Modeling and Analysis of Cylinder Fin Body for IC Engine

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Abstract: In an internal combustion engine, the cylinder head (often informally abbreviated to just head) sits above the cylinders on top of the cylinder block. It closes in the top of the cylinder, forming the combustion chamber. This joint is sealed by a head gasket. In most engines, the head also provides space for the passages that feed air and fuel to the cylinder, and that allow the exhaust to escape. The head can also be a place to mount the valves, spark plugs, and fuel injectors.

The major automobile component subject to high temperature variation and thermal stress is engine cylinder. Fins are used on the surface of engine cylinder to increase the heat transfer rate. Heat rejection rate in engine cylinder fins can be enhanced by increasing its surface area. The objective of the present investigation is to examine the thermal properties by varying geometry, and material cylinder fins using solid works and Ansys work bench and the models are created by changing the geometry like (i) no of fins (ii) fin thickness (iii) gap between fins.

In this paper 2 different types of boundary conditions (static, thermal) were applied and calculated results like deformation, stress, strain, safety factor, total temperature distribution, heat flux values, after calculating all these results finally, concluded with optimum fins shape and their materials with suitable graphs and table.

KEYWORDS: Solid Works, Ansys, Fins, deformation, safety factor

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I. INTRODUCTION

Cylinder head

In an internal combustion engine, the cylinder head (often informally abbreviated to just head) sits above the cylinders on top of the cylinder block. It closes in the top of the cylinder, forming the combustion chamber. This joint is sealed by a head gasket. In most engines, the head also provides space for the passages that feed air and fuel to the cylinder, and that allow the exhaust to escape. The head can also be a place to mount the valves, spark plugs, and fuel injectors.

Fins

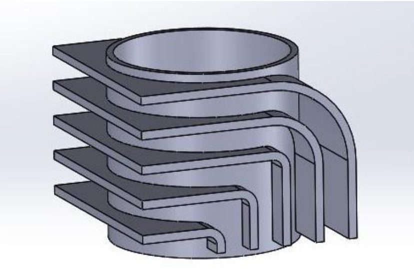
The term extended surface is commonly used in reference to a solid that experiences energy transfer by conduction and convection between its boundary and surroundings, a temperature gradient in x direction sustains heat transfer by conduction internally at the same time, there is heat dissipation by convection into an ambient at T∞ from its surface at temperature TS, given as

$$Q = h\,As\,(T_S - T_\infty)$$

Where h=convection heat transfer coefficient

AS =Heat transfer area of a surface

When the temperatures TS and T∞ are fixed by design considerations, there are only two ways to increase the heat transfer rate:(i) to increase the convection coefficient h, (ii) to increase the surface area A. in this situations, in which an increase in h is not practical or economical, because increasing h may require the installation of pump or fan or replacing existing one with larger one, the heat transfer rate can be increased by increasing the surface area. For heat transfer from a hot liquid to a gas, through a wall, the value of heat transfer coefficient on the gas side is usually very less compared to that liquid side (hgas<<<<hliquid) .to compensate low heat transfer coefficient, the surface area on the gas side may be extended for a given temperature difference between surface and its surroundings.



These extended surfaces are called fins. The fins are normally thin strips of highly conducting metals such as aluminum, copper, brass etc. The fins enhance the heat transfer rate from a surface by exposing larger surface area to convection. The fins are used on the surface where the heat transfer Coefficient is very low. Total heat produced by the combustion of charge in the engine cylinder may not convert into useful power at the crankshaft. So loss of heat approximately at the cylinder walls is 30% due to cooling. If this heat is not removed from the cylinders it would result in the pre-ignition of the charge and also damage the cylinder material. as well as the lubricant may also burn away, so that causing the piston may seizing keeping the above factor in view , it is observed that suitable heat must be maintained in the cylinder. So that excess heat removed by adding the fins to the cylinder walls.

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II. PROBLEM IDENTIFICATION

Indian two-wheeler market is the world's second biggest market. Among the three segments (motorcycles, scooters and mopeds) of the Indian two wheeler market, major growth trends have been seen in the motorcycle segment over the last four to five years due to its resistance and balance even on bad road conditions. In Indian motorcycles, Air-cooling is used due to reduced weight and simple in construction of engine cylinder block. As the air-cooled engine builds heat, the cooling fins allow the wind and air to move the heat away from the engine. Low rate of heat transfer through cooling fins is the main problem in this type of cooling.

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 surface of 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 the 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 varying geometry, material of cylinder fins.

III. MATERIAL SELECTION

Al-2024,al-5059,al-6061 are selected material. These material are the alloys of aluminium which are light weight which reduces the weight of the engine. These material have have good thermal properties.

IV. LITERATURE REVIEW

G. Babu and M. Lavakumar analyzed the thermal properties by varying geometry, material and thickness of cylinder fins. The models were created by varying the geometry, rectangular, circular and curved shaped fins and also by varying thickness of the fins. Material used for manufacturing cylinder fin body was Aluminium Alloy 204 which has thermal conductivity of 110-150W/mk and also using Aluminium alloy 6061 and Magnesium alloy which have higher thermal conductivities. They concluded that by reducing the thickness and also by changing the shape of the fin to curve shaped, the weight of the fin body reduces thereby increasing the efficiency. The weight of the fin body is reduced when Magnesium alloy is used and using circular fin, material Aluminium alloy 6061 and thickness of 2.5mm is better since heat transfer rate is more and using circular fins the heat lost is more, efficiency and effectiveness is also more.

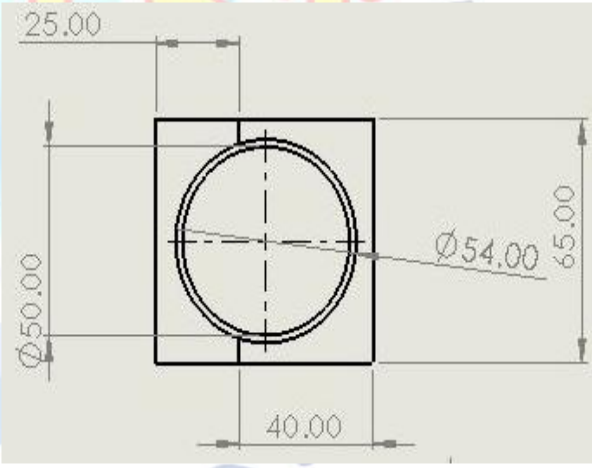
J. Ajay Paul et.al. carried out Numerical Simulations to determine heat transfer characteristics of different fin parameters namely, number of fins, fin thickness at varying air velocities. A cylinder with a single fin mountedon it was tested experimentally. They concluded that 1. When fin thickness was increased, the reduced gap between the fins resulted in swirls being created which helped in increasing the heat transfer. 2. Large number of fins with less thickness can be preferred in high speed vehicles than thick fins with less numbers as it helps inducing greater turbulence and hence higher heat transfer.

