ANALYSIS OF HEAT TRANSFER RATE BY VARYING COOLING FLUID FOR ENGINE CYLINDER FINS

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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 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 this 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.
Keywords:- Ansys, Catia, Engine Cylinder Fins

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.

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:

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 resignation 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:
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.

2. METHODS OF COOLING

Various methods used for cooling of automobile engines are:
1.Air Cooling 2.Water cooling

2.1 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. 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.
ACS (Auto Club Suisse) maintains historical monuments to that era on the Susten Pass where two radiator refill stations remain (See a picture here). These have instructions on a cast metal plaque and a spherical bottom watering can hanging next to a water spigot. The spherical bottom was intended to keep it from being set down and, therefore, be useless around the house, in spite of which it was stolen, as the picture shows.
During that period, European firms such as Magirus-Deutz built air-cooled diesel trucks, Porsche built air-cooled farm tractors, and Volkswagen became famous with air-cooled passenger cars. In the USA, Franklinbuilt air-cooled engines. The Czechoslovakia based company Tatra is known for their big size air cooled V8 car engines, Tatra engineer Julius Mackerle published a book on it. Air cooled engines are better adapted to extremely cold and hot environmental weather temperatures, you can see air cooled engines starting and running in freezing conditions that stuck water cooled engines and continue working when water cooled ones start producing steam jets.

2.2 LIQUID COOLING

Today, most engines are liquid-cooled.

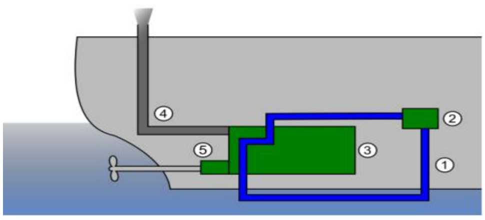


Fig:1 A fully closed IC engine cooling system

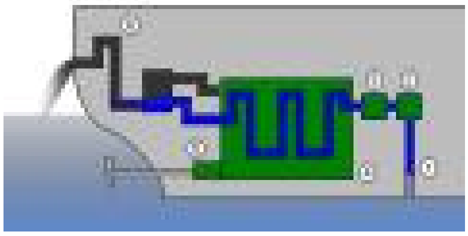


Fig:2 Open IC engine cooling system

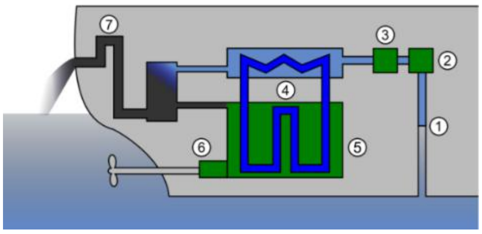


Fig:3 Semi closed IC Engine cooling system

Liquid cooling is also employed in maritime vehicles (vessels, ...). 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.

INTRODUCTION OF 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 behaviour 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.

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.

ANSYS provides a cost-effective way to explore the performance of products or processes in a virtual environment. This type of product development is termed virtual prototyping.

With virtual prototyping techniques, users can iterate various scenarios to optimize the product long before the manufacturing is started. This enables a reduction in the level of risk, and in the cost of ineffective designs. The multifaceted nature of ANSYS also provides a means to ensure that users are able to see the effect of a design on the whole behavior of the product, be it electromagnetic, thermal, mechanical etc.

3.1 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 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 describes the processes in terminology slightly more attune to the software.

Build Geometry

tested using the work plane coordinate system within ANSYS.

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.

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.

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.

Obtain Solution

This is actually a step, because ANSYS needs to understand within what state (steady state,

transient… etc.) the problem must be solved.

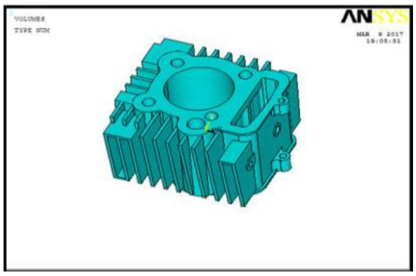
Present the Results

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.

Thermal analysis of fin body:

Set Units - /units,si,mm,kg,sec,k File- change Directory-select working folder File-Change job name-Enter job name Preferences-Thermal\preprocessor-Element type-add/edit/delete-Select Add-Solid 20 node 90

Construct a two or three dimensional representation of the object to be modeled and



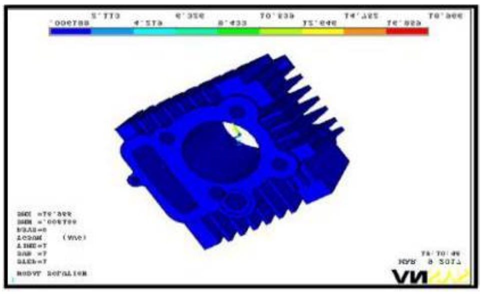
3.2MESHED MODEL OF ALUMINIUM ALLOY 204 3MM THICKNESS

Finite element analysis or FEA representing a real project as a "mesh" a series of small, regularly shaped tetrahedron connected elements, as shown in the above fig.And then setting up and solving huge arrays of simultaneous equations. The finer the mesh, the more accurate the results but more computing power is required.

