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# Modeling and Thermal Analysis of Engine Cylinder Fin Body by Varying Materials

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## ABSTRACT:

The Engine cylinder is one of the major automobile components, which is subjected to high temperature variations and thermal stresses. In order to cool the cylinder, fins are provided on the cylinder to increase the rate of heat transfer. By doing thermal analysis on the engine cylinder fins, it is helpful to know the heat dissipation inside the cylinder.The principle implemented in this project is to increase the heat dissipation rate by using the invisible working fluid, nothing but air. We know that, by increasing the surface area we can increase the heat dissipation rate, so designing such a large complex engine is very difficult. The main purpose of using these cooling fins is to cool the engine cylinder by air.The main aim of the project is to analyze the thermal properties by material and thickness of cylinder fins.

Parametric models of cylinder with fins have been developed to predict the thermal behavior. The models are created by the geometry, rectangular and also by varying thickness of the fins. Cooling fluids used in this thesis is air. The 3D modeling software used is Pro/Engineer. Thermal analysis is done on the cylinder fins to determine variation in temperature distribution. The analysis is using ANSYS. Presently Material used for manufacturing cylinder fin body is Aluminum Alloy 204 which has thermal conductivity of 110-150W/mk. In this thesis, the material for the cylinder fins is modified Aluminum alloy 7075, Cast Iron and Copper and analyzed for heat transfer rates compared with that of original material.

## 1. INTRODUCTION:

The internal combustion engine is an engine in which the combustion of a fuel (normally a fossil fuel) occurs with an oxidizer (usually air) in a combustion chamber. In an internal combustion engine, the expansion of the high-temperature and -pressure gases produced by combustion applies direct force to some component of the engine, such as pistons, turbine blades, or a nozzle. This force moves the component over a distance, generating useful mechanical energy.

## NECESSITY OF COOLING SYSTEM IN IC ENGINES:

It is seen that the quantity of heat given to the cylinder walls is considerable and if this heat is not removed from the cylinders it would result in the resignation of the charge. In addition, the lubricant would also burn away, thereby causing the seizing of the piston. Excess heating will also damage the cylinder material. Keeping the above factors in view, it is observed that suitable means must be provided to dissipate the excess heat from the cylinder walls, so as to maintain the temperature below certain limits. However, cooling beyond optimum limits is not desirable, because it decreases the overall efficiency due to the following reasons: Thermal efficiency is decreased due to more loss of heat to the cylinder walls. The vaporization of fuel is less; this results in fall of combustion efficiency. Low temperatures increase the viscosity of lubrication and hence more piston friction is encountered, thus decreasing the mechanical efficiency. Though more cooling improves the volumetric efficiency, yet the factors mentioned above result in the decrease of overall efficiency.

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Thus it may be observed that only sufficient cooling is desirable and any deviation from the optimum limits will result in the deterioration of the engine performance.

## AIR-COOLING:

Cars and trucks using direct air cooling (without an intermediate liquid) were built over a long period beginning with the advent of mass produced passenger cars and ending with a small and generally unrecognized technical change. Before World War II, water cooled cars and trucks routinely overheated while climbing mountain roads, creating geysers of boiling cooling water. This was considered normal, and at the time, most noted mountain roads had auto repair shops to minister to overheating engines. ACS (Auto Club Suisse) maintains historical monuments to that era on the Susten Pass where two radiator refill stations remain (See a picture here). These have instructions on a cast metal plaque and a spherical bottom watering can hanging next to a water spigot. The spherical bottom was intended to keep it from being set down and, therefore, be useless around the house, in spite of which it was stolen, as the picture shows.

During that period, European firms such as Magirus-Deutz built air-cooled diesel trucks, Porsche built air-cooled farm tractors, and Volkswagen became famous with air-cooled passenger cars. In the USA, Franklin built air-cooled engines. The Czechoslovakia based company Tatra is known for their big size air cooled V8 car engines,Tatra engineer Julius Mackerle published a book on it. Air cooled engines are better adapted to extremely cold and hot environmental weather temperatures, you can see air cooled engines starting and running in freezing conditions that stuck water cooled engines and continue working when water cooled ones start producing steam jets. The main aim of the project is to design cylinder with fins for a 150cc engine, by changing the geometry and thickness of the fins and to analyze the transient thermal properties of the fins.