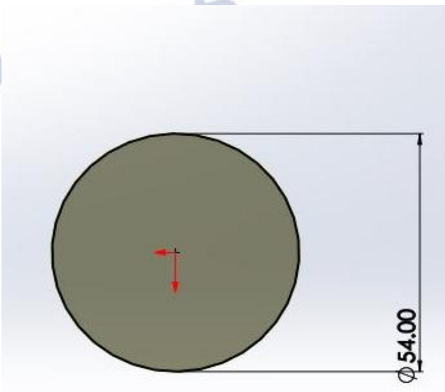
. N. Phani Raja Rao et.al. analyzed the thermal properties by varying geometry, material and thickness of cylinder fins. Different material used for cylinder fin were Aluminium Alloy A204, Aluminium alloy 6061 and Magnesium alloy which have higher thermal conductivities and shown that by reducing the thickness and also by changing the shape of the fin to circular shaped, the weight of the fin body reduces thereby increasing the heat transfer rate and efficiency of the fin

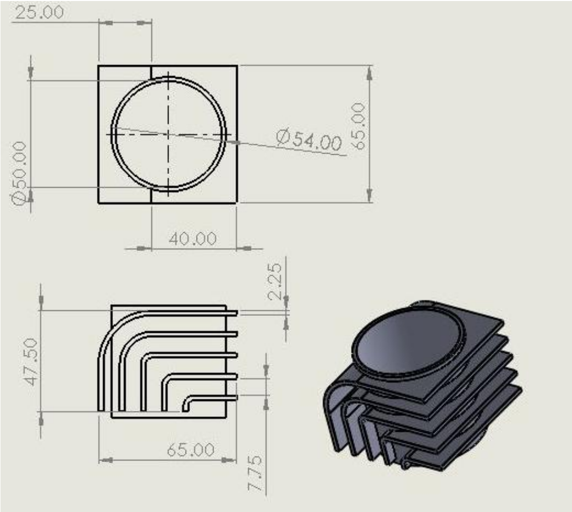
V. MODELING

Solid-Works is solidmodeling computer-aided design (CAD) and computer aided engineering (CAE) computer program. SolidWorks is a solid modeler, and utilizes a parametric feature-based approach which was initially developed by PTC (Solid works/Pro-Engineer) to create models and assemblies. The software is written on Parasolid-kernel.

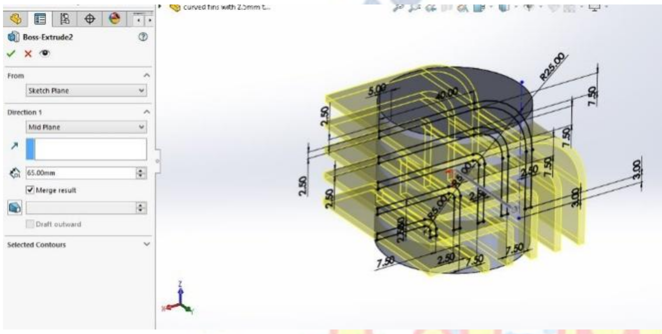
Parameters refer to constraints whose values determine the shape or geometry of the model or assembly. Parameters can be either numeric parameters, such as line lengths or circle diameters, or geometric parameters, such as tangent, parallel, concentric, horizontal or vertical, etc. Numeric parameters can be associated with each other through the use of relations, which allows them to capture design intent.



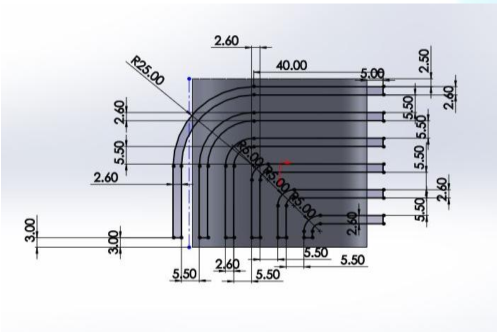




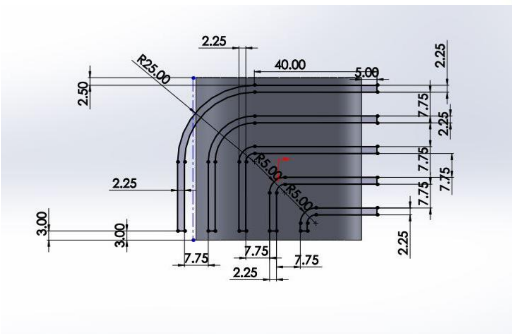
Curved fins 2.5mm thickness with 7.5mm fin to fin gap



Curved fins 2.6mm thickness with 5.5mm fin to fin gap



Curved fins 2.25mm thickness with 7.75mm fin to fin gap



VI. ANALYSIS

ANSYS ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software implements equations that govern the behavior of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. This type of analysis is typically used for the design and optimization of a system far too complex to analyses by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations

6.1MATERIAL PROPERTIES

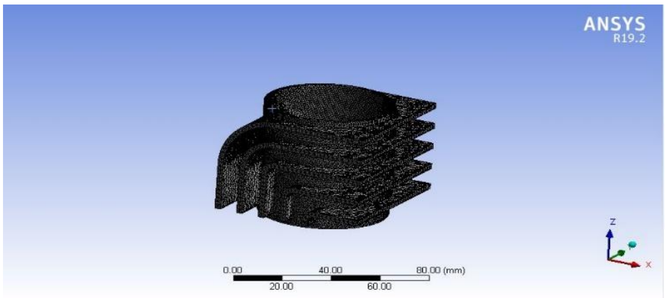
Al-6061
Young's modulus: - 6.89*10^10 Pa
Poison ratio: 0.329
Density: 2700 Kg/m^3
Yield strength: 276Mpa
Thermal conductivity: 167 w/m-k

Al-2024
Ex: - 73.1*10^9 Pa
Poison ratio: 0.32
Density: 2780 Kg/m^3
Yield strength: 325 Mpa
Thermal conductivity: 121 w/m-k

