IJOSTHE
ISSN: 2349-0772 | Volume 5 Issue 2 April 2018|www.ijosthe.com

ANALYSIS OF HEAT TRANSFER RATE OF IC ENGINE CYLINDER

Rakesh Kumar Gupta
Mechanical Department
SISTECH Bhopal

Sanjay Singh
Associate Professor, Mechanical Dept.
SISTEC Bhopal

ABSTRACT

The main object of the present work to enhance the heat transfer rate from existing design of engine cylinder block by changing its design and also with new material. For that two cad models have been created with the help of CATIA software and then transient thermal analysis where performed using ANSYS at two different ambient temperatures for both winter and summer seasons. For the winter season the ambient temperature 22ºC is used and for summer season 45ºC for actual as well as proposed design of IC engine one by one to optimize geometrical parameters and enhanced heat transfer rate. it has been observed from the results of transient thermal analysis the proposed design of engine cylinder block has better performance and heat transfer rate as compared to actual design of engine cylinder block.

Keywords: Heat transfer rate, Internal Combustion engine, Transient thermal analysis Engine design, etc

I. INTRODUCTION

The cooling fins are commonly used to cool various components in sectors such as turbines, heat exchangers, motors, etc. Currently, there is a great demand for compact and economical heat sinks. The ribs are the most important feature in the geometry of the heat sink. A rib is usually a flat surface that extends from the heat sink plane.

It is used to increase the heat transfer from and to the environment by increasing the convective heat transfer area. Air cooling is also accepted as an important method in the thermal design of electronic enclosures because, in addition to being accessible, it is safe, does not pollute the air and does not add vibration, noise and moisture to the system in which it is used.

The use of ribs is one of the cheapest and most common ways to dissipate unnecessary heat and has been used successfully for many technical applications.

Due to the low cost of production and high thermal efficiency, rectangular louvers are the most commonly used type of pens.

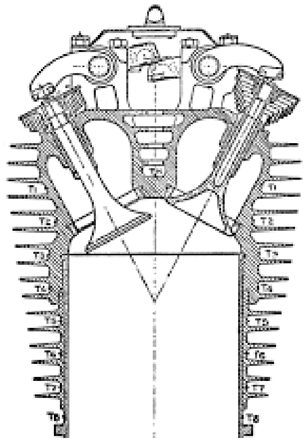


Fig. 1.1 Cylinder fins

Most internal combustion engines are cooled by the fluid using air (a gaseous fluid) or a refrigerant flowing through an air-cooled heat exchanger (radiator). In the air cooling system, the air flowing over and around the cylinder attracts heat. Here are the fins cast in cylinder head and cylinder, which form an additional conductive and radiating surface. In the water cooling system of the cooling machines, the walls and cylinder heads are equipped with sheaths. The cooling fins keep the Chevrolet battery at the ideal temperature. We know that in combustion engines, the combustion of air and flue gas is generated, the temperature of the gases is about 2300-2500 ° C. This is a very high temperature and the oil film between the moving parts and can adhere or weld. Therefore, this temperature should be reduced to about 150-200 ° C at which the engine operates more efficiently. Too much cooling is also undesirable because it reduces thermal efficiency. Therefore, the purpose of the cooling system is to keep the engine at the maximum operating temperature. It should be noted that the engine is quite inefficient in the cold and the cooling system is therefore designed so that it does not cool when the engine is heated and is sufficient to reach maximum operating temperature so that it begins to cool.

1.1 AIR COOLING SYSTEM

The air-cooled system is generally used in small engines up to 15-20 kW and in aerodynamic engines. In this system, nerves or surfaces are provided in the walls of the cylinder, in the cylinder head, etc. The amount of heat released in the air depends on

- Amount of air flowing through the slats.
- surface of the fin
- Thermal conductivity of the metal used for the lamellas.

1.1.1 ADVANTAGES OF THE AIR COOLED SYSTEM

The following are the advantages of the air cooling system:

- The radiator / pump is missing, so the system is light.
- In the case of water cooling, there are losses, but in this case there are no losses.
- Coolant and antifreeze solutions are not required.
- This system can be used in cold climates where it can be frozen when using water.

