HEAT TRANSFER ANALYSIS OF DIFFERENT TYPES OF FINS OF AN ENGINE

A Project Report submitted in partial fulfillment of requirements for the award of the B.Tech degree in Mechanical Engineering

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CERTIFICATE

This is to certify that the Project Report entitled HEAT TRANSFER ANALYSIS OF DIFFERENT TYPES OF FINS OF AN ENGINE that is being submitted by G,CHIHNITA(Y17ME062),I.TEJASWINI(Y17ME065),K.ABHISHIEK(Y17ME090),S.MANITEJA(L18ME207),K.PRADEEP CHANDRA(Y17ME075),M.RUPESH(Y17ME109) in partial fulfillment for the award of the Degree of Bachelor of Technology in Mechanical Engineering is a bonafide work carried out by him/her under my guidance and supervision.

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EVALUATION SHEET

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CONTENTS

ABSTRACT

The majority of the Indian Populus uses motorbikes as their daily transport vehicles. With increasing popularity, the demand for lighter, faster, longer, and better performing vehicles is also increasing. To that end developments in designs have been in a continual trend. This project as a part of making the vehicle perform better makes use of modifications to an existing Engine Block's cooling system and in the process improving its thermal properties as well as some physical properties.

A Honda Unicorn 160CC BS-VI Engine has been chosen as the base model. A CAD model is made using CATIA software and another model is made similar to the original changing the fin shapes from rectangular to triangular.

This model is then imported into ANSYS software for thermal analysis as a CATpart file. Transient thermal analysis of the 2 models of the engines considering two materials Grey Cast Iron and A319 (Grey Cast Iron is the material used in the original Engine and A319 is an aluminum alloy with good thermal conductivity and high heat resistance) is done.

These results are then used to evaluate the heat transfer rate per unit mass for each of the models considering both CI and A319. These values are then compared to identify the engine block with the highest thermal reliability in the 4 engine block designs.

The thermal properties of the Engines usually depended upon the thermal conductivity, surface area of contact, and shape of the fins. So, by modifying these parameters an optimal engine block has been designed and analyzed.

LIST OF FIGURES:

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CHAPTER 1

INTRODUCTION

1. INTRODUCTION:

The main aim of the project is to study the heat transfer of different types of fins present in an engine

1.1 BASIC COMPONENTS OF AN ENGINE:

Engine block, piston, crank shaft, valves, Fins,Etc.

ENGINE BLOCK: The purpose of the engine block is to support the components of the engine. Additionally, the engine block transfers heat from friction to the atmosphere and engine coolant. The material selected for the engine block is either gray cast iron or aluminum alloy.

Figure 1.1 engine block

PISTON: The piston is a component of the internal combustion engine. The main function of the piston is to transform the pressure generated by the burning air-fuel mixture into force, acting on the crankshaft.

Figure 1.2 piston

CRANK SHAFT: The crankshaft is essentially the backbone of the internal combustion engine. The crankshaft is responsible for the proper operation of the engine and converting a linear motion to a rotational motion.

Figure 1.3 crank shaft

VALVES: Engine valves are mechanical components used in internal combustion engines to allow or restrict the flow of fluid or gas to and from the combustion chambers or cylinders during engine operation.

Figure 1.4 valves

FINS: The fins enhance the heat transfer rate from a surface by exposing larger surface area to convection. The fins are used on the surface where the heat transfer Coefficient is very low. Total heat produced by the combustion of charge in the engine cylinder may not convert into useful power at the crankshaft.

TYPES OF FINS: The different types of fin geometries used in an IC engine are Rectangular fins, Triangular fins, Trapezoidal fins and Pin fins.

1.2 HEAT TRANSFER: Heat transfer is a discipline of thermal engineering that concerns the

generation, use, conversion, and exchange of Thermal energy (Heat) between physical systems. Heat transfer is classified into various mechanisms, such as thermal conduction, thermal convection, thermal radiation, and transfer of energy by phase changes.

<u>THERMAL CONDUCTION:</u> Thermal conduction is the transfer of internal energy by microscopic collisions of particles and movement of electrons within a body. The colliding particles, which include molecules, atoms and electrons, transfer disorganized microscopic kinetic and potential energy, jointly known as internal energy. Conduction takes place in all Phases: solid, liquid, and gas.

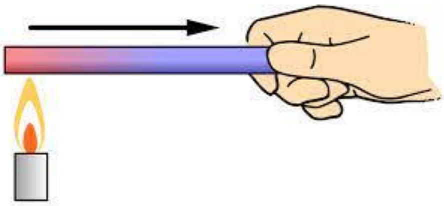


Figure 1.5 conduction through rod

In thermodynamics, we considered the amount of heat transfer as a system undergoes a process from one equilibrium state to another. Thermodynamics gives no indication of how long the process takes. In heat transfer, we are more concerned about the rate of heat transfer. The basic requirement for heat transfer is the presence of a temperature difference. The temperature difference is the driving force for heat transfer, just as voltage difference for electrical current. The total amount of heat transfer Q during a time interval can be determined from:

$$Q = \int_0^{\Delta t} Q^{\circ} dt \quad \text{(KJ)}$$

The rate of heat transfer per unit area is called heat flux, and the average heat flux on a surface is expressed as

$$q^{\circ} = \frac{Q^{\circ}}{A}$$

Heat spontaneously flows from a hotter to a colder body. For example, heat is conducted from the hotplate of an electric stove to the bottom of a saucepan in contact with it. In the absence of an opposing external driving energy source, within a body or between bodies, temperature differences decay over time, and thermal equilibrium is approached, temperature becoming more uniform.

<u>THERMAL CONVECTION:</u> Convective heat transfer, often referred to in thermodynamic contexts simply as convection (though not to be confused with Convection as used in other contexts), is the Transfer of heat from one place to another by the movement of fluids. Convection is usually the dominant form of heat transfer in liquids and gases.

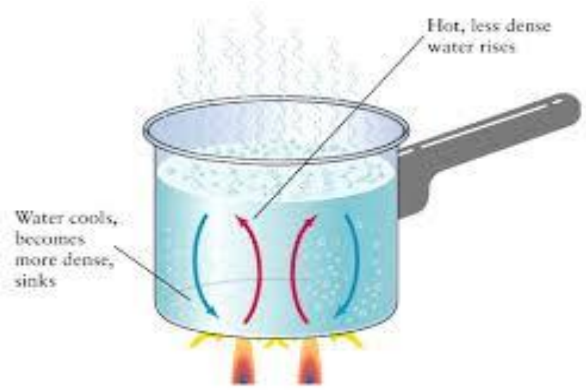


Figure 1.6: - Figure depicting convection of heat to outer environment

Convection can be "forced" by movement of a fluid by means other than buoyancy forces (for example, a water pump in an automobile engine). Thermal expansion of fluids may also force convection. In other cases, natural buoyancy forces alone are entirely responsible for fluid motion when the fluid is heated, and this process is called "natural convection". An example is the draft in a chimney or around any fire. In natural convection, an increase in temperature produces a reduction in density, which in turn causes fluid motion due to pressures and forces when fluids of different densities are affected by gravity.

Thermal convection is the process of energy transport affected by the circulation or mixing of a fluid medium (gas, liquid, or a powdery substance). Convection is possible only in a fluid medium and is directly linked with the transport of the medium itself. Macroscopic particles of a fluid moving in space cause the heat exchange, and thus convection constitutes the macro form of the heat transfer.

Fuel or Natural Convection occurs when the fluid circulates virtue of the natural differences in densities of hot and cold fluids.

