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Modelling and Analysis of IC Engine Fins by using Different Materials

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ABSTRACT

Heat transfer is a very main phenomenon within the investigation of any inside combustion engine. Thermal efficiency of interior combustion engine is immediately linked with heat transfer. Consequently, heat transfer enhancement can make stronger thermal efficiency of inner combustion engine. In this case, we had regarded air cooled IC Engine. Heat Transfer through cylinder head consists of conduction through walls and convective heat transfer due to surrounding air flow. Design of multiplied surfaces is compulsory in air cooled IC engines to increase the warmness transfer. Fins are the important component in an IC engine cylinder block which is responsible for heat removal during the combustion process via convection process. The efficient removal of heat transfer can always maintain the consistent efficiency of an IC engine. The fins are of different types which are generally used based on the heat transfer rate requirement.

The main aim of this project is to find the best material for cooling fins to increase the heat transfer rate. The modelling of cylinder block with fins is done by using SOLIDWORKS 2016. The design specifications of the IC engine Cylinder block with fins are is taken from Honda CB Shine 125CC. The FEA analysis is done by using ANSYS Workbench 19.2. FEA analysis is done through Steady-State Thermal which used to find out the total heat flux distribution and temperature distribution. Four different materials are selected and analysis is done by using them, to select the best material.

KEYWORDS:*Heat Transfer, Thermal Efficiency, Combustion, Convection, Ansys, FEA Analysis*

1.INTRODUCTION

The engine is the heart of the vehicle. It is a complex machine that is built to convert the heat from burning gas into the force that turns the road wheels. Fundamentally, the running of any vehicles relies upon the performance of the engine. The choice of best engine modelling and assembling are basically dependent upon the concluding of materials because internal ignition engines directly connected with the thermal conductivity of the materials. The thermal examination is the piece of material science that examines the properties of materials that are engaged in with thermal examination and moreover subjected to change with change in temperature. The thermal examination is furthermore every now and again used for streamlining of Heat transfer through the structures like internal ignition motors, moulding blocks and in various more applications when heat exchange happens with conduction and convection modes.

The thermal structures must be designed and evaluated to make, disperse the reasonable proportion of undesirable heat with the required amount. In the study of heat transfer, fins are the surfaces that extend 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. The issue emerges when the heat exchanged by these fins are not sufficiently adequate to cool the heat producing devices and makes damage to the parts of the devices. The essential arrangement accessible is that the state of fins can be optimized with the end goal that the heat exchange thickness is greatest when the space and the materials utilized for the finned surfaces are imperatives. The fundamental point of the task is to advance the thermal properties of fins by moving geometry and heat exchange rate.

KEYWORDS: Thermal Conductivity, Thermal Examination, Fins, Imperatives.

STRUCTURE OF PAPER

The paper is organized as follows: In Chapter 1, the introduction of the paper is provided. In Chapter 2 we discussedMethodology. In Chapter 3 we have Material Selection and Design Specifications. Chapter 4 Deals with Modeling of IC Cylinder Block with Fins using SolidWorks. Chapter 5 Deals with the Analysis of IC Engine Cylinder Block Fins using Ansys. Chapter 6 tells us about the Conclusions of the paper with acknowledgement and references.

1.2. HEAT TRANSFER

Heat is a form of energy that derives its origins at the molecular scale. Those molecules of a substance vibrate at their positions either fixed or not when energy is supplied to them. When they vibrate, they often transfer their energy to the surrounding molecules, allowing them to vibrate.

Heat energy can transfer from one body to another, or from one body location to another. The study of the methods and techniques adopted to transfer heat energy is called 'Heat Transfer.' In order to enable heat transfer between 2 bodies, there must be a temperature difference between them. That ensures that these two bodies must be at two different temperatures, one higher than another, that allow heat to flow from one body to another. Modes of heat transfer

In our daily life, it has been observed that when a pan full of water is boiled on a flame, temperature of water increases. However, when the flame is turned off it slowly cools down

This happens due to the phenomenon of heat transfer occurring between the pan full of water and flame. It has been confirmed that heat transfer takes place from hotter objects to colder objects.

When objects are falling at different temperatures or if there is an object at a different temperature from the surroundings, then the transfer of heat takes place such that both the object and the surroundings reach an equilibrium temperature.

There are three modes of heat transfer. They are:

- Conduction
- Convection
- Radiation

1. Conduction of heat

Conduction is a process where heat transfer takes place from the hotter part of the body to the colder part without involving any actual movement of the body molecules. Here, the heat transfer occurs from one to another molecule as a result of the molecules' vibratory motion. Transfer of heat happens through the process of conduction occurring in substances which are in direct contact with each other. Generally, it takes place in solids.

Conduction example: frying vegetables in a pan is an example of conduction. Heat transfer takes place from flame to the pan and then to the vegetables.

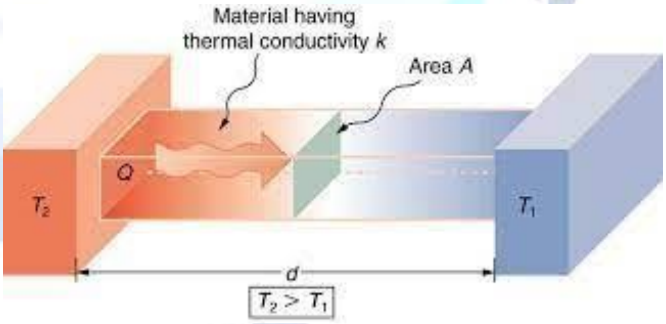

Fig.1.1. Conduction

Based on the conductivity of heat, substances can be classified as conductors and insulators.

Substances that conduct heat easily are known as conductors and those that do not conduct heat are known as insulators.

2. Convection of heat

This is a process where heat is transferred in both liquid and gases from a region of higher

temperature to that of lower temperature. Convection heat transfer happens partly because of either the actual movement of molecules or due to the mass transfer. Convection example:
Heating of milk in a pan.

Fig.1.2. Convection

Convection is classified as natural (or free) and forced convection depending on how the fluid motion is initiated.

a. Natural Convection

Natural convection is a method of heat transfer in which natural means influence the motion of the fluid. There is no influence from external facts. This movement of molecules in the fluid is due to the differences between densities of different regions of the same fluid. The density of a fluid decreases when it heats and vice versa. That is because of the thermal expansion of the fluid (the speed of molecules increases with the temperature increase, which results in the increase of the volume of the fluid. Although the volume increases, the mass remains constant. Therefore, the density decreases).

When we heat a fluid in a container from its bottom, the density of the bottom layer of the fluid decreases. Then the lower density region tends to move to the top of the container. Then the cooler fluid at the top of the container replaces the bottom region. This continues, as a result, convection occurs.

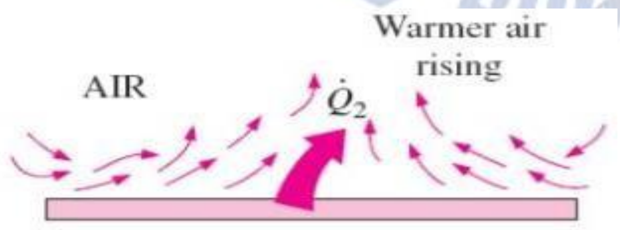

Fig.1.3. Natural Convection

Examples of natural convection include cooling down a boiled egg when kept in the normal air, loss of cool of a cool drink can, etc. When considering the mechanism of natural convection, first, the temperature of the outside of a hot object (kept in cold air) drops down.

At the same time, the temperature of the air adjacent to the object will rise due to heat transfer. Then the density of this adjacent layer of air decreases. As a result, the air rises upward. Cold air will replace this region. Then the convection continues. In the end, the object will cool down.

b. Forced Convection

Forced convection is a method of heat transfer in which external means influence the motion of the fluid. There, external sources such as pumping, fans, suction devices, etc. are useful in generating the fluid motion. This method is very valuable because it can efficiently transfer heat from a heated object. Some common examples of this mechanism include air conditioning, steam turbines, etc.

When considering the mechanism of forced convection, it is has a complicated mechanism than the natural way. That is because, in this method, we have to regulate two factors; fluid motion and heat conduction. These two factors have a strong connection since the fluid motion can enhance the heat transfer. Ex: higher the rate of motion of the fluid, higher the heat transfers.

