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

Design and Thermal Analysis on Engine Cylinder Fin by Varying Fin Material

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ABSTRACT

The 220cc 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 220cc engine cylinder fins, it is helpful to know the heat dissipation through the cylinder. The principle implemented in this project is to increase the heat dissipation rate by using the invisible working fluid, nothing but air.

The main purpose of using these cooling fins is to cool the 220cc engine cylinder by any air. We know that, by increasing the surface area of the fin can increase the heat dissipation rate, so designing such a large complex 220cc engine is very difficult. A parametric model of piston bore fins has been developed to predict the thermal behavior. The parametric model is created in 3D modeling software Solid works. Thermal analysis is done on the fins to determine variation in temperature distribution over time. The analysis is done using ANSYS. Analysis is conducted by varying material. Presently Material used for manufacturing fin body is Cast Iron. In this thesis, it is replaced by aluminum alloy 6082. By observing the analysis results, total heat flux is more for aluminum alloy 6082 than remaining aluminum alloy 6082, magnesium alloy materials for both condenser and evaporator. So aluminum alloy would be better for cylindrical fins.

INTRODUCTION

Heat Engines

Any type of engine or machine which derives heat energy from the combustion of fuel or any other source and coverts this energy into mechanical work is termed as a heat engine.

Heat engines may be classified as:

- External Combustion Engines
- Internal Combustion Engines

According to the cycle of operations again these engines are classified as

- Two-stroke engines
- Four-stroke engine

Heat Transfer in The Cylinder to The Different Parts of Engine

Conduction

Conduction is the transfer of heat by direct contact of particles of matter. The transfer of energy could be primarily by elastic impact as in fluids or by free electron diffusion as predominant in metals or photon vibration as predominant in insulators. In other words, heat is transferred by conduction when adjacent atoms vibrate against one another, or as electrons move from atom to atom.

Conduction is greater in solids, where atoms are in constant contact. In liquids (except liquid metals) and gases, the molecules are usually further apart, giving a lower chance of molecules colliding and passing on thermal energy. Heat conduction is directly analogous to diffusion of particles into a fluid, in the situation where there are no fluid currents. This type of heat diffusion differs from mass diffusion in behavior, only in as much as it can occur in solids, whereas mass diffusion is mostly limited to fluids. Metals (e.g. copper, platinum, gold, iron, etc.) are usually the best conductors of

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thermal energy. This is due to the way that metals are chemically bonded, have free-moving electrons which are able to transfer of thermal energy rapidly through the metal.

LITERATURE SURVEY

Cooling System of IC Engines: 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

Basic Principles: In this project objective is to check which material fits the most for the engine cylinder. The basic principle behind selecting a material is based on the thermal conductivity of the metal. Engine life and effectiveness can be improved with effective cooling. The cooling mechanism of the air cooled engine is mostly dependent on the fin design of the cylinder head and block. The heat is conducted through the engine parts and convected to air through the surfaces of the fins. Insufficient removal of heat from engine will lead to high thermal stresses and lower engine efficiency. As the air-cooled engine builds heat, the cooling fins allow the wind and air to move the heat away from the engine. Low rate of heat transfer through cooling fins is the main problem in this type of cooling. Most internal combustion engines are fluid cooled using either air (a gaseous fluid) or a liquid coolant run through a heat exchanger (radiator) cooled by air.

Thermal Analysis: Thermal analysis is a branch of materials science where the properties of materials are studied as they change with temperature. Several methods are commonly used - these are distinguished from one another by the property which is measured. Thermal Analysis is also often used as a term for the study of Heat transfer through structures. Many of the basic engineering data for modeling such systems comes from measurements of heat capacity and Thermal conductivity.