FORCED CONVECTION: When the work is done to blow or pump the fluid, it is said to be Forced

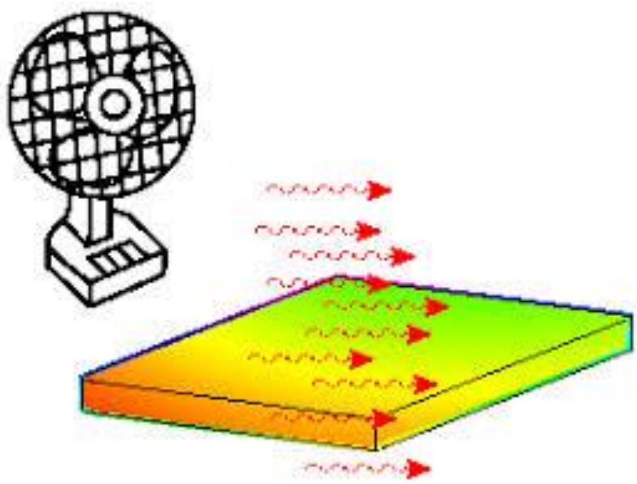


Figure 1.7: - Figure illustrating removal of heat from hot block by forced convection

For example, when water is heated on a stove, hot water from the bottom of the pan rises, displacing the colder denser liquid, which falls. After heating has stopped, mixing and conduction from this natural convection eventually result in a nearly homogeneous density, and even temperature. Without the presence of gravity (or conditions that cause a g-force of any type), natural convection does not occur, and only forced-convection modes operate.

THERMAL RADIATION: Thermal radiation is electromagnetic radiation generated by the thermal motion of particles in matter. All matter with a temperature greater than absolute zero emits thermal radiation. Particle motion results in charge-acceleration or dipole oscillation which produces electromagnetic radiation.

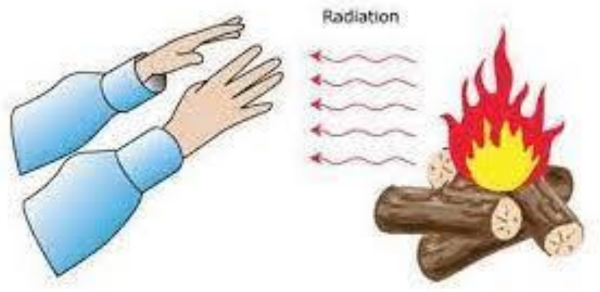


Figure 1.8: - Figure showing radiation heat from fire

The characteristics of thermal radiation depend on various properties of the surface from which it is emanating, including its temperature, its spectral emissivity, as expressed by Kirchhoff's law. The radiation is not monochromatic, i.e., it does not consist of only a single frequency, but comprises a continuous spectrum of photon energies, its characteristic spectrum. If the radiating body and its surface are in thermodynamic equilibrium and the surface has perfect absorptivity at all wavelengths, it is characterized as a black body. A black body is also a perfect emitter. The radiation of such perfect emitters is called black-body radiation. The ratio of any body's emission relative to that of a black body is the body's emissivity, so that a black body has an emissivity of unity.

1.3 METHODS OF COOLING IN ENGINES:

The heat transfer rate depends on the velocity of the vehicle, fin geometry, and the ambient temperature. Insufficient removal of heat from the engine will lead to high thermal stresses and lower engine efficiency. Enhancement in the geometry of the fin can be improved the heat transfer rate from the engine.

In an I.C. engine, the temperature of the gases inside the engine cylinder may vary from 35C or less to as high as 2750°C during the cycle. If an engine is allowed to run without external cooling, the cylinder walls, cylinder, and pistons will tend to assume the average temperature of the gases to which they are exposed, which may be of the order of 1000 to 1500°C. Obviously at such a high temperature; the metals will lose their characteristics and the piston will expand considerably and sieve the liner. Of course, theoretically, the thermal efficiency of the engine will improve without cooling but actually, the engine is seized to run. If the cylinder wall temperature is allowed to rise above a certain limit, about 65°C, the lubricating oil will begin to evaporate rapidly and both cylinder and piston may be damaged.

There are mainly following two methods of cooling I.C. engines:

1. Air cooling
2. Water liquid cooling.

In the Air-Cooling System, heat is carried away by air flowing over and around the cylinder. Here fins are cast on the cylinder head and cylinder barrel which provide an additional conductive and radiating surface. The fins are arranged at a right angle to the cylinder axis. The number and dimensions should be adequate to take care of the surplus heat dissipation.

Air-cooled engines remove engine heat by using the air that hits the engine when the bike is moving. This is why they have fins on the outside to create more surface area for the air to pass over. This cooling method is very simple, lightweight and requires no special devices

Air-cooled engines rely on the circulation of air directly over heat dissipation units or hot areas of the engine to cool them in order to keep the engine within operating temperatures.

In all combustion engines, a great percentage of the heat generated (around 44%) escapes through the exhaust, not through the metal fins of an air-cooled engine (12%). About 8% of the heat energy is transferred to the oil, which although primarily meant for lubrication, also plays a role in heat dissipation via a cooler. Air-cooled engines are used generally in applications which would not suit liquid cooling, as such modern air-cooled engines are used in motorcycles, general aviation aircraft, lawn movers, generators, outboard motors, pump sets, saw benches and auxiliary power units.

In Water/Liquid Cooling System, the cylinder and heads are provided with jackets through which the cooling liquid can circulate. The heat is transferred from the cylinder wall to the liquid by convection and conduction. The liquid becomes heated in its passage through the jackets and itself cooled utilizing an air-cooled radiator system. The heat from the liquid in turn is transferred to the air.

Water cooling is a method of heat removal from components and industrial equipment. Evaporative cooling using water is often more efficient than air cooling.

Water is inexpensive and non-toxic however it can contain impurities and cause corrosion.

Water cooling is commonly used for cooling automobile internal combustion engines and power stations. Water coolers utilizing convective heat transfer are used inside high-end personal computers to lower the temperature of CPUs.

Other uses include the cooling of lubricant oil in pumps; for cooling purposes in heat exchangers; for cooling buildings in HVAC and in chillers.

CHAPTER 2

LITERATURE REVIEW

Literature review: -

Heat transfer is a thermal energy which occurs in transits due to temperature difference. The modes of heat transfer are conduction, convection and radiation. Fin is a thin component or appendage attached to larger body or structure. Based upon the cross-sectional area type, straight fins are of different types such as rectangular fin, triangular fin, trapezoidal fin parabolic fin or cylindrical fin. Fin performance can be measured by using the effectiveness of fin, thermal resistance and efficiency. Triangular fins and rectangular fins have applications on cylinders of air-cooled cylinders and compressors, outer space radiators and air-conditioned systems in space craft. Several authors paid attention in analyzing the performance of fins.

Thirumaleshwar [1] in his book provided an introduction to modes of heat transfer. He had given detailed information of extended surfaces such as boundary conditions and analysis. Arora et al. [2] in their book provided an introduction to triangular fins and they had given detailed information of triangular fins its boundary conditions and analysis. Incorporeal [3] in his book proposed a correlation for triangular fins. He discussed two-dimensional fin analysis participating in heat transfer.

Mahesh et al [4] in their book gave practical applications of triangular and rectangular fins. Kumar et al. [5] In their article provided experimental investigation to predict the performance of heated triangular fin array within a vertically oriented and air-filled rectangular enclosure to analyze the effects of several influencing parameters

Rajput, R. [6] In their book fin mostly used when effectiveness of fin must be greater than or equal to 2 s. Teerakulpisut [7] in his paper presented application of modified Bessel functions in the analysis of extended surface heat transfer and differential equations are formulated from the fundamentals of conduction and convection heat transfer.

Rahim et al. [8] in their paper analyzed heat transfer through a wall containing triangular fins partially embedded in its volume, Narve et al. [9] in their paper studied heat transfer characteristics of natural convection heat flow through vertical symmetrical triangular fin arrays. They studied experimentally and results are compared with equivalent rectangular fin arrays. Average and base Nusselt numbers and Grashoff number are calculated. They observed that with increase in Grashoff number, average and base Nusselt number increases, Similarly average Nusselt number increases with spacing whereas base Nusselt number increases to maximum value.

Kushwaha, A. and Kirar,R.[10] have suggested now a day's we want everything will be compact you cannot install a big heat sink for your device because it increases cost and size of your device. Bilirgen, H.and Dunbar, S.[11] investigated temperature distribution and heat transfer and the effects of fin spacing, fin height, fin thickness, and fin material for a single row of finned tubes in Cross flow.

Guo,S.and Zhang,J.and Li,G.and Zhou,F.[12] have analyzed for a nonlinear equation Laplace transformation technique is easy to solving problem than other method. Mirapalli,S.and Kishore,P.S.[13] Have analyzed for an equal heat transfer triangular fin requires much less volume than rectangular fin.