1.1.2 DISADVANTAGES OF THE AIR-COOLED SYSTEM

- In comparison, it is less efficient. It is used in aerospace and motorcycle engines where engines are directly exposed to air.

1.2 FAILURE DUE TO ENGINE COOLING

Most of the research devoted to the engines focuses on the combustion process, and that's right. In fact, combustion is the driving force for the entire system, and a deeper understanding of this process is the most likely way to make significant improvements. In engines, a combustion chamber is formed in the volume enclosed between a closed cylinder and a piston. In each cycle a charge of fuel and oxidant is ignited. This starts a flow of energy from chemical to thermal to mechanical, the latter being associated with the movement of the piston.

The engines can be built on the basis of various thermodynamic cycles, with Otto and Diesel being the most popular, each with a specific combustion strategy. Regardless of the combustion strategy, the key issue is at the microscopic level. For efficient reaction, the fuel and oxidant must react under the right conditions (eg, concentration and temperature) to produce leaks with as little energy as possible. Most of the process takes place in the combustion chamber core and this was the main objective of engine development during the time that the engines existed.

The improvements were radical and led to the current high pressure direct injection systems with controlled load movement. As a result, the relative effect of the chamber walls on the load has increased. This area is characterized by high temperature gradients that do not create optimal combustion conditions (lack of ignition, fast cooling, slow flame spread / combustion).

The combustion process has the net effect of supplying the heat source to the thermal engine.

The process of converting thermal energy into mechanical energy has thermodynamic limitations that could be misinterpreted as leaks. The true heat loss in the combustion chamber is the heat flow through the walls. The combustion process reaches temperatures above 2000 K and no conventional material is suitable for the production of an adiabatic chamber with moving parts. Today, the only practical alternative is to use metals and control the temperature of the components with a suitable cooling system. As a result, a significant portion of the heat generated is transported through the cooling system without benefit. The heat transfer between the load and the walls is dominated by forced convection [2].

$$Nu = \frac{hD}{k} \quad (1)$$

h is one of the factors in the equation, making Nu a property of the flow as well. D (m) is a length characteristic of the geometry at study, for the typical example of a pipe, D is the diameter. As a dimensionless quantity, Nu is of great help to transfer findings between similar cases.

II. LITERATURE REVIEW

Mahendran.V and Venkatasalakumar .A et al. [1] The body of the cylinder clamp for the Bajaj CT 100cc motorcycle is modeled with the parametric software Solid Works 2012. In this document, a thermal analysis is performed for the two cast iron and 6061 aluminum alloy materials. The material for the original model is modified considering its thermal conductivity and lamella design. When the results of the thermal analysis are observed, the aluminum alloy has a lower weight, so that the use of the 6061 aluminum alloy is a better heat transfer material. In addition, reducing the thickness of the rib increases the heat transfer rate.

K. Parthiban, D. Senthilkumar and S. Maniamramasamy et al. [2] An investigated water cooling system is used instead of an air cooling system and analyzed with water as the working fluid. An increased constant heat transfer of the water could increase within the performance of the four-stroke two-wheel motor and reduce the evaporation of the oil lubricating the piston and the cylinder wall.. The liquid motor has a longer life than an air-cooled engine. It has been found that the volumetric efficiency of the liquid-cooled engine is greater every day than its air-cooled counterpart. It is recommended to operate the continuous circulation cooling system with continuous circulation to prevent the engine from overheating and to reduce the evaporation of the oil.

Abhishek Mote, Akshay Choukse, Atharva Godbole, Dr. Pradeep Patil and Avinash Kumar Namdeo et al. [3] They found that higher air velocities around the extended surfaces increase heat transfer. The change in the vehicle speed changes the heat transfer rate significantly. As a result, the effectiveness of the rib continues to vary with vehicle speed. The physical dimensions of the fin also affect the efficiency of the fin. It was found that the efficiency of the rib / heat transfer rate increased when the air velocity was multiplied from 11.11 m / s to 16.667 m / s.