Analyzation is also done by varying the materials of fins. Present used material for cylinder fin body is Aluminum alloy 201 which has thermal conductivity of 110 – 150 w/mk. Our aim is to change the material for fin body by analyzing the fin body with other materials and also by changing the geometry and also thickness. Geometry of fins – Rectangular, Circular and Curve Shaped Thickness of fins – 3mm and 2.5mm

Materials – Aluminum Alloy A204, Aluminum Alloy 7075, Cast Iron and Copper.

## COOLING SYSTEM OF IC ENGINES

### Overview

Heat engines generate mechanical power by extracting energy from heat flows, much as a water wheel extracts mechanical power from a flow of mass falling through a distance. Engines are inefficient, so more heat energy enters the engine than comes out as mechanical power; the difference is waste heat which must be removed. Internal combustion engines remove waste heat through cool intake air, hot exhaust gases, and explicit engine cooling. Engines with higher efficiency have more energy leave as mechanical motion and less as waste heat. Some waste heat is essential: it guides heat through the engine, much as a water wheel works only if there is some exit velocity (energy) in the waste water to carry it away and make room for more water. Thus, all heat engines need cooling to operate.

Cooling is also needed because high temperatures damage engine materials and lubricants. Internal-combustion engines burn fuel hotter than the melting temperature of engine materials, and hot enough to set fire to lubricants. Engine cooling removes energy fast enough to keep temperatures low so the engine can survive. Some high-efficiency engines run without explicit cooling and with only accidental heat loss, a design called adiabatic. For example, 10,000 mile-per-gallon "cars" for the Shell economy challenge are insulated, both to transfer as much energy as possible from hot gases to mechanical motion, and to reduce reheat losses when restarting.

Such engines can achieve high efficiency but compromise power output, duty cycle, engine weight, durability, and emissions.

## BASIC PRINCIPLES:

Most internal combustion engines are fluid cooled using either air (a gaseous fluid) or a liquid coolant run through a heat exchanger (radiator) cooled by air. Marine engines and some stationary engines have ready access to a large volume of water at a suitable temperature. The water may be used directly to cool the engine, but often has sediment, which can clog coolant passages, or chemicals, such as salt, that can chemically damage the engine. Thus, engine coolant may be run through a heat exchanger that is cooled by the body of water. Most liquid-cooled engines use a mixture of water and chemicals such as antifreeze and rust inhibitors. The industry term for the antifreeze mixture is *engine coolant*. Some antifreezes use no water at all, instead using a liquid with different properties, such as propylene glycol or a combination of propylene glycol and ethylene glycol.

Most "air-cooled" engines use some liquid oil cooling, to maintain acceptable temperatures for both critical engine parts and the oil itself. Most "liquid-cooled" engines use some air cooling, with the intake stroke of air cooling the combustion chamber. An exception is Wankel engines, where some parts of the combustion chamber are never cooled by intake, requiring extra effort for successful operation. There are many demands on a cooling system. One key requirement is that an engine fails if just one part overheats. Therefore, it is vital that the cooling system keep *all* parts at suitably low temperatures.

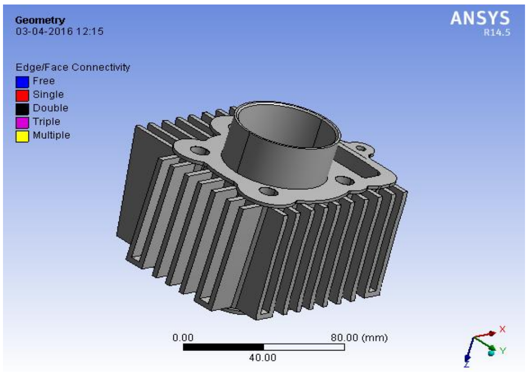
Liquid-cooled engines are able to vary the size of their passageways through the engine block so that coolant flow may be tailored to the needs of each area. Locations with either high peak temperatures (narrow islands around the combustion chamber) or high heat flow (around exhaust ports) may require generous cooling. This reduces the occurrence of hot spots, which are more difficult to avoid with air cooling.

Air cooled engines may also vary their cooling capacity by using more closely-spaced cooling fins in that area, but this can make their manufacture difficult and expensive. Only the fixed parts of the engine, such as the block and head, are cooled directly by the main coolant system. Moving parts such as the pistons, and to a lesser extent the crank and rods, must rely on the lubrication oil as a coolant, or to a very limited amount of conduction into the block and thence the main coolant.

