Journal of Engineering Sciences
Vol 10, Issue 12, DEC/2019
ISSN NO:0377-9254

HEAT TRANSFER ANALYSIS OF IC ENGINE FINS AND THEIR OPTIMISATION BY VARYING MATERIAL AND GEOMETRY

Vemula Sameera Chandra[1], Dr. V. P. Venkataramana Murthy[2], Dr. P. Sekhar Babu[3], Dr. M. Babu[4]

PG Student[1], Professor[2,3,4], Department of Mechanical Engineering, Narsimha Reddy Engineering College, Hyderabad 500100

Email id:sameer.vemula@gmail.com

Abstract— The Engine cylinder is the major component of the internal combustion engine. It is subjected to high temperature variations and thermal stresses. To cool the cylinder of the engine, fins are provided on the surface of the cylinder to increase the rate of heat transfer. The main aim of the project is to analyze, compare different thermal properties by varying material and thickness of cylinder fins. Parametric models of IC engine cylinder with fins have been developed to predict the transient thermal behavior. In this project air cooled 200CC engine with horizontal rectangular fins of 2mm and 1.5mm thickness is designed. Also, two different materials Al2024 and Al6063 with 110-151W/mK and 180-200W/mK respectively are taken. The Al2024 has a density of 2.78g/CC and a specific heat of 0.875J/g°C. The Al6063 has a density of 2.7g/CC and a specific heat of 0.9 J/g °C. In this project SolidWorks is used for 3D modelling. For analyzing properties ANSYS is used. The principle implemented in this project is to increase the heat dissipation rate by using the invisible working fluid i.e. air.

Keywords— Fins, Thermal analysis, Material, Thickness

1. INTRODUCTION

1 .1 Overview

We realize that if there should be an occurrence of Internal Combustion motors, burning of air and fuel happens inside the motor chamber and hot gases are created. This is an exceptionally high temperature and may result into consuming of oil film between the moving parts and may result in seizing or welding of same. In an inward ignition motor, the development of the high-temperature and hot gases created by burning. This is an extremely high temperature and may result into consuming of oil film between the moving parts and may result it seizing or welding of same. Along these lines, this temperature must be diminished to around 150-200°C at which the motor will work generally productively. It lessens the warm productivity. Along these lines, the object of cooling framework is to keep the motor running at its most productive working temperature. It is to be noticed that the motor is very wasteful when it is cold and subsequently the cooling framework is planned so that it avoids cooling when the motor is heating up and till it achieves most extreme effective working temperature, at that point it begins cooling. To abstain from overheating, and the subsequent sick impacts, the heat transferred to a motor part (after a specific level) must be evacuated as fast as could reasonably be expected and be passed on to the environment. It will be appropriate to state the cooling framework as a temperature guideline framework. It ought to be recollected that reflection of heat from the working medium by method for cooling the motor segments is a direct thermodynamic misfortune.

1.2 Necessity of Cooling System in IC Engines

All the heat created by the ignition of fuel in the engine chambers isn't changed over into valuable power at the crankshaft. A run of the mill dispersion for the fuel vitality is given underneath:

Valuable work at the crank shaft = 25 %

Loss to the cylinder walls = 30 %

Loss in exhaust gases = 35 %

Loss in friction = 10 %

It is seen that the amount of heat given to the chamber dividers is impressive and if this heat isn't expelled from the chambers it would bring about the pre-ignition of the charge. Moreover, the oil would likewise consume with extreme heat, along these lines causing the seizing of the cylinder. Abundance heating will likewise harm the chamber material.

1.3 Methods of Cooling

Different strategies utilized for cooling of vehicle engines are:

