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Thermal Analysis of IC Engine Cylinder Block with Fins Perpendicular to the Axis of Piston Movement

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Abstract: **The combustion chamber of engine cylinder of motor cycle is subjected to a high temperature and thermal stresses, on which fins are, mounted in order to cool the cylinder, fins are provided on the cylinder to increase the heat transfer rate. In this report thermal analysis of engine block with fins were analyzed. By doing thermal analysis on cylinder block fins, it is helpful to know the heat dissipation inside the cylinder. The principle behind the cooling of the cylinder block is to extend the fins over the cylinder block by which the heat transfer rate will be increased. The parametric model of engine block fins has been developed in 3D software Solidworks and thermal analysis is done on the fins and the block to determine temperature variation in transient state and in steady state that is, with and without consider over time. The Thermal analysis is done by using ANSYS software. Analysis is conducted with varying material also. In this thesis report two model were created in software and modified design of the same model were analyzed, and comparison of two models according to geometry and material wise analyzed. The new material was chosen as aluminium alloy 1050 for this analysis.**

Keywords: **Engine Cylinder Fins, Geometry, Material, Thermal Analysis.**

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1. INTRODUCTION

In an combustion chamber of internal combustion engine, combustion occur at high temperature and pressure due to which chances of piston seizure , overheating, chances of piston ring, compression ring, oil ring etc can be affected . Excess temperature can also damage the cylinder material. Due to overheating chances of pre-ignition also occurs. In Air cooled motorcycle engines heat release to the atmosphere through forced convection. The rate of heat transfer depends upon the wind velocity, geometry of engine surface, external surface area and the ambient temperature. In this work analysis is done on engine block fins considering temperature inside by means of conduction and convection, air velocity is not consider in this work. Motorbikes engines are normally designed for operating at a particular atmosphere temperature, however cooling beyond optimum limit is also not considered because it can reduce overall efficiency. Thus it may be observed that only sufficient cooling is desirable.

Inside the cylinder the temperature of gases will be around $800℃ - 2000℃$. This is very high temperature and may result into burning of oil film between the moving parts this temperature must be reduced to about 150-200℃ at which engine will work more efficiently.

2. FINITE ELEMENT MODELLING

Modeling of Existing Model of Cylinder Block with Perpendicular Fins:

The specification of first model engines cylinder block with dimensions of $120 \times 130 \times 63$ was made in 3D modeling software Solidworks. There are Total number of fins were 7 , with number of gaps between the fins are 6,the thickness of fin are 3 mm, where the gap between the fins are 7 mm , in this model length of stroke is 63 mm.

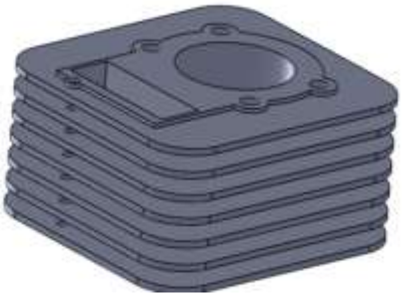


Fig.1: Solid Model of First Existing Model (3 mm thickness)

Modification of Existing Model of Cylinder Block with Perpendicular Fins:

This modification is done for weight reduction in model, number of gaps between the fins were increased by 1 mm that is from 7 to 8 mm. and thickness of fins were decreased by 1 mm for 5 fins and first and last fin were of 0.5 mm reduction in thickness.

Fig.2: Modified Solid Model of Existing Model (2.5 mm thickness)

Meshing of First Existing Model:

Model	Nodes	Elements
Solid	179579	88235

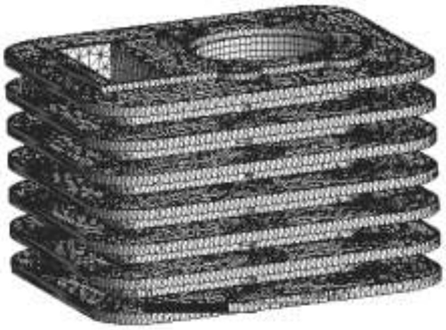


Fig.3: Mesh Model of Existing Model

Meshing of Modified Existing Model:

Model	Nodes	Elements
Solid	127023	66856

Fig.4: Mesh Model of Modified Existing Model

3. MATERIALS AND PROPERTIES

(i) Mechanical Properties AA 1050:

Sr no.	Material Properties	Unit	Values
1	Tensile strength	N/mm^2	100- 135
2	Yield strength	N/mm^2	75 N/mm^2
3	Shear strength	N/mm^2	70 N/mm^2
4	Elongation	%(A 50)	4-5
5	Brinell hardness	HB	35
6	Thermal conductivity	W/m-k	229
7	Melting range	ºC	645- 647
8	Electrical conductivity	% IACS	58.4
9	Coefficient of thermal expansion		23.5 X 10^{-6}
10	Elastic modulus	GPa	69
11	Density	Kg/m^3	2710
12	Specific heat	J/Kg -ºC	900

(ii) Mechanical Properties of Materials Aluminium Alloy:

Sr no.	Material Properties	Unit	Values
1	Density	Kg/m^3	2770
2	Coefficient of thermal expansion	1/K	23x 10^{-6}
3	Specific heat	J/Kg -ºC	875
4	Compressive yield strength	Pa	2800x 10^{-5}
5	Tensile ultimate strength	Pa	3100
6	Young’s modulus	GPa	71
7	Poisson’s ratio		0.33
8	Bulk modulus	Pa	6.9608x 10^{10}
9	Shear modulus	Pa	2.6692x 10^{10}
10	Thermal conductivity	W/m-k	120-160 m-k

(iii) Mechanical Properties of Materials Gray Cast Iron:

Sr no.	Material Properties	Unit	Values
1	Density	Kg/m^3	7200
2	Young’s modulus	GPa	110
3	Poisson’s ratio		0.28
4	Bulk modulus	Pa	8.33x 10^{10}
5	Shear modulus	Pa	4.2969x 10^{10}
6	Tensile ultimate strength	Pa	2.4x 10^8
7	Compressive ultimate strength	Pa	8.2x 10^8
8	Thermal conductivity	W/m-k	52
9	Specific heat	J/Kg -ºC	447
10	Coefficient of thermal expansion	1/K	11x 10^{-6}

(iv) Mechanical Properties of Materials Magnesium Alloy:

Sr no.	Material Properties	Unit	Values
1	Density	Kg/m^3	1800
2	Young's modulus	GPa	45 GPa
3	Poisson's ratio		0.35
4	Bulk modulus	Pa	5.0×10^{10}
5	Shear modulus	Pa	1.6667×10^{10}
6	Tensile yield strength	Pa	1.93×10^{8}
7	Compressive ultimate strength	Pa	1.93×10^{8}
8	Thermal conductivity	W/m-k	156
9	Specific heat	J/Kg -ºC	1024
10	Coefficient of thermal expansion	1/K	26×10^{-6}

4. STEADY STATE THERMAL ANALYSIS

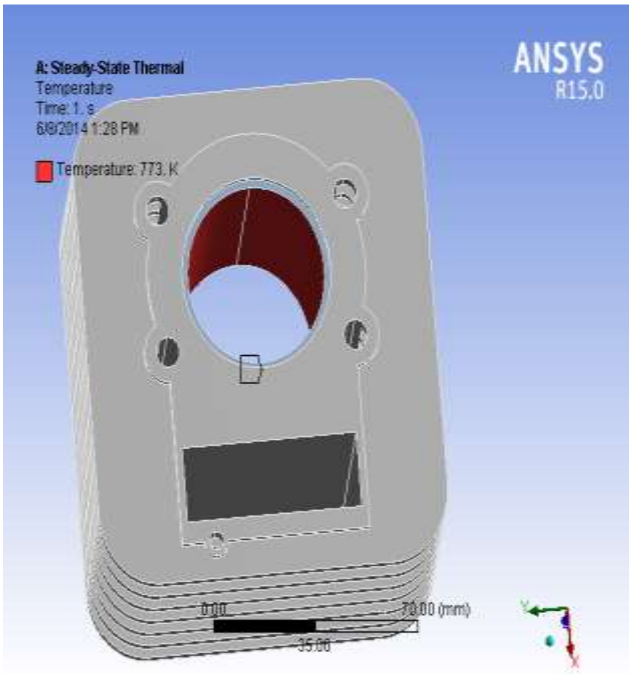
A steady state thermal analysis calculates the effect of steady thermal load on a system or component, analyst were also doing the steady state analysis before performing the transient analysis. A steady state analysis can be the last step of transient thermal analysis. We can use steady state thermal analysis to determine temperature, thermal gradient, heat flow rates and heat flux in an object that do not vary with time.