High performance engines frequently have additional oil, beyond the amount needed for lubrication, sprayed upwards onto the bottom of the piston just for extra cooling. Air-cooled motorcycles often rely heavily on oil-cooling in addition to air-cooling of the cylinder barrels. Liquid-cooled engines usually have a circulation pump. The first engines relied on thermo-syphon cooling alone, where hot coolant left the top of the engine block and passed to the radiator, where it was cooled before returning to the bottom of the engine. Circulation was powered by convection alone.

## THERMAL ANALYSIS OF FIN BODY RECTANGULAR Case1 2.5 MM THICKNESSMATERIAL- ALUMINUM ALLOYS 204

## MODEL IMPORTED FROM PRO/ENGINEER

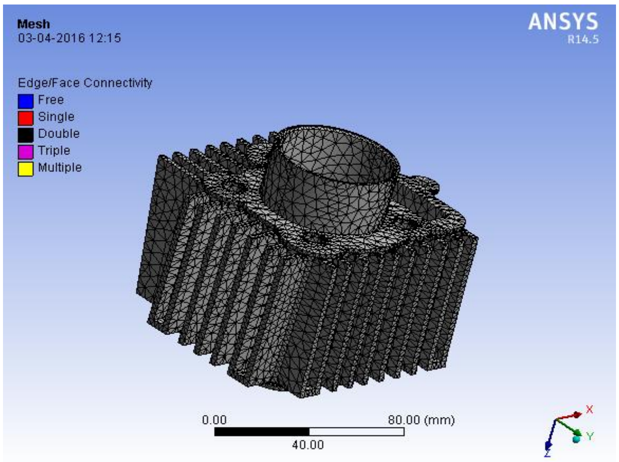



MATERIAL PROPERTIES:

Thermal Conductivity – 120 w/mk
Specific Heat – 0.963 J/g ºC

Density – 2.8 g/cc

MESHED MODEL




LOADS:

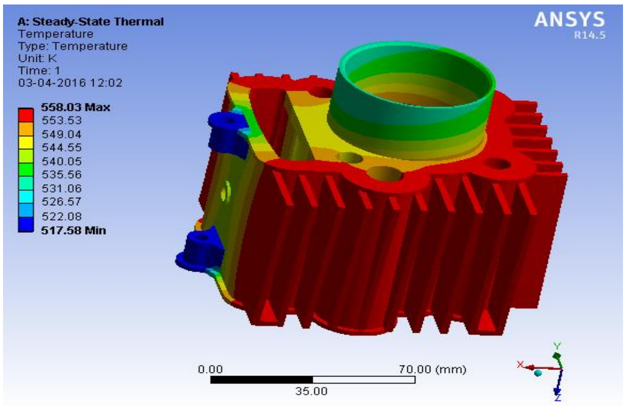
Temperature -558 K

Film Coefficient – 25 w/m$^2$ K

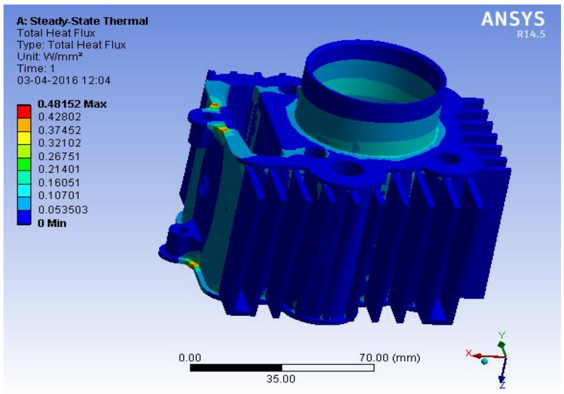
Bulk Temperature – 313 K

## RESULTS

## TEMPERATURE




## HEAT FLUX




## MATERIAL - ALUMINUM ALLOY 7075

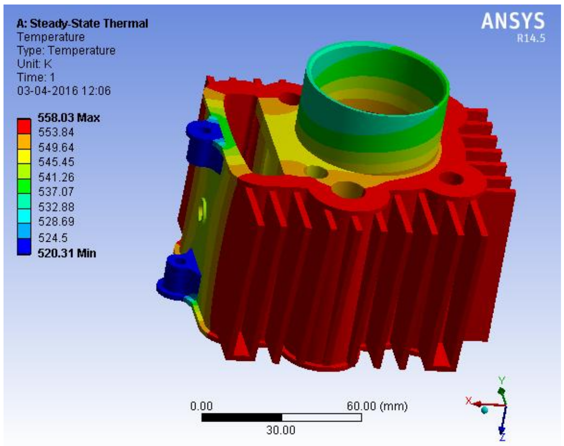
MATERIAL PROPERTIES:

Thermal Conductivity – 173 w/mk

Specific Heat – 0.960 J/g °C

Density – 2.81g/cc

## TEMPERATURE

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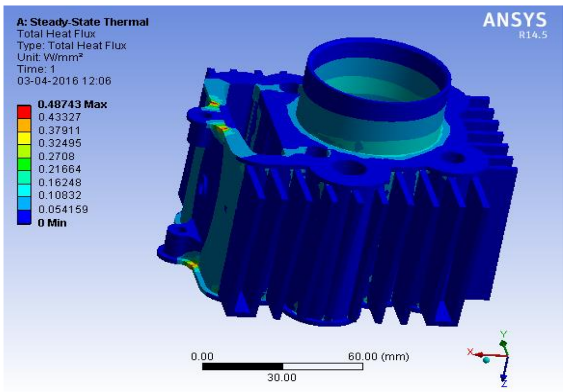

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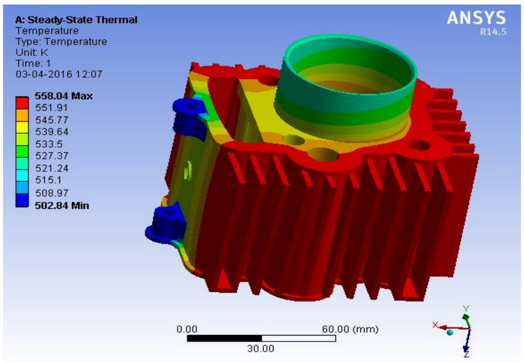
## MATERIAL- CAST IRON

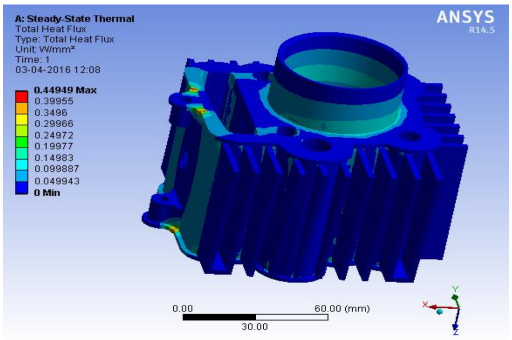
MATERIAL PROPERTIES:

Thermal Conductivity – 83 w/mk
Specific Heat 0.165 J/g °C
Density – 7.2 g/cc

## TEMPERATURE



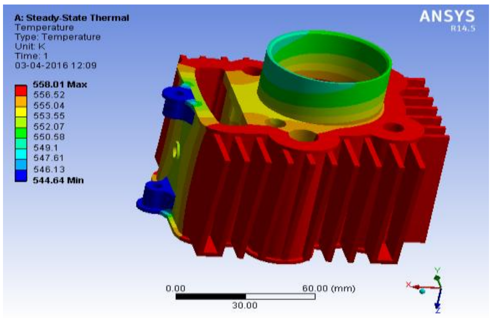

## HEAT FLUX



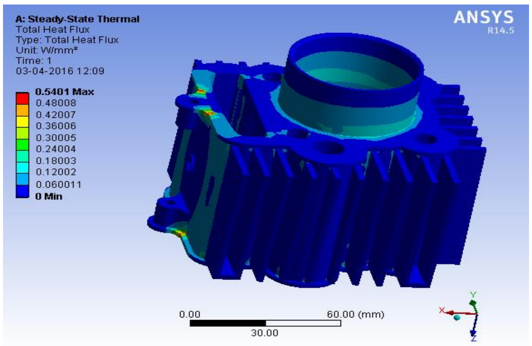

## MATERIAL- COPPER

MATERIAL PROPERTIES:
Thermal Conductivity – 400 w/mk
Specific Heat– 0.385 J/g °C
Density – 8.933 g/cc