1. Air Cooling
2. Liquid cooling

Vol 10, Issue 12, DEC/2019
ISSN NO:0377-9254

1.3.1 Air-Cooling

Autos and trucks utilizing direct air cooling (without a moderate fluid) were worked over an extensive stretch start with the coming of mass created traveler vehicles and closure with a little and for the most part unrecognized specialized change. Prior to World War II, water cooled vehicles and trucks routinely overheated while ascending mountain streets, making springs of bubbling cooling water. This was viewed as typical, and at the time, most noted mountain streets had auto fix shops to pastor to overheating engines. ACS (Auto Club Suisse) keeps up recorded landmarks to that period on the Susten Pass where two radiator refill stations remain (See an image here). These have directions on a cast metal plaque and a round base watering can hanging alongside a water nozzle. The circular base was expected to shield it from being set down and, along these lines, be pointless around the house, disregarding which it was stolen, as the image appears. During that period, European firms, for example, Magirus-Deutz fabricated air-cooled diesel trucks, Porsche assembled air-cooled ranch tractors, and Volkswagen ended up well known with air-cooled traveller vehicles. In the USA, Franklin assembled air-cooled engines. The Czechoslovakia based organization Tatra is known for their enormous size air cooled V8 vehicle engines, Tatra engineer Julius Mackerle distributed a book on it. Air cooled engines are better adjusted to amazingly cold and sweltering natural climate temperatures, you can see air cooled engines turning over and running in solidifying conditions that stuck water cooled engines and keep working when water cooled ones begin delivering steam planes.

1.3.2 Liquid Cooling

Today, most engines are fluid cooled. Fluid cooling is additionally utilized in oceanic vehicles (vessels) For vessels, the seawater itself is generally utilized for cooling. Now and again, compound coolants are additionally utilized (in shut frameworks) or they are blended with seawater cooling.

1.3.3 Transition Away from Air Cooling

The difference in air cooling to fluid cooling happened toward the beginning of World War II when the US military required dependable vehicles. The subject of bubbling engines was tended to, looked into, and an answer found. Past radiators and engine squares were appropriately planned and endure strength tests, yet utilized water siphons with a flawed graphite-greased up "rope" seal (organ) on the siphon shaft. The seal was acquired from steam engines, where water misfortune is acknowledged, since steam engines as of now exhaust enormous volumes of water. Since the siphon seal spilled mostly when the siphon was running and the engine was hot, the water misfortune dissipated unnoticeably, leaving, best case scenario a little corroded follow when the engine ceased and cooled, along these lines not uncovering noteworthy water misfortune. Car radiators (or heat exchangers) have an outlet that feeds cooled water to the engine and the engine has an outlet that feeds heated water to the highest point of the radiator. Water flow is helped by a turning siphon that has just a slight impact, working over such a wide scope of paces that its impeller has just a negligible impact as a siphon. While running, the spilling siphon seal depleted cooling water to a level where the siphon could never again return water to the highest point of the radiator, so water course stopped and water in the engine bubbled. Be that as it may, since water misfortune prompted overheat and further water misfortune from bubble over, the first water misfortune was covered up.

1.4 AIR COOLING SYSTEM

The essential guideline associated with this technique is to have current of air streaming ceaselessly over the heated metal surface from where the heat is to be evacuated. The heat scattered relies on following components:

a) Surface region of metal into contact with air.

b) Mass stream rate of air.

c) Temperature distinction between the heated surface and air.

d) Conductivity of metal.

In this way for a powerful cooling the surface region of the metal which is in contact with the air ought to be expanded. This is finished by utilizing blades over the chamber barrels. These balances are either given a role as an indispensable piece of the chamber or separate finned barrels are embedded over the chamber barrels. These blades are either given a role as an indispensable piece of the chamber or separate finned barrels are embedded over the chamber barrel. Now and again, especially on account of air engines, the balances are machined from the fashioned chamber spaces.

To expand the contact zone even more, puzzles are utilized once in a while. Utilization of copper and steel compounds has likewise been made to improve heat transfer due to their better warm conductivity.

1.5 ADVANTAGES

1. Air cooled engines are lighter as a result of the nonattendance of the radiator, the cooling coats and the coolant.

2. They can be worked in outrageous atmospheres, where the water may solidify.

3. In specific regions where there is shortage of cooling water, the air cooled engine is a bit of leeway.

4. Upkeep is simpler in light of the fact that the issue of spillage isn't there.

5. Air cooled engines get start sooner than the water-cooled engines.

1.6 DISADVANTAGES

1. It is difficult to keep up cooling all around the chamber, so the contortion of the chambers happens. This deformity has been helped now and then by utilizing blades parallel to the chamber hub. This is additionally useful where various chambers straight are to be cooled. In any case, this builds the general engine length.

2. As the coefficient of heat transfer for air is not as much as that for water, there is less productive cooling for this situation and therefore the most elevated helpful pressure proportion is lesser on account of air cooled engines than in the water cooled ones.

3. The fan utilized is massive and assimilates a significant part of the engine control (about 5%) to drive it.

4. Air cooled engines are progressively uproarious, in light of the nonattendance of cooling water which goes about as sound separator.