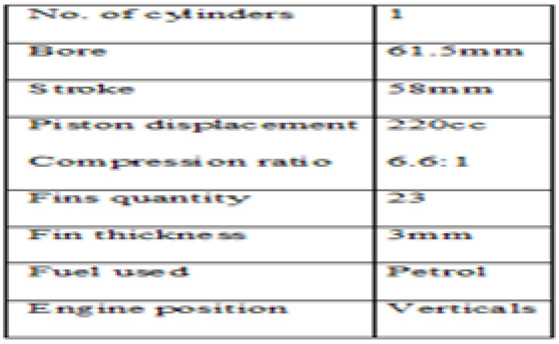
Introduction To CAD

From this inception, it has been human nature to innovate, discover, invent new things and so has been his creation. Design may be pronounced as the synonym for creation. So there is no end to man’s creation, design and hence CAD. By passage of time it’ll be even smarter, quicker and sophisticated. COMPUTER-AIDED DESIGN (CAD) AND COMPUTER-AIDED MANUFACTURING (CAM).

A Solid Works model consists of parts, assemblies, and drawings.

- Part: Individual components are drawn in the form of part drawings.
- Assembly: The individual parts are assembled in this region.

In this a cylinder fin body for 220cc motorcycle is modeled using parametric software



No. of cylinders	1
Bore	61.5mm
Stroke	58mm
Piston displacement	220cc
Compression ratio	6.6:1
Fins quantity	23
Fin thickness	3mm
Fuel used	Petrol
Engine position	Verticals

Fig 4.1 Front view of Cylinder block

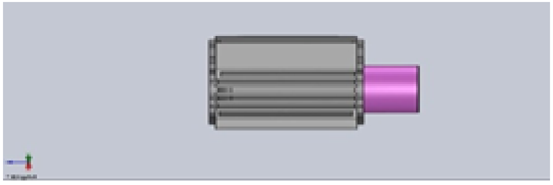


Fig 4.3 Right hand side view of the cylinder Block

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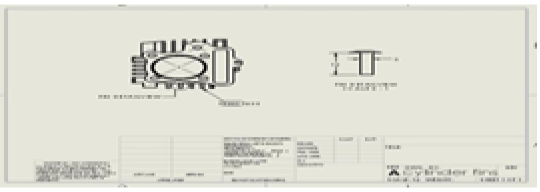


Fig 4.5 Dimensions of 220 CC engine Cylinder Block model designed in Solid work

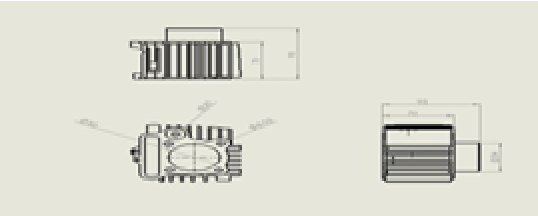
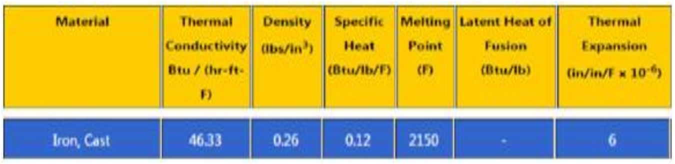


Fig 4.6 Fin dimensions

Thermal Analysis of Cast Iron made of Cylinder Fins

Material used: CAST IRON



Material	Thermal Conductivity Btu / (hr-ft-F)	Density (lbs/in^3)	Specific Heat (Btu/lb/F)	Melting Point (F)	Latent Heat of Fusion (Btu/lb)	Thermal Expansion (in/in/F x 10^{-6})
Iron, Cast	46.33	0.26	0.12	2150	-	6

Element type: solid/Brick 8 node 45

Meshing type: Tetra mesh

Figure 5.1.1: Bore boundary condition imposed as temperature = 200°

Figure 5.1.2: Fin boundary condition imposed as Temperature of Cylinder wall ie. fins = 20° C convective 5 w/m^2/° C

Figure 5.1.3: Convection 5 w/m^2/° C

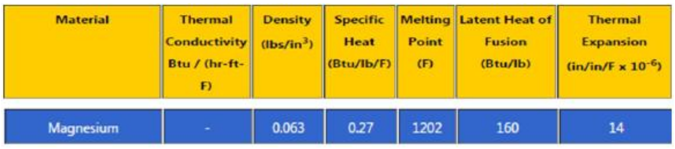
RESULTS:

	CAST IRON
TEMPERATURE DISTRIBUTION(deg centigrade)	176.8
TOTAL HEAT FLUX(W/m2)	39628

As shown in next figure Temperature distribution over a Steady State thermal analysis at Min temperature 1.76.88° C

Thermal Analysis of Cylinder Fins by made of Magnesium Alloy

Material used: Magnesium Alloy



Material	Thermal Conductivity Btu / (hr-ft-F)	Density (lbs/in^3)	Specific Heat (Btu/lb/F)	Melting Point (F)	Latent Heat of Fusion (Btu/lb)	Thermal Expansion (in/in/F x 10^{-6})
Magnesium	-	0.063	0.27	1202	160	14

Figure 5.1: Magnesium alloy material properties

Figure 5.2.1Fin boundary condition imposed as Temperature of Cylinder wall ie. fins = 20° C convective 5 w/m^2/° C

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Figure 5.2.2: Convection 5 w/m^2/° C

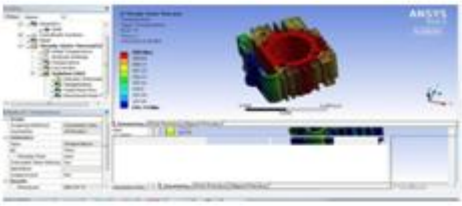


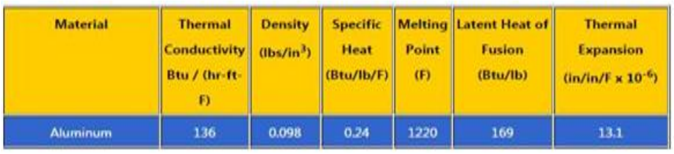
Figure 5.2.3: Temperature distribution over a Steady State thermal analysis at Minimum temperature 191.74° C of Magnesium Alloy

RESULTS:

	MAGNESIUM ALLOY
TEMPERATURE DISTRIBUTION(deg centigrade)	191.74
TOTAL HEAT FLUX(W/m2)	42157

Thermal Analysis of Cylinder Fins by mode Aluminum Alloy 6082

Material used: Aluminum Alloy



Material	Thermal Conductivity Btu / (hr-ft-F)	Density (lbs/in^3)	Specific Heat (Btu/lb/F)	Melting Point (F)	Latent Heat of Fusion (Btu/lb)	Thermal Expansion (in/in/F x 10^{-6})
Aluminum	136	0.098	0.24	1220	169	13.1

Figure 5.3: Aluminum alloy material properties

Figure 5.3.1: Fin boundary condition imposed as Temperature of Cylinder wall ie. fins = 20° C convective 5 w/m^2/° C

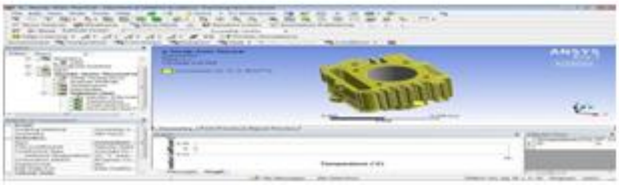
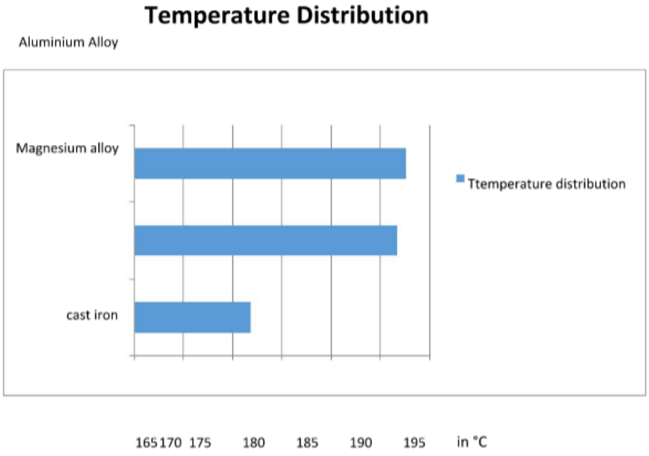