Jacob,A. and Chandrashekhara,G. and George,J.and George,J.[14] have suggested that triangular fin it requires much less volume (fin material) than a rectangular profile. And for a parabolic profile, heat transfer rate per unit volume is only slightly greater than that for the triangular profile. Lee,K.H. and Son,J.W. and Kim,H.I. and In,B.D. [15] have experimentally used rectangular and triangular heat sink attach with thermoelectric generator for generating electricity from exhaust gas of diesel engine and its use in another place where it required.

Pise,T. and Awasarmol,U.A. [16] have used Rectangular fin array compare the natural convection heat transfer at different angles of inclination and its effect on fin performance like heat transfer rate, effectiveness and efficiency. Kumar,G. and Kamal,R.S.and Dwivedi,A.and Yadav,A.S.and Patel,H .[6] in their article provided experimental investigation to predict the performance of heated triangular fin array within a vertically direction and its effects in brief.

Cuse,E.and Cuse,P.M..[17] investigated in porous fin efficiency reduces and fin effectiveness exponentially decrease compare to Rectangular fin. Kumar,D.S.(2011), [18] in their book straight triangular fin is of great importance because it yields the maximum heat flow per unit weight of fin.

CHAPTER 3

PROBLEM DESCRIPTION AND METHODOLOGY

Problem description:

India is the second-largest producer of two-wheelers. Major problems faced by two-wheeler engine users are due to its overheating and weight.

Overheating causes the following problems: -

3.1. **Engine detonation**: -

Due to the high amount of heat in the engine the fuel combusts prematurely or erratically in the engine. Detonation happens when the fuel combusts before reaching its maximum state of combustion. This reduces the amount of energy released from the fuel, thus hurts the overall fuel economy. The detonation also creates intense stress for the engine since the explosion creates a force that pushes in a direction opposite to that of the piston`s compression stroke.

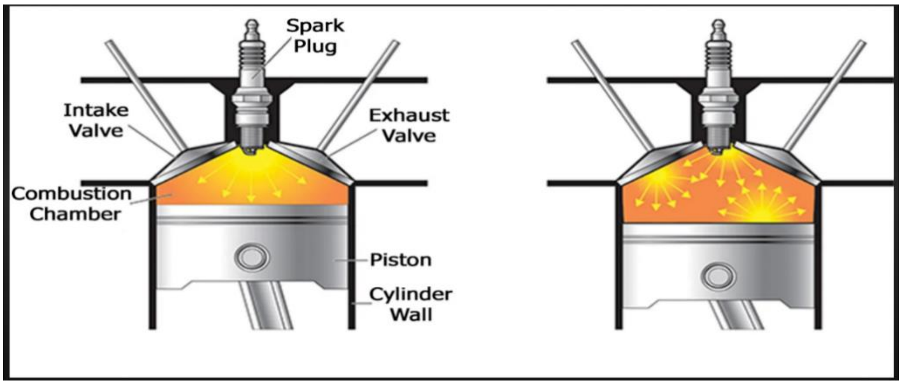


Figure 3.1 : Figure illustrating occurance of detonation

3.2.**SCUFFED PISTONS**: **-** Due to overheating as the piston heats up, they expand to the point that they begin contacting the walls. This contact problem is known as scuffing-scratched, abraded, or worn pitches that especially affect the piston`s ring lands and wrist pins. This can lead to piston failure.

Figure 3.2 : Figure shows scratches on the piston

Blown head gaskets: -

The head gasket creates a tight seal, ensuring that air, oil, and coolant remain where they should. Head gaskets often suffer serious forms of damage as the result of overheating. As the head gasket expands in its tightly, \the stresses often cause the gasket to wrap and break. blown head gasket creates serious problems for an engine. Repairing this issue also tends to cost quite a lot. The best way to avoid overheating in engine.

Figure 3.3: Figure illustrating Failed head gasket

Added weight: -

If any of the effective cooling systems are provided like a liquid cooling system it results in the added weight to the engine which in turn increases the fatigue of the user.

Objective: -

The objective is to provide the engine with the best cooling system to avoid the ill effects due to overheating taking into consideration of the engine weight. hence, the best factor to evaluate this is to calculate the heat transfer to mass ratio. Higher the heat transfer to mass ratio higher the engine is preferrable.

3.3. METHODOLOGY:

1. Considered a Honda unicorn engine for experimentation and its part body is drawn using Catia software
2. Considering the best way cooling system to the engine is by providing the extended surfaces known as fins
3. Taken into account different shapes of fins like rectangular and triangular for analysis

CHAPTER 4

ENGINE DESCRIPTION

ENGINE DESCRIPTION:

TYPE: 4-Stroke, Spark-Ignition(SI), BS-VI Engine

Displacement: 162.7 cc

Maximum Engine Output: 9.5Kw @ 7500 rpm

Maximum Torque: 14 N-m @ 5500 rpm

Fuel System: PGM-FI

Bore x Stroke : 57.3 x 63.1 mm

Compression Ratio: 10$\pm$0.2

Starting Method: Self or Kick.

CHAPTER 5

SOFTWARE DESCRIPTION

5.1 CATIA:

CATIA Overview

CATIA v5 is an Integrated Computer Aided Engineering tool:

1. Incorporates CAD, CAM, CAE, and other applications
2. Completely re-written since CATIA v4 and still under development
3. CATIA v5 is a native Windows application
4. User friendly icon based graphical user interface
5. Based on Variational/ Parametric technology
6. Encourages design flexibility and design reuse
7. Supports Knowledge Based Design

CATIA v5 Philosophy

- A Flexible Modelling environment
    1. Ability to easily modify models, and implement design changes
    2. Support for data sharing, and data reuse
- Knowledge enabled
    1. Capture of design constraints, and design intent as well as final model geometry
    2. Management of non-geometric as well as geometric design information

- The 3D Part is the Master Model

    1. Drawings, Assemblies and Analyses are associative to the 3D parts. If the part designs changes, the downstream models with change too.P

CATIA v5 Applications

- Product Structure
- Part Design
- Assembly Design
- Sketcher
- Drafting(Interactive and Generative)
- Wireframe and Surface
- Freestyle Shaper
- Digital Shape Editor
- Knowledge ware
- Photo Studio
- 4D Navigator (including kinematics)
- Manufacturing
- Finite Element Analysis

Part Design

1. Base Features
2. Pad
3. Pocket
4. Shaft
5. Slot
6. Hole
7. Groove

- Reference Elements

  1. Point
  2. Line
  3. Plane

- Dress-up Features

  1. Fillets
  2. Chamfers
  3. Draft Shall
  4. Thickness

- Transformation Feature

  1. Translation
  2. Rotation
  3. Pattern
  4. Scale

5.2 ANSYS:

ANSYS 2021 R1

Ansys 2021 R1 delivers significant improvements in simulation technology together with nearly unlimited computing power to help engineers across all industries reimagine product design and achieve product development goals that were previously thought impossible. From small to mid-sized companies to global organizations, companies of every size seek new ways for pioneering breakthrough innovations that are safer and more reliable to win the race to market. ANSYS 2021 R1 helps engineering teams improve their decision-making earlier in the design process, enabling them to rapidly develop new products by avoiding costly mistakes that can negatively impact product quality and reliability. Leveraging improved workflows and leading-edge capabilities that span Ansys' flagship suites, teams are tackling design challenges head-on, eliminating the need to make costly workflow tradeoffs, developing next-generation innovations with increased speed, significantly enhancing productivity and delivering high-quality products to market faster than ever.

ANSYS Workbench is a workflow analysis platform, combining the strength of simulation tools with the tools necessary to manage projects. To build an analysis, add building blocks called systems to the main project workspace. These systems make up a flowchart-like diagram that represents the data flow through the project. Each system is a block of one or more components called *cells*, which represent the sequential steps necessary for the specific type of analysis. Once added, they can be linked together to share or transfer data between systems.

Cells can work with various ANSYS applications and analysis tasks; some of these open in tabs within the Workbench environment, while others open independently in their windows.