KM Sajesh, Neelesh Soni and Siddhartha Kosti et al. [4] On the basis of the study carried out in the fin of the rectangular motor by means of temporary thermal analysis and stationary condition in the ANSYS 16.0 workbench. The turbulence of the air flow increases between the ribs in the generation of the hole. The heat lost by the body can be increased by increasing the expansion, ie by increasing the diameter of the opening created in the fin. The finned temperature is reduced, resulting in holes. It follows from the results that, before a fundamental amount of four hundred seconds, the transition temperature of all fins has reached stable temperatures. The fin with a ten millimeter diameter hole reduces the minimum temperature of 1036.5 K for a fin without perforation at a minimum temperature of 989.03 K.

Mr. Manir Alam and Mrs. M. Durga Sushmitha et al. [5] A motorcycle cylinder claw body is a CATIA-carved parametric operating software system. The first model is modified by constantly changing the geometry of the fin body, the distance between the fins and the thickness of the fins. The material used as a gift for the body of the fin is made of wrought iron. The thermal analysis is completed for the 3 complete materials in the wrought iron, copper and aluminum alloy 6082.Density is a lesser amount for 6082 aluminum alloy than various materials, therefore, the body weight of the fin is a minimal amount of utilization of the atomic alloys number 13 6082. The physical thermal phenomenon is in addition to copper compared to alternative materials 2.

III. OBJECTIVE

There are following objective are to be expected from the present work

1. The primary object of the present work to increase heat transfer rate from existing cylinder block.
2. To study the behavior of heat transfer from IC engine
3. To evaluate the heat transfer rate in Actual cylinder block.
4. To evaluate the heat transfer rate with proposed design of cylinder block.
5. To optimize the cylinder block design from the basis of heat transfer rate.
6. To maximize the heat transfer rate from the cylinder block.

IV. METHODOLOGY

The heat transfer analysis takes place the following assumptions:

1. Conductive heat transfer in the IC engine fins is one dimensional and is along the x- direction
2. Heat losses by the convection from the sides of the heat sink at constant ambient temperatureT_∞. The heat sink in the steady state condition.

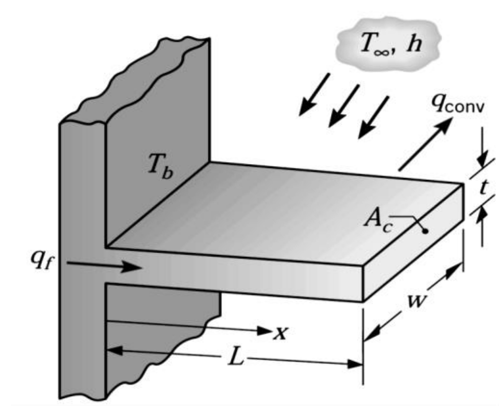


Figure 4.1: Theoretical information of fin geometry

From the figure 4.1 it is cleared that the heat flow direction is x and the cross sectional area of the fin is taken as function of x.

Consider the small volume element of the fin which in length dx. A balance of energy is performed on this element in which it is assumed that the element is at constant and uniform temperature of T.

Heat in to the left face = Heat out from the right face + Heat loss by convection

This yield

$$Q_x = Q_{x+\Delta x} + Q_{con}$$

Table 4.1: Technical Specifications of Hero Honda Splendor	
Engine Type	4-Stroke, Single Cylinder OHC (overhead cam), Air Cooled
Displacement	97.2 CC

Power	5.74 kW (7.8 Ps) @ 7500 RPM
Torque	0.82 Kg-m (8.04 N-m) @ 4500 RPM
Bore x Stroke	50.0 mm x 49.5 mm
Compression Ratio	9.0:1
Transmission	4-Speed, Constant Mesh
Clutch	Multi-plate Wet
Fuel Type	Petrol
Kerb Weight	116 Kg (Kick) / 119 Kg (Self)
Length	1980 mm
width	725 mm
Height	1075 mm
Wheelbase	1235 mm
Ground Clearance	165 mm
Fuel Tank Capacity	12.8 Litre, 1.0 Litre (Usable Reserve)
Minimum Turning	1.90 Meter
Seat Height	795 mm

Case I: The fin of infinite length:

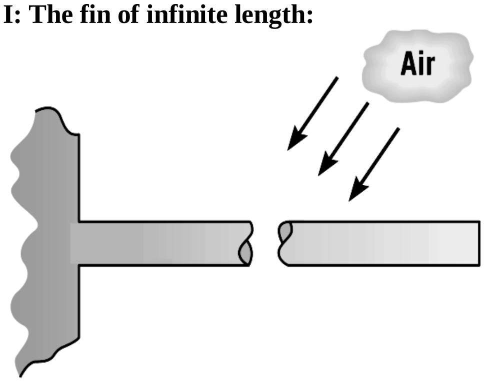


Figure 4.2: heat transfer by infinite length fin

$$Q_{Fin} = \sqrt{hPkA}(T_0 - T_\infty)$$

Case II: Fin Insulated at the tip:

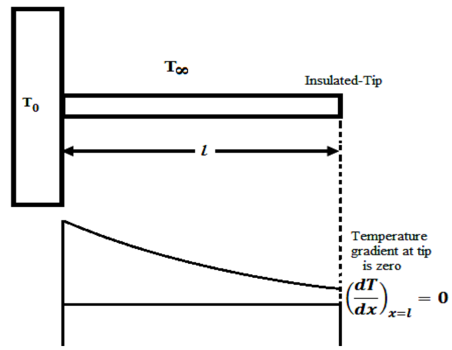


Figure 4.3: Fin insulated at tip

$$\boldsymbol{Q_{Fin} = \sqrt{hPkA}(T_0 - T_\infty)\tanh(ml)}$$

Where:

$$m = \sqrt{\frac{hP}{kA}}$$

h = convective heat transfer coefficient in W/m^2K

P = Perimeter in m

k = Thermal conductivity in W/mK

A =Cross sectional area in m^2

Case III : The finite length of the fin

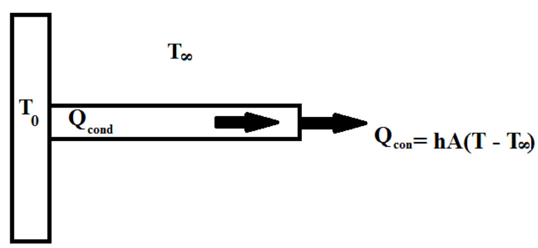


Figure 4.4: **heat transfer by finite length fin**

$$Q_{Fin} = \sqrt{hPkA}\,(T_0 - T_\infty)\left[\frac{\tanh\,(ml) + \frac{h}{km}}{1 + \frac{h}{km}\tanh\,(ml)}\right]$$

Boundary Conditions of the structure:

1. The maximum temperature generated in the cylinder block is measured at 650 ° C (John B.LHeywood "Engine Heat Transfer").

2. The ambient temperature is assumed and set as 25 ° C in winter and 45 ° C in summer.

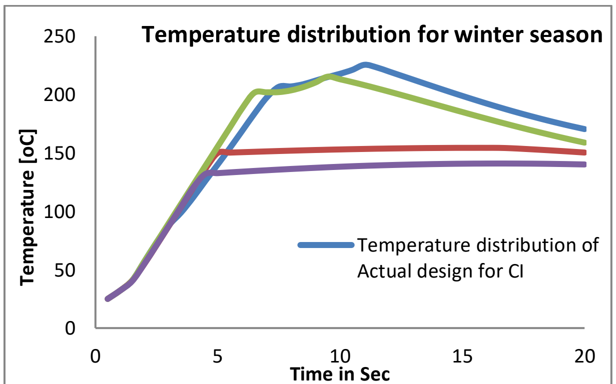
3. The value of the isotropic thermal conductivity of the material is 83 W / m oC.

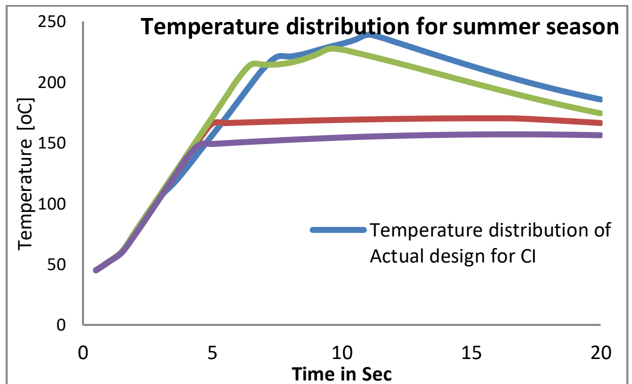
4. Since the cylinder block of an internal combustion engine moves into an open space, it is assumed that in this open space the available normal air temperature and the value of the convection coefficient for this work is assumed to be 100 W / m2.

