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Thermal Analysis of IC Engine

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Abstract: **Calculating the heat transfer rate of the engine is very difficult due to the complex geometry design of the engine and the periodic flow of air and fuel during engine operation for full cycles. Various theories hypothesize that about 25% of the energy contained in the fuel is converted into useful work and the remaining 75% is released into the environment by the engine. The main objective of the present work is to improve the heat transfer rate of existing constructions of the engine cylinder block by modifying its construction and also with new materials. To this end, two CAD models were created using CATIA software, then a transient thermal analysis with ANSYS at ambient temperature for the summer season of 45°C for the real one and the proposed internal combustion engine design was performed one after the other. Other to optimize the geometric parameters and improve the heat transfer rate. From the results of the transient thermal analysis, it was found that the proposed engine cylinder block design has better performance and heat transfer rates than the actual engine cylinder block design.**

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

I. Introduction

The inside burning motor (inward ignition motor) has been essential for the organization since the start of the nineteenth century. Albeit the fuel is unique (oil was not monetarily delivered until the 1850s), the idea was something very similar. The principal inside burning motors were mostly utilized in industry, yet were subsequently presented in vehicles that could now continue all alone. The principal current vehicle was planned and made by Karl Benz in 1885, it was known as the Motorwagen and 25 of these were sold somewhere in the range of 1888 and 1893 for the offer of vehicles. The main economy vehicle delivered was the Ransomed Olds Mobile in 1902.

An engine is a gadget that changes over nuclear power into mechanical work. Nuclear power is created by the ignition of the air-fuel blend in the chamber through beginning cycles given by the sparkle plug. Since it utilizes heat energy, it is known as a warmth motor. It is a wellspring of energy for specific employments.

The chamber head closes one side of the chamber. They will commonly go about as one piece and drive the chamber. A gasket is put between the chamber and the head the gasket is set with a particular end reason to go about as an attaching gadget and furthermore to lessen deadness.

A. Engine Cylinder and Combustion Chamber

It is realized that in inner ignition motors the burning of air and fuel happens in the motor chamber and hot gases are shaped. The gas temperature will be around 2300-2500°C. This is an extremely high temperature that can consume the oil film between moving parts and cause them to seize or weld, which can diminish the danger of the cylinder, cylinder ring, cylinder ring, cylinder ring seizure, etc.

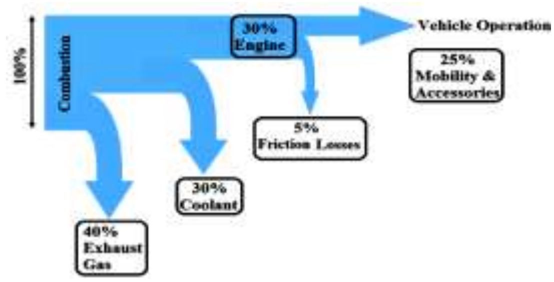

Fig. 1: Typical energy path in internal combustion engine vehicle

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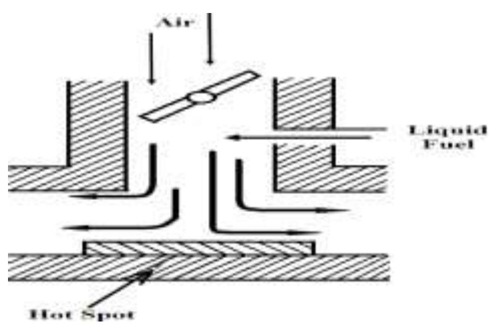

Fig. 2: Air fuel intake system

II. Literature Review

Mahendra Kumar Ahirwar et. al. [1] This article gives an exhaustive outline of late writing. The cooling component of the air-cooled motor mostly relies upon the design of the head and chamber block blades. Cooling blades are utilized to build the pace of warmth move over a given region. Motor life and proficiency can be improved with proficient cooling.

Ravi Gupta et. al. [2] This paper attempted to track down the best material as far as the most elevated warmth move rate for cooling as the principle angle, safe motor activity, high strength, light weight and furthermore least expense to use for the chamber block. The limited component strategy with ANSYS programming was utilized as a recreation instrument for the examination.

Mulukuntla Vidya Sagar et. al. [3] To cool the chamber, balances are given on the outside of the chamber to expand the pace of warmth move. The primary goal of this venture is to investigate warm properties, for example, direct warmth motion, absolute heat motion and temperature circulation by shifting the calculation, material and the thickness of the blades (3 mm, 2 mm). a generally square chamber model made in SOLIDWORKS-2013, which is brought into ANSYS WORKBENCH-2016 for transient warm investigation with normal inward temperature and stale air - improved on case as a coolant on the outer surface with an appropriate film move coefficient, for example, limit conditions.