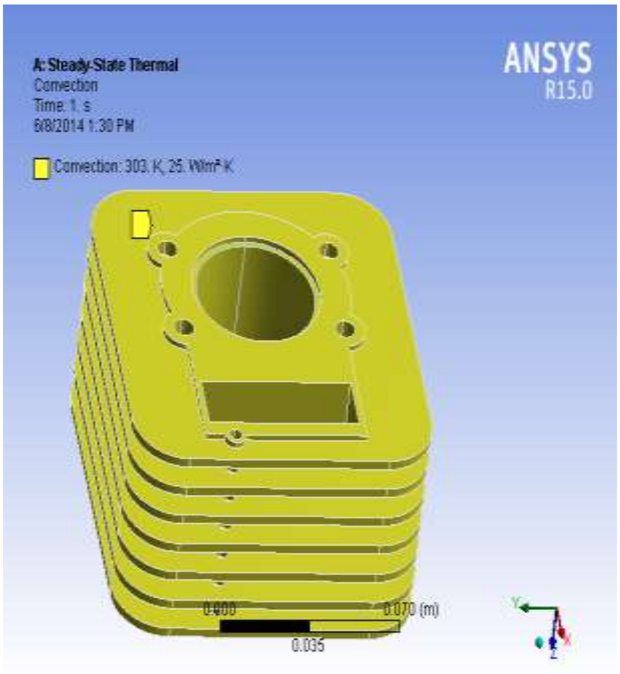
A steady state thermal analysis may be either linear with constant material properties or non linear with material properties that depend on temperature. The thermal properties of most material do vary with temperature, so the analysis is usually non linear.

Boundary Conditions:

The following are the input parameters

Sr. No.	Loads	Units	Value
1	Inlet temperature	K	773
2	Film coefficient	W/m^2 K	25
3	Ambient temperature	K	303
4	Material		Aluminium Alloys





5. RESULT AND DISCUSSION

Temperature Distribution of Existing Models:

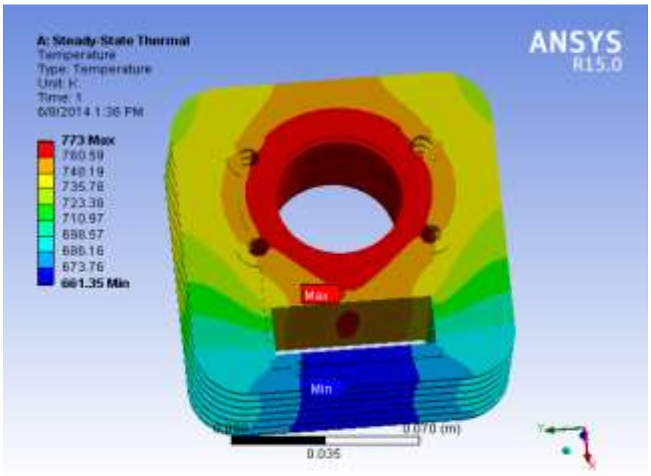


Fig.5: Aluminium Alloys

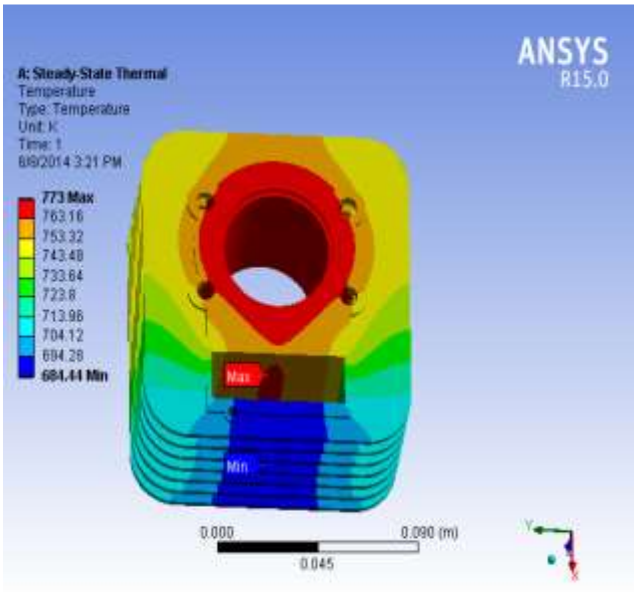


Fig.6 : Aluminium Alloys 1050

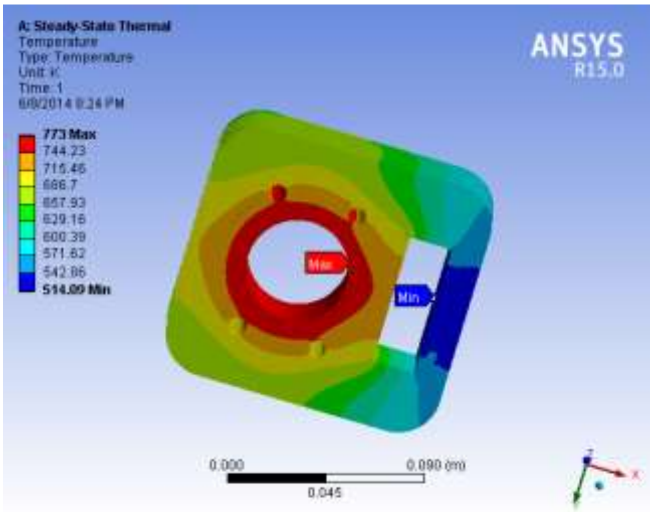


Fig.7 : Grey Cast Iron

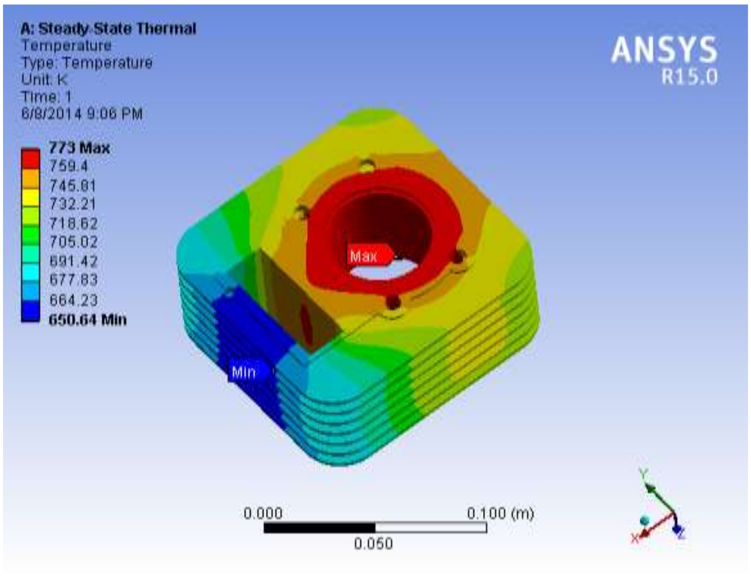


Fig.8 : Magnesium Alloys

Temperature Distribution of Modified Models:

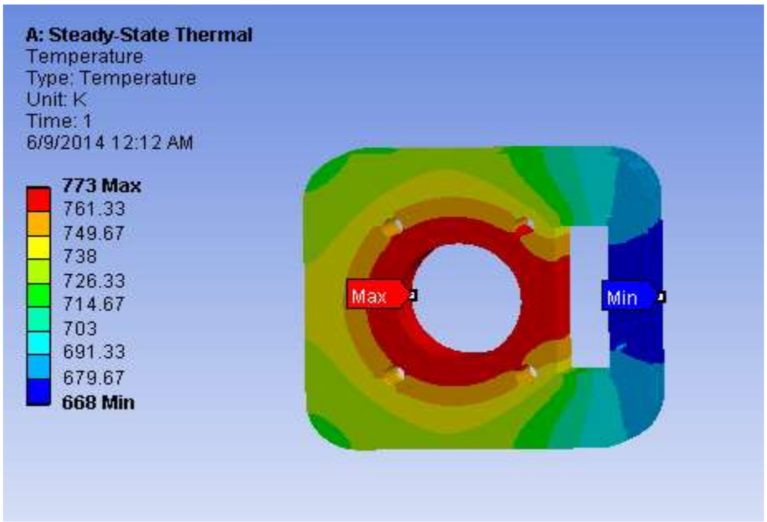


Fig.9 : Aluminium Alloys

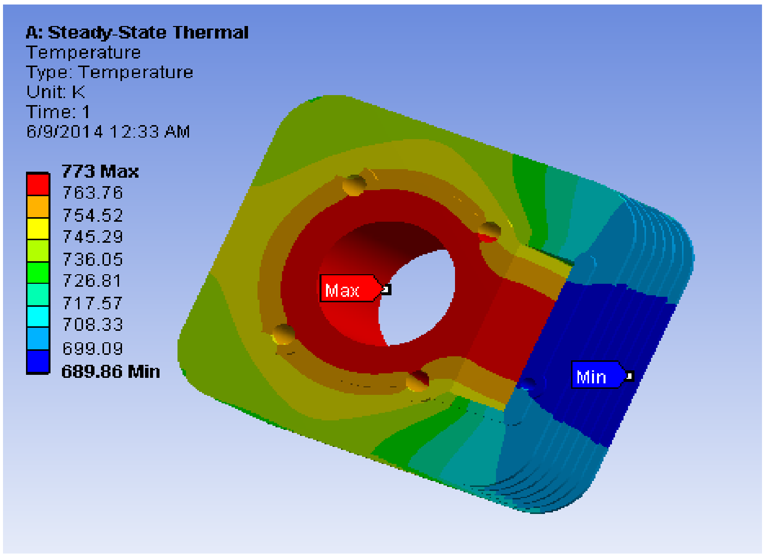


Fig.10 : Aluminium Alloys 1050

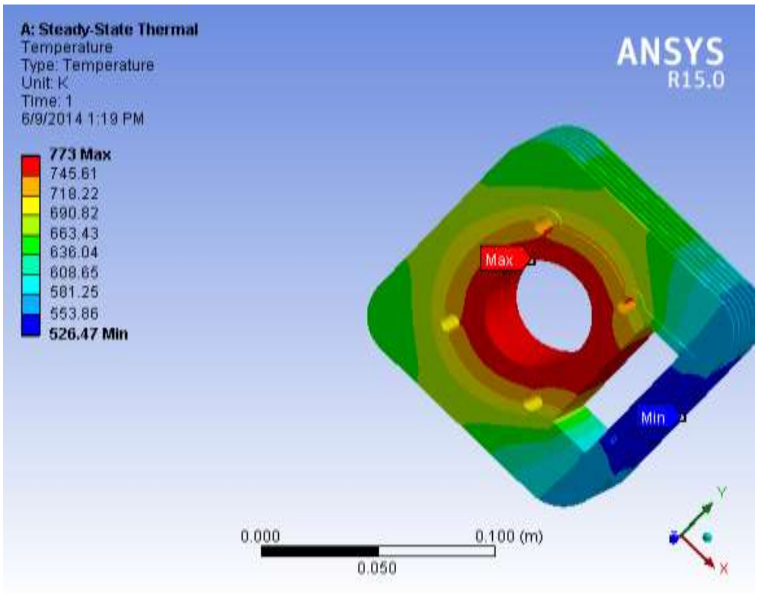


Fig.11: Grey Cast Iron

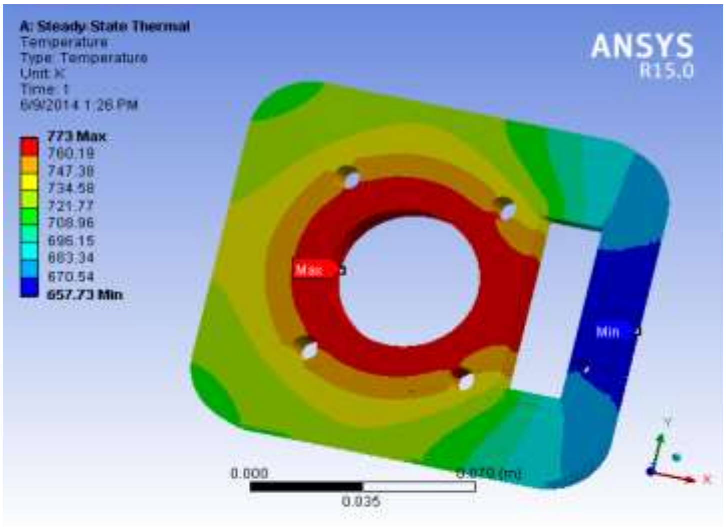


Fig.12: Magnesium Alloys

Total Heat Flux of Existing Models:

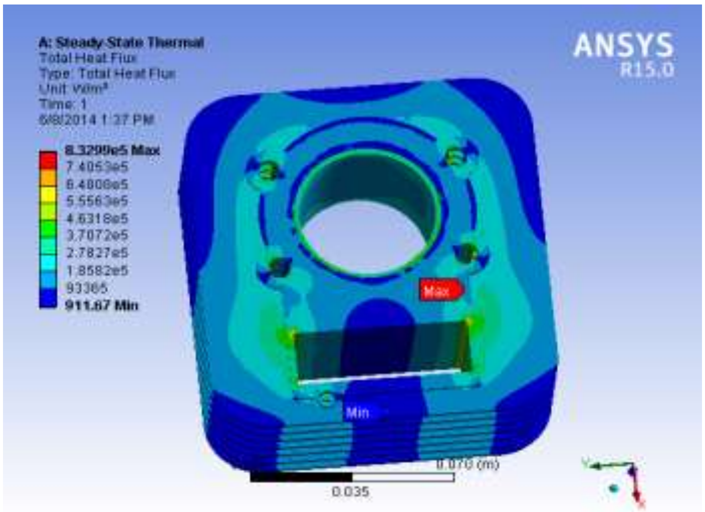


Fig.13: Aluminium Alloys

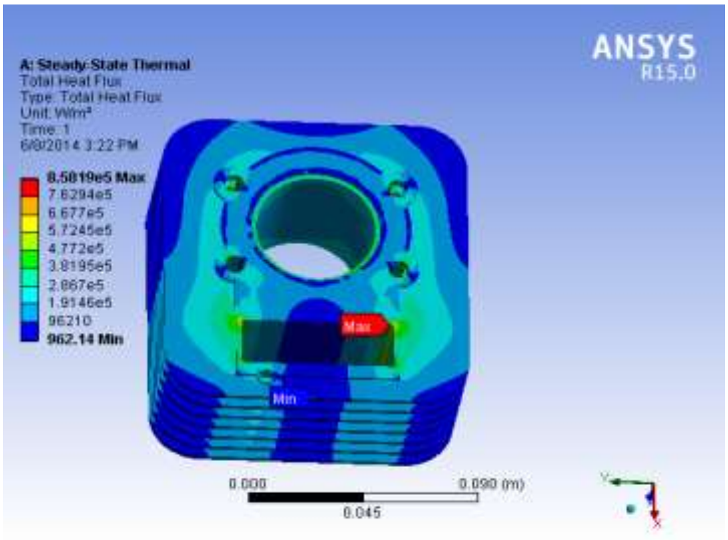


Fig.14 : Aluminium Alloy 1050

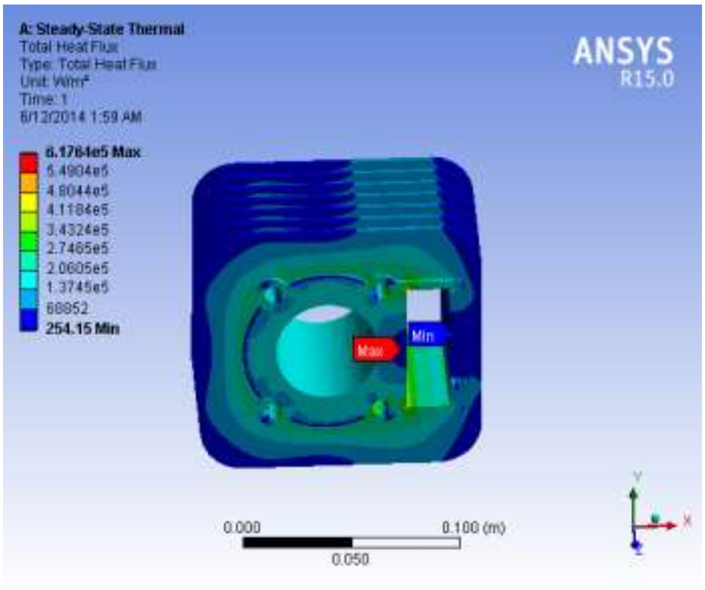


Fig.15: Grey Cast Iron

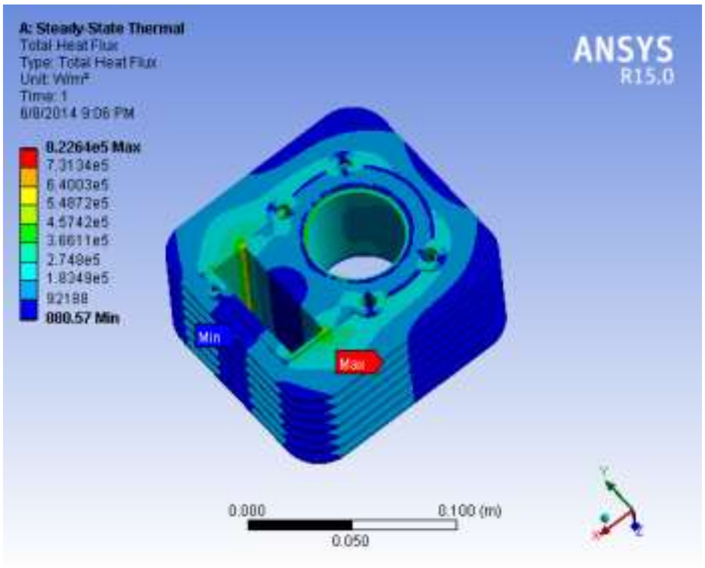


Fig.16: Magnesium Alloys

Total Heat Flux of Modified Models:

Fig.17: Aluminium Alloys

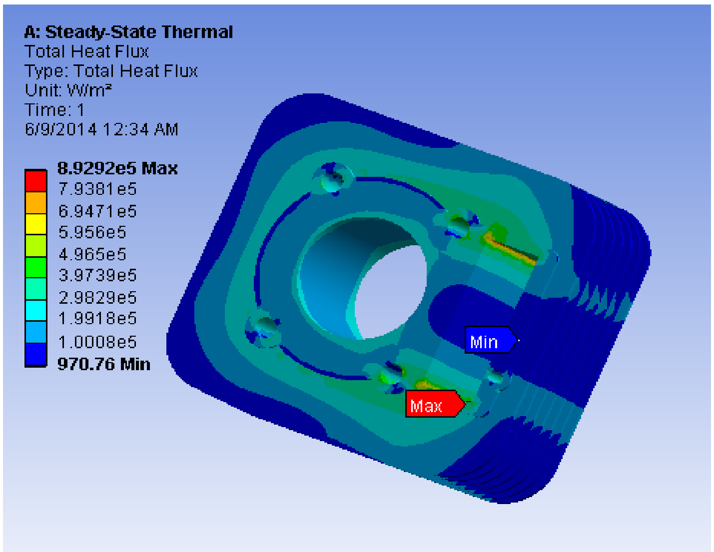


Fig.18: Aluminium Alloy 1050

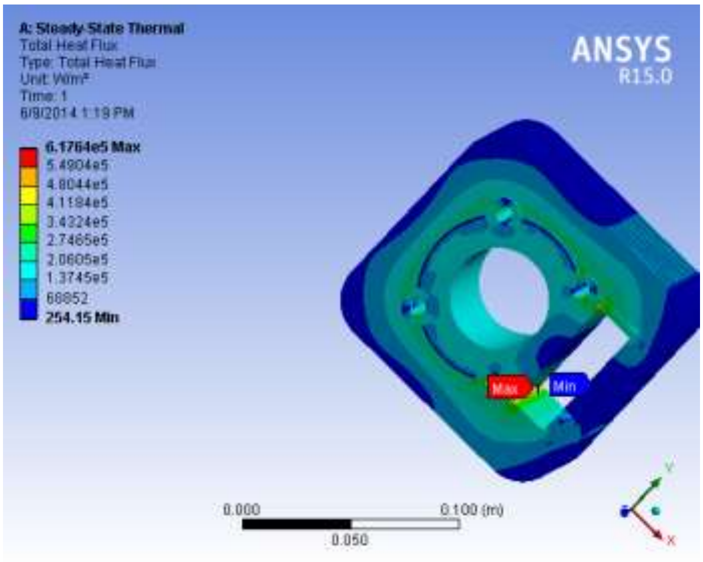


Fig.19: Grey Cast Iron

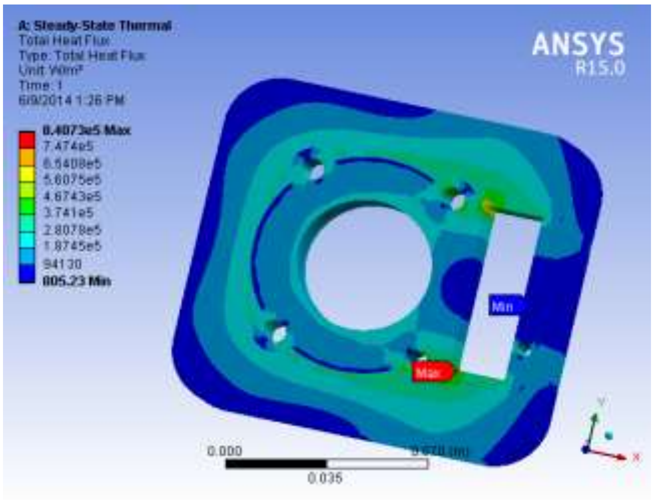


Fig.20: Magnesium Alloys

Materials	**Temperature Distribution** (° *K*)			
	Model 1		**Modified Model**	
	max	min	max	Min
Aluminum alloys	773	661.35	773	668
Aluminum alloy 1050	773	684.44	773	689
Cast iron alloys	773	514.09	773	526.47
Magnesium alloys	773	650.64	773	657.73

Materials	**Heat Flux(W/m^2)**			
	Model 1		**Modified Model**	
	max	min	max	min
Aluminum alloys	8.329× 10^5	911.67	8.574× 10^5	857.3
Aluminum alloy 1050	8.581× 10^5	962.14	8.929× 10^5	970.76
Cast iron alloys	6.1764× 10^5	254.15	6.176× 10^5	245.15
Magnesium alloys	8.226× 10^5	880.57	8.40× 10^5	805.23

6. CONCLUSION