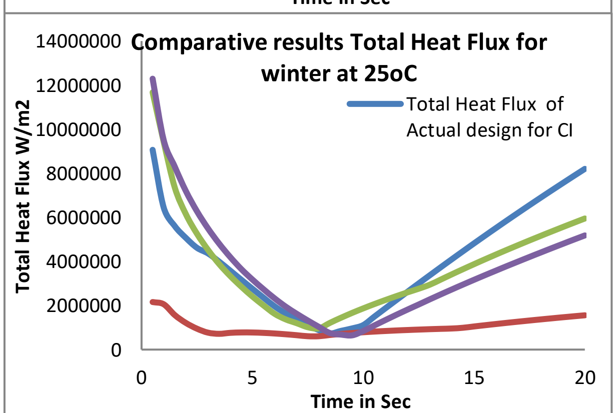
5. The quasi-linear thermal dissolution solvent is used for transient thermal analysis.

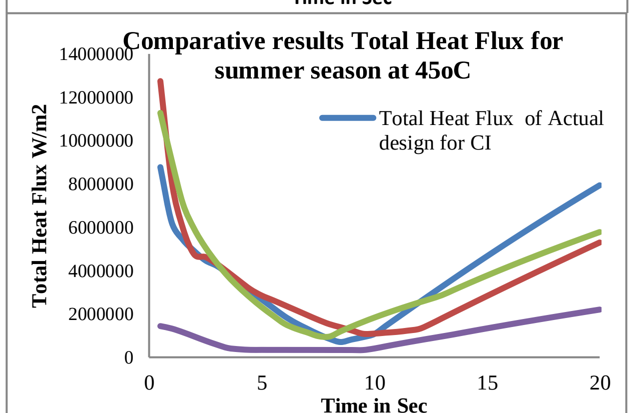
RESULTS

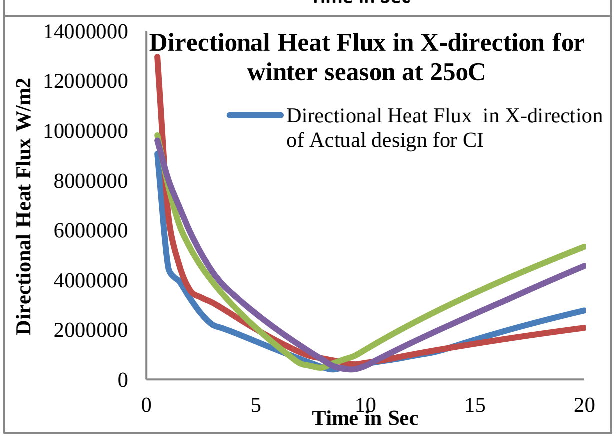
The transient thermal analysis ware performed using ANSYS workbench based on finite volume method for actual and proposed design with inter-cooling water jacket and also for two different materials such as cast iron and aluminium alloy.