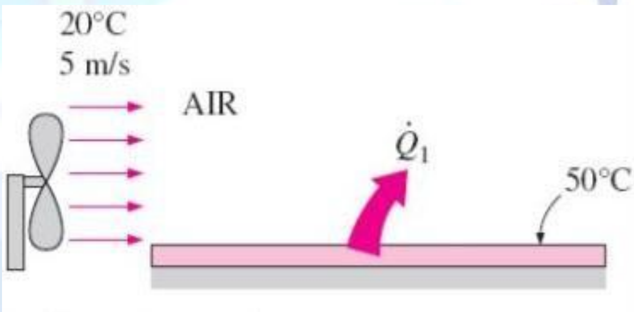

Fig.1.4. Forced Convection

3. Radiation of heat

Radiation of heat is the process where heat is transferred from one to another body without involving the medium molecules. This type of heat transfer does not depend on the medium. The speed of radiation which can be transmitted from an outside at a flat-out temperature T is represented by the Stefan-Boltzmann law as

$Q = \sigma AT4$

Where, $\sigma = 5.670 \times 10 -8 W/m2$

is the Stefan Boltzmann steady. The black body is perfect surface for emanates radiation at most extreme rate, and the radiation exchanged by a black body is called black body radiation. Absorptivity α is another critical property of a plane, is clarified as the division of the radiation vitality occurrence on a surface that is gotten by the surface. The whole radiation occurrence on it is consumed by black body. That is, a blackbody is a flawless safeguard (α=1) of radiation.

One of the modes of heat transfer examples is in an oven, the substances are heated directly without a heating medium.

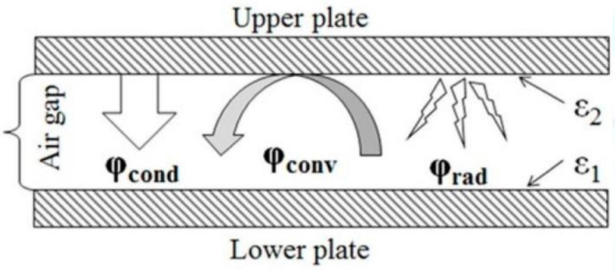

Fig.1.5. Radiation

1.3. WHY ENGINE COOLING IS REQUIRED

The cooling system is an important part of an automobile engine. The cooling system serves three important functions. First, it removes excess heat from the engine; second, it maintains the engine operating temperature where it works most efficiently; and finally, it brings the engine up to the right operating temperature as quickly as possible. Cooling is important, especially in hot climates as high temperatures tend to damage engine materials and lubricants. Hence, it would not be incorrect to say that the lifespan of an engine, and its survival, rests on its cooling system.

1.4. DIFFERENT TYPES OF COOLING SYSTEM

The cooling tech for a bike has three categories, based on the cooling method deployed.

1. Air-Cooled
2. Oil-Cooled
3. Liquid-Cooled

1. Air-cooled engines

Air-cooled engines are the most commonly used technology, in the majority of Indian bikes. They use air as the cooling agent for engine cooling. They have fins around the engine cylinder that facilitates cooling by exposing the increased surface area to air for bringing the temperature down. Pros of Air-cooled Engines are:

• Easy to Manufacture
• Cheaper on Price
• Easy to Maintain

Cons of Air-cooled Engines are:

• Cannot be used for High Performances
• Are least efficient
• May lead to Engine Seizure

2. Oil-cooled Engines

Oil-cooled engines help maintain the viscosity and lubrication of the oil through an optimal operating temperature. To do this, the oil is circulated between an oil cooler and is cooled by the flowing air, that, in turn, cools down the engine oil. This cooled engine oil is rolled back via another jacket.

Pros of Oil-cooled engines are:

• Much more efficient than simple air cooling
• Technologically simpler
• Cheaper and easier to maintain

Cons of Oil-cooled engines are:

• This too cannot be installed on high-performance bikes
• Better than air-cooled ones but not on par with the liquid-cooled option with respect to efficiency.

3. Liquid-cooled Engines

Liquid-cooled Engines are used by all high-capacity bikes in India as well as abroad. It ensures stable performance even in crowded traffic conditions, on uphill, and during high- speed riding. In this system, there is a web of passages around the cylinder that circulates the coolant, which, in turn, keeps the engine temperature cool and under control.

Pros of Liquid-cooled engines

• Keeps the engine cooler than the other two options.
• Can maintain performance and high speed for a long duration
• Their efficiency is much better than their air-cooled and oil-cooled counterparts.

Cons Liquid-cooled Engines

• Much costlier and more complex to make
• Costlier to maintain than the air-cooled or oil-cooled ones.

1.5. EXTENDED SURFACE (FINS)

In the study of heat transfer, fins are surfaces that extend 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 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 problems.

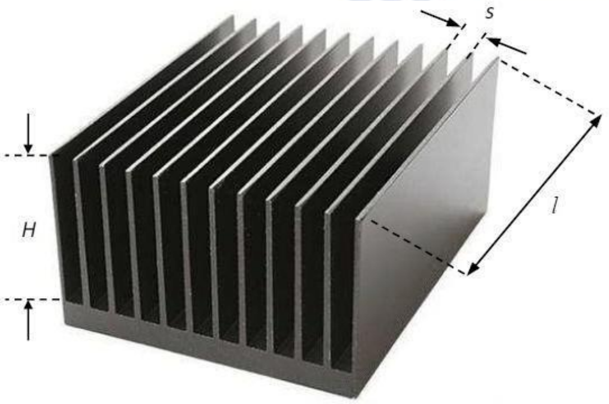

Fig.1.6. Fin of a heat sink

Fins are widely used in various engineering equipment's for increasing heat transfer rate from a surface. A fin is a surface that increases from a part to enhance the amount of heat switch to or from the nearby enhancing convection. Increasing the temperature difference between the item and the environment, growing the convection heat switch coefficient, or growing the surface area of the item will increase the heat dissipation. Adding a fin to the item, however, will increase the surface region and can on occasion be reasonably-priced approach to heat transfer troubles. Most commonly used materials for fins are aluminium and its alloy, Copper and its alloy, Brass. There are exceptional types of shape and length fins utilized in engineering applications to increasing the heat transfer rate. They are:

- Rectangular fin
- Triangular fin
- Trapezium fins
- Circular segmental fins
- Angular fin

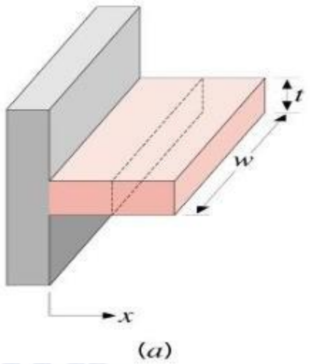

Fig.1.7. Rectangular Fin

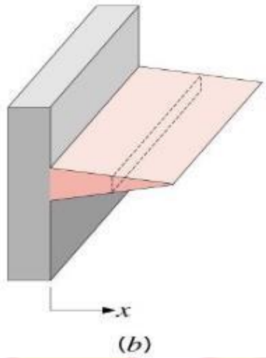

Fig.1.8. Triangular Fin

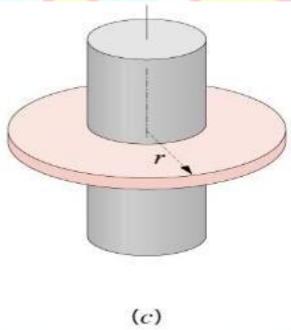

Fig.1.9. Circular Fin

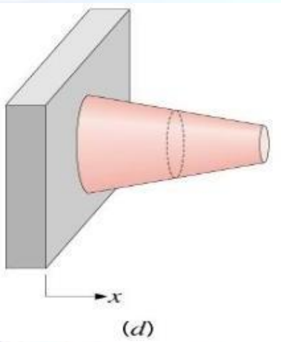

Fig.1.10. Conical Fin

Applications of Fins

1. Air-cooled IC engines
2. Refrigeration condenser tubes
3. Electric transformers
4. Reciprocating air compressors

5. Semiconductor devices
6. Automobile radiator
7. Cooling of Electronic components
8. Economizers of steam power plants
9. Heat exchangers of a wide variety, used in different industries
10. Cooling of electric motors, transformers etc.
11. Radiators for automobiles
12. Air cooled cylinders of compressors, IC engines
13. Dry type cooling towers

1.6. LITERATURE REVIEW

Kirubadurai.B, Magesh.G, Rajkumar.G, Suresh Kumar.K, have found out that Engine life time can be increased with increases the heat transfer rate from engine block to atmosphere, so external surface is required to increase heat transfer rate from the engine block. But in segmental designed fin having some problems to transfer the heat. In this research consider all existing problem and rectified all this type of problem by modified design. In this research have designed a cylinder fin which is used in a Hero Honda Motorcycle and modelled in parametric 3D modelling software Solid works. From the analytical solution, thermal analysis and flow simulation we get that the heat transfer to the atmosphere is more while comparing the existing fin. Hence the change in geometry of fin increases the rate of heat transfer from 1025K to 631K.So the difference of heat transfer temperature different 130K.