In this present work, cylinder block was made in 3D software Solidworks in which perpendicular fins are mounted. After that modifications is done in engine cylinder block fins, thickness is reduced from 3 mm to 2 mm. so that weight will reduced , second thing to choose material which has to replace the existing materials , in this analysis aluminium alloy 1050 is chosen for thermal analysis to evaluate the better heat transfer rate. In first case due to modification weight of block reduced to **13.2 %,** in second case due to material change weight reduced to **2.1 %** without compromising with strength.

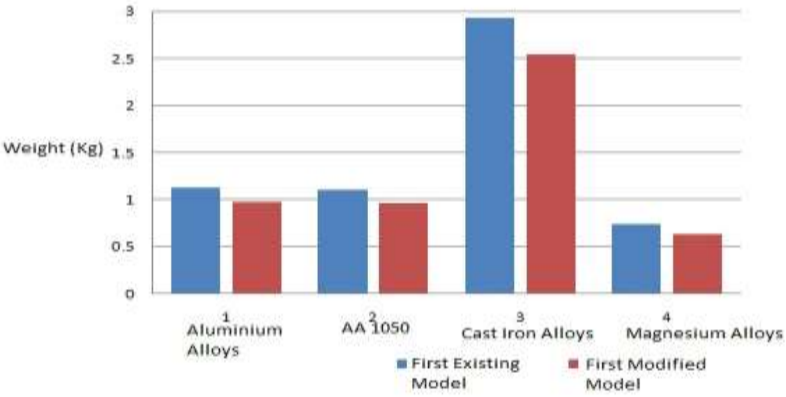


Fig.21: Weight of Engine Block of First Existing Model and Modified Model Comparing With Different Materials

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