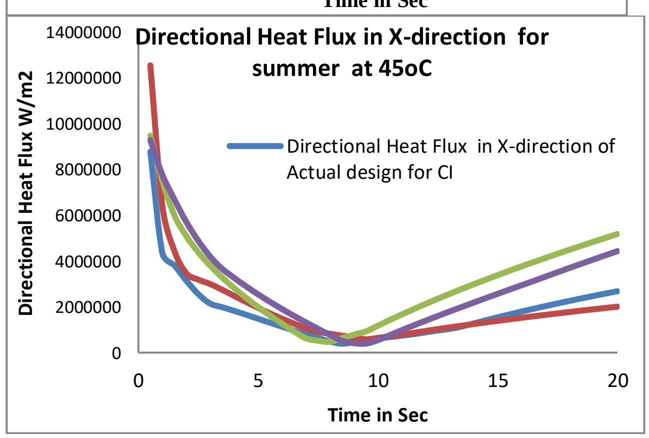


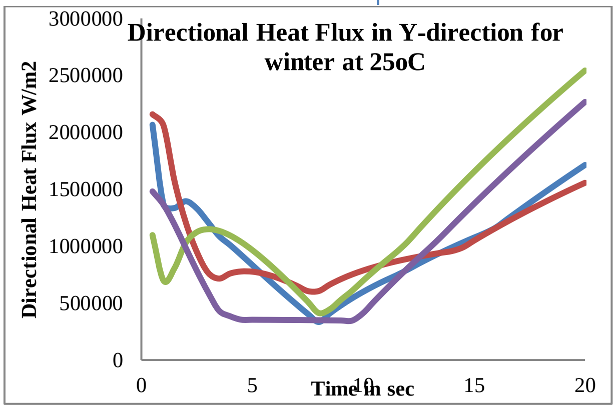


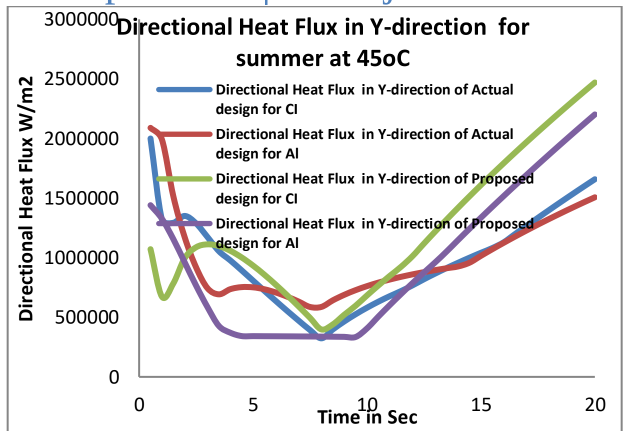


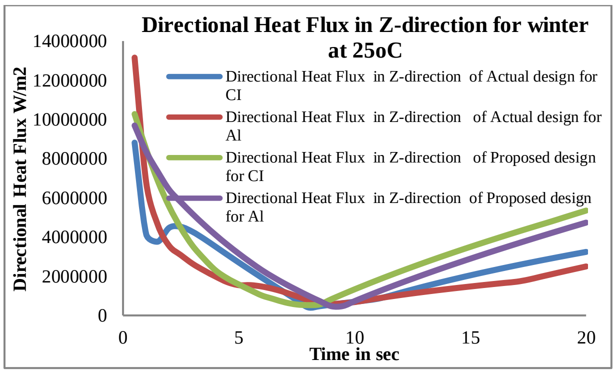


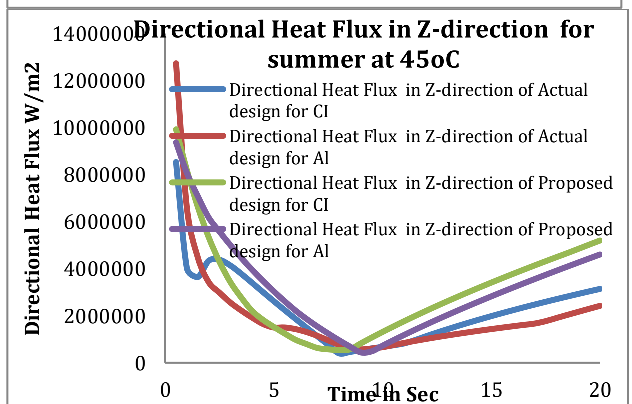


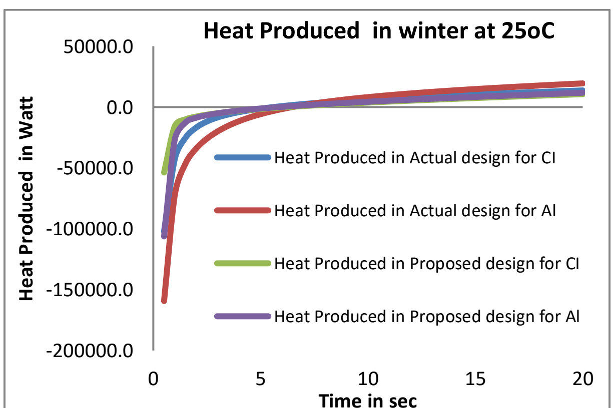


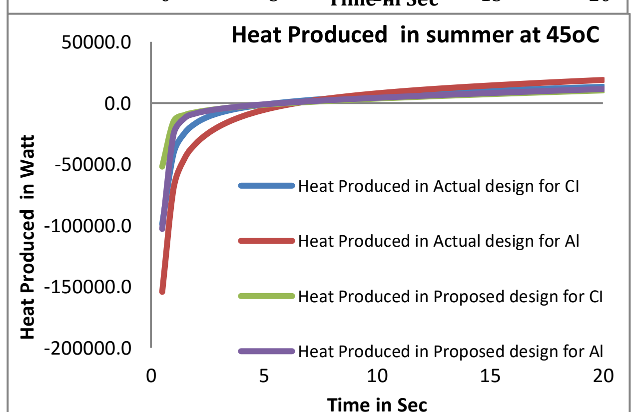

Directional Heat Flux in Y-direction for winter at 25oC
Directional Heat Flux W/m2
Time in sec
0
500000
1000000
1500000
2000000
2500000
3000000
0
5
10
15
20

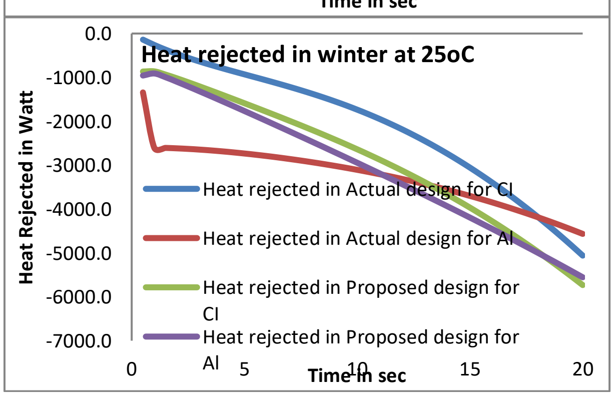

Directional Heat Flux in Y-direction for summer at 45oC
Directional Heat Flux in Y-direction of Actual design for CI
Directional Heat Flux in Y-direction of Actual design for Al
Directional Heat Flux in Y-direction of Proposed design for CI
Directional Heat Flux in Y-direction of Proposed design for Al
Directional Heat Flux W/m2
Time in Sec
0
500000
1000000
1500000
2000000
2500000
3000000