Deepak Gupta et al. have designed a cylinder fin body used in a 100cc Hero Honda Motorcycle and modelled in parametric 3D modelling software Pro/Engineer. Presently used material for fin body is aluminium alloy fins and internal core with grey cast iron replaced with Aluminium alloy 6063 and grey cast iron separately for entire body. The shape of the fin is rectangular; we have changed the shape with circular shaped. The default thickness of fin is 3mm; we are reducing it to 2.5mm. They have done thermal analysis on the fin body by varying materials, geometry and thickness. By observing the analysis results, using circular fin, material Aluminium alloy 6063 and thickness of 2.5mm is better since heat transfer rate is better. But by using circular fins the weight of the fin body increases. So, if we consider weight, using circular fins is better than other geometries. So, they say Aluminium alloy 6063 is better, reducing thickness to 2.5mm is better and using fin shape circular by analysis and fin shape curved by weight is better. By observing the results, using circular fins the heat lost is more, efficiency and effectiveness is also more.

Prof. Arvind S. Sorathiya, Hiren P. Hirpara, Prof. Dr. P.P. Rathod, have found out that heat release from the cylinder did not improve when the cylinder had more fins and too narrow a fin pitch at lower wind velocities, because it is difficult for the air flow into the narrower space between fins, so temperature between them increased. Optimized fin pitches with the greatest effective cooling are at 20mm for non-moving and 8mm for moving. Heat transfer rate increase in permeable fins of same dimension solid fins. Material cost of fins are lesser 10-30% in permeable fins as compared to solid fins for same heat transfer rate.

Ajay Sonkar, Ishwar Singh Rajput, Jageshwar Dhruv, Kishor Kumar Sahu, have noticed that temperature of Fin with extensions increases about 2 % to 3% as compare to fin without extensions. Fin with extensions provide near about 4 % to 13% more enhancement of heat transfer as compare to fin without extensions. Heat transfer through fin with trapezoidal extensions higher than that of fin with other types of extensions. By providing extensions in fin there is no improvement in thermal flux. From analysis we have got that the thermal flux decreases with extensions. In this thesis, we concluded that using extension in fins surface is having better heat transfer rate as compared to normal fin.

Ramesh Kumar. A, Nandha Kumar. S, Department of Mechanical Engineering, Sona College of Technology, have realized from the results it is very clear that the use of fin with extensions, provides both effective and efficient heat transfer. Fin with extensions provide near about 5% to 13% more in enhancement of heat transfer as compared to fin without extensions. Heat transfer through fin with rectangular extensions higher than that of fin with other type of extensions. Temperature at end of fin with rectangular extensions is minimum as compared to fin with other types of extensions. The effectiveness of fin with rectangular extensions greater than other extensions.

Bassam A/K Abu-Hijleh, 2003, numerically investigated problem of cross flow forced convection heat transfer from a horizontal cylinder with multiple, equally spaced, high conductivity permeable fins on its outer surface. The heat transfer characteristics of cylinder with permeable and solid fins were studied with different parameters like number of fins, and fins heights with wide range of Reynolds number (5-200). From this study it has been observed that permeable fins offered much higher Nusselt number than the solid fins under the same operating condition. Permeable fins resulted in much larger aerodynamic and thermals wakes which significantly reduced the effectiveness of the downstream fins, especially at ɵ<90°. A single long permeable fin tended to offer the best convection heat transfer from a cylinder. This has great practical implications in terms of weight and cost of fins needed to achieve a certain level of heat transfer enhancement.

Fernando Illán et al, 2010, in his paper heat transfer from cylinder to air of two stroke internal combustion finned engine has been simulated. For this purpose, a 2D model has been done. Starting from the geometry of a real engine, annular cylindrical and spherical symmetric walls to fins has been used to obtain an equivalent simplified geometry, where the heat transfer rate is the same as that in the real engine. The cylinder body, cylinder head (both provided with fins), and piston have been numerically analysed and optimized in order tominimize engine dimensions. The maximum temperature admissible at the hottest point of the engine has been adopted as the limiting condition.

Ashok Tukaram Pise, 2010, in his paper natural convection heat transfer from solid and permeable fins are investigated by experimental analysis. Permeable fins are formed by modifying the solid rectangular fins with drilling three holes per fins inline at one half lengths of the fins of two-wheeler cylinder block. Engine cylinder blocks having solid and permeable fins were tested for different inputs like 75W, 60W, 45W, 30W and 15W.

They had derived following observations from their experimental works:

- Temperature profile shows that the base temperatures of solid fins are more elevated as compared to permeable fins. Also, the tip temperatures of solid fins are more elevated as compared to permeable fins. It means that heat transfer rate is more in permeable fins as compared to the solid fins.
- The average heat transfer coefficient and the ratio of heat transfer coefficient of the cylinder with permeable fins to the cylinder with solid fins have been increased by significance value.
- There is reduction in area due to which material cost are less about 10-30%.

2. METHODOLOGY

2.1. Cylinder Temperature Heat Distribution

Whenever a moving gas comes into contact with a wall, there exists a relatively stagnant gas layer which acts as a thermal insulator. The resistance of this laver heat flow is quite high. Heat transfer from the cylinder gases takes place through the gas layer and through the cylinder walls to the cooling medium. A large temperature drop is produced in the stagnant layer adjacent to the walls. The peak cylinder gas temperature may be 2800 K while the temperature of the cylinder inner wall surface may be only 450 K due to cooling. Heat is transferred from the gases to the cylinder walls when the gas temperature is higher than the wall temperature. The rate and direction of flow of heat varies depending upon the temperature differential. If o cooling is provided, there could be no heat flow, so that the whole cylinder wall would soon reach an average temperature of the cylinder gases. By providing adequate cooling, the cylinder wall temperature can be maintained at optimum level.

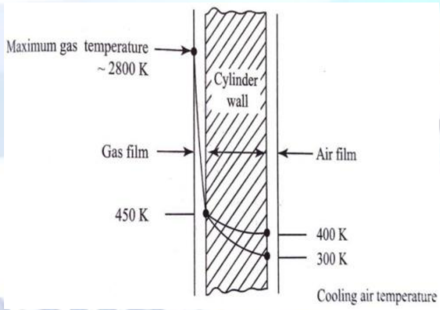

Fig.2.1. Cylinder wall temperature of a properly cooled cylinder

2.2. Heat Tranfer

Heat transfer occurs when there is a pressure difference. As a result of combustion, high temperatures are produced, inside the engine cylinder. Considerable heat flow occurs from the gases to the surrounding metal walls. In addition to this the shearing of the oil film (separating the bearing surfaces) transforms available energy into internal energy of the oil film. This increases the temperature of oil film and results in heat transfer from the oil to the bearing surfaces. However, the heat transfer on this account is quite small. Hence, the cylinder walls must be adequately cooled to maintain safe operating temperatures in order to maintain the quality of the lubricating oil. Heat transfer from gases to the cylinder walls may occur predominantly by convection and radiation whereas the heat transfer through the cylinder wall occurs only by conduction. Heat is ultimately transferred to the cooling medium by all the three modes of heat transfer.