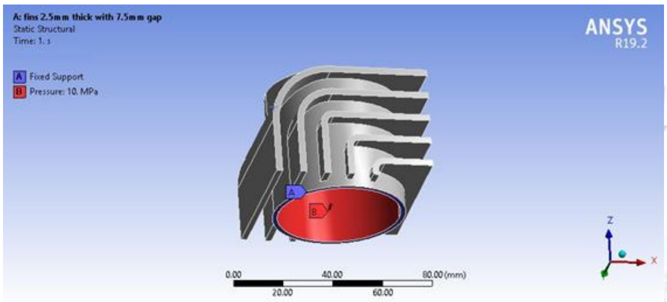
Al-5059
Young's modulus: - 6.9*10^10 Pa
Poison ratio: 0.331
Density: 2690 Kg/m^3
Yield strength: 300Mpa
Thermal conductivity: 104 w/m-k

6.2 Meshing

After completion of material selection here we have to create meshing for each object meshing means it is converting single part into no of parts. And this mesh will transfer applied loads for overall object. After completion meshing only we can solve our object. Without mesh we cannot solve our problem. And here we are using tetra meshing and the model shown in below.



6.3 STATIC ANALYSIS



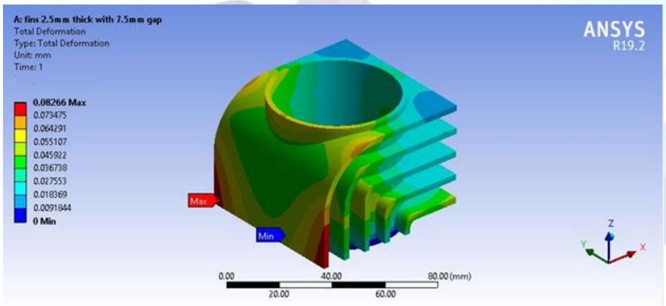
Static structural →supports→fixed support→select bottom fins area

Pressure →10 Mpa

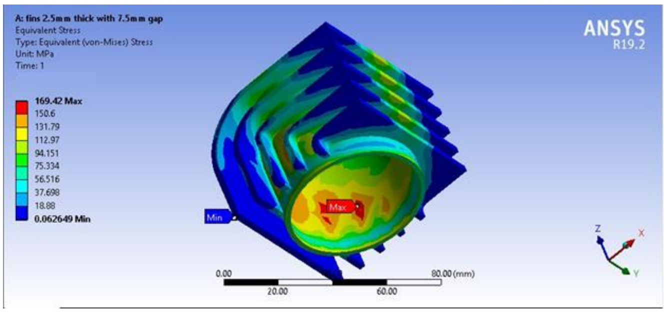
6.3.1 Curved fins with 2.5mm thickness and fin to fin gap 7.5mm