## TEMPERATURE

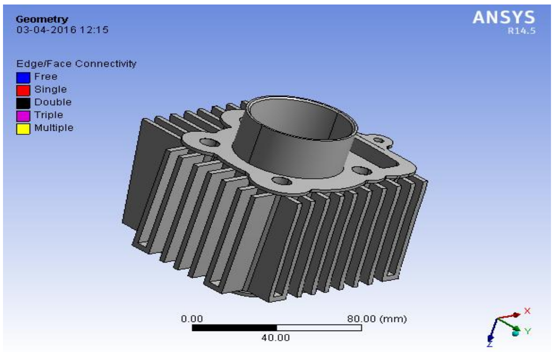



## HEAT FLUX

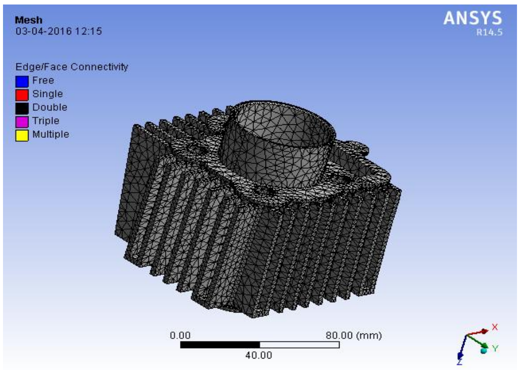



## CASE2 -3MM THICKNESS

## MODEL IMPORTED FROM PRO/ENGINEER




## MESHED MODEL




## MATERIAL- ALUMINUM ALLOY 204

## TEMPERATURE

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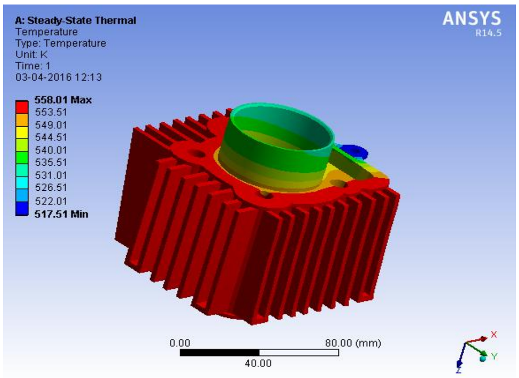
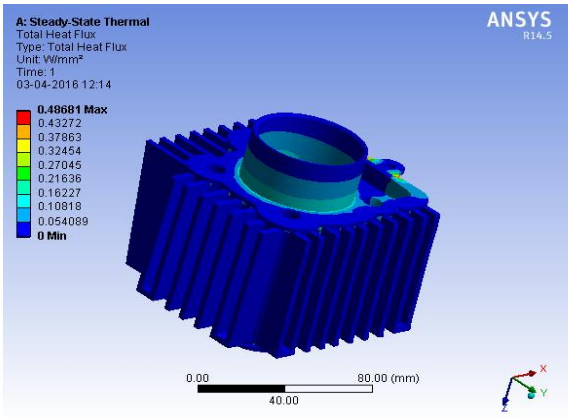
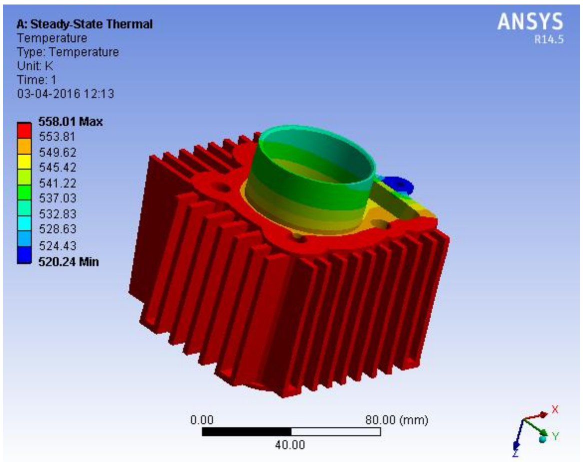