Pulkit Sagar et. al. [4] In this work, an air-cooled cruiser motor deliveries warmth to the air through the constrained convection mode, the balances are given on the external surface of the motor chamber block. Warmth move relies upon air speed, surrounding temperature, blade math and balance surface. The ribs leave the cooling wind on their surface and move the warmth from the outside of the ribs to the air. The examination included deciding the impact of math, diverse shape and surface harshness of the ribs on heat move.

III. Objective

The following objectives can be expected from this work

1. The main goal of this thesis is to increase the heat transfer rate of an existing cylinder block.
2. To study the heat transfer behavior of internal combustion engines
3. To evaluate the rate of heat transfer in the actual cylinder block.
4. Evaluate the heat transfer rate using the proposed cylinder block design.
5. Optimize the cylinder block design based on the heat transfer rate.
6. To maximize the heat transfer rate of the cylinder block.

IV. Methodology

The heat transfer analysis is performed under the following assumptions:

1. The conductive heat transfer in the fins of the internal combustion engine is one-dimensional and occurs along the x-direction
2. Loss of heat by convection of the sides of the radiator at constant ambient temperature T_∞.
3. The steady-state heat sink.

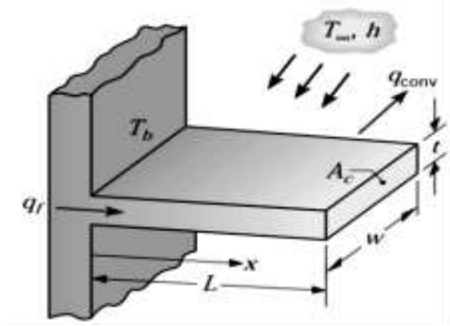

Fig. 3: Theoretical information of fin geometry

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

Case I: The fin of infinite length:

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

Case II: Fin Insulated at the tip

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

Case III: The finite length of the fin

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

CAD geometry: In this work, the cylinder block CAD geometry is created using CATIA software and then imported into the ANSYS workbench for further analysis. A three-dimensional view of the cylinder block is shown in Figure 4.

Fig 4: CAD geometry of Actual engine cylinder block

Meshing: The total node is generated 792792 and the total number of elements is 458302.

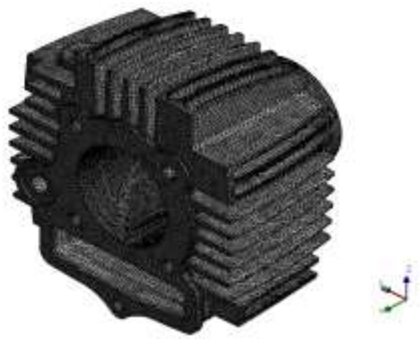

Fig. 5: Meshing of Actual engine cylinder block

The material properties of this case are as follows: Density: 7200 kg m-3, Isotropic thermal conductivity: 83 W / m °C, Specific heat: 165J / kg °C.

Temperature distribution of the actual construction of the IC engine block:

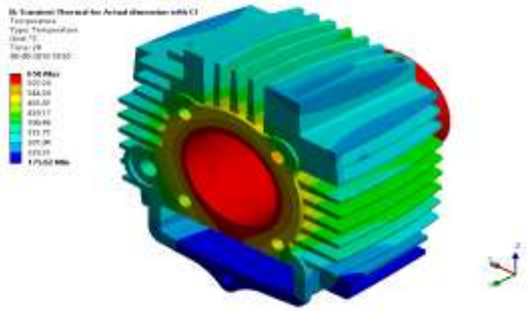

Fig 6: Temperature distribution over cylinder block for CI

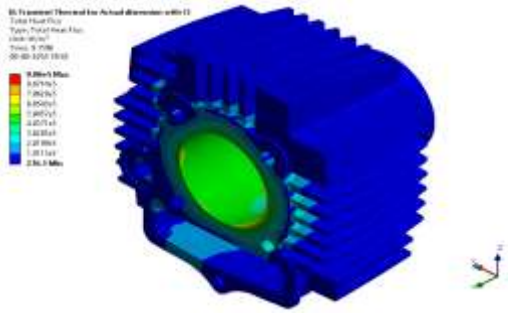

Fig. 7: Total Heat flux of actual design of engine block for CI

Boundary condition:

1. The most extreme temperature created on inside the chamber block is taken as 650°C (John B.L Heywood "Motor Heat move").
2. The encompassing temperature accepted as 45°C for summer season.
3. The worth of Isotropic warm conductivity of the material is taken as 190 W/m °C.
4. Since this chamber square of an IC motor moved in open space that is the reason it is accepted that in this open space, the ordinary air temperature accessible and its convective coefficient an incentive for the current work is taken as 100 W/m^2.
5. The Quasi Linear Thermal Transient Solution solver is utilized for transient warm investigation.