6.3.1.1 Al-6061

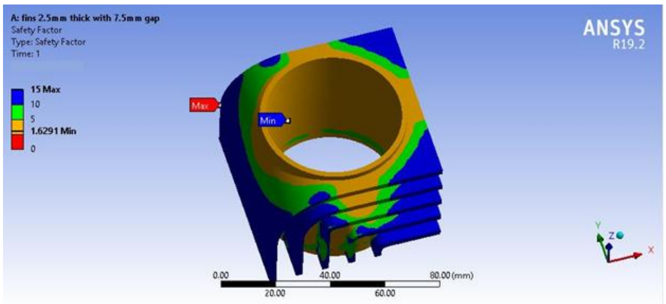
Deformation



Stress

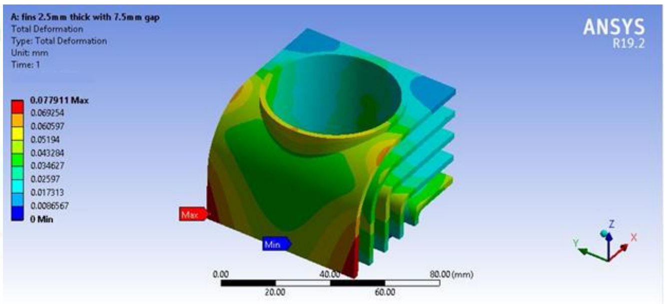


Safety Factor

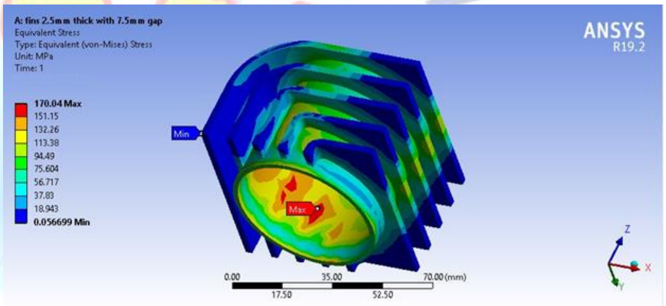


6.3.1.2 Al-2024

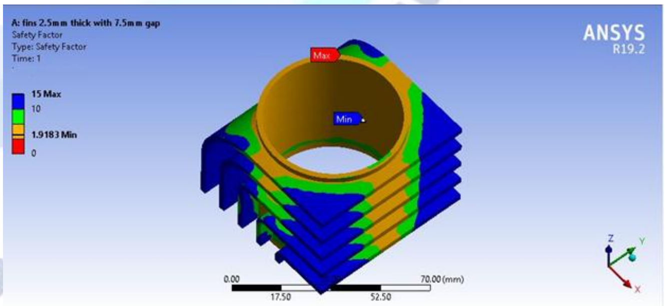
Deformation



Stress

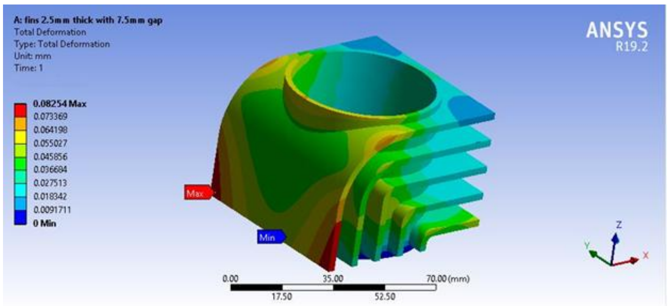


Safety Factor

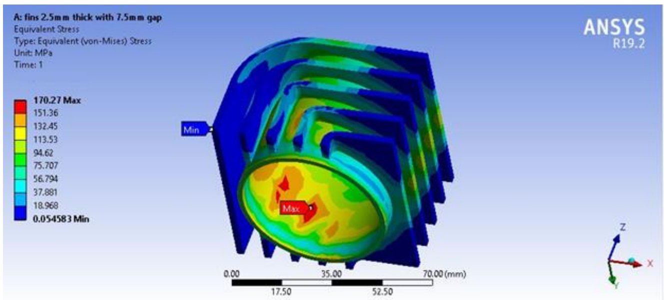


6.3.1.3 Al-5059

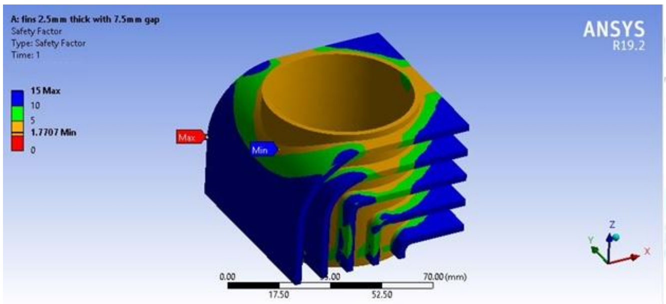
Deformation



Stress



Safety Factor



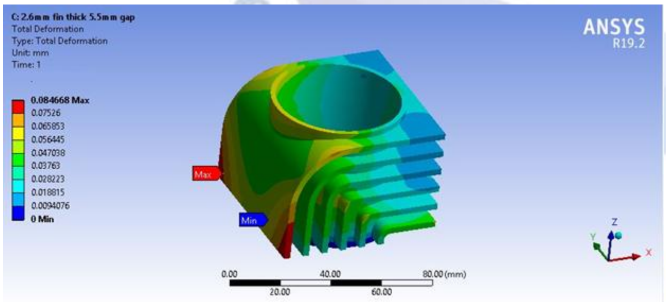
	Al-6061	Al-2024	Al-5059
Deformation (mm)	0.08266	0.077911	0.08254
Stress (Mpa)	169.42	170.04	170.27
Safety factor	1.6291	1.9183	1.7707

Table 6.3.1

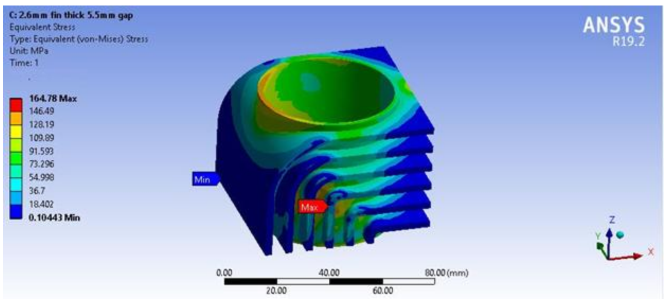
6.3.2 Curved fins with 2.6mm thickness and fin to fin gap 5.5mm