Nodal temperature of Aluminium Alloy 204 3mm thickness

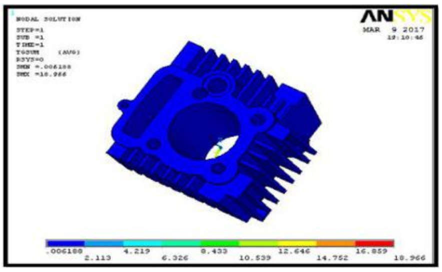
According to the contour plot, the temperature distribution maximum temperature at bore because the operating temperature passing inside of the bore. So we applied the temperature inside of the bore and applied the convection to fins. Then the maximum temperature at bore and its distributed to outer surface of the fins.

General post processer- contour plot-Thermal Gradient-Thermal Gradient Vector Sum



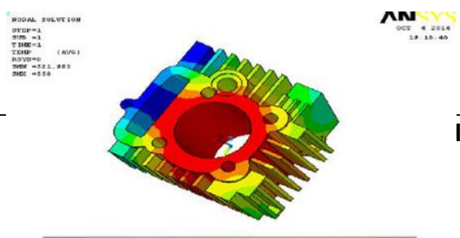
Thermal Gradient of Aluminium Alloy 204 3mm thickness

According to the contour plot, the thermal gradient maximum at bore because the operating temperature passing inside of the bore. So we applied the temperature inside of the bore and applied the convection to fins. Then the minimum gradient at fins. According to the above contour plot, the maximum gradient is 18.966 k/m and minimum gradient is 0.006188 k/m.General post processer- contour plot-Thermal Flux –Thermal Flux Vector Sum



Nodal Temperature of Aluminium Alloy 6061 3mm thickness

According to the contour plot, the temperature distribution maximum temperature at bore because the operating temperature passing inside of the bore. So we applied the temperature inside of the bore and applied the convection to fins. Then the maximum temperature at bore and its distributed to outer surface of the fins.

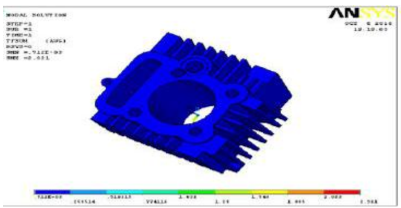


3.3 NODAL TEMPERATURE OF MAGNESIUM ALLOY 3MM THICKNESS

According to the contour plot, the temperature distribution maximum temperature at bore because the operating temperature passing inside of the bore. So we applied the temperature inside of the bore and applied the convection to fins. Then the maximum temperature at bore and its distributed to outer surface of the fins.

3.4THERMAL GRADIENT SUM OF MAGNESIUM ALLOY 3MM THICKNESS

According to the contour plot, the thermal gradient maximum at bore because the operating temperature passing inside of the bore. So we applied the temperature inside of the bore and applied the convection to fins. Then the minimum gradient at fins. According to the above contour plot, the maximum gradient is 14.597 k/m and minimum gradient is 0.00448 k/m.



3.5 THERMAL FLUX SUM OF MAGNESIUM ALLOY 3MM THICKNESS

According to the contour plot, the thermal flux maximum at bore because the operating temperature passing inside of the bore. So we applied the temperature inside of the bore and applied the convection to fins. Then the minimum thermal flux at fins. According to the above contour plot, the maximum thermal flux is 2.321 k/m and minimum thermal flux is 0.712E-03 k/m.

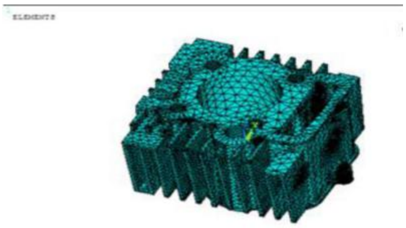
ALUMINUM ALLOY 204 – 2.5mm THICKNESS

MODEL ANALYSIS OF ALUMINUM ALLOY 204 – 2.5mm THICKNESS

MODEL IMPORTED FROM PRO/ENGINEER

MATERIAL PROPERTIES Thermal Conductivity – 120 w/mk Specific Heat – 0.963 J/g °C Density – 2.8 g/cc

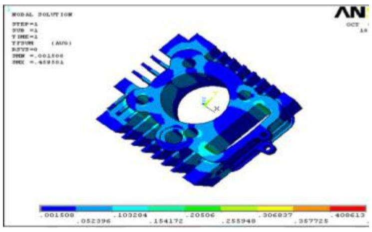
MESHED MODEL



3.6 NODAL TEMPERATURE OF ALUMINIUM ALLOY 204 2.5MM THICKNESS

According to the contour plot, the temperature distribution maximum temperature at bore because the operating temperature passing inside of the bore. So we applied the temperature inside of the bore and applied the convection to fins. Then the maximum temperature at bore and its distributed to outer surface of the fins.