5. Some engine parts may end up out of reach effectively because of the managing astounds and cooling, which makes the support troublesome.

6. The cooling blades around the chambers may vibrate under specific conditions because of which commotion level would be extensively improved

1.7 DIFFERENCE BETWEEN AIR COOLED ENGINES AND WATER-COOLED ENGINES

Air cooling utilizes wind current coordinated at blades on the chambers and heads is the cooling medium: heat is transferred straightforwardly to the air. The air comes either by normal convection (e.g., a bike) or by constrained air (e.g., air-cooled VW or Porsche engine.)

Water cooled engines course coolant around the heads + chambers however an encompassing water coat, and utilize a different high efficiency radiator for the last heat trade to the air. (Marine engines are somewhat extraordinary - they utilize the encompassing water rather, either straightforwardly or through a water-to-water heat exchanger.)

Air-cooled engines are less complex, lighter and simpler to keep up as they don't have the 'wet' cooling framework components. They exceed expectations in virus atmospheres where coolant solidifying can be an issue. In any case, air cooling is less proficient because of the low heat limit of air so these engines experience the ill effects of problem areas which lessens control, builds discharges and abbreviates their life.

Air-cooled engines are additionally extensively noisier - both from the engine legitimately and furthermore from the air blower cooling fan whenever utilized.

Water-cooled engines exploit water's high heat ability to proficiently divert the heat. So they offer the best authority over temperature taking into account progressively forceful/effective tuning and ideal head plan. While they have expanded close term support costs (coolant, water siphon, hoses, and so forth.) they compensate for it in a more drawn out lived engine centre (longer time between update.)

Water-cooled engines are additionally calmer because of the protecting properties of the water coat and the reduced wind stream necessity.

Water cooling additionally allows greater adaptability in engine engineering and establishment since there isn't a need to pipe cooling air straightforwardly to the chambers.

1.8. Generalization Difficulties

It is hard to make speculations about air-cooled and fluid cooled engines. Air-cooled Volkswagen kombis are known for fast wear in typical use and here and there unexpected disappointment when driven in sweltering climate. On the other hand, air-cooled Deutz diesel engines are known for unwavering quality even in outrageous heat, and are frequently utilized in circumstances where the engine runs unattended for a considerable length of time at once. Likewise, it is normally alluring to limit the quantity of heat transfer organizes so as to expand the temperature distinction at each stage. Nonetheless, Detroit Diesel 2-stroke cycle engines generally use oil cooled by water, with the water thus cooled via air.

The coolant utilized in numerous fluid cooled engines must be re-established occasionally, and can solidify at conventional temperatures in this manner causing lasting engine harm. Air-cooled engines don't require coolant administration, and don't experience the ill effects of solidifying, two

Vol 10, Issue 12, DEC/2019
ISSN NO:0377-9254

generally referred to points of interest for air-cooled engines. Notwithstanding, coolant dependent on propylene glycol is fluid to - 55 °C, colder than is experienced by numerous engines; recoils marginally when it takes shape, in this manner maintaining a strategic distance from engine harm; and has an administration life more than 10,000 hours, basically the lifetime of numerous engines.

2. Aim of The Project

The primary part of the venture is to design with 200CC engine with fins, by changing the geometry (thickness of the fins) and to dissect the thermal properties of the fins. Examination is likewise done by changing the materials of fins. Present utilized material for chamber blade body is Cast Iron. Our point is to change the material for balance body by investigating the fin body with different materials and thickness of the fins. Geometry of fins – Original model and Modified Model

For Original Model - Thickness of fins – 2mm

For changed model - Thickness of fins – 1.5mm

Materials – Aluminium Alloy 2024 and Aluminium Alloy 6063

2.1 Steps Involved in The Project

1. Modelling
2. Thermal Analysis

For modelling of the balance body, we have utilized SolidWorks, which is a parametric 3D demonstrating programming. For analysis we have utilized ANSYS 14.5

3.Modelling and Design

Design

We have taken 200CC engine of bikes with horizontal fins of thickness 2mm common for two materials Al2024 and Al6063