## HEATFLUX

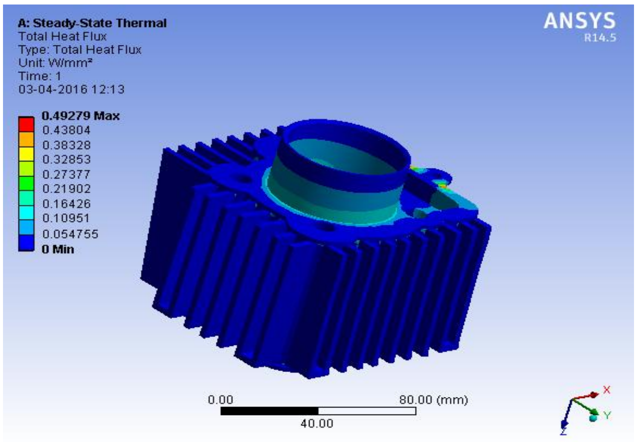



## MATERIAL- ALUMINUM ALLOY – 7075

## TEMPERATURE

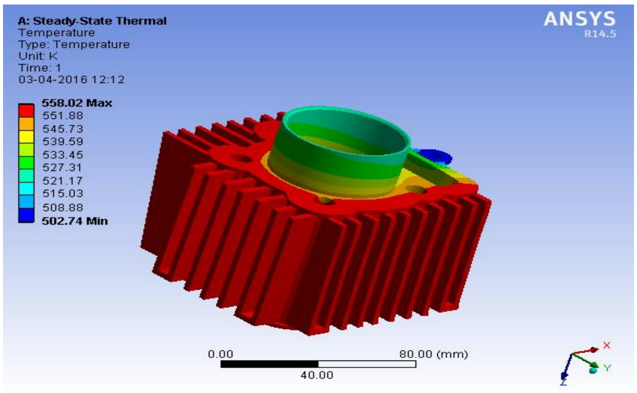



## HEAT FLUX




## MATERIAL- CAST IRON

## TEMPERATURE

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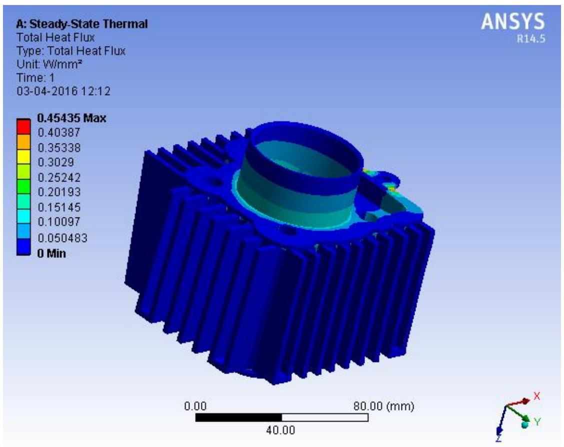


## MATERIAL- COPPER

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## RESULTS TABLE

### Case1 -2.5mm thickness

| | Aluminum Alloy 204 | Aluminum Alloy 7075 | Cast Iron | Copper |
|---|---|---|---|---|
| Temperature (K) | 558.03 | 558.03 | 558.04 | 558.01 |
| Thermal Flux (w/mm²) | 0.48152 | 0.48743 | 0.44949 | 0.5401 |

### Case2 -3mm thickness

| | Aluminum Alloy 204 | Aluminum Alloy 7075 | Cast Iron | Copper |
|---|---|---|---|---|
| Temperature (K) | 558.01 | 558.01 | 558.02 | 558 |
| Thermal Flux (w/mm²) | 0.48681 | 0.49279 | 0.45435 | 0.54617 |

## CONCLUSION:

In this thesis, a cylinder fin body for a 150cc motorcycle is modeled using parametric software Pro/Engineer. The original model is changed by changing the thickness of the fins. The thickness of the original model is 3mm, it has been reduced to 2.5mm. By reducing the thickness of the fins, the overall weight is reduced. Present used material for fin body is Aluminum Alloy 204. In this thesis, other materials Aluminum 7075, Cast Iron and Copper are considered for analysis. Thermal analysis is done for all materials.
The material for the original model is changed by taking the consideration of their densities and thermal conductivity. By observing the thermal analysis results, thermal flux is more for Cast Iron than other materials and also by reducing the thickness of the fin, the heat transfer rate is increased. But the density of Cast Iron is more than aluminum alloys so weight of cylinder fin body is more than aluminum alloys. Thermal flux is also calculated theoretically. By observing the results, heat transfer rate is more when the thickness of the fin is 2.5mm. So we can conclude that using Aluminum alloy 7075 and taking thickness of 2.5mm is better.

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