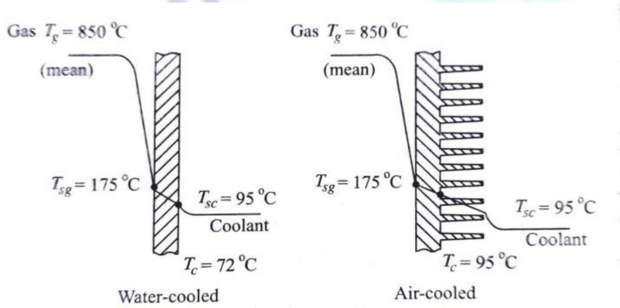

Fig.2.2. Temperature profile across cylinder

In this case, Tg, is the mean gas temperature which may be as high as 850 °C. This may not be confused with the peak temperature of the cycle which may be two or three times this value. Largest temperature drop, however, occurs in the boundary-layer of the gas which lies adjacent to the cylinder wall. There is a corresponding boundary-layer in the cooling medium on the outer side of the cylinder. However, because of fins in the air-cooled engines the effect of external boundary-layer is reduced. The conduction of heat through cylinder walls with corresponding temperature gradients is illustrated in Fig.13.5 The gas film, being of low conductivity, offers a relatively high resistance to the heat flow, whilst on the water jacket side there is usually a layer of corrosion products, scale etc., which are poor conductors of heat. The least resistance to the heat flow occurs through the metal cylinder wall, as shown by temperature gradient there. In actual practice because of the cyclic operation of engines, there is a cyclic variation of the gas temperature within the cylinder the effect of which is to cause a wave of heat to travel into the metal which gradually dies out and after the warm-up period a steady flow condition prevails. It has been experimentally established that in internal combustion engines the cyclic temperature variations die out fast before the fluctuations reach the outside surface of the cylinder.

2.3. HEAT TRANSFER FROM FINNED SURFACES

The rate of heat transfer from a surface at a temperature Ts to the surrounding medium at $T\infty$ is given by Newton's law of cooling as $Qconv = hAs(Ts - T\infty)$ where As is the heat transfer surface area h is the convection heat transfer coefficient. When the temperatures Ts and T` are fixed by design considerations, as is often the case, there are two ways to increase the rate of heat transfer: to increase the convection heat transfer coefficient h or to increase the surface area As. Increasing h may require the installation of a pump or fan, or replacing the existing one with a larger one, but this approach may or may not be practical. Besides, it may not be adequate. The alternative is to increase the surface area by attaching to the surface extended surfaces called fins made of highly conductive materials such as aluminium. Finned surfaces are manufactured by extruding, welding, or wrapping a thin metal sheet on a surface. Fins enhance heat transfer from a surface by exposing a larger surface area to convection and radiation.

2.4. FIN EFFECTIVENESS

Fins are used to enhance heat transfer, and the use of fins on a surface cannot be recommended unless the enhancement in heat transfer justifies the added cost and complexity associated with the fins. In fact, there is no assurance that adding fins on a surface will [17] enhance heat transfer. The performance of the fins is judged on the basis of the enhancement in heat transfer relative to the no-fin case. We can draw several important conclusions from the fin effectiveness relation above for consideration in the design and selection of the fins: • The thermal conductivity k of the fin material should be as high as possible. Thus, it is no coincidence that fins are made from metals, with copper, aluminium, and iron being the most common ones. Perhaps the most widely used fins are made of aluminium because of its low cost and weight and its resistance to corrosion. • The ratio of the perimeter to the cross-sectional area of the fin p/Ac should be as high as possible. This criterion is satisfied by thin plate fins and slender pin fins. • The use of fins is most effective in applications involving a low convection heat transfer coefficient. Thus, the use of fins is more easily justified when the medium is a gas instead of a liquid and the heat transfer is by natural convection instead of by forced convection. Therefore, it is no coincidence that in liquid-to-gas heat exchangers such as the car radiator, fins are placed on the gas side.

2.5. PROPER LENGTH OF THE FIN

An important step in the design of a fin is the determination of the appropriate length of the fin once the fin material and the fin cross section are specified. You may be tempted to think that the longer the fin, the larger the surface area and thus the higher the rate of heat transfer. Therefore, for maximum heat transfer, the fin should be infinitely long. However, the temperature drops along the fin exponentially and reaches the environment temperature at some length. The part of the fin beyond this length does not contribute to heat transfer since it is at the temperature of the environment. Therefore, designing such an "extra-long" fin is out of the question since it results in material waste, excessive weight, and increased size and thus increased cost with no benefit in return (in fact, such a long fin will hurt performance since it will suppress fluid motion and thus reduce the convection heat transfer coefficient). Fins that are so long that the temperature approaches the environment temperature cannot be recommended either since the little increase in heat transfer at the tip region cannot justify the disproportionate increase in the weight and cost. To get a sense of the proper length of a fin, we compare heat transfer from a fin of finite length to heat transfer from an infinitely long fin under the same conditions.

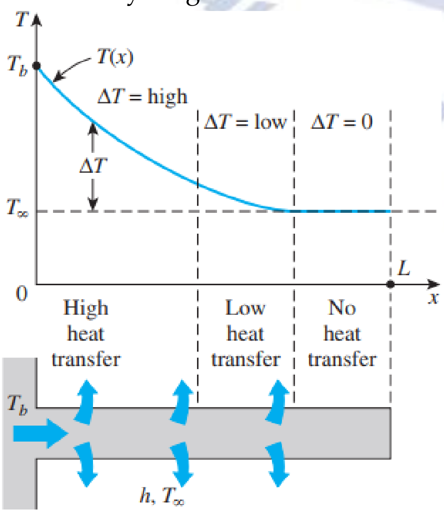

Fig.2.3. Temperature profile along the fin

A common approximation used in the analysis of fins is to assume the fin temperature to vary in one direction only (along the fin length) and the temperature variation along other directions is negligible. Perhaps you are wondering if this one-dimensional approximation is a reasonable one. This is certainly the case for fins made of thin metal sheets such as the fins on a car radiator, but we couldn't be so sure for fins made of thick materials.

3. MATERIAL SELECTION AND DESIGN SPECIFICATION

3.1. MATERIAL SELECTION

The best material to select for fins would be the one with the highest thermal conductivity and appropriate thickness to ensure maximum heat transfer rates. Material thermal resistance, corrosion resistance and material weight are also important factors, especially at high temperatures.

MATERIAL 1: ALUMINIUM 6061

6061 is a precipitation-hardened aluminium alloy, containing magnesium and silicon as its major alloying elements. Originally called "Alloy 61S", it was developed in 1935. It has good mechanical properties, exhibits good weldability, and is very commonly extruded (second in popularity only to 6063). It is one of the most common alloys of aluminium for general-purpose use.

6061 is commonly used for the following:

• construction of aircraft structures, such as wings and fuselages, more commonly in homebuilt aircraft than commercial or military aircraft. 2024 alloy is somewhat stronger, but 6061 is more easily worked and remains resistant to corrosion even when the surface is abraded, which is not the case for 2024, which is usually used with a thin Alclad coating for corrosion resistance.

• yacht construction, including small utility boats.

• automotive parts, such as the chassis of the Audi A8 and the Plymouth Prowler.

• flashlights

• aluminium cans for the packaging of food and beverages.

1. Density: 2700 $kg/m3$
2. Specific heat: 897 J/kgK
3. Thermal conductivity: 172 W/mK

MATERIAL 2: ALUMINIUM 2024

2024 aluminium alloy is an aluminium alloy, with copper as the primary alloying element. It is used in applications requiring high strength to weight ratio, as well as good fatigue resistance. It is weldable only through friction welding, and has average machinability. Due to poor corrosion resistance, it is often clad with aluminium or Al-1Zn for protection, although this may reduce the fatigue strength. In older systems of terminology, 2XXX series alloys were known as duralumin, and this alloy was named 24ST.

2024 is commonly extruded, and also available in alclad sheet and plate forms. It is not commonly forged.

1. Density: 2780 $kg/m3$
2. Specific heat: 874 J/kgK
3. Thermal conductivity: 153 W/mK

MATERIAL 3: ALUMINIUM NITRIDE

Aluminium nitride (AlN) is a solid nitride of aluminium. It has a high thermal conductivity of up to 321 W/mK and is an electrical insulator. Its wurtzite phase (w-AlN) has a band gap of ~6 eV at room temperature and has a potential application in optoelectronics operating at deep ultraviolet frequencies.