6.3.2.1 Al-6061

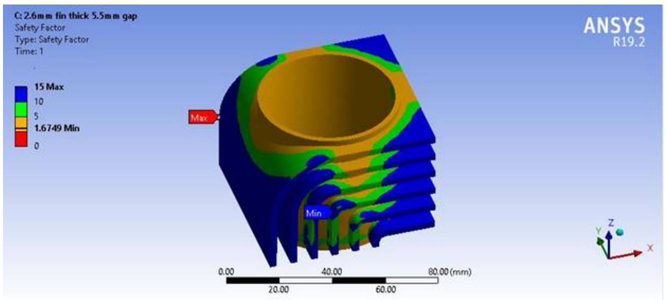
Deformation



Stress

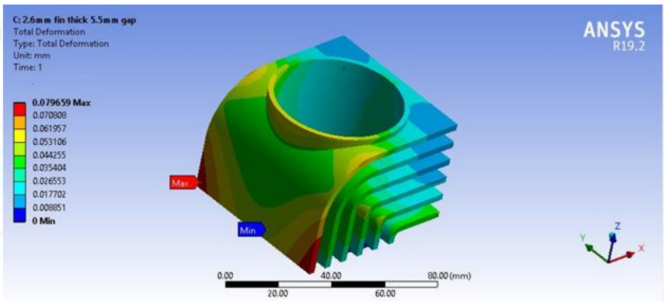


Safety Factor

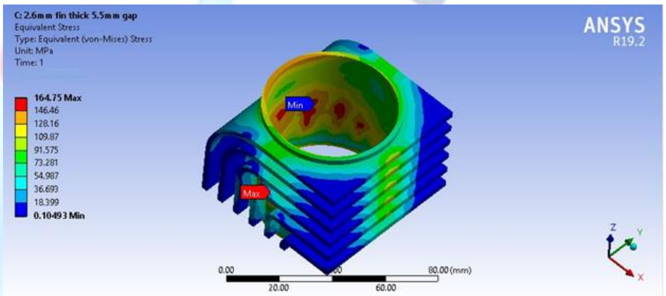


6.3.2.2 Al-2024

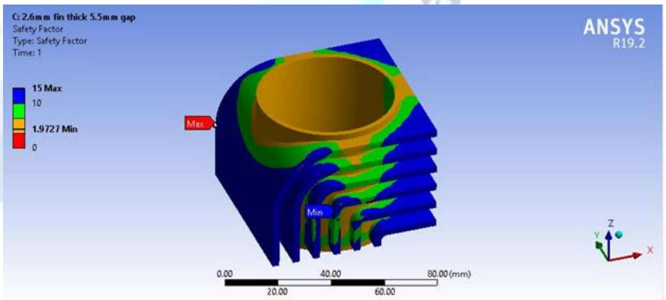
Deformation



Stress

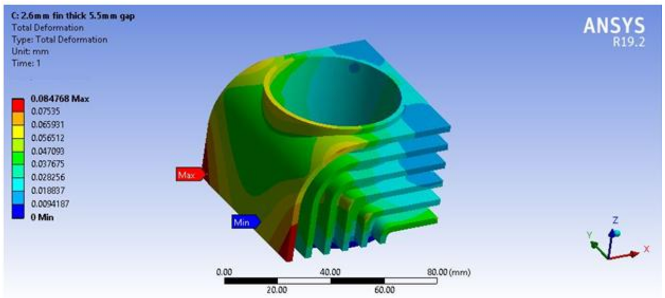


Safety Factor

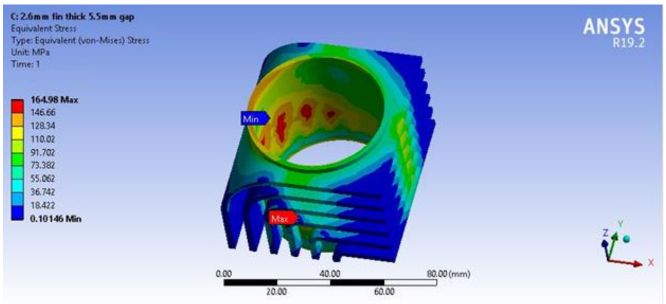


6.3.2.3 Al-5059

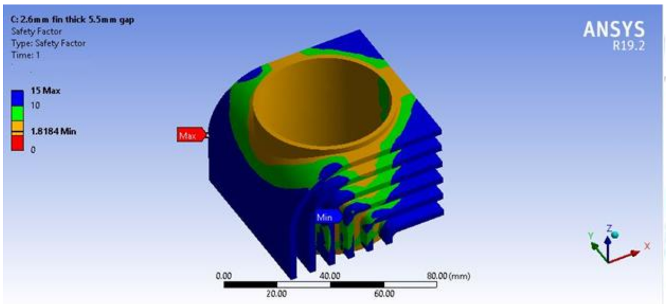
Deformation



Stress



Safety Factor



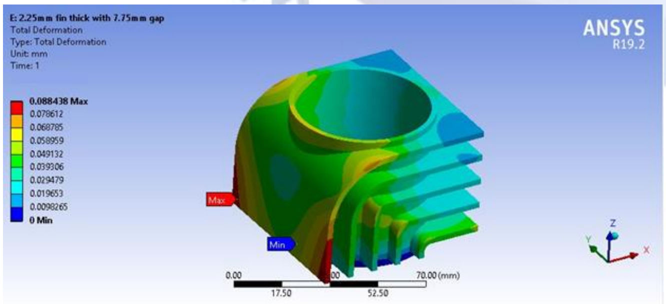
	Al-6061	Al-2024	Al-5059
Deformation (mm)	0.084668	0.079659	0.084768
Stress (Mpa)	164.78	164.75	164.98
Safety factor	1.6749	1.9727	1.8184

Table 6.3.2

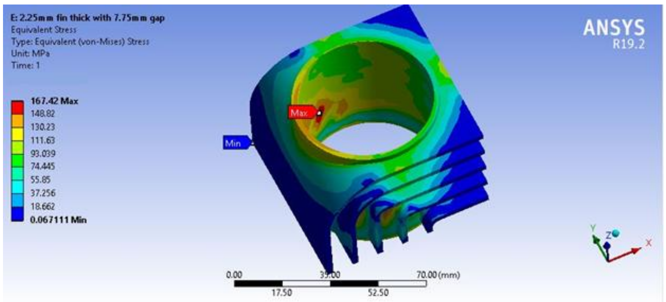
6.3.3 CURVED FINS WITH 2.25MM THICKNESS AND FIN TO FIN GAP 7.75MM