Temperature distribution of actual design of engine block for Al Alloy:

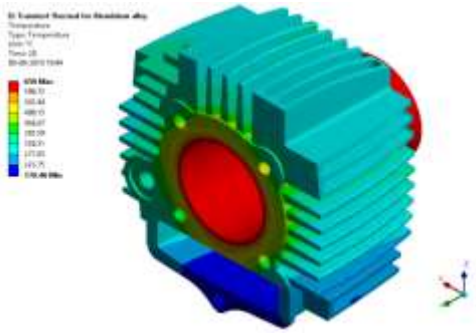

Fig. 8: Temperature distribution of actual design of engine block for Al Alloy

The maximum temperature is 650°C and minimum temperature is 170.46°C.

Total Heat flux of actual design of engine block for Al alloy:

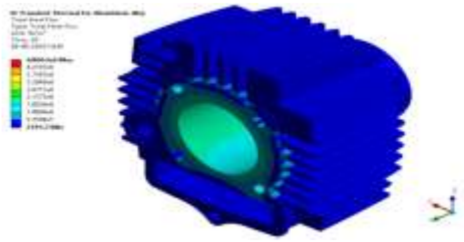

Fig. 9: Total Heat flux of actual design of engine block for Al alloy

Transient thermal analysis for the proposed project-1 with cast iron:

CAD geometry: A three-dimensional view of the proposed design-1 engine block is shown in Fig.10.

Fig 10: CAD geometry of proposed design-1 of engine cylinder block

Meshing:

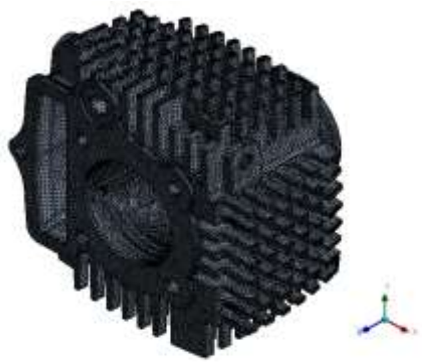

Fig. 11: Meshing of proposed design-1 of engine cylinder block

The total node is generated with 803957 and the total number of elements is 455264.

Proposed design-1 Temperature distribution of the engine cylinder block for IC:

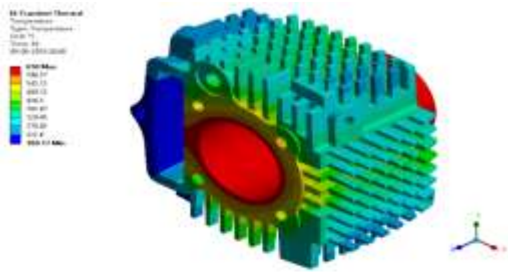

Fig. 12: Temperature distribution over cylinder block of proposed design-1 for CI

The maximum temperature is 650 ºC and minimum temperature is 169.17 ºC.

Total Heat flux of proposed design-1 of engine cylinder block for CI:

The total heat flux generated in the engine cylinder is 7.0734e6 W/m^2 as shown in Figure No. 13.

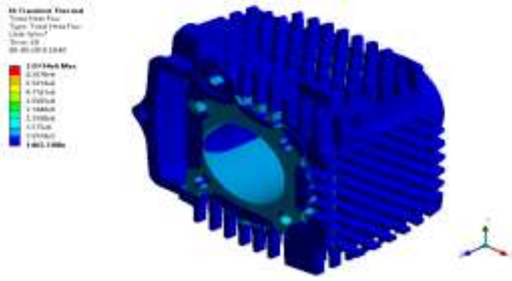

Fig. 13: Total Heat flux of proposed design-1of engine block for CI

Temperature distribution of proposed design-1 of engine block for Al alloy:

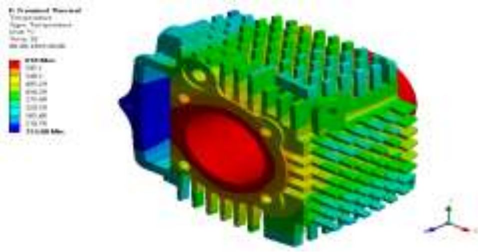

Fig. 14: Temperature distribution of proposed design-1of engine block for Al alloy

Total heat flux of engine block design 1 proposed for aluminum alloy:

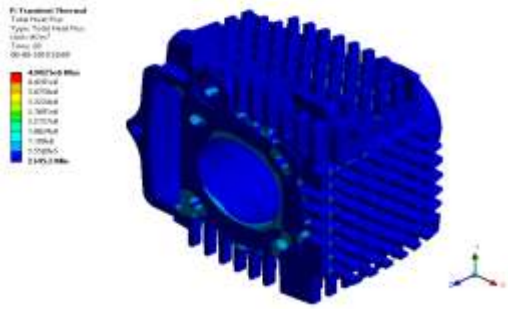

Fig.15: Total Heat flux of proposed design-1of engine block for Al alloy

Transient thermal analysis for the proposed design of an engine block with cast iron intercooler:

CAD geometry: A three-dimensional view of the proposed intercooled engine block design is shown in Figure 16.

Figure 16: CAD geometry of proposed design with water jacket

Meshing:

Fig. 17: Meshing of proposed design -2 with water jacket

The total node is generated 972853 and the total number of elements is 560322.

Proposed design 2 Motor block temperature distribution for IC:

The maximum temperature is 650 ℃ and the minimum temperature is 156.26 ℃.

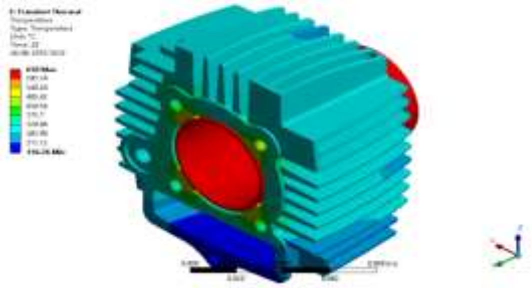

Fig 18: Temperature distribution over of proposed design-2 of engine block for CI

New Proposed Design 2 Total Motor Block Heat Flux for IC:

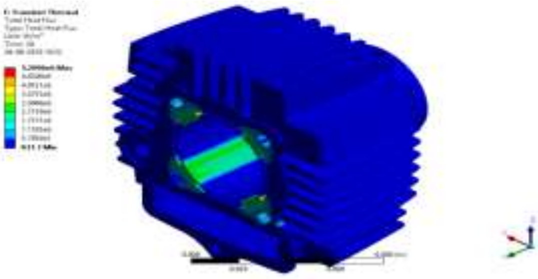

Fig. 19: Total Heat flux of new proposed design-2 of engine block for CI

Transient Thermal Analysis of Proposed Engine Block Design-2 with Al alloy:

The maximum temperature is 650 ℃ and the minimum temperature is 119.21 ℃.

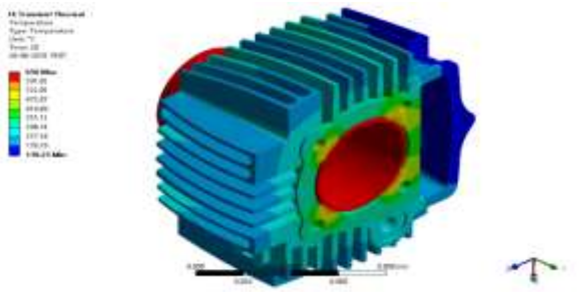

Fig. 20: Temperature distribution of proposed design-2 at engine block for Al Alloy

Proposed design - 2 total heat flows of the engine block per aluminum alloy:

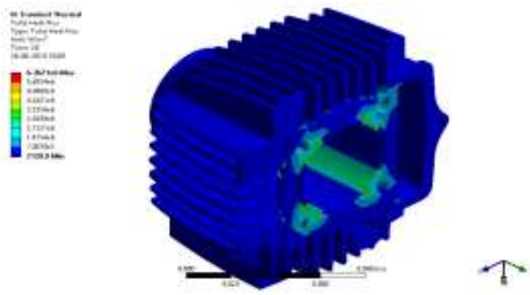

Fig. 21: Total Heat flux of proposed design-2 at engine block for Al Alloy

Transient Thermal Analysis for Proposed Design 3 of Motor Block for IC:

CAD Geometry: A three-dimensional view of the proposed intercooled engine block design is shown in Figure 22.