ANSYS applications enable to define analysis characteristics such as geometry dimensions, material properties, and boundary conditions as parameters. It is easier to manage parameters at the project level in the Workbench environment. To perform analysis, work through the cells of each system in order typically from top to bottom defining inputs,
project parameters, running simulation, and investigating the results. Workbench enables one to easily investigate design alternatives by modifying any part of the analysis or vary one or more parameters and then automatically update the project to see the effect of the change on the simulation result.

CHAPTER 6

DESIGN AND THERMAL ANALYSIS OF ENGINE BLOCK

Design and Thermal Analysis of Engine Block:

Design of The Honda Unicorn Engine Block:

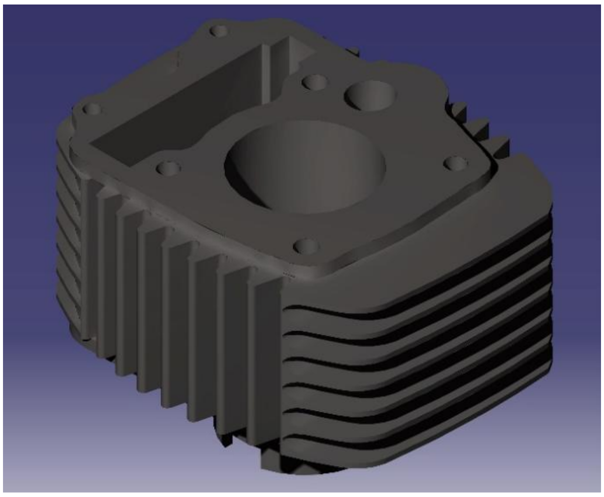
The CAD model of the engine block is designed in CATIA V5 R21 using the part design feature and is saved in CATPart file format which can be imported into ANSYS Workbench software.

Transient Thermal Analysis:

Transient Thermal analysis is used to determine the temperatures and thermal quantities that change over time. The loads applied in the transient thermal analysis are the function of time. The temperature applied is about 800°C and temperature distribution and heat flux is noted for a different element.

Model :

The thermal analysis of the Engine block is done in ANSYS Workbench 2021 R1. The engine model is slightly altered giving it triangular fins as experimentation. These models saved in CAT Part format are capable to be imported into the ANSYS system as new



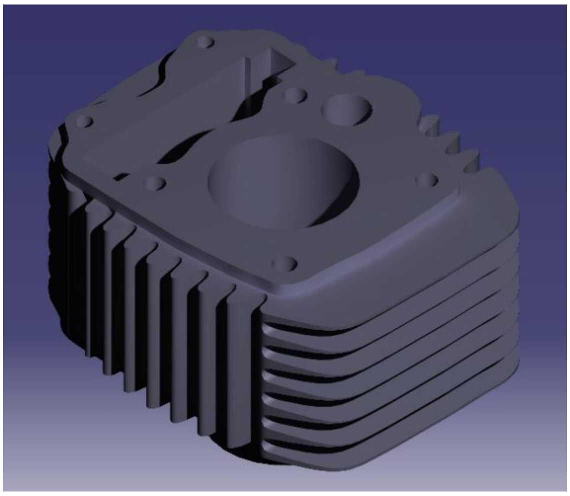


Figure 6.1,6.2: Isentropic views of Engine block with rectangular and triangular fins

Model details:

ENGINE BLOCK	
TYPE	4 STROKE,SI,BS-VI ENGINE
DISPLACEMENT	162.7CC
MAX ENGINE OUTPUT	9.5Kw at 7500 rpm
MAX TORQUE	14N-m at 5500 rpm
FUEL SYSTEM	PGM-FI
BORE X STROKE	57.3x63.1 mm
COMPRTESSION RATIO	10+0.2
STARTING METHOD	SELF/KICK

Materials

The materials used here are Grey Cast Iron and A319 Aluminum alloy. The Original engine model that is included by the manufacturer and is standard issue engine is made up of Cast Iron while A319 material is an experimental m

Properties of CI

(a) Carbon:

As the carbon content increases, the melting point (as compared to steels) is lowered to between 1200° to 1140°C, and thus, carbon acts as a graphitiser. But, the more the graphite formed, the lower are the mechanical properties.

(b) Silicon (0.5-3.0%):

Silicon mainly controls the form of carbon present in the cast iron. Silicon is a strong graphitiser. Depending on its content (and the rate of cooling), silicon not only helps to precipitate graphite during solidification but may also graphitise the secondary as well as eutectoid cementite. Once the graphite flake has formed, its shape cannot be changed later by any method. Figure. 15.1 (b) illustrates the effect of carbon and silicon on the structure of white or grey cast irons. Silicon lowers the eutectic composition approximately by 0.30% carbon for each 1% silicon, i.e., the eutectic composition is then calculated by using CEV. Silicon also lowers eutectoid carbon content. Depending on the silicon content and the rate of cooling, the carbon content of pearlite decreases to be as low as 0.50% with 2.5% silicon. Silicon shifts the graphite eutectic line upwards such that the temperature interval between the graphite line and the cementite line increases from 6°C at 0% Si to 35°C at 2% Si (this increases the degree of undercooling to help in graphite formation).

(c) Sulphur and Manganese:

Sulphur (0.06-0.12%), when present as FeS (which increases the tendency to brittleness) tends to promote cementite formation, i.e., retards graphitisation and increases the size of the flakes. Manganese (0.5-1.0%) is a mild carbide-former and controls the effect of sulphur if enough amount of Mn is present (one part of sulphur to 1.72 parts of manganese), as it has more affinity for sulphur (than Fe has) to form MnS, which rises to the top of casting to join the slag-thus removes the red-shortness of FeS eutectic. Manganese, thus, has an indirect effect to promote graphitisation as it removes sulphur, (which promotes cementite formation). More direct effects of manganese include a strong cementite-stabilising effect on eutectoid-graphitisation (around 1% Mn may be added to get pearlitic matrix in graphitic cast irons), hardening of iron, refinement in grains and an increase in strength.

(d) Phosphorus (0.1-0.9%):

When phosphorus is less than 0.3%, it dissolves in ferrite, otherwise, it forms Fe3P which forms eutectic (91.19% Fe, 1.92%C, 6.89%P) called steatite, which is brittle (causes cold-shortness, i.e., castings are unsuitable for shock-resistance) and low melting, M.P. 960°C. This increases the range of eutectic solidification, and thus, helps to form graphite, and improves castability even of thin and intricate sections. A 1% phosphorus in iron results in steatite which accounts for 10% by volume of the casting; the embrittling effect of steatite is evident.

PROPERTIES OF A319

Brinell Hardness	235
Tensile stress	41.9 ksi
Modulus of Elasticity	18.2Msi
Thermal conductivity	83 W/mK

ALLOY COMPOSITION OF ALLOY

Aluminum alloy is a 6% Si and 3.5% Cu alloy with a 1.0 Fe maximum. It has excellent casting and machining characteristics. Corrosion resistance and weldability are very good. Mechanical

ELEMENT	Wt.%
Si	6.1
Fe	0.68
Mg	0.30
Cu	3.01
Mn	0.32
Zn	0.71
Al	88.88

Alloy	**Latent heat**	**Volume expansion on melting=%**	**Thermal conductivity**	**Density**
A319	400	9%	109W/mK	2090kg/m^3

properties are good in both the heat-treated (T5) and non-heat-treated conditions. The above materials have been applied to the models and their respective masses are obtained using the measure feature.

	CI Engine block masses	A319 Engine block masses
Rectangular fins engine block mass:	4.420 kg	1.316 kg
Triangular fins engine block mass	4.224 kg	1.257 kg

Analysis Conditions

Assumptions made to be here:

1. The heat conduction in the fin is steady-state and one dimensional.

2. The fin material is homogeneous and isotropic.

3. There is no energy generation in the fin.

4. The convective environment is characterized by a uniform and constant heat transfer coefficient and temperatures.

5. The engine block material has a constant thermal conductivity.

6. The contact between the base of the fin and the primary surface is perfect.

Meshing Properties:

The model has been meshed with the standard meshing tetrahedral procedures and default meshing settings and no additional refinements have been used in the process of meshing the part design. For analysis. The size of each element is 1.08×10^{-2} m.