6.3.3.1 Al-6061

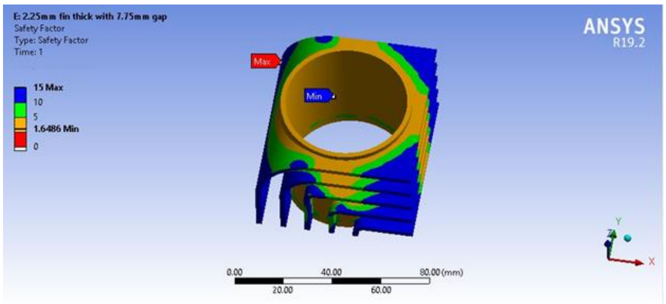
Deformation



Stress

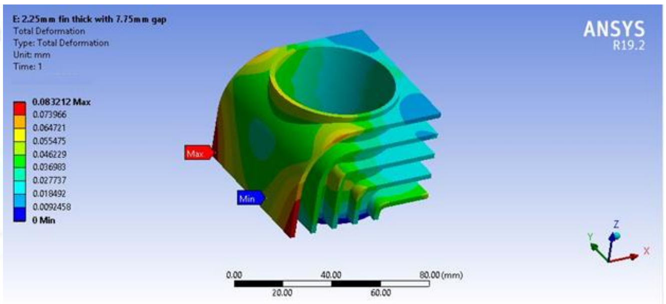


Safety Factor

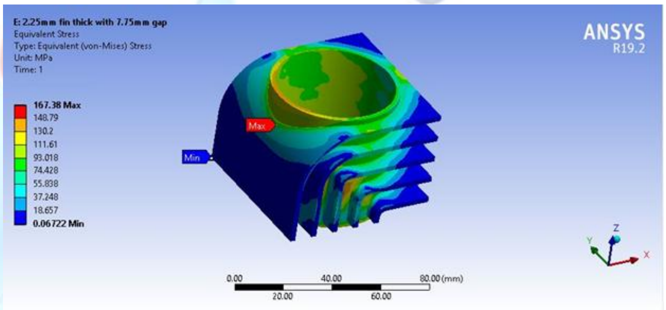


6.3.3.2 Al-2024

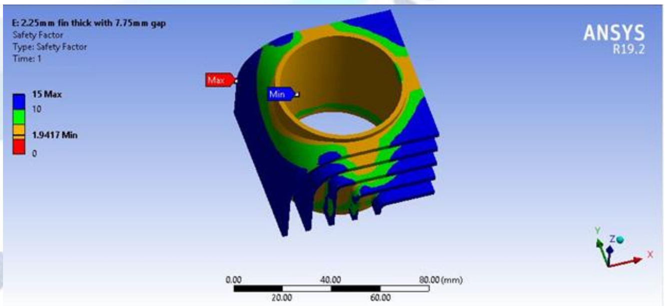
Deformation



Stress

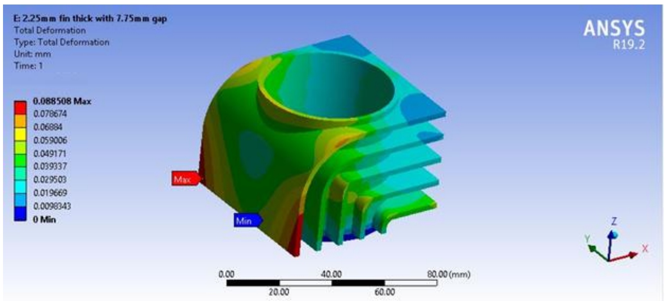


Safety Factor

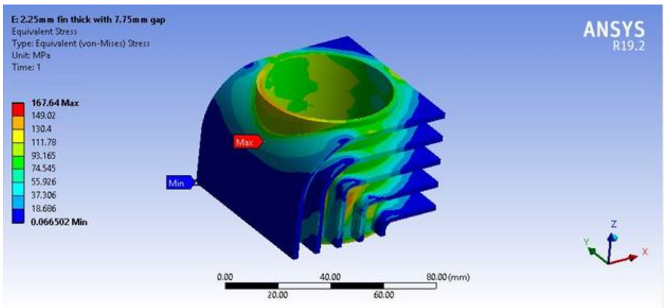


6.3.3.3 Al-5059

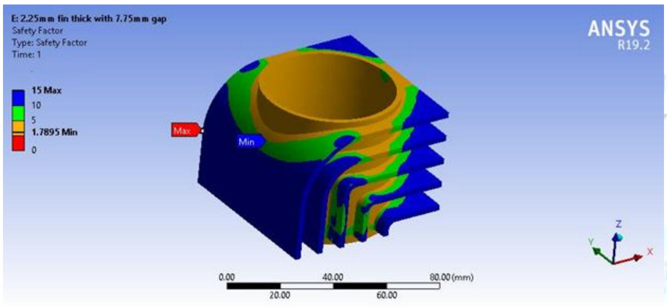
Deformation



Stress



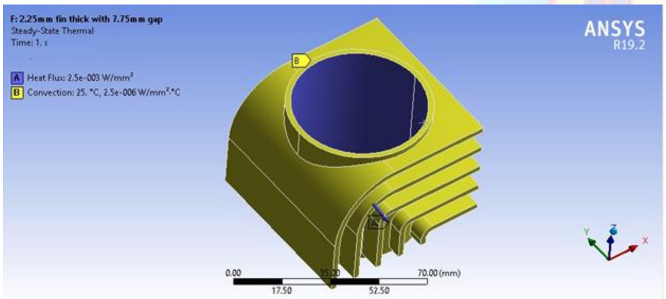
Safety Factor



	Al-6061	Al-2024	Al-5059
Deformation (mm)	0.088438	0.083212	0.088508
Stress (Mpa)	167.42	167.38	167.64
Safety factor	1.6486	1.9417	1.7895

Table 6.3.3

VII. THERMAL ANALYSIS



Heat flux → select all inner areas →2.5e-3 w/mm^2

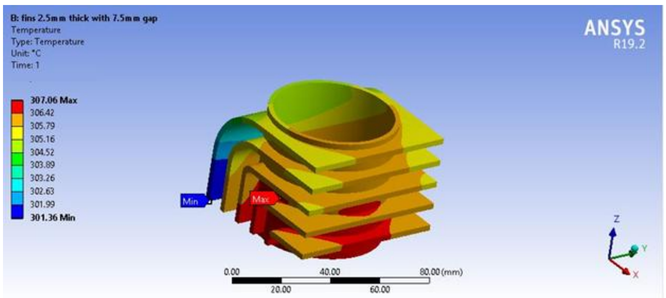
Coefficient of film→2.5e-6 w/mm^2,*c

Bulk temperature → 25*c

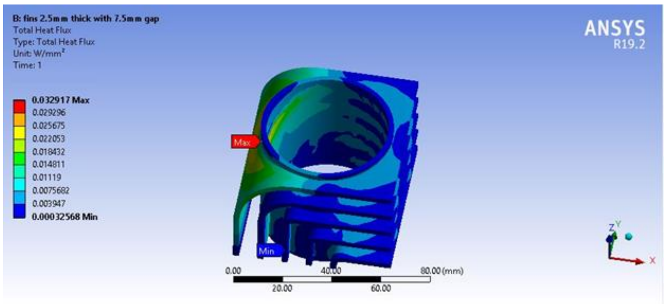
7.1 CURVED FINS WITH 2.5MM THICKNESS AND FIN TO FIN GAP 7.5MM