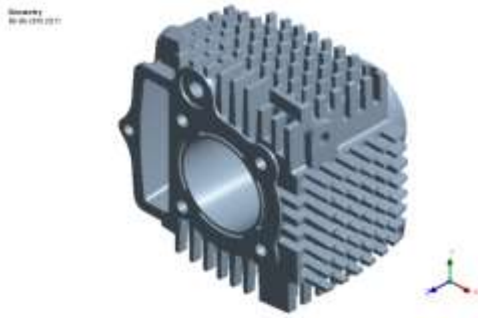

Fig. 22: CAD geometry of proposed design with water jacket

Meshing:

Fig. 23: Meshing of proposed design-3 of engine block

The total node is generated with 938346 and the total number of elements is 531983.

Proposed design 3 Temperature distribution of the motor block for IC:

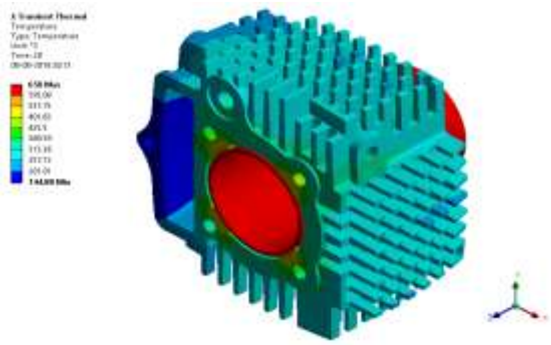

Fig. 24: Temperature distribution on proposed design-3 at engine cylinder block for CI

The temperature distribution over the whole body of the engine block is shown in figure no. The maximum temperature is 650 °C and the minimum temperature is 144.88 ° C.

Total heat flux of the proposed design 3 of the engine cylinder block for IC:

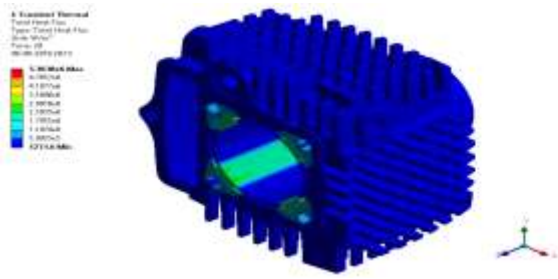

Fig 25: Total Heat flux for proposed design-3 of engine cylinder block for CI

Temperature distribution of proposed design-3 of engine cylinder block for Al alloy:

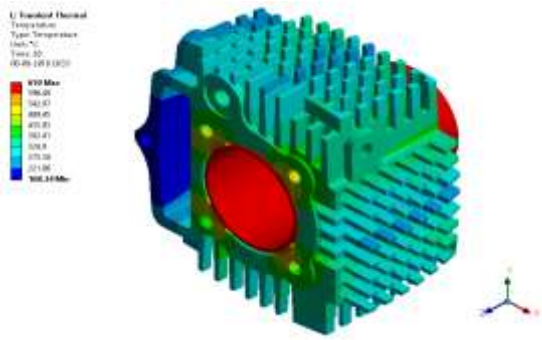

Fig. 26: Temperature distribution of proposed design-3 at engine block for Al Alloy

The maximum temperature is 650 °C and the minimum temperature is 168.34 ° C.

Total heat flux of engine cylinder block proposed 3 construction for aluminum alloy:

The total heat flux generated in the proposed construction 3 of the ribbed motor block interrupted with intercooling is 5.932e6 W / m2, as in figure 27 with outlines of different colors.

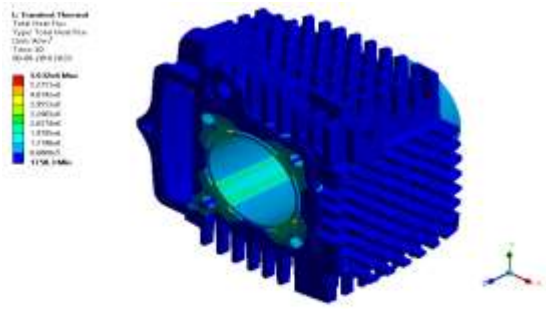

Fig. 27: Total Heat flux of proposed design-3 of engine cylinder block for Al alloy

V. Result and Discussion

The transient thermal analysis was performed with the ANSYS workbench based on the finished volume method for the current and proposed construction with and without an intermediate cooler and also for two different materials such as cast iron and aluminum alloy. The results obtained from the above parameters have been discussed in this chapter using various tabular and graphical representations.