After meshing the number of elements in each of the part bodies are as follows

No of elements for triangular block: 20906

No of elements for rectangular block: 21888

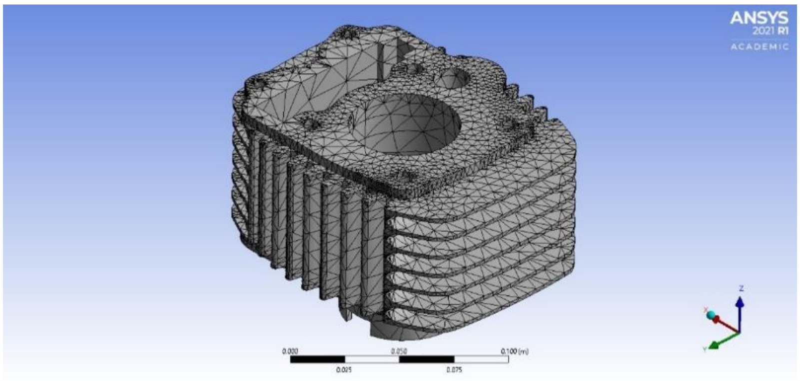


Figure 6.3: Meshing of Engine Block with Rectangular Fins

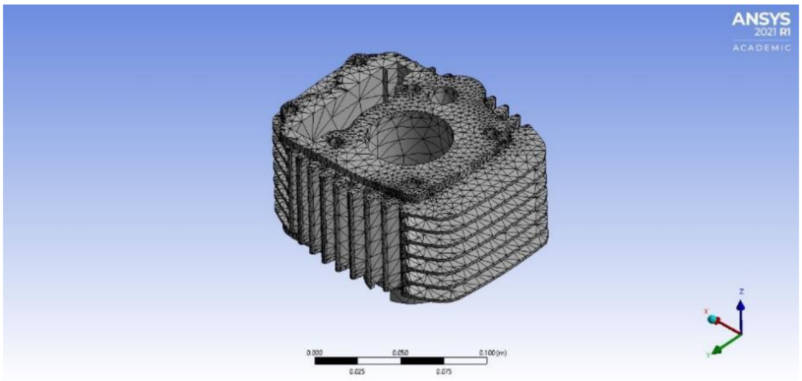


Figure 6.4: Meshing of Engine Block with Triangular Fins

Input parameters

Initial temp	30°C
Combustion temp	800°C
Convective heat transfer coefficient of air	10 W/m^2K

CHAPTER 7

RESULTS AND DISCUSSIONS

Results and Discussion:

The Transient Thermal analysis of the Engine block before and after modifications have been obtained by solving the elements using ANSYS Workbench 2021R1 Software and the Temperature and Heat flux behaviors of the Engines Have been Recorded.

Temperature Distribution

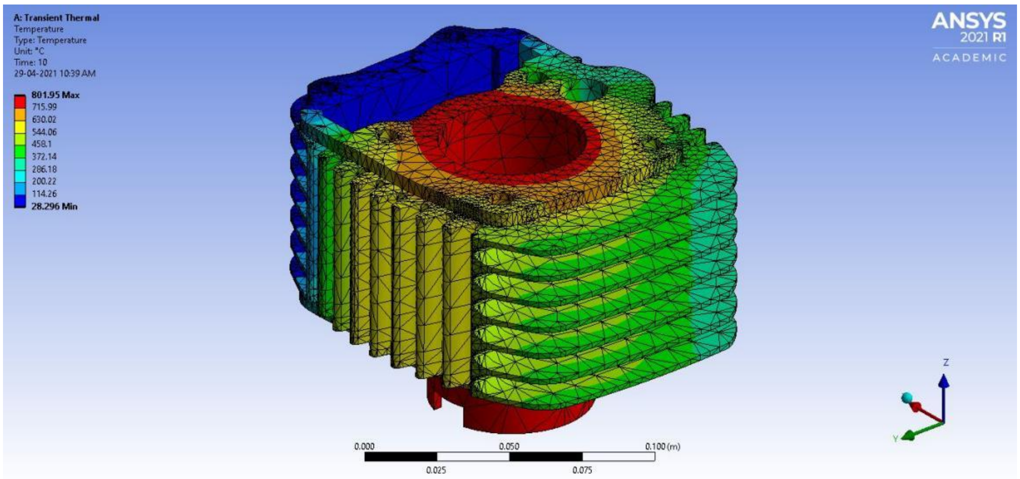
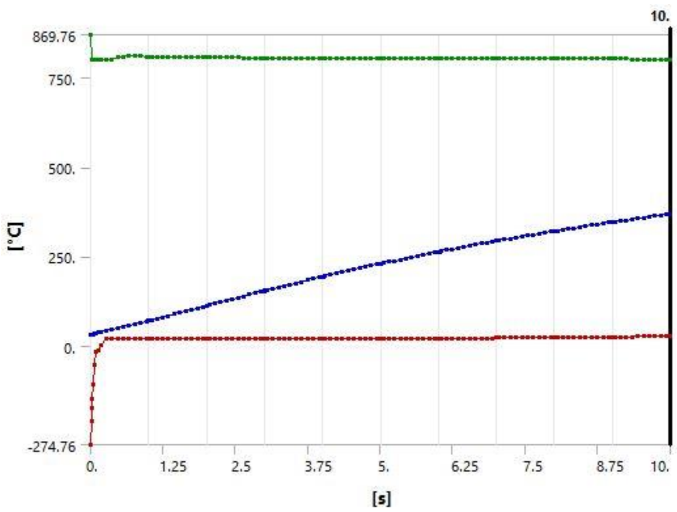


Figure 7.1: Temperature Distribution of Original Engine Model made of Grey CI



GREEN - Maximum Temperature

Blue – Average Temperature

Red – Minimum Temperature

Figure 7.2: Graph for Temperature Distribution of Original Engine Model made of Grey CI

