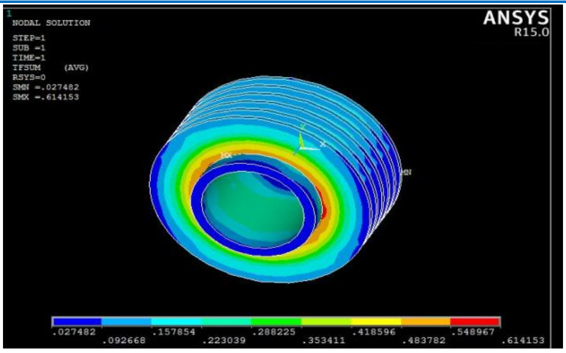


FIG 6.3 Heat flux in rectangular fins for Al7075

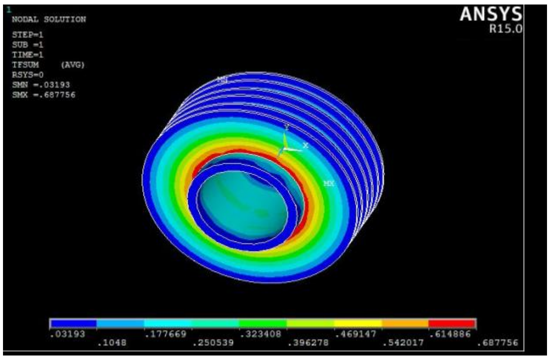


FIG 6.4 Heat flux in trapezoidal fins for Aluminum alloy204

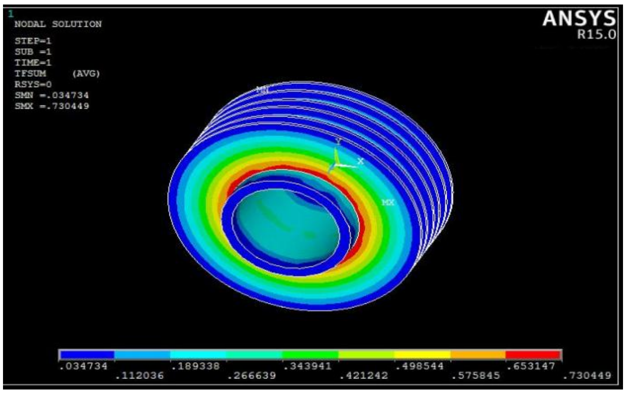


FIG 6.5 Heat flux in trapezoidal fins for Aluminum alloy6061

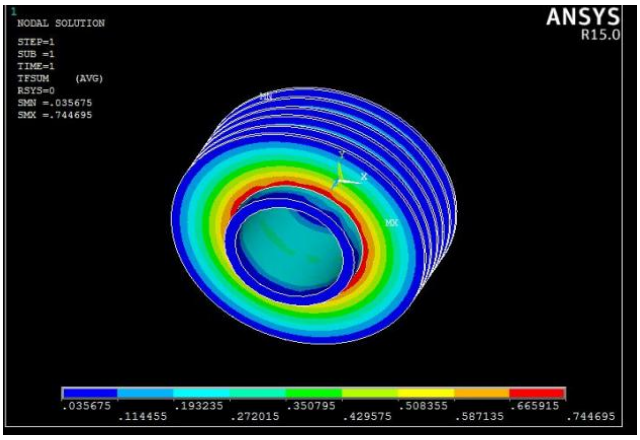


FIG 6.6 Heat flux in trapezoidal fin for Aluminum alloy7075