Hypothesis

The following assumptions are made to perform a thermal analysis of the cylinder block.

- Symmetrical flow and identical heat transfer throughout the heat sink
- An isothermal boundary condition is used for the base and ribs.

Results of the current and proposed design of the cylinder block of the internal combustion engine:

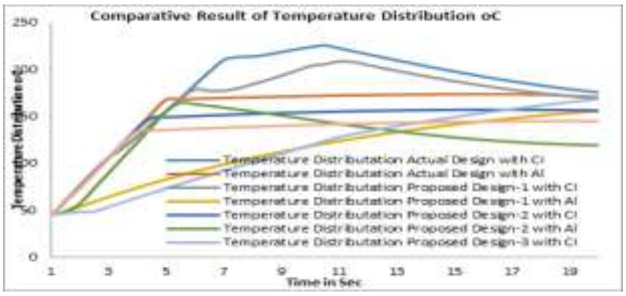

Fig. 28: Comparative Result of Temperature Distribution

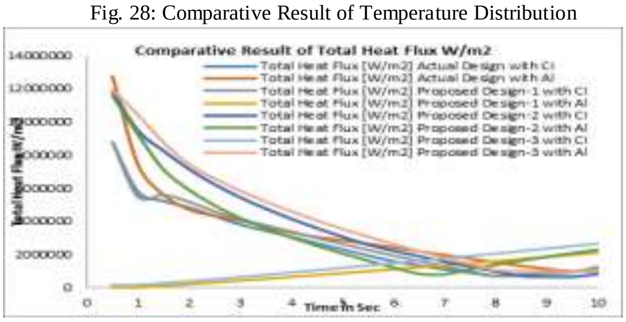

Fig. 29: Comparative Result of Total Heat Flux

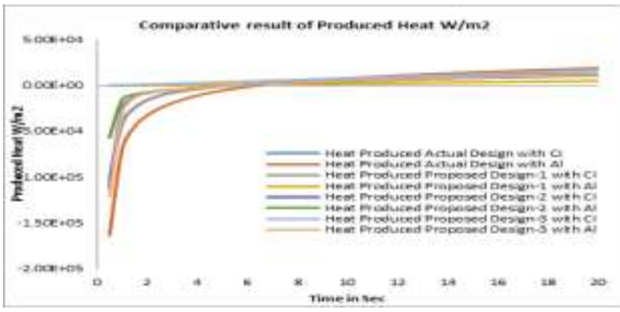

Fig. 30: Comparative Result of Produced heat

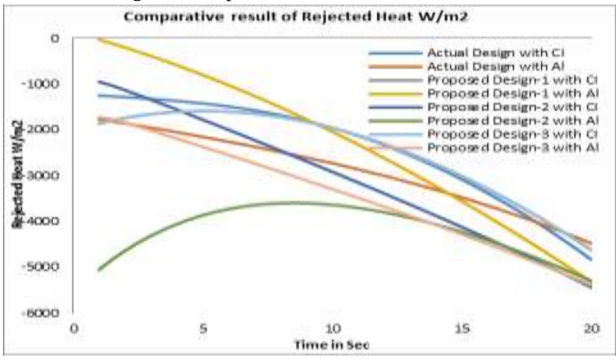

Fig. 31: Comparative Result of Heat rejected

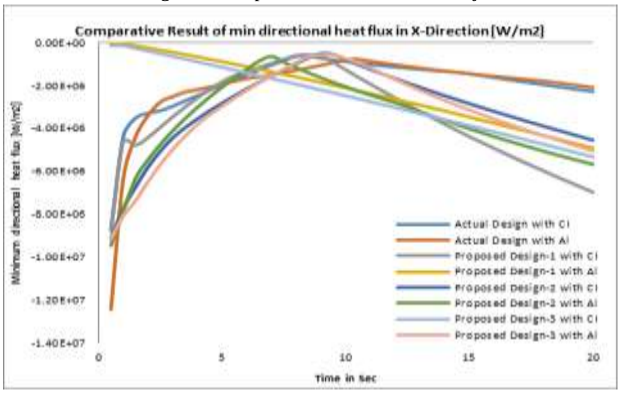

Fig. 32: Comparative Result of min directional heat flux in X-direction

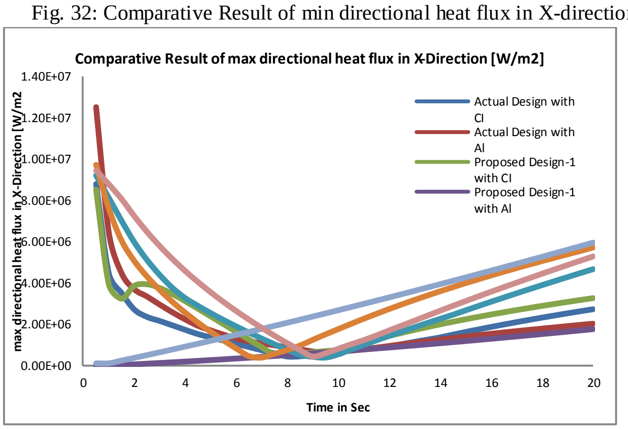

Fig. 33: Comparative Result of max directional heat flux in X-direction