Actual

Bore = 5cm

Stroke = 10cm

Volume = 196.4285CC

Fin thickness = 2mm

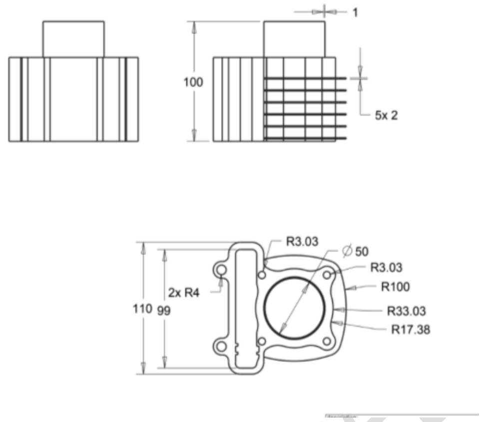

Figure 3.1: Actual Drafting Image (thickness 2mm)

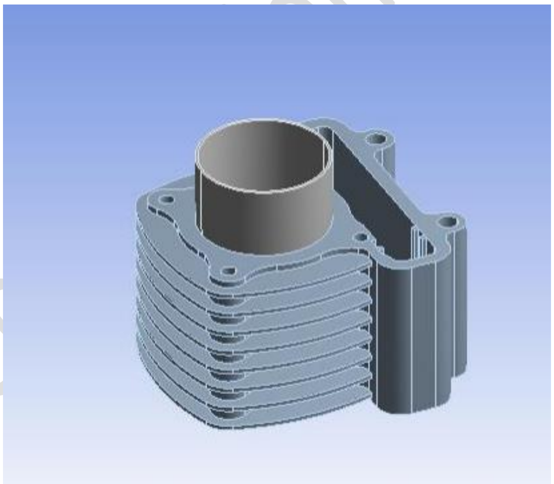

Figure 3.2: Image of engine cylinder fin designed in SolidWorks Thickness 2mm

3.3 Modified Design

Here in the 200cc engine 2mm fin is replaced with 1.5mm thickness with same bore and stroke

Modified

Bore = 5cm

Stroke = 10cm

Volume = 196.4285CC

Fin thickness = 1.5mm

Vol 10, Issue 12, DEC/2019
ISSN NO:0377-9254

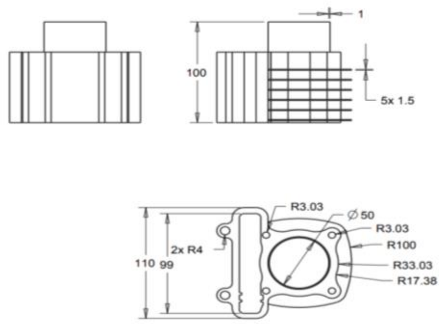

Figure 3.3: Modified Drafting Image (thickness 1.5mm)

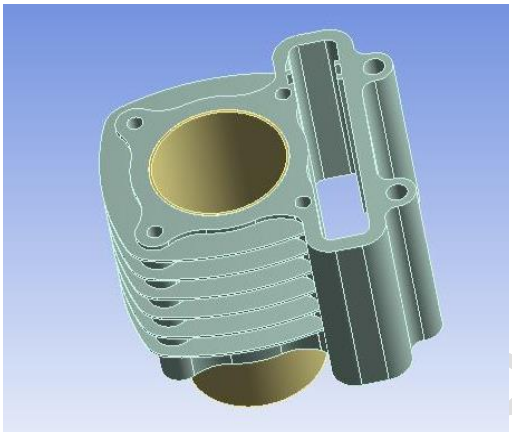

Figure 3.2: Image of engine cylinder fin designed in SolidWorks Thickness 1.5mm

4.Material Data

Temperature -550 K

Film Coefficient – 39.9 w/m^2 K

Bulk Temperature – 283 K

Table 1: Material Data

Materail Name	**Densit y g/CC**	**Specific heat J/g °C**	**Thermal conductivity W/mK**
Al 2024	2.78	0.875	151
Al 6063	2.7	0.9	200