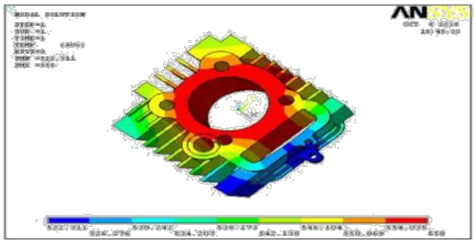
THERMAL FLUX SUM



3.7 THERMAL FLUX SUM SUM OF ALUMINIUM ALLOY 204 2.5MM THICKNES

According to the contour plot, the thermal flux maximum at bore because the operating temperature passing inside of the bore. So we applied the temperature inside of the bore and applied the convection to fins. Then the minimum thermal flux at fins.

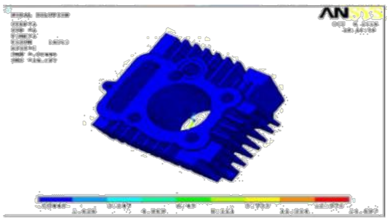
According to the above contour plot, the maximum thermal flux is 0.459501 k/m and minimum thermal flux is 0.001508 k/m.



3.8 NODAL TEMPERATURE OF ALUMINIUM ALLOY 6061 2.5 MM THICKNESS

According to the contour plot, the temperature distribution maximum temperature at bore because the operating temperature passing inside of the bore. So we applied the temperature inside of the bore and applied the convection to fins. Then the maximum temperature at bore and its distributed to outer surface of the fins.

THERMAL GRADIENT SUM OF ALUMINIUM ALLOY 6061 2.5 MM THICKNESS



According to the contour plot, the thermal gradient maximum at bore because the operating temperature passing inside of the bore.

So we applied the temperature inside of the bore and applied the convection to fins. Then the minimum gradient at fins.

According to the above contour plot, the maximum gradient is 2.694 k/m and minimum gradient is 0.009125 k/m.

THERMAL FLUX SUM

3.9 THERMAL FLUX SUM OF ALUMINIUM ALLOY 6061 2.5 MM THICKNESS

According to the contour plot, the thermal flux maximum at bore because the operating temperature passing inside of the bore. So we applied the temperature inside of the bore and applied the convection to fins. Then the minimum thermal flux at fins. According to the above contour plot, the maximum thermal flux is0.484947 k/m and minimum thermal flux is 0.001643 k/m.

THERMAL FLUX SUM OF MAGNESIUM ALLOY 2.5 MM THICKNESS

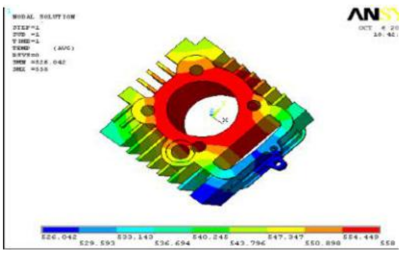
According to the contour plot, the thermal flux maximum at bore because the operating temperature passing inside of the bore. So we applied the temperature inside of the bore and applied the convection tofins. Then the minimum thermal flux at fins. According to the above contour plot, the maximum thermal flux is 0.477984 k/m and minimum thermal fluxis 0.001604 k/m.

4. CONCLUSION

In this thesis, a cylinder fin body for a 150cc motorcycle is modeled using parametric software Pro/Engineer. The original model is changed by changing the thickness of the fins. The thickness of the original model is 3mm, it has been reduced to 2.5mm. By reducing the thickness of the fins, the overall weight is reduced.

Present used material for fin body is Aluminum Alloy 204. In this thesis, two other materials are considered which have more thermal conductivities than Aluminum Alloy 204. The materials are Aluminum alloy 6061 and Magnesium Alloy. Thermal analysis is done for all the three materials. The material for the original model is changed by taking the consideration of their densities and thermal conductivity.

By observing the thermal analysis results, thermal flux is more for Aluminum alloy 6061 than other two materials and also by reducing the thickness of the fin, the heat transfer rate is increased.



Thermal flux is also calculated theoretically. By observing the results, heat transfer rate is more when the thickness of the fin is 2.5mm.

So we can conclude that using Aluminum alloy 6061 and taking thickness of 2.5mm is better.

5.REFERENCES

[1] Thermal Engineering by I. Shvets, M. Kondak

[2] Thermal Engineering by Rudramoorthy

[3] Thermal Engineering by R.K. Rajput

[4] Thermal Engineering by Sarkar

[5] Online Materials

[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

[9] Free Air Stream, SAE Paper 1999-01-3307, (1999). (4) Thornhill, D., Graham, A., Cunnigham, G., Troxier, P. and Meyer, R.,

[10]Experimental Investigation into the Free Air-Cooling of Air-Cooled Cylinders, SAE Paper 2003-32-0034, (2003). (5) Pai, B.U., Samaga, B.S. and Mahadevan, K., Some

[11]Experimental Studies of Heat Transfer from Finned Cylinders of Air-Cooled I.C. Engines, 4th National Heat Mass Transfer Conference, (1977), pp.137–144.