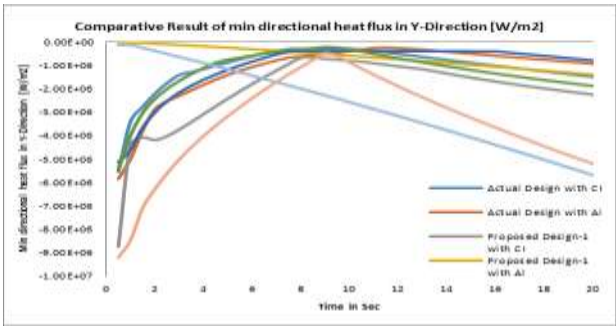

Fig. 34: Comparative Result of min directional heat flux in Y-direction

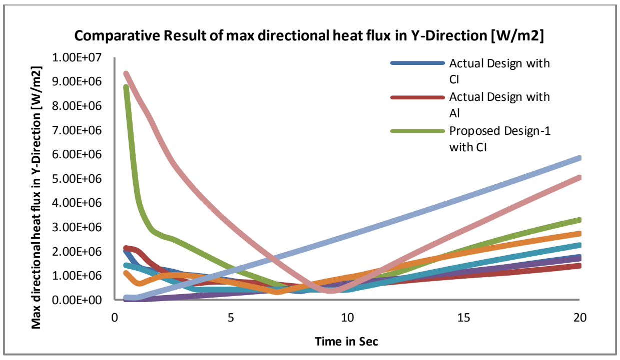

Fig. 35: Comparative Result of max directional heat flux in Y-direction

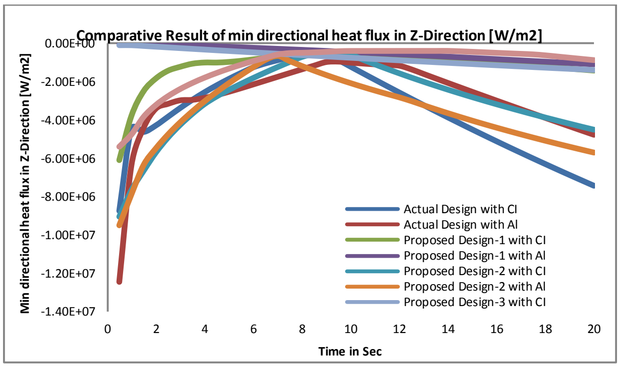

Fig 36: Comparative Result of min directional heat flux in Z-direction

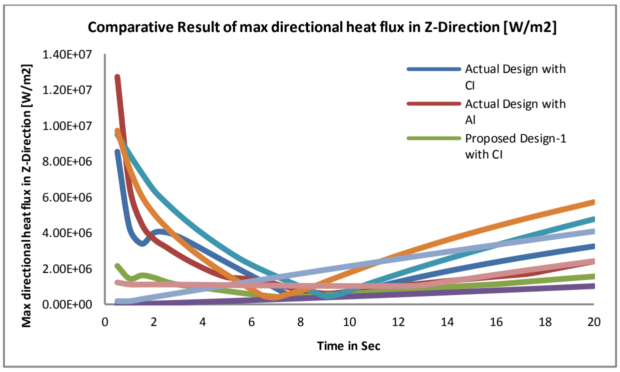

Fig. 37: Comparative Result of max directional heat flux in Z-direction

Table 1 Comparative results of Temperature Distribution

Design of Cylinder block	Temperature Distribution (°C)	Total Heat Flux (W/m²)
Actual design with CI	175.62	9.08E+05
Actual design with Al alloy	170.46	4.81E+06
Proposed design-1 with CI	169.17	7.07E+06
Proposed design-1 with Al alloy	155.88	4.98E+06
Proposed design-2 with CI	156.26	5.21E+06
Proposed design-2 with Al alloy	119.21	6.36E+06
Proposed design-3 with CI	168.34	5.93E+06
Proposed design-3 with Al alloy	144.88	5.38E+06