Among the applications of AlN are

- opto-electronics,
- dielectric layers in optical storage media,
- electronic substrates, chip carriers where high thermal conductivity is essential,
- military applications,
- as a crucible to grow crystals of gallium arsenide,
- steel and semiconductor manufacturing.

1. Density: 3255 $kg/m3$
2. Specific heat: 740 J/kgK
3. Thermal conductivity: 321 W/mK

MATERIAL 4: ALUMINIUM 2014

It is easily machined in certain tempers, and among the strongest available aluminium alloys, as well as having high hardness. However, it is difficult to weld, as it is subject to cracking.

2014 is the second most popular of the 2000-series aluminium alloys, after 2024 aluminium alloy. It is commonly extruded and forged. The corrosion resistance of this alloy is particularly poor. To combat this, it is often clad with pure aluminium. If unclad 2014 aluminium is to be exposed to the elements, it should be painted as a corrosion protection measure. Prior to the adoption of The Aluminium Association alloy designations in 1954, 2014 was known by the industry conventional designation "14S".

1. Density: 2800 $kg/m3$
2. Specific heat: 870 J/kgK
3. Thermal conductivity: 192 W/mK

3.2. DESIGN SPECIFICATIONS

Prof. Arvind S. Sorathiya, Hiren P. Hirpara, Prof. Dr. P.P. Rathod, in their report named "An Effect of Different Parameters of Fins on Heat Transfer of IC Engine- Review Study" have done an extensive research on different motorcycles available in India. From that report, we have taken the fin parameters of Honda CB Shine engine.

ModelName	HondaCB Shine
CC	125
Bore	50 mm
Stroke	63 mm
No.offins on the engine	6

Finpitch	10 mm
Fin thickness	1.5 mm
Positionoffin w.r.ttocylinder	Perpendicular
MaxFin length	20 mm

4. INTRODUCTIONTOSOLIDWORKS

The SOLIDWORKS® CAD software is a mechanical design automation application thatlets designers quickly sketch out ideas, experiment with features and dimensions, and producemodelsand detailed drawings.

SOLIDWORKSisamoderncomputeraideddesign(CAD)program.Itenablesdesigners to create a mathematically correct solid model of an object that can be stored in adatabase.Whenthemathematicalmodelofapartorassemblyisassociatedwiththeproperties of the materials used, we get a solid model that can be used to simulate and predictthebehaviourofthepartormodelwith finiteelementandothersimulationsoftware.Thesame solid model can be used to manufacture the object and also contains the informationnecessary to inspect and assemble the product. The marketing organization can produce salesbrochuresandvideosthatintroducethe producttopotentialcustomers.SolidWorks andsimilar CAD programs have made possible concurrent engineering, where all the groups thatcontributeto theproductdevelopment process canshareinformation real-time.

DIFFERENTMODESINSOLIDWORKS

1. PARTMODE

The part mode is very first and basic mode of SolidWorks in which a 3D model iscreated. To create any design, you have to sketch from sketching environment. First, you needtoselectsketchingplanetocreatesketchforthebasefeature.Threedefaultplanesareprovided named as Front Plane, Top Plane and Right Plane. After completion of drawingsketches,youcangiveproperdimensionsandapplytherequiredrelationsinthesamesketching environment. The Sheet Metal and Surface Modelling tools are also present in thismode for special design of the part. You can create core and cavity in the part mode by usingmould design tools and also design welded structures in this mode by using related tools. Youcananalysethepartmodel forvarious stressesapplied toit inthe realphysicalconditions by usingtoolcalledSimulationXpress.Ithelpsyoutoreducethecostandtimeintestingyourdesignin real physical testing conditions.

2. ASSEMBLYMODE

In Assembly Mode, the assembly is created by assembling the components created earlierin the part mode to form complete model. You can also create model by creating parts in theassembly mode. Assembly is created by mating relations between parts. These relations aretermedas Matetool.

In Assembly Mode, after assembling the components you can also animate the modelwith the use of Motion Study Tab. The Evaluate Command Manager Tab is provided in theassembly mode. This mode consists of tools like measure, Collision Detection, InterferenceChecking etc. In Motion Study Tab we can assign motors, actuators, force and gravity to thecomponents and can physically simulate the motion of an assembly with different graphs andresults.

3. DRAWINGMODE

The Drawing Mode is used for the detailing of any created part or assembly. All thedetailing or documentation is done in 2D format in this mode. The documentation consists ofdifferent drawing views and the details in the drawing views. You can detail all the views bysimply dragging and dropping parts or assemblies that you created in Part Mode or AssemblyMode. Drawing Mode provides all the tools required to generate and modify the drawingviewsand add dimensions and annotations to them.

SolidWorkshasaproperty of Bi-directionalAssociativity,which givesmajor advantage tothis software. As this property ensures that any change in the dimensions of a part in thedrawing view will lead to the change in the design of part in the part as well as intheassemblymode, and vice versa.

USESOFSOLIWORKS

1. This can help's the product designers to convert new product ideas into reality.

2. This can increase the productivity without lowering the cost, because it gives various data and technical communication, which helps to your design and helps to validate with standards.

3. It contains simulation technology, which enables to verify your design.

4. It contains basic parts or data of standard bolt and nut, gears, cams, bearings etc. These are the product design interface and are capable of 3D solid modelling, Conceptual design, Assembly structure planning, direct model editing, large assembly design, advanced surface design, sheet metal design, weldments, Plastic parts designing, CAD productive tools, Reverse engineering, Mould designing, Piping & tubing and electrical cable harness conduit designs.

DIFFERENTFEATURESINSOLIDWORKS

1. **Extruded Boss Feature:** The Extruded Boss is the most basic of all SOLIDWORKSfeatures,and extrudes asketchalong a straight-linepathto add material.

2. **Fillet Feature:** Fillets are classified as applied features, and as such do not require a sketchto be used. Fillets serve to round off edges and/or corners by adding or removing material,depending on whether the edge is internal or external. It should be noted that fillets ofdifferent sizes must be created as separate features. Typically, it is best practice to create thelargestfillets first, and follow with smaller fillets.

3. **Shell Feature:** The Shell command allows you to define a wall thickness and automaticallyhollow the part, while allowing faces to be removed as needed. If no faces are specified to beremoved during a Shell feature, the part will be hollow, but this can only be seen by creating acrosssection ofthe part.

4. **Extruded Cut Feature:** Using the Extruded Boss/Base model created in the ExtrudedBoss/Baseblog,wewillmodify the3D blockto includeacirclefeaturebyremovingmaterial.

5. **Revolve Boss Feature:** Revolves add or remove material by revolving one or more profilesaround a centreline. You can create revolved boss/bases, revolved cuts, or revolved surfaces.Therevolvefeaturecan beasolid, a thin feature, or asurface.

Swept Boss Feature: Sweep creates a base, boss, cut, or surface by moving a profile(section) along a path. A sweep can be simple or complex. To generate the sweep geometry,thesoftwarecreatesaseriesofintermediatesecti onsmadebyreplicatinga profileatvariouspositionsalong thepath.Theintermediatesectionsarethen blendedtogether. Additional parameters can be included in the sweep feature such as guide curves, profile orientationoptions,and twist to create awidevariety of shapes.

6. **Loft Feature:** Loft creates a feature by making transitions between profiles. A loft can be abase,boss, cut, orsurface.

You create a loft using two or more profiles. Only the first, last, or first and last profiles canbe points. All sketch entities, including guide curves and profiles, can be contained in a single3Dsketch.

7. **Mirror Feature:** Mirror copies the selected features or all features, mirroring them about theselectedplaneor face.

8. **Pattern Feature:** Pattern repeats the selected features in an array based on a seed feature.Youcan createalinearpattern, acircularpattern,acurvedriven pattern,a fillpattern, orusesketchpoints or table coordinates to create thepattern.

a. **Curve Driven Patterns:**

The Curve Driven Pattern tool allows you to create patternsalong a planar or 3D curve. To define the pattern, you can use any sketch segment, orthe edge of a face (solid or surface), that lies along the plane. You can base yourpatternonan opencurve,or onaclosedcurve, such as acircle.

b. **Linear Patterns:**Use linear patterns to create multiple instances of one or morefeaturesthat you canspaceuniformly alongone or twolinear paths.

c. **Circular Patterns:**Use circular patterns to create multiple instances of one or morefeaturesthat you can spaceuniformly aroundan axis.