Figure 5.3.2: Convection 5 w/m^2/° C

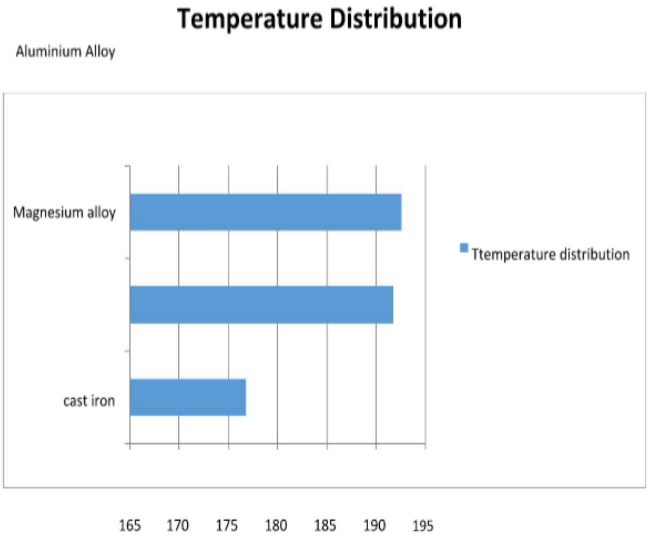
RESULTS:

	ALUMIUM ALLOY
TEMPERATURE DISTRIBUTION(deg centigrade)	192.59
TOTAL HEAT FLUX(W/m2)	42310