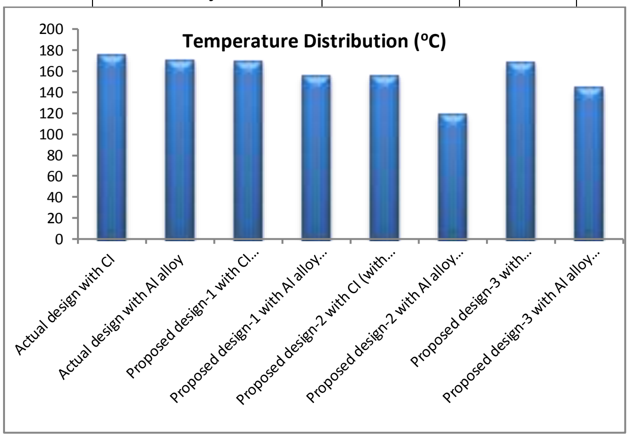

Figure 38: Comparative Result of temperatures

VI. Conclusion

Numerical and transient warm breaks down were performed to streamline the mathematical boundaries for heat move from the genuine motor chamber block and the proposed chamber block plan.

The accompanying focuses have been recognized as conclusive explanations which read as follows.

1. The consequence of the transient warm investigation of the current plan motor chamber block for cast iron as material at a climatic temperature of 45 °C shows the temperature circulation on the chamber block, the greatest temperature is 650 °C and the temperature least is 175.62 °C, the absolute warm motion created is 9.08 °C and 6 W/m2.

2. The aftereffect of the transient warm examination of the current plan motor chamber block for aluminum combination as material at a barometrical temperature of 45 °C shows the temperature dispersion on the chamber block, the greatest temperature is 650 °C and the base temperature is 170.46 °C, the complete warmth motion produced is 4.8063 °C and 6 W/m2.

3. The aftereffect of the transient warm examination of the proposed development 1 of the motor chamber block with intruded on ribs for CI as material at a climatic temperature of 45 °C shows the temperature appropriation on the chamber block, the greatest temperature is 650 °C and the base temperature is 169.17 °C, complete The warmth transition produced is 7.0734e6 W/m2.

4. The aftereffect of the transient warm examination of the proposed development 1 of the motor chamber block with intruded on ribs for aluminum compound as material at air temperature of 45 °C shows the temperature dissemination on the chamber block, the most extreme temperature is 650 °C and the base temperature is 155.88 °C, the absolute warmth transition produced is 4.9825e5 W/m2.

5. The consequence of the transient warm examination of the proposed development 2 of the intercooled motor chamber block for IC as material at 45 °C air temperature shows the temperature dispersion on the chamber block, the greatest temperature is 650 °C and the base temperature is 156.26 °C, the complete warmth motion produced is 5.2096e6 W/m2.

6. The consequence of the transient warm examination of the proposed development 2 of the motor chamber block with intercooler for an aluminum amalgam as material at 45 °C environmental temperature shows the temperature dispersion on the chamber block, the most extreme temperature is 650 °C and the base temperature is 119.21 °C, the absolute warmth transition produced is 6.3621e6 W/m2.

7. The aftereffect of the transient warm investigation of the proposed development 3 of the intercooled ribbed motor chamber block with IC intercooler as material at 45 ° C environmental temperature shows the temperature conveyance on the chamber block, the greatest temperature is 650 °C and the base temperature is 144.88 °C, the all out heat motion produced is 5.3838e6 W/m2.

8. The consequence of the transient heat examination of the proposed development 3 of the intercooled ribbed motor chamber block with aluminum composite as material at an air temperature of 45 °C shows the temperature dispersion. The greatest temperature is 650 °C and the base temperature is 168.34 ºC, the absolute warmth motion produced is 5.932 e6 W/m2

In rundown, the proposed plan of the motor chamber block, utilizing an aluminum amalgam for the intercooler gadgets, has better execution and better warmth scattering from the warming zone in the inner burning motor, which is the reason this work has zeroed in additional on this point and furthermore recommended.

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