0
5
10
15
20

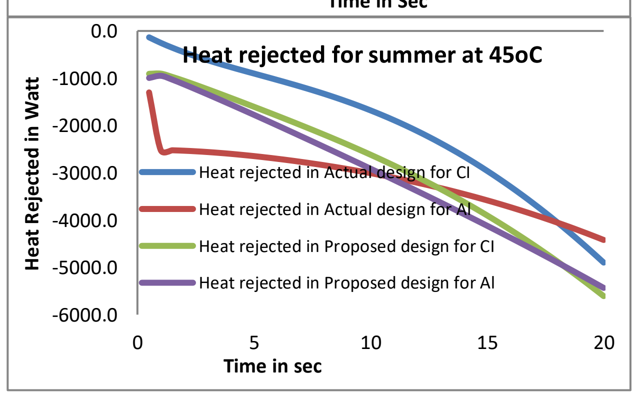

Directional Heat Flux in Z-direction for winter at 25oC
Directional Heat Flux in Z-direction of Actual design for CI
Directional Heat Flux in Z-direction of Actual design for Al
Directional Heat Flux in Z-direction of Proposed design for CI
Directional Heat Flux in Z-direction of Proposed design for Al
Directional Heat Flux W/m2
Time in sec
0
2000000
4000000
6000000
8000000
10000000
12000000
14000000
0
5
10
15
20


Directional Heat Flux in Z-direction for summer at 45oC
Directional Heat Flux in Z-direction of Actual design for CI
Directional Heat Flux in Z-direction of Actual design for Al
Directional Heat Flux in Z-direction of Proposed design for CI
Directional Heat Flux in Z-direction of Proposed design for Al
Directional Heat Flux W/m2
Time in Sec
0
2000000
4000000
6000000
8000000
10000000
12000000
14000000
0
5
10
15
20