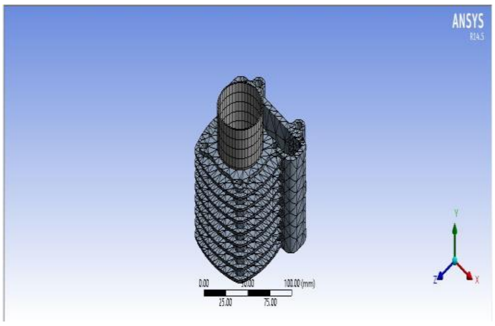

Figure 4.1: Meshed image ofAl2024 with thickness 2mm

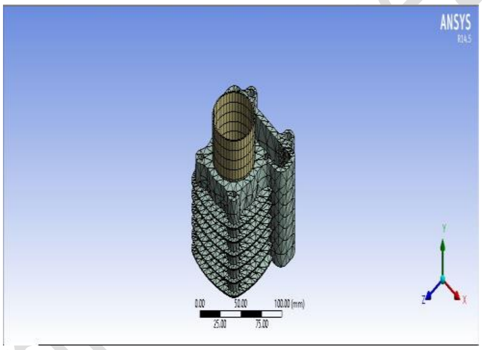

Figure 4.2: Meshed image of Al2024 with thickness1.5mm

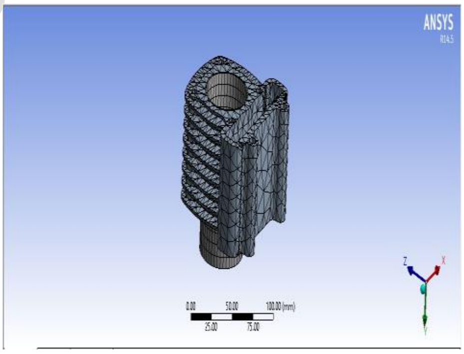

Figure 4.3: Meshed image of with thickness Al6063 2mm

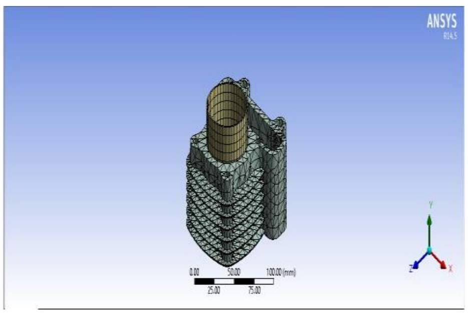

Figure 4.4: Meshed image of Al6063 with thickness 1.5mm

Journal of Engineering Sciences

Vol 10, Issue 12, DEC/2019

ISSN NO:0377-9254

5.RESULT

The analysis done so far for the duration of 500seconds.