Sketch Driven Patterns: Using sketch points within a sketch, you can specify a featurepattern. The seed feature propagates throughout the pattern to each point in the sketch.Youcan usesketchdriven patternsfor holes orother featureinstances.

MODELLING

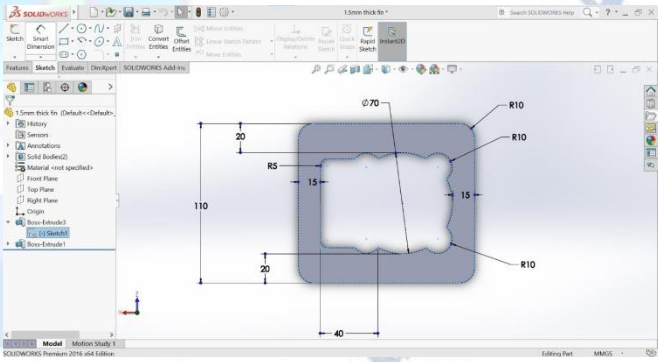

Fig.4.1.Model ofFin withathickness of1.5 mm

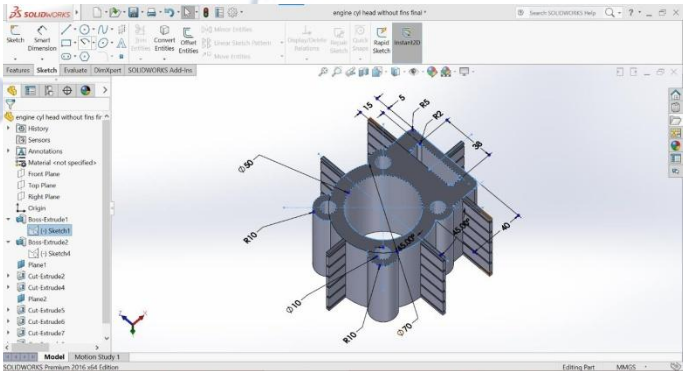

Fig.4.2.Modelof CylinderBlock

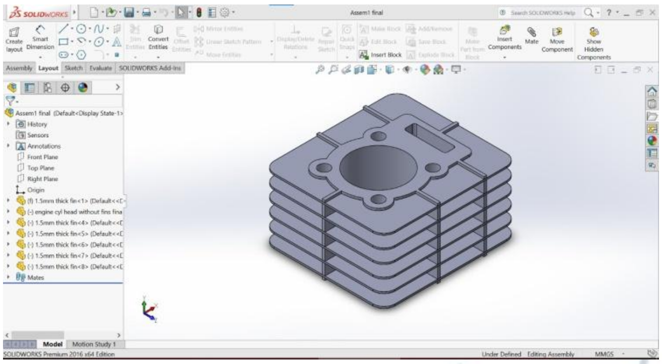

Fig.4.3.Modelof Cylinderblock withfins

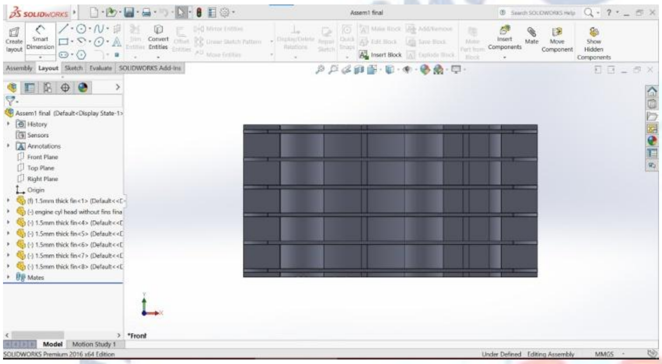

Fig.4.4.Front view ofmodel of Cylinderblock with fins

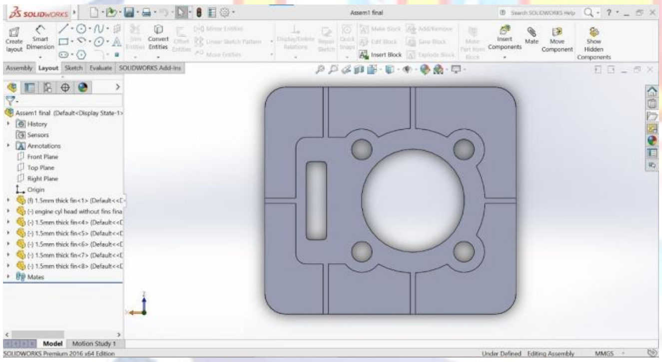

Fig.4.5.Top view ofmodel of Cylinderblock with fins

5. ANALYSIS OF IC ENGINE CYLINDER BLOCK WITH FINS USING ANSYS

5.1. INTRODUCTION TO ANSYS

Ansys is general purpose finite element analysis (FEA) software package. Finite element numerical method of a deconstructing a complex system into very small pieces (user designated size) called element. The software implements equations that governs the behaviour of these elements and solver them all; creating a comprehensive explanation of how the system acts as a whole. These results than can be presented in tabulate or graphical forms. This type of analysis is typically used for the designed and optimization of system for too complex to analyse by hand. Systems that make fir into this category are too complex due to their geometry, or governing equations. Ansys is the standard FEA teaching tool within the engineering department at many colleges. Ansys is also used in civil and Electrical engineering, as well as physics and chemistry department

Ansys provide a cost-effective way to explore the performance of the products and processes in a virtual environment. This type of product development is termed as virtual Prototyping. With virtual prototyping techniques users can iterate various scenarios to optimize the product long before manufacturing is started. This enables a reduction in level of risk, And in the cost of ineffective designs. The multifaceted nature of Ansys also provides a means of ensure that users are able to see the effect of designs on the whole behaviour of the product, be it electromagnetic, thermal, mechanical etc.

5.2. TYPES OF ENGINEERING ANALYSIS

STUCTURAL analysis consists of linear and non-linear models. Linear models use simple parameters and assume that material is not plastically deformed. Non- linear models consist of stressing the materials past its elastic capacities. The stresses in material then vary with amount of deformation as in.

VIBRATIONAL analysis is used to test a material against random vibrations, shock and impact. Each of these incidents may act on the natural vibrational frequency of material which in turn may cause resonance and subsequent failure.

FATIGUE analysis helps designers to predict the life of the materials or structure by showing the effects of cyclic loading on the specimen. Such analysis can show the areas where crack propagation is most likely occurred. Failure due to fatigue may also show the damage tolerance of the material.

HEAT TRANSFER analysis models the conductivity or thermal fluid dynamics of the material or structure. This may consist of steady state or transient transfer. Steady state transfer refers to constants thermo properties in the material that yield linear heat diffusion.

5.3 GENERIC STEPS TO SOLVING ANY PROBLEMIN ANSYS

Likesolvinganyproblemanalytically,youneedtodefine

(1) Yoursolution domain,
(2) Thephysicalmodel,
(3) Boundaryconditionsand
(4) Thephysicalproperties.

Youthen solvethe problem andpresent theresults.

In numerical methods, the main difference in an extra step called mesh generation. This is thestep that divides the complex model in to small elements that become soluble in an otherwisetoo complex situation. Below describes the process in terminology. Slightly more attune toothesoftware.

1. BUILD GEOMETRY Construct a 2 or 3–D representation of the objectto be modelledandtested using the workplanecoordinates system in Ansys.
2. DEFINEMATERIALPROPERTIESNowthattheparte xists,definealibraryofnecessary materials that composed an object (or project) being modelled. This includesthermaland mechanicalproperties.
3. GENERATE MESH At this point Ansys understands the makeup of the part. Now definehowthemodel system should be broken down into finitepieces.
4. APPLY PRESSURE Once the system is fully designed, the last task is to burden thesystemwith constraints, suchas physical loadingsor boundary conditions.
5. OBTAIN SOLUTION This is actually a step because Ansys need to understand withinwhatstate (steadystate, transient…etc.)Theproblemmust besolved.
PRESENTTHERESULTSAfterthesolutionhasbeeno btainedtherearemanywaystopresentAnsys results,Choosefrom manyoptions such astables, graphs andcontour lots.