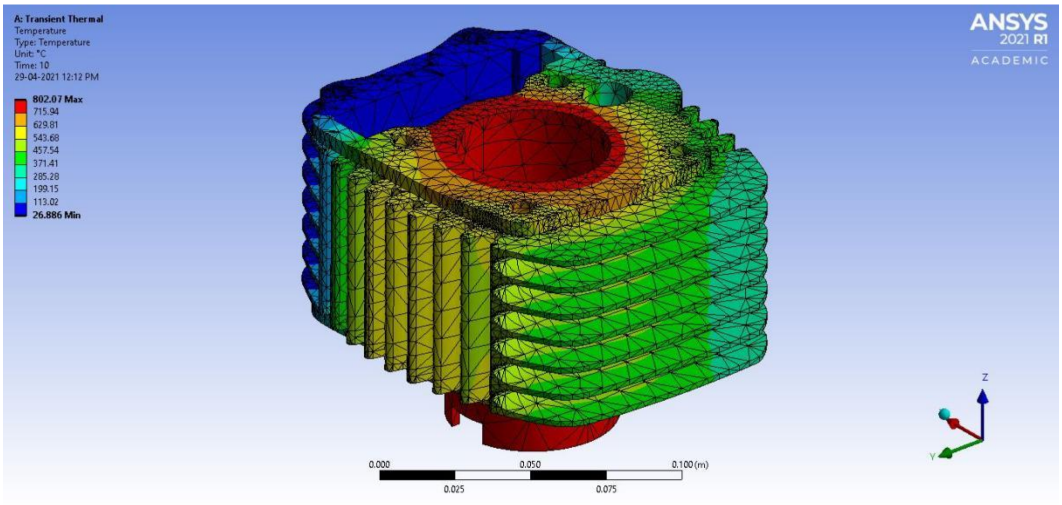
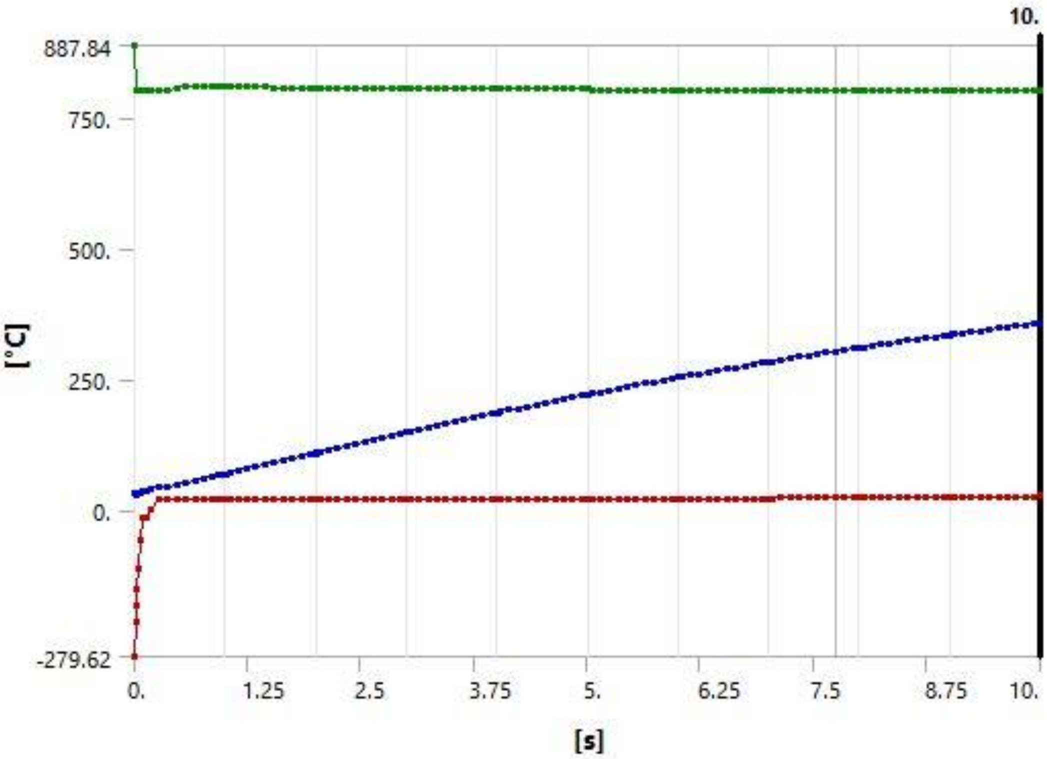


Figure 7.3: Temperature Distribution of Original Engine Model with A319



GREEN - Maximum Temperature

Blue – Average Temperature

Red – Minimum Temperature

Figure 7.4: Graph for Temperature Distribution of Original Engine Model made of A319

This Engine block model having Rectangular shaped fins and made of Grey Cast Iron has a Maximum temperature of 801.95°C and a Minimum temperature of 28.29°C. While the block of the same shape but made up of A319 has a slightly higher maximum temperature of 802.07°C and a lower Minimum temperature of 26.88°C

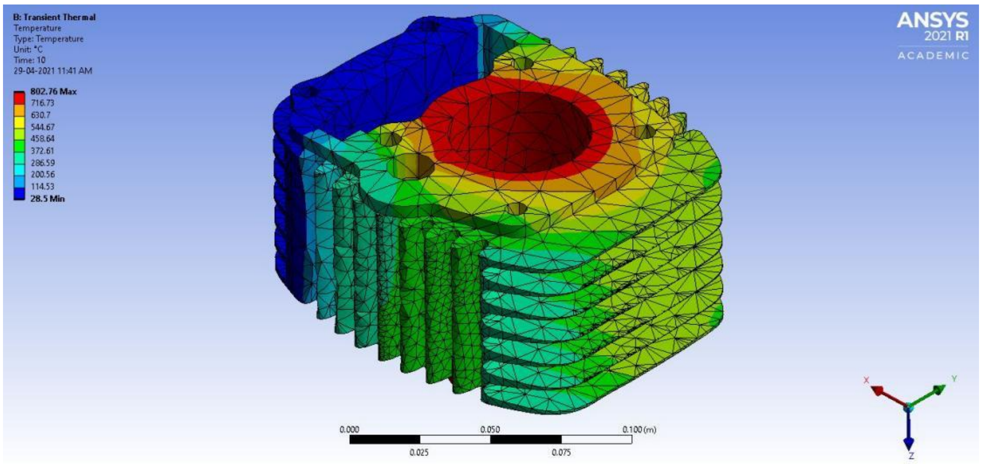
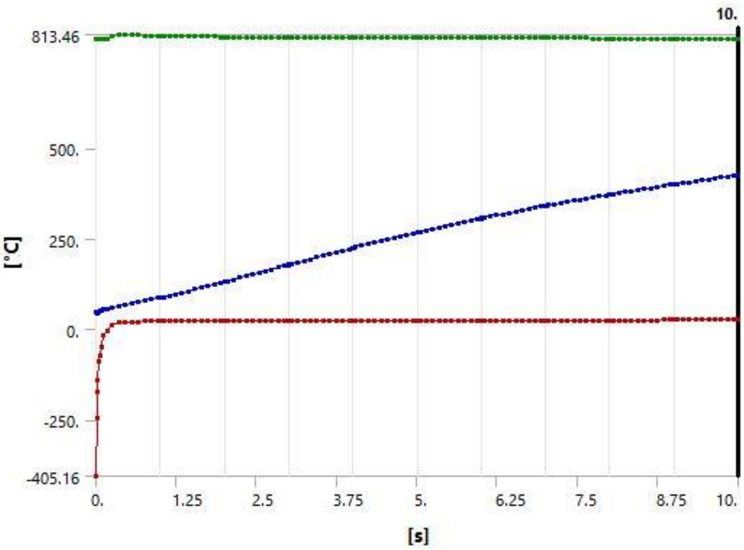


Figure 7.5: Temperature Distribution of Modified Engine Model made of Grey CI



GREEN - Maximum Temperature

Blue – Average Temperature

Red – Minimum Temperature

Figure 7.6: Graph for Temperature Distribution of Modified Engine Model made of Grey CI

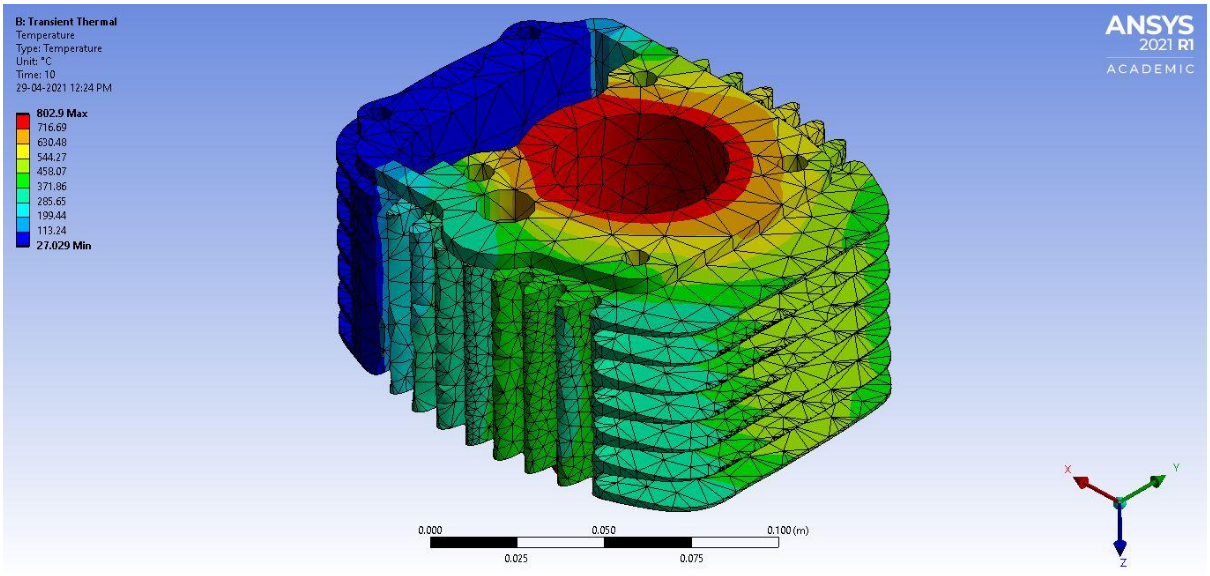
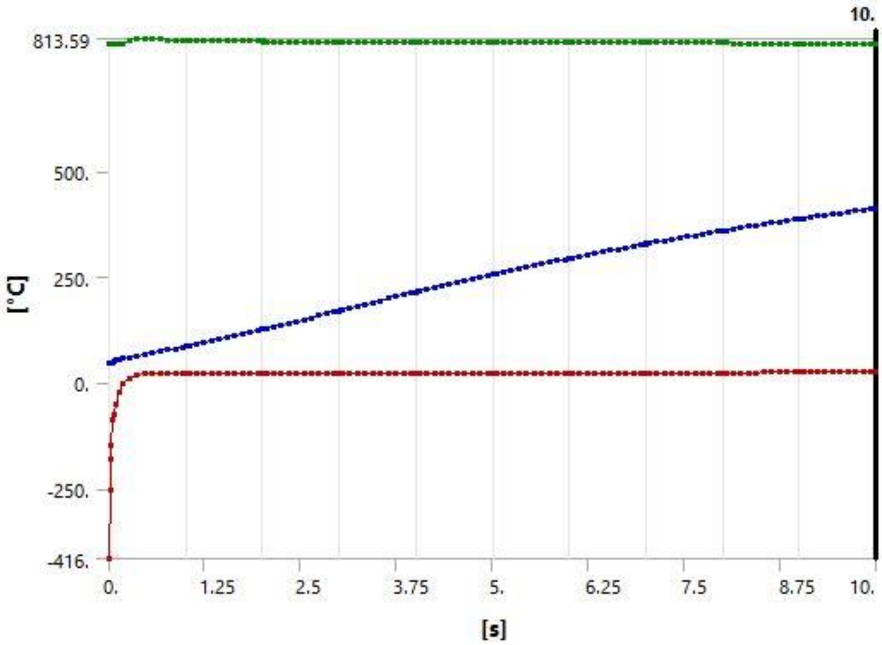