GRAPH OF TEMPERATURE DISTRIBUTION

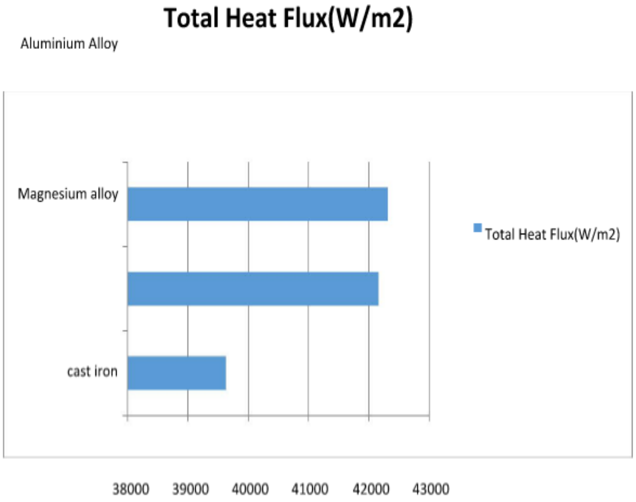


Graph: Temperature Distribution Vs Material Applied

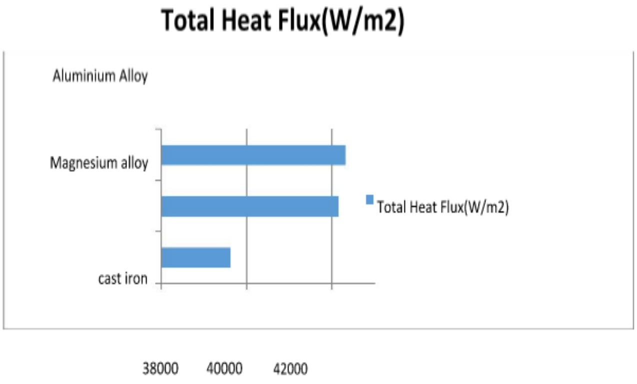


Graph: Temperature Distribution Vs Material Applie

GRAPH TOTAL HEAT FLUX

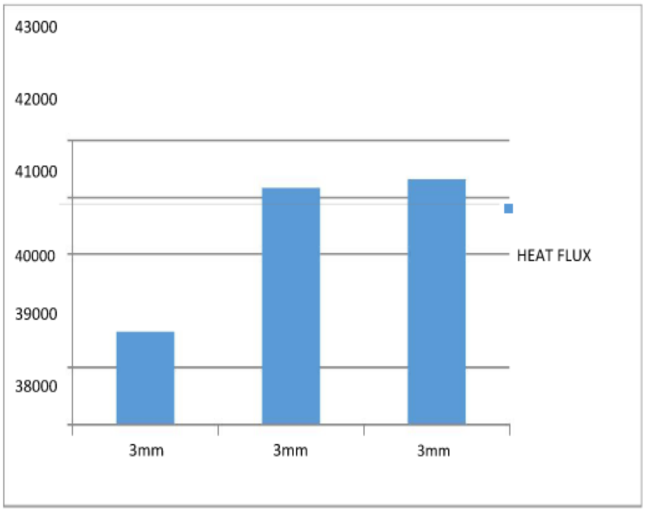


Graph: Total heat flux Vs Material Applied



Graph: Total heat flux Vs Material Applied

HEAT FLUX



Graph: Total heat flux Vs fin length

RESULTS AND DISCUSSIONS

FEA has become a solution to the task of predicting failure duet unknown stresses by showing problem areas in a material and allowing designers to see all of the theoretical stresses within. This method of product design and testing is far superior to the manufacturing costs which would accrue if each sample was actually built and tested.

In practice, a finite element analysis usually consists of three principal steps:

Preprocessing

The user constructs a model of the part to be analyzed in which the geometry is divided into a number of discrete sub regions, or elements," connected at discrete points called nodes." Certain of these nodes will have fixed displacements, and others will have prescribed loads.

These models can be extremely time-consuming to prepare, and commercial codes vie with one another to have the most user-friendly graphical "preprocessor" to assist in this rather tedious chore. Some of these preprocessors can overlay mesh on a preexisting CAD file, so that finite element analysis can be done conveniently as part of the computerized drafting and-design process.

Analysis

The dataset prepared by the preprocessor is used as input to the finite element code itself, which constructs and solves a system of linear or nonlinear algebraic equations

Kinjo = if

Where u and f are the displacements and externally applied forecast the nodal points. The formation of the K matrix is dependent on the type of problem being attacked, and this module will outline the approach for truss and linear elastic stress analyses. Commercial codes may have very large element libraries, with elements appropriate to a wide range of problem types. One of FEA's principal advantages are that many problem types can be addressed with the same code, merely by specifying the appropriate element types from the library.

Post processing

In the earlier days of finite element analysis, the user would pore through reams of numbers generated by the code, listing displacements and stresses at discrete positions within the model.

It is easy to miss important trends and hot spots this way, and modern codes use graphical displays to assist in visualizing the results. A typical postprocessor display overlay colored contours representing stress levels on the model, showing a full field picture similar to that of photo elastic or moiré experimental results. After the solution has been obtained, there are many ways to present ANSYS' results.

	CAST IRON	MAGNESIUM ALLOY	ALUMINIUM ALLOY 6082
TEMPERATURE DISTRIBUTION (degree centigrade)	176.8	191.74	192.59
TOTAL HEAT FLUX(W/m2)	39628	42157	42310

Table 6.1 Final result obtained from ANSYS

By observing the analysis results, total heat flux is more for aluminum alloy 6082 than remaining two materials for both condenser and evaporator. So using aluminum alloy 6082 is better.

CONCLUSION & FUTURE SCOPE

The following conclusions can be drawn from the present work: -

The parametric model is created in 3D modeling software Solid works. Thermal analysis is done on the fins to determine variation temperature distribution over time. The analysis is done using ANSYS. Analysis is conducted by varying material. Presently Material used for manufacturing fin body is Cast Iron. In this thesis, it is replaced by aluminum alloy.

By observing the analysis results, total heat flux is more for aluminum alloy than remaining two materials for both condenser and evaporator. So using aluminum alloy is better.

The 220cc 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 220cc 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 220cc engine is very difficult. The main purpose of using these cooling fins is to cool the 220cc engine cylinder by any air A parametric model of piston bore fins has been developed to predict the thermal behavior.

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