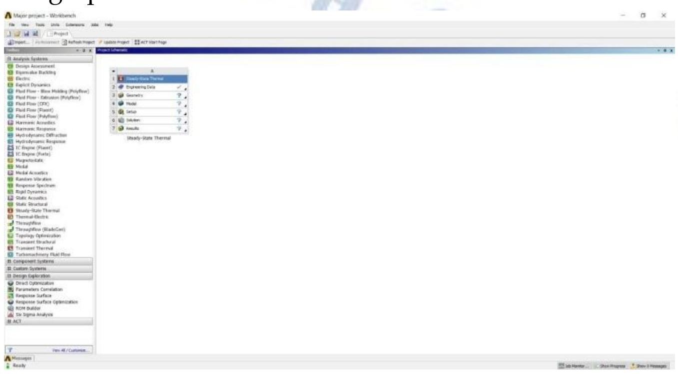

Fig.5.1. ANSYS 19.2 Interface

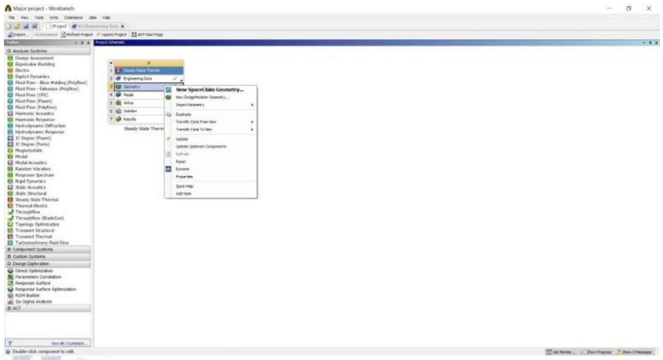

Fig.5.2. Importing Geometry from SOLIDWORKS 2016

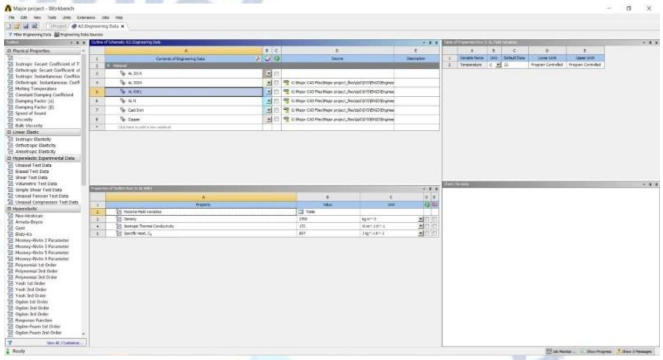

Fig.5.3. Adding materials from Engineering Data Sources

5.4. MESHED MODEL

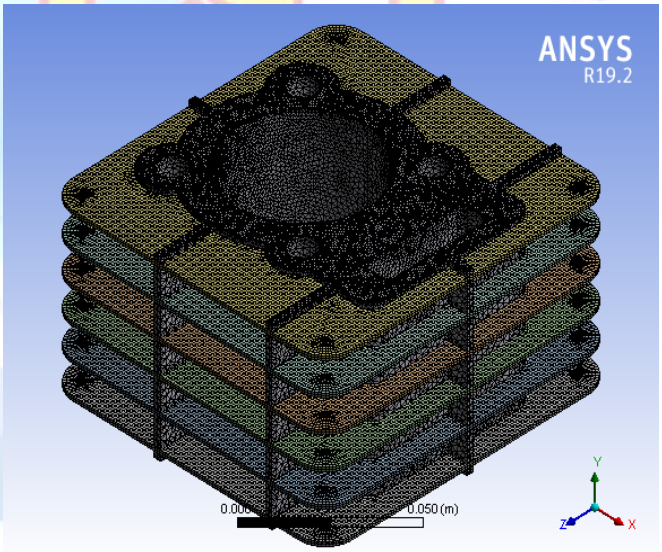

Fig.5.4. Meshed model of Cylinder block with fins

Meshing Parameters:

Element size: 1 mm

Edge sizing: 0.5 mm

Nodes: 648888

Elements: 203727

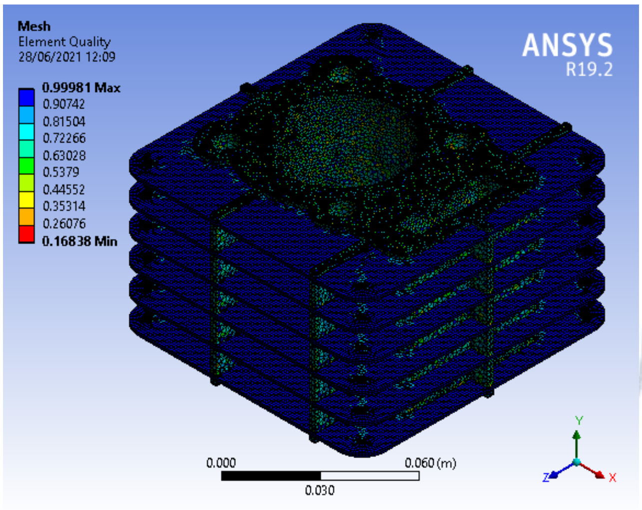

Fig.5.5. Element quality of the Mesh

5.5. ANALYSIS RESULTS MATERIAL 1: ALUMINIUM 6061

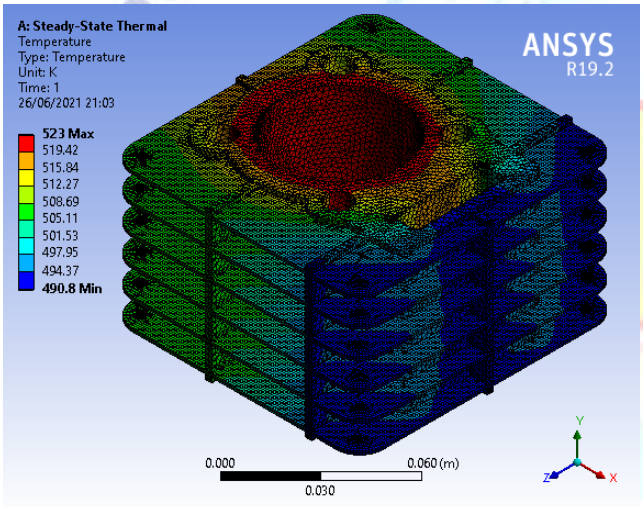

Fig.5.6. Temperature distribution of AL6061

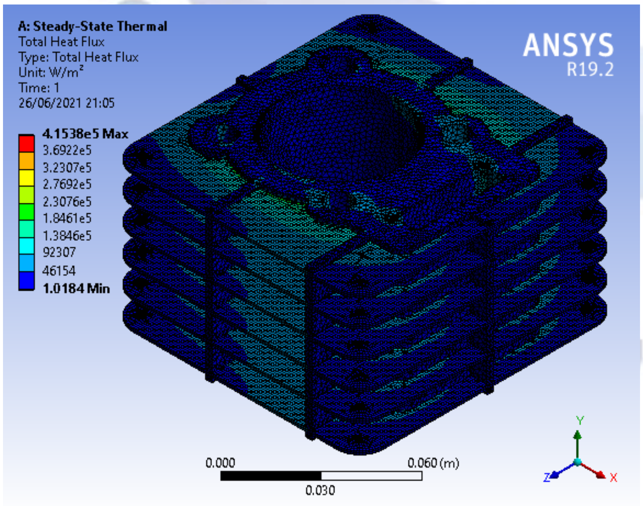

Fig.5.7. Total heat flux distribution of AL6061

MATERIAL 2: ALUMINIUM 2024

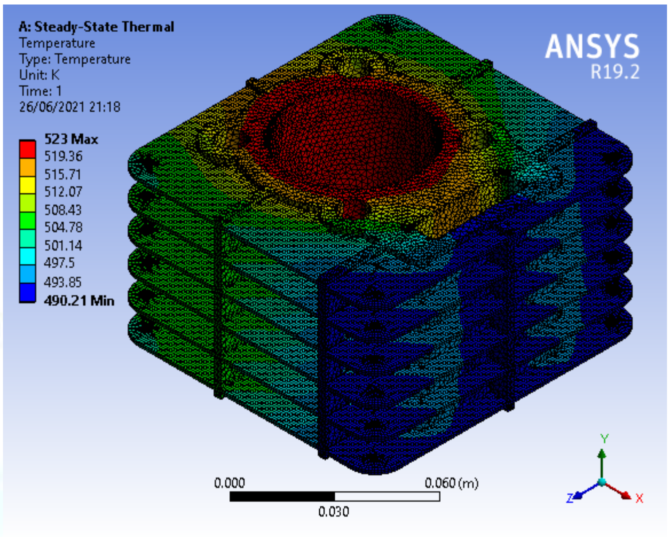

Fig.5.8. Temperature distribution of AL2024

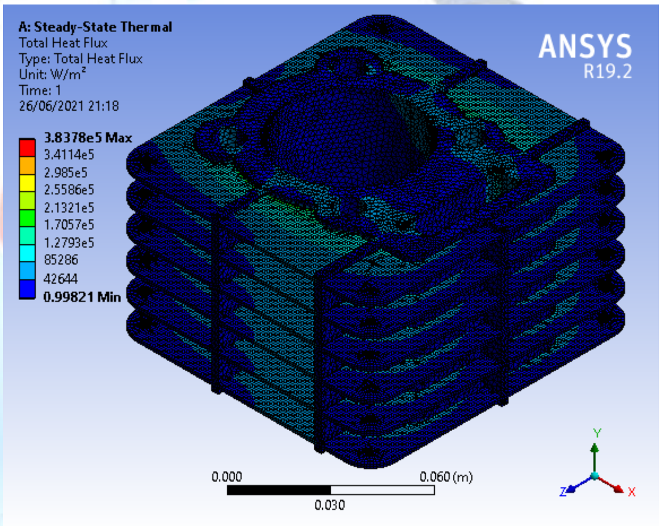

Fig.5.9. Total heat flux distribution of AL2024

MATERIAL 3: ALUMINIUM NITRIDE

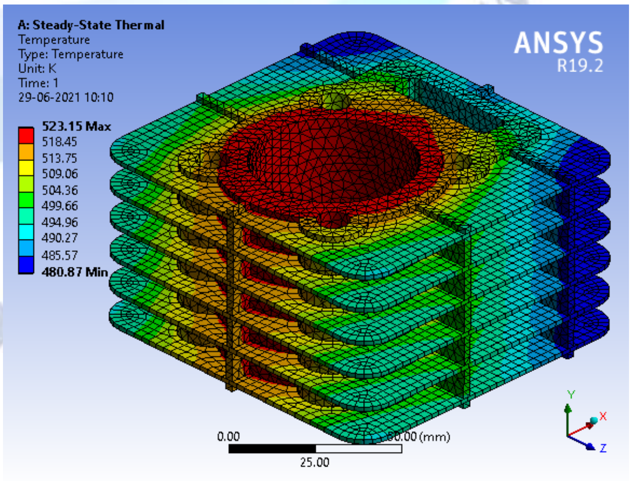

Fig.5.10. Temperature distribution of ALN

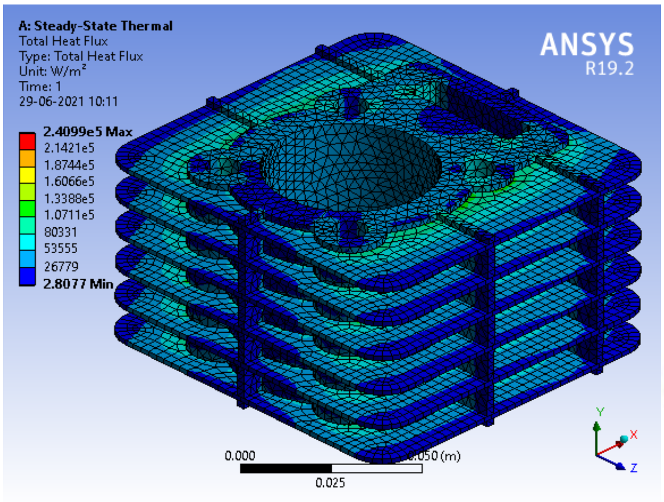

Fig.5.11. Total heat flux distribution of ALN

MATERIAL 5: ALUMINIUM 2014

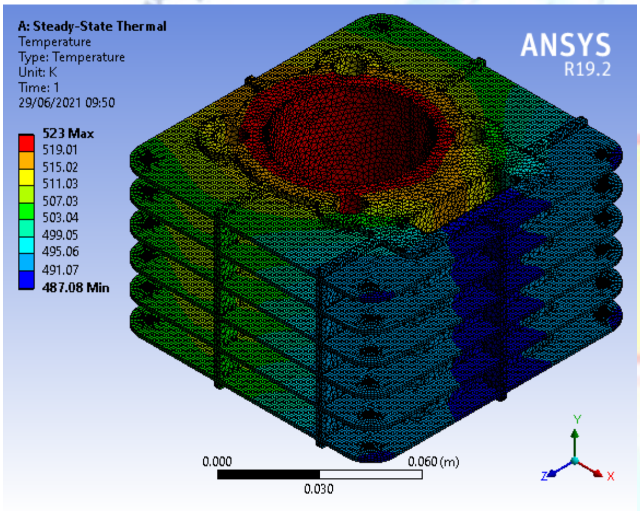

Fig.5.12. Temperature distribution of AL2014

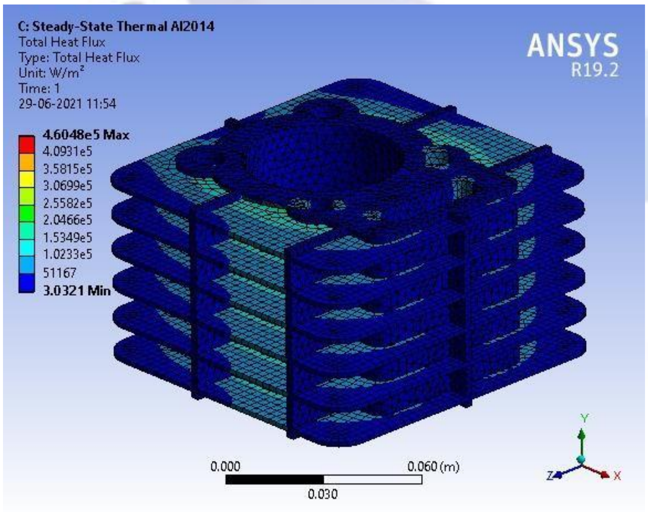

Fig.5.13. Total heat flux distribution of AL2014

6: CONCLUSION

6.1. Conclusion

In this project work, design and analysis of the temperature distribution and heat flux distribution of IC engine cylinder block with fins is done. Four materials are selected for the fins and analysed each material by applying it on the fins. We have selected cylinder material as cast iron. The model is designed in SOLIDWORKS 2016 and the analysis is done by using ANSYS 19.2 package.

When applied a temperature of 523 K, the material AL6061 showed a minimum temperature of 490 K, minimum heat flux of 1.0184 W/m2 and maximum heat flux of 4.1538 e5 W/m2. The material AL2024 showed a minimum temperature of 490.21 K, minimum heat flux of 0.99821 W/m2 and maximum heat flux of 3.8378 e5 W/m2. The material ALN showed a minimum temperature of 480.87 K, minimum heat flux of 2.8077 W/m2 and maximum heat flux of 2.4099 e5 W/m2. The material AL2014 showed a minimum temperature of 487.08 K, minimum heat flux of 3.0321 W/m2 and maximum heat flux of 4.6048 e5 W/m2.

From the analysis, we can say that the temperature is minimum for Aluminium Nitride and heat flux is minimum for Al2024. Since, the temperature is higher by 10 K and also the maximum heat flux is higher for Al2024 when compared to ALN we can say that

Aluminium Nitride is the most preferable material for fins on the IC engine cylinder block.

6.2. Acknowledgement

We would like to express our sincere gratitude to our project guide, Assistant Professor Dr N Madhan Mohan Reddy, Department of Mechanical Engineering, Anurag University for his guidance and tireless effort for co-operation during our entire period of project. We express our sincere thanks to him for patiently guiding us and encouraging the team

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