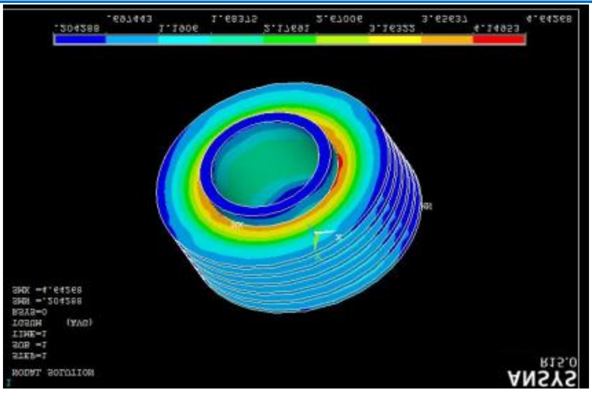


FIG 6.7 Temperature gradient in rectangular fins for Aluminum alloy204

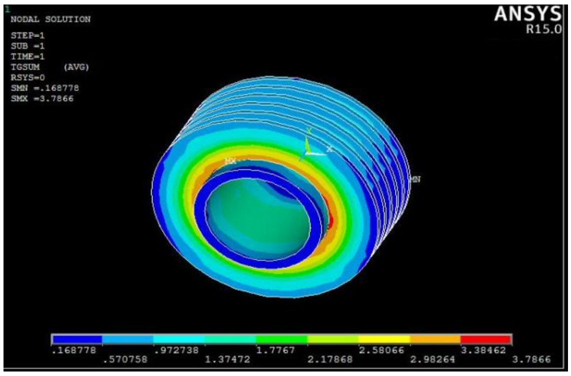
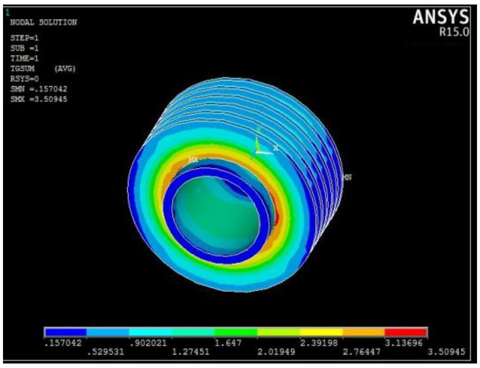


FIG 6.8 Temperature gradient in rectangular fins for Aluminum alloy6061



Temperature gradient in rectangular fins for Aluminum alloy7075

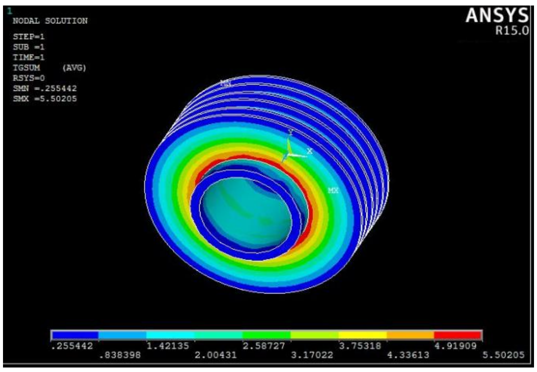
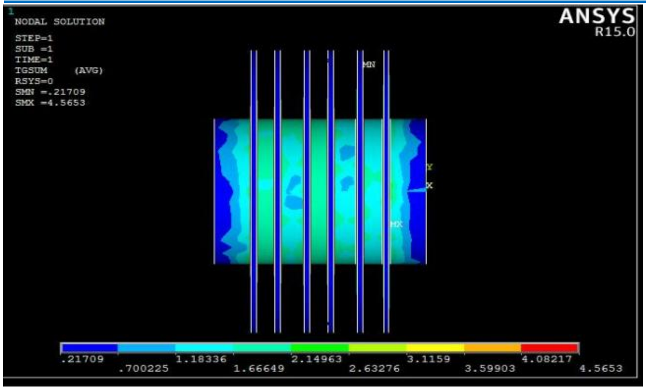