Heat Produced in winter at 25oC
Heat Produced in Actual design for CI
Heat Produced in Actual design for Al
Heat Produced in Proposed design for CI
Heat Produced in Proposed design for Al
Heat Produced in Watt
Time in sec
50000.0
0.0
-50000.0
-100000.0
-150000.0
-200000.0
0
5
10
15
20


Heat Produced in summer at 45oC
Heat Produced in Actual design for CI
Heat Produced in Actual design for Al
Heat Produced in Proposed design for CI
Heat Produced in Proposed design for Al
Heat Produced in Watt
Time in Sec
50000.0
0.0
-50000.0
-100000.0
-150000.0
-200000.0
0
5
10
15
20


Heat rejected in winter at 25oC
Heat rejected in Actual design for CI
Heat rejected in Actual design for Al
Heat rejected in Proposed design for CI
Heat rejected in Proposed design for Al
Heat Rejected in Watt
Time in sec
0.0
-1000.0
-2000.0
-3000.0
-4000.0
-5000.0
-6000.0
-7000.0
0
5
10
15
20


Heat rejected for summer at 45oC
Heat rejected in Actual design for CI
Heat rejected in Actual design for Al
Heat rejected in Proposed design for CI
Heat rejected in Proposed design for Al
Heat Rejected in Watt
Time in sec
0.0
-1000.0
-2000.0
-3000.0
-4000.0
-5000.0
-6000.0
0
5
10
15
20

References

1. P.s shenoy, et al "dynamic analysis of loads and stresses in connecting rods" , j.mechanical engineering science,vol.220, pp.615-624 , 2006.

2. T.g.thomas et al"design of connecting rod for heavy duty applications produced by different processes for enhanced fatigue life", sastech journal volume 10, issue 1, may 2011.

3. James.r.dale "connectin rod evaluation" metal powder industries federation, jan-2005

4. Sasi prabhala, et al , design and weight optimization of ic engine, international journal of advanced engineering research and studies , vol.2 , issue.1 , pp. 56-58 , 2012.

5. A.r bhagat et al "thermal analysis & optimization of ic engine piston using fem" international journal of modern engineering research, vol.2, issue.4, pp.2919-2921, 2010.

6. P. Brabec et al "fem analysis of connecting rod for stationary engine" xiii. International scientific meeting motor vehicles & engines, kragujevac 2004.

7. T.t.mon et al "finite element analysis on thermal effect of vehicle engine ", proceedings of muceet2009 malaysian technical universities conference on engineering and technology, june 20~22, 2009**.**

8. Vivek c pathade.et al "stress analysis of ic engine connecting rod by fem", issn 2277-3754 international serbia issn 0352 292x.journal of engineering and innovative technology (ijeit) volume 1, issue 3, march 2012.

9. Ramanpreet singh "stress analysis of orthotropic andisotropic connecting rod using finiteelement method, international journal of mechanical engineering & robotics research *issn 2278 – 0149, vol. 2, no. 2, april 201.*

10. Prof. N.p.doshi et al "analysis of connecting rod using analytical and finite element method", international journal of modern engineering research (ijmer), pp-65-68 issn: 2249-6645, vol.3, issue.1, jan-feb. 2013.

11. Om parkash et al " optimizing the design of connecting rod under static and fatigue loading", international journal of research in management, science & technology (e-issn: 2321-3264), vol. 1; no. 1, june 2013. 1. P.s shenoy, et al "dynamic analysis of loads and stresses in connecting rods" , j.mechanical engineering science,vol.220, pp.615-624 , 2006.

12. T.g.thomas et al"design of connecting rod for heavy duty applications produced by different processes for enhanced fatigue life", sastech journal volume 10, issue 1, may 2011.

13. James.r.dale "connection rod evaluation" metal powder industries federation, jan-2005.

14. A.r bhagat et al "thermal analysis & optimization of ic engine piston using fem" international journal of modern engineering research, vol.2, issue.4, pp.2919-2921, 2010.