7.1.1 Al-6061

Total Temperature

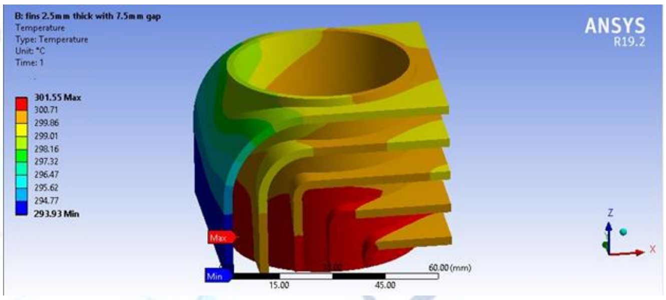


Heat Flux

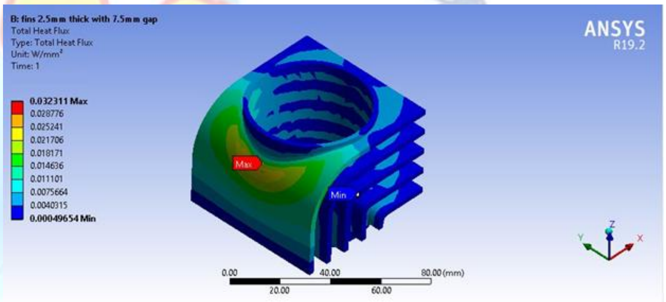


7.1.2 Al-2024

Total-temperature

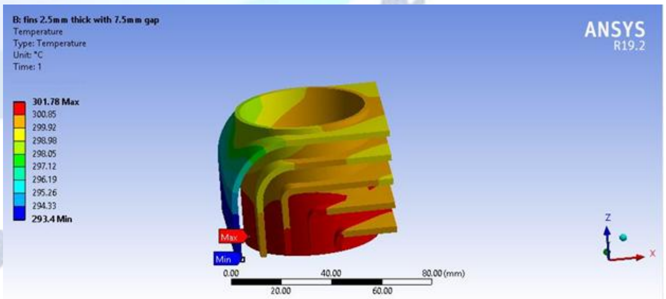


Heat Flux

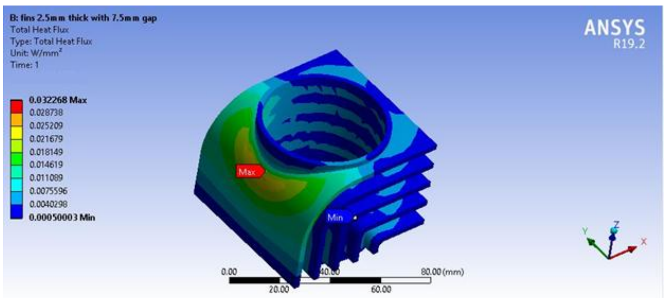


7.1.3 Al-5059

Total temperature



Heat Flux



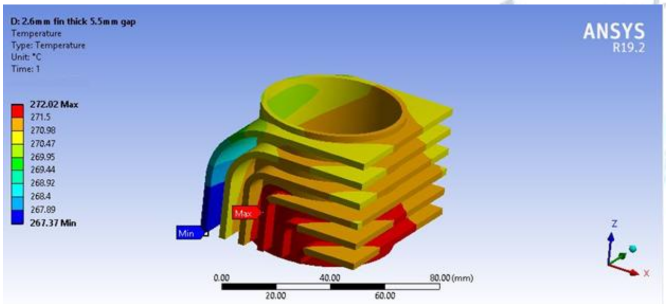
	Al-6061	Al-2024	Al-5059
Total temperature maximum (*C)	307.06	301.55	301.78
Total temperature minimum (*C)	301.36	293.93	293.4
Heat flux (w/mm^2)	0.032917	0.032311	0.032268

Table 7.1

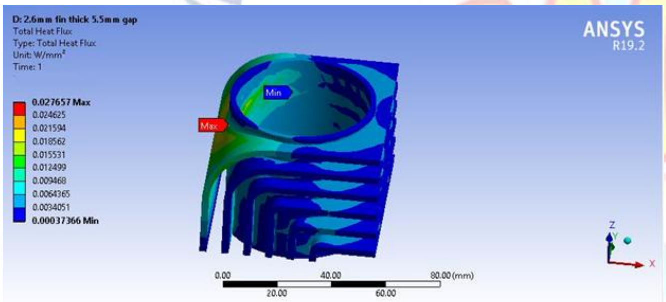
7.2 CURVED FINS WITH 2.6MM THICKNESS AND FIN TO FIN GAP 5.5MM

7.2.1 Al-6061

Total temperature

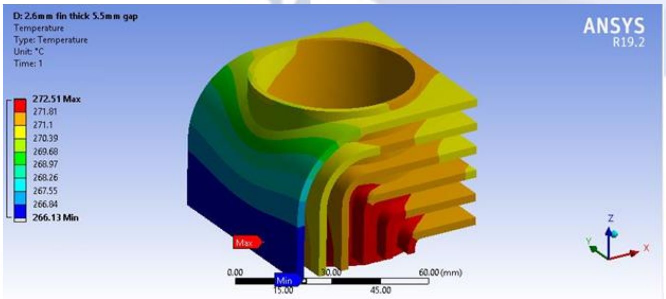


Heat Flux

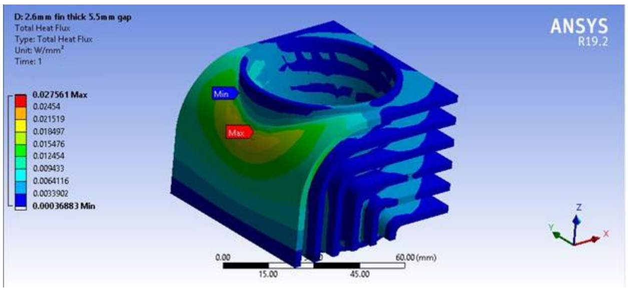


7.2.2 Al-2024

Total-temperature

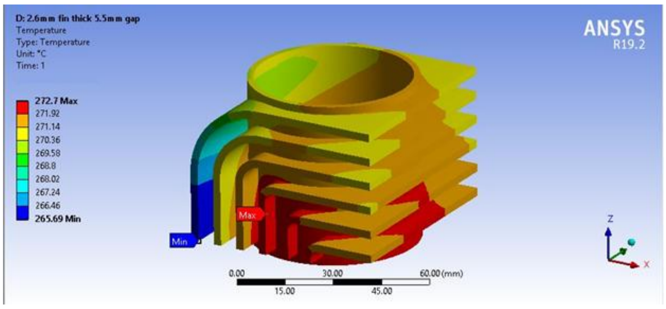


Heat Flux

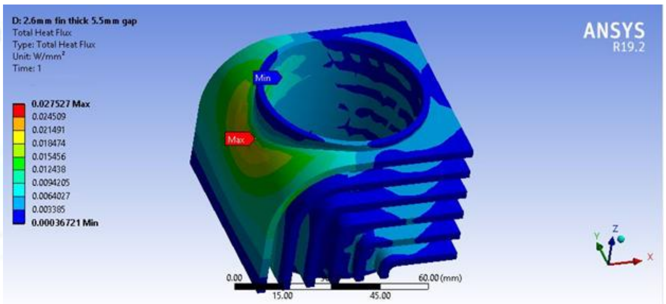


7.2.3 Al-5059

Total temperature



Heat-Flux



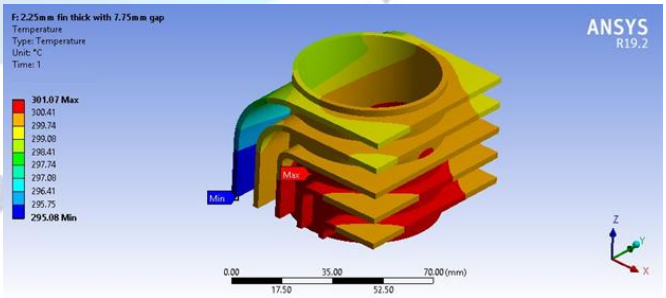
	Al-6061	Al-2024	Al-5059
Total temperature maximum (*C)	272.02	272.51	272.7
Total temperature minimum (*C)	267.37	266.13	265.69
Heat flux (w/mm^2)	0.027657	0.027561	0.027527

Table 7.2

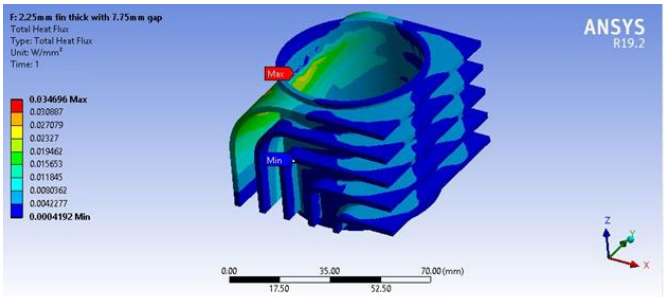
7.3 CURVED FINS WITH 2.25MM THICKNESS AND FIN TO FIN GAP 7.75MM