Figure 7.7: Temperature Distribution of Modified Engine Model made of A319



GREEN - Maximum Temperature

Blue – Average Temperature

Red – Minimum Temperature

Figure 7.8: Graph for Temperature Distribution of Modified Engine Model with A319

This Engine block model having Triangular shaped fins and made of Grey Cast Iron has a Maximum temperature of 802.76°C and a Minimum temperature of 28.5°C.

While the block of the same shape but made up of A319 has a slightly higher maximum temperature of 802.9°C and a lower Minimum temperature of 27.02°C

Heat Flux Distribution

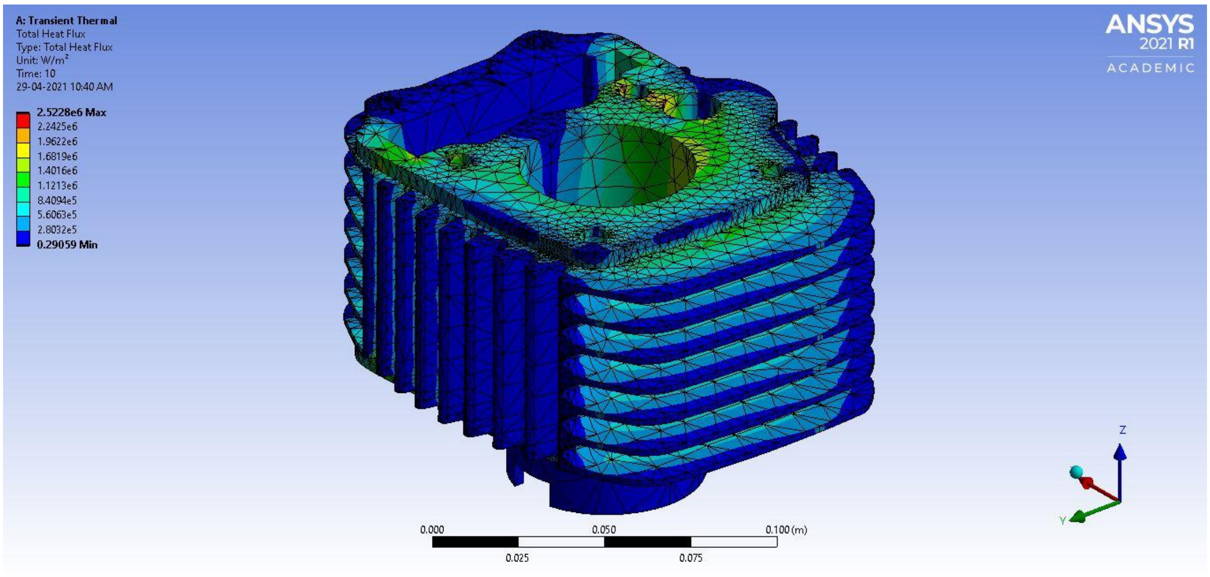


Figure 7.9: Heat Flux of Original Engine made of Grey CI

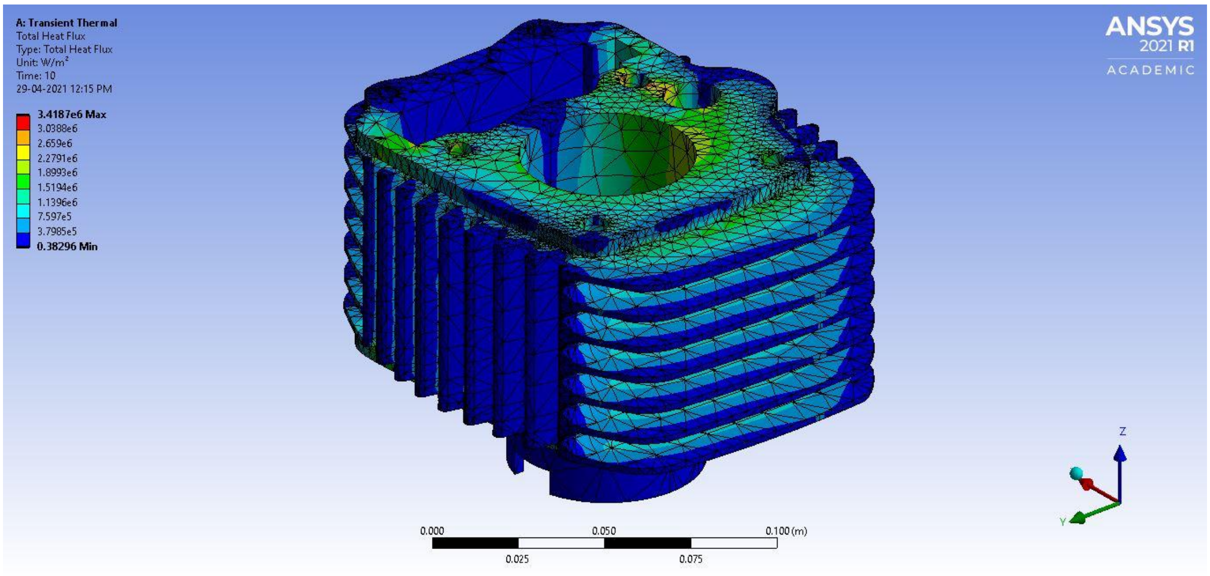


Figure 7.10: Heat Flux of Modified Engine made of Grey CI

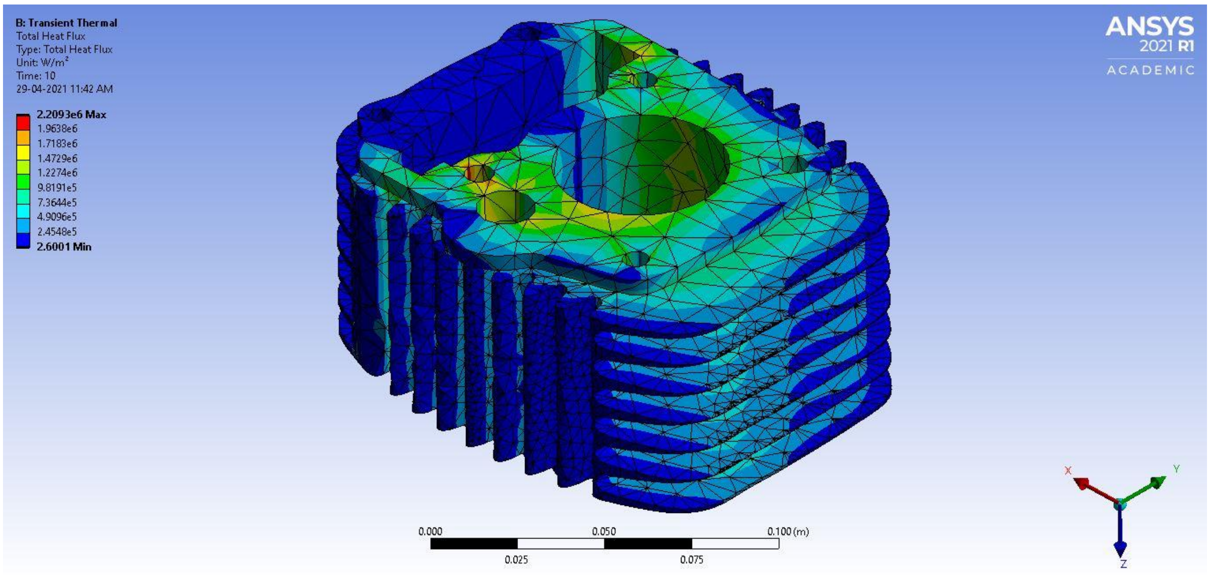


Figure 7.11: Heat Flux of Modified Engine Made of Grey CI

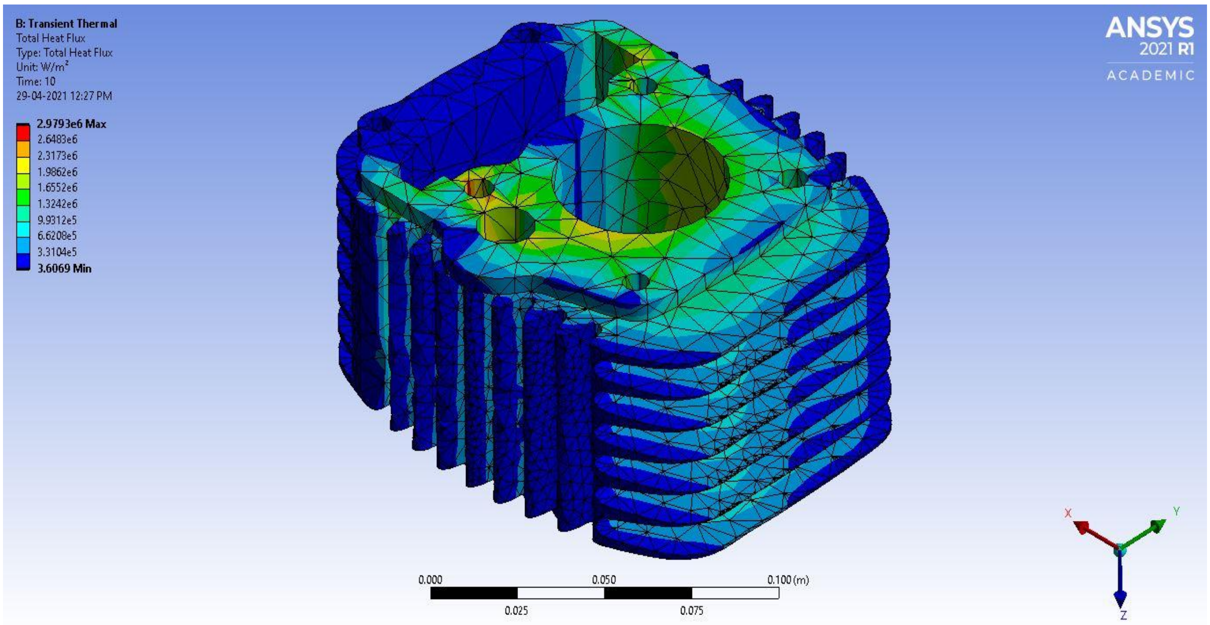


Figure 7.12: Heat Flux of Modified Engine Made of A319

Comparison of Heat Transfer Rates

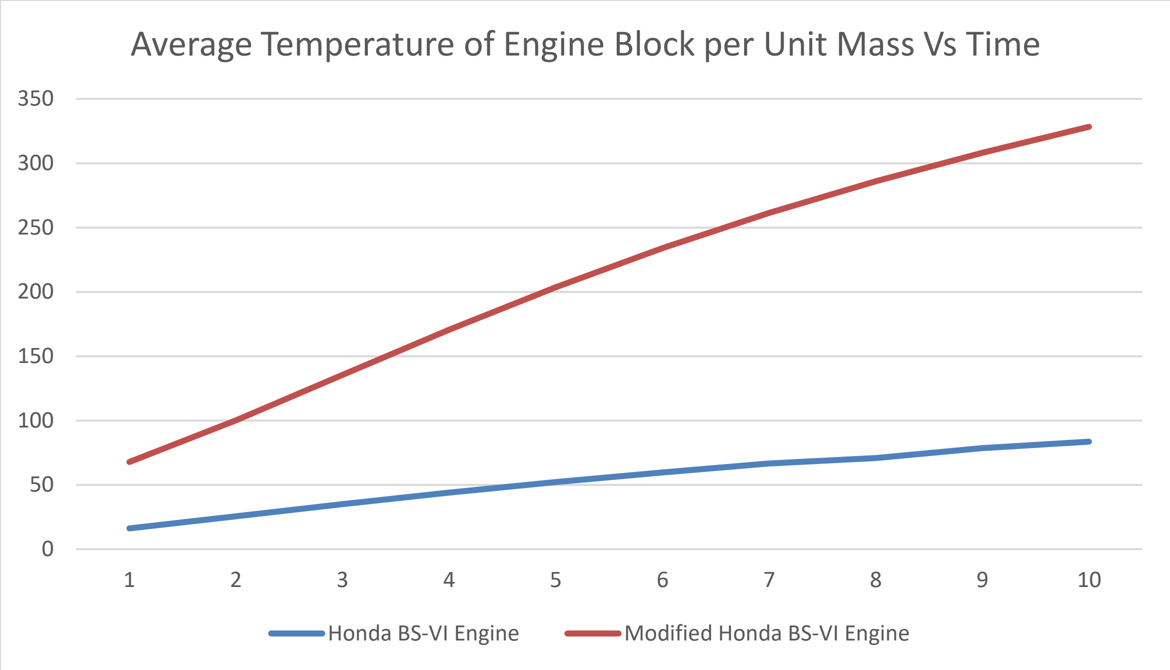


Figure 7.13: Average Temperature of engine block per unit mass Vs Time graph

	Original Engine GCI	Original Engine A319	Modified Engine GCI	Modified Engine A319
Max. Temperature (°C)	801.950	802.070	802.760	802.970
Min. Temperature (°C)	28.290	26.880	28.500	27.020
Heat Transfer Rate (kW)	10.981	11.002	13.562	13.592
Heat transfer Rate per Unit Mass (kW/kg)	2.484	8.360	3.210	10.812

Comparing these Analysis results it can be understood that the engine having A319 material has a higher rate of heat transfer per unit mass as the average temperature difference per unit mass from the Cylinder to the fins is larger when compared to that of Grey Cast Iron.

CHAPTER 8

CONCLUSIONS

Conclusion:

It can be said that an effective method for the design of highly effective fins can be achieved by altering the shape, size, material of the engine block. Rectangular fins have higher Heat transfer rates as they have more surface area but compromise the engine weight when compared to Triangular fins. Larger fins have better heat transfer rates as they have larger surface areas. Material plays an important role in the engine’s thermal properties as most of the engine's heat dissipation capabilities heavily depend upon thermal conductivity. In this case, A319 with higher thermal conductivity is capable of dissipating more heat per unit mass than compared to Grey Cast Iron.

From the above, it can be understood that in an Engine block made of A319 triangular fins can be preferred to be used to obtain better thermal performance and behavior than the standard Grey Cast Iron block with rectangular fins.

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