5.1: Case I Al2024 with 2mm thickness

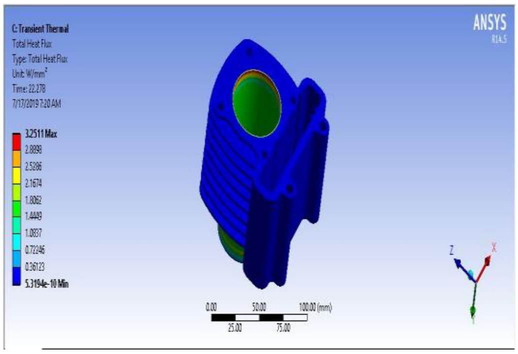

Figure 5.1: Transient thermal Heat flux image Al2024 of with 2mm thickness

5.2: Case II Al2024 with 1.5mm thickness

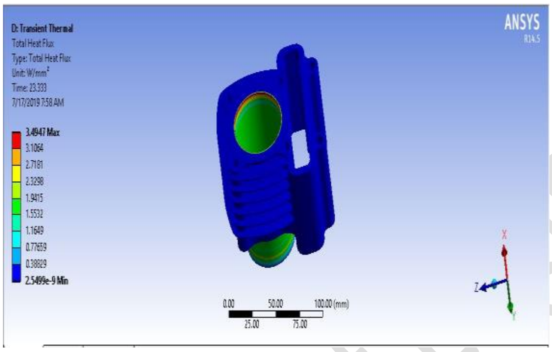

Figure 5.2: Transient thermal heat flux image Al2024 of with 1.5mm thickness

5.3: Case III Al6063 with 2mm Thickness

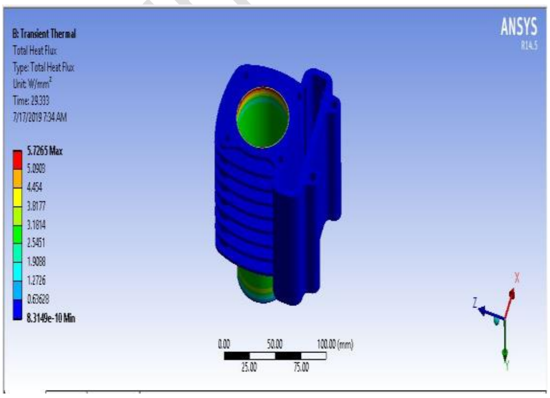

Figure 5.3: Transient thermal heat flux image of Al6063 with 2mm thickness

5.4: Case IV Al6063 with 1.5mm thickness

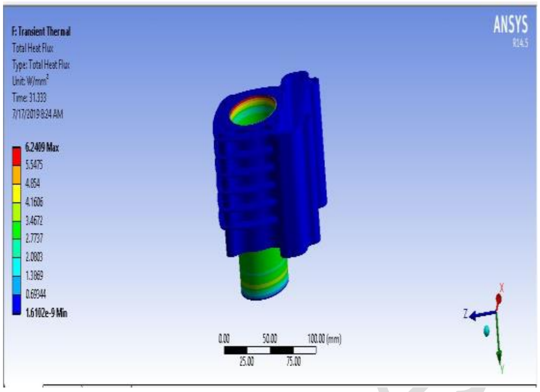

Figure 5.4: Transient thermal heat flux image of Al6063 with1.5mm thickness

5.5 Result Table

Table 2: Result Table

S.No.	Material	Thickness (mm)	Minimum Thermal flux (W/mm²)	Maximum Thermal Flux (W/mm²)
1	Al 2024	2	5.3194e-010	3.2511
2	Al 2024	1.5	2.5499e-009	3.4947
3	Al 6063	2	8.3149e-010	5.7265
4	**Al 6063**	**1.5**	**1.6102e-009**	**6.2409**

5.5: Discussions

1. From the results it is clear that there exists difference between values of the two materials used.
2. The difference is slight when compared to fin thickness within their own metal.
3. The highest thermal flux is noticed in Al6063 of 1.5mm thickness with a value of 6.2409W/ mm² followed by Al6063 of 2mm thickness with 5.7265W/ mm²
4. From all the Heat flux values of all conditions the Al6063 model of 1.5mm thickness is appreciable.

6. CONCLUSION

In this venture we have planned the balance group of a 200CC engine according to the parameter differing figuring out procedure.

- We are diminishing the fin thickness from 2mm to 1.5mm.
- In this we enhance the materials present utilized material is Al2024 and supplanting materials are Aluminum 6063 and dark solid metal.
- We are doing show investigation utilizing strong works programming and planning in SolidWorks and ANSYS.
- Finally, we are looking at all the outcomes for unique and optimized fin body. The material is AL 6063.
- In Aluminum 6063 the heat transition worth is more when contrasted with another alloy of aluminium.

Finally, we realize that it is better to use Al6063 with 1.5mm thickness when compared with others assembling of engine cylinder fin is safer and more efficient.

7. FUTURE SCOPE

The main aim of present modelled and analysed project work is to increase the heat transfer rate from the cylinder of IC engine to outer environment. So, we performed the transient thermal analysis on actual designed single cylinder engine of 200CC. There are also some possible future works possible for further analysis.

- Radiation analysis: we can also be performed this for the same work.
- In the analysis performed, the present work material used for cylinder block are aluminium alloys Al2024 and Al6063, some other materials like latest discoveries and high conductivities may also use.
- CFD analysis can also be performed to understand the air flow around the cylinder block.
- Evaluation of different thermal properties by varying the geometry (size, number of fins, shape and thickness of the heat sink, fins) also be performed.

References

[1]. Thermal Engineering by R.K. Rajput

[2]. Thermal Engineering by Sarkar

[3]. Thermal Engineering by Rudramoorthy

[4]. Online Materials

[5]. Heat and Mass Transfer Data Book - C. P. Kothandaraman

[6]. Investigation into the Temperature and Heat Transfer Distribution around Air-Cooled Cylinders SAE paper 2006-32-0039/20066539

[7]. Thornhill D. and May A., An Experimental Investigation into the Cooling of Finned Metal Cylinders in a free Air Stream, SAE Paper

[8]. Gibson H., The Air Cooling of Petrol Engines, Proceedings of the Institute of Automobile Engineers, Vol.XIV, 243-275

[9]. Experimental Studies of Heat Transfer from Finned Cylinders of Air-Cooled I.C. Engines, 4th National Heat MassTransferConference.

[10]. (Nabemoto, A. and Chiba, T., Flow over Fin Surfaces of Fin Tubes, Bulletin of the Faculty of Engineering, Hiroshima University, (in Japanese), Vol.33, No.2 (1985), pp.117–125.

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