7.3.1 Al-6061

Total temperature

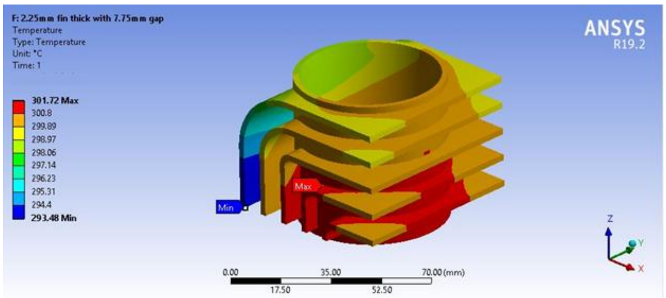


Heat Flux

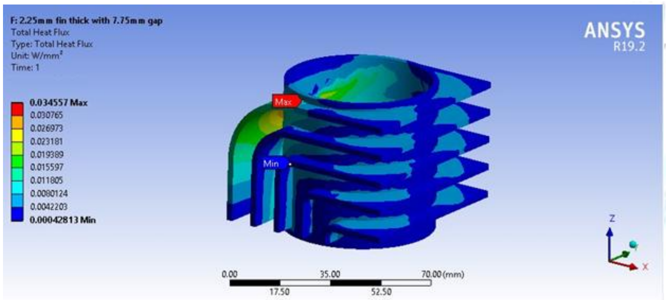


7.3.2 Al-2024

Total-temperature

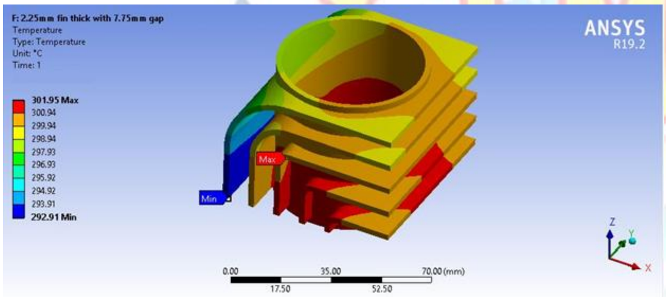


Heat Flux

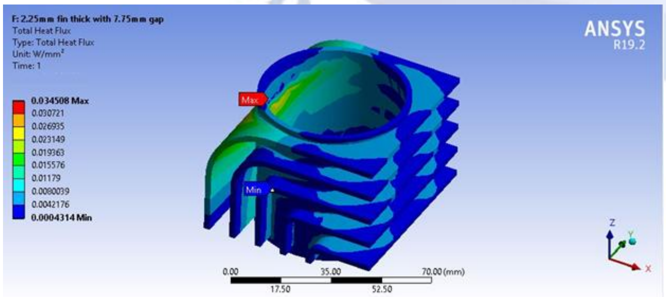


7.3.3 Al-5059

Total temperature



Heat Flux



	Al-6061	Al-2024	Al-5059
Total temperature maximum (*C)	301.07	301.72	301.95
Total temperature minimum (*C)	295.08	293.48	292.91
Heat flux (w/mm^2)	0.034696	0.034557	0.034508

Table 7.3

VIII. CONCLUSION

The main aim of the project is to increase the heat transfer through cooling fins, to meet this aim here curved cylinder fins designed by using cad tool solid works, in this process this curved fins cylinder optimized with different types of fin thickness and their gap between fins and also number of fins, and to analyses these models here 3 materials were chosen (al-6061, al-2024, al-5059), by using Ansys workbench here calculated each material/model maximum bearing capacity by applying static loads. And after using forced convection in Ansys fluent calculated each material/model heat transfer rate values,

From static analysis results it is clearly shown that each design can with stand up to 10Mpa of pressure on it and these values are consider based on safety factor values, here multiple pressure values applied on each design/material until minimum safety factor value to reach 1.5, among all materials al-2024 has high yield strength value, it means by using this material our object can with stand more pressure on it, by knowing only static analysis results it is not possible to choose an optimum material or model, to get more accurate results here thermal and fluent boundary conditions were applied.

From thermal analysis results heat flux values are high for curved fins with 2.25mm thickness with 7.75mm gap in between, From all these results curved fins with 2.25mm thickness with 7.75mm fins are having high surface heat transfer coefficient values for each material, and also it has performing better in static conditions also, Finally thesis concluded curved fins with 2.25mm thickness with 7.75mm gap in between with al-2024 material, and this material can withstand high pressure values and it can increases the durability of the object and also increases the object performance

REFERENCES

[1] Paul W.Gill, James H. Smith, JR., and Eugene J. Ziurys., 1959, Internal combustion engines - Fundamentals, Oxford & IBH Publishing Company

[2] Dr. Kirpal Singh, 2004, Automobile engineering vol.II, Standard Publishers Distributors, Delhi.

[3] Prof. R.B.Gupta, 1998, "Automobile engineering," Satya Prakashan, Incorporating, Tech India Publications.

[4] Prof. R.K. Rajput, "Heat and Mass Transfer", S. Chand Publications.
[5] KENNEDY, F. E., COLIN, F. FLOQUET, A. AND GLOVSKY, R. Improved Techniques for Finite Element Analysis of Surface Temperatures. Westbury House page 138-150, (1984).
[6] COOK, R. D. Concept and Applications of Finite Element Analysis, Wiley, Canada, (1981).
[7] BEEKER, A.A. The Boundary Element Method in Engineering, McGraw-Hill, New York, (1992).
[8] ZIENKIEWICZ, O. C. The Finite Element method, McGraw-Hill, New York, (1977).
[9] Free Air Stream, SAE Paper 1999-01-3307, (1999). (4) Thornhill, D., Graham, A., Cunnigham, G., Troxier, P. and Meyer, R.,
[10] 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
[11] Experimental Studies of Heat Transfer from Finned Cylinders of Air-Cooled I.C. Engines, 4th National Heat Mass Transfer Conference, (1977), pp.137–144.
[12] 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.
[13] Nabemoto, A., Heat Transfer on a Fin of Fin Tube, Bulletin of the Faculty of Engineering, Hiroshima University, (in Japanese), Vol.33, No.2 (1985), pp.127–136.