FIG 6.10 Temperature gradient in rectangular fins for Aluminum alloy204



6.11 Temperature gradient in rectangular fins for Aluminum alloy6061

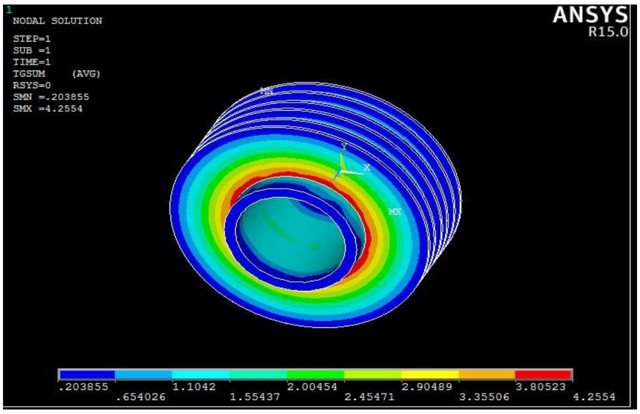


FIG 6.12 Temperature gradient in trapezoidal fins for Al7075

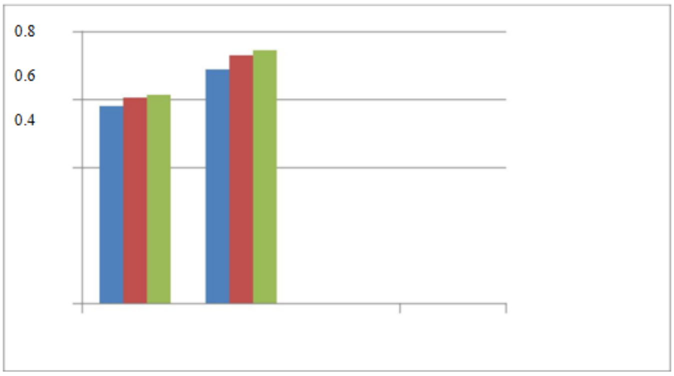
Table 6.1: Comparison of heat flux and thermal gradient for rectangular profile

s.no	Type of material	Heat flux	Temperature gradient
1	Aluminum alloy204	0.580335	4.6426
2	Aluminum alloy6061	0.605856	3.7866
3	Aluminum allioy7075	0.614153	3.5094

Table 6.2: Comparison of heat flux and thermal gradient for

S. No	Type of material	Heat flux	Temperature Gradient
1	Aluminum alloy204	0.687756	5.50205
2	Aluminum alloy6061	0.730449	4.5653
3	Aluminum alloy7075	0.744695	4.2554

Graph 6.1: Heat flux vs shape of fin profile:



CONCLUSION

This project we have designed a cylinder fin body and modeled in CATIA V5 software. Presently used materials for fin body is Aluminum alloy 204. We are replacing with Aluminum alloy 6061 and Aluminum alloy 7075. The shape of profile is rectangular; we have changed the shape of fin with trapezoidal profile.

We have done thermal analysis on fin body by varying fin material and geometry. By observing the results, using trapezoidal profile, material Aluminum alloy 7075 is better since heat transfer is more.

REFERENCES

[1]. R. Arularasan, Pamizhselvan, B. Hemanadhan, T. thamizhselvan, B. Arun kumar, Senthilnathan, S Prathap., Modeling and simulation of engine cylinder fin by using fea.

[2]. Sampath SS, Sawan Shetty and Chithirai Pon Selvan M., Estimation of Heat Dissipation from Plate with Multiple Tapered and Rectangular Fins.

[3]. Prof. Arvind S.Sorathiya, Ashish kumar N. Parmar, Prof. (Dr.) Pravin P. Rathod., Review Paper on Effect of Cylinder Block Fin Geometry on Heat Transfer Rate of Air-Cooled 4S SI Engine.

[4]. M Syamala Devi, E Venkateswara Rao, K Sunil Ratna Kumar Optimization of Engine Cylinder Fin by Varying its Geometry and Material.

[5]. P. Sai Chaitanya, B. Suneela Rani, K. Vijaya Kumar Thermal Analysis of Engine Cylinder Fin by Varying Its Geometry and Material.

[6]. Magarajan U, Thundil karuppa Raj R. and Elango T. Numerical Study on Heat Transfer of Internal Combustion Engine Cooling by Extended Fins Using CFD