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GEOMETRY AND MATERIAL OPTIMIZATION OF KIRLOSKER ENGINE CYLINDER FINS

K.Madhuri[1], L Mohana Rao[2]

[1]PG scholar Dept Of Mechanical, Sri Venkateswara college of engineering,(INDIA)

[2]Asst.Prof Dept Of Mechanical, Sri Venkateswara college of engineering,(INDIA)

ABSTRACT

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 cylinder to increase the rate of heat transfer By doing steady state thermal analysis on the engine cylinder fins, it is helpful to know the heat dissipation inside the cylinder and total heat flux(heat transfer rate) 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 aim of my project is modeling and coupled field analysis (thermo mechanical) on kirlosker engine cylinder. Different geometry of fins are rectangular fins, curved fins, rectangular pin fins and cylindrical pin fins are modeled by using The three dimensional modeling software used is parametric CREO3.0. Temperature distribution and heat transfer rate is analyzed for different materials are aluminum, gray cast iron, structural steel and glass epoxy by using FEA software ANSYS 15.0. The principle implemented in this project is to increase the heat transfer rate by using the invisible working fluid, nothing but **air.***

KEYWORDS: Ansys15.0, Coupled field, creo3.0, Engine fins, heat transfer rate.

I.INTRODUCTION

A cylinder is the central working part of a reciprocating engine or pump, the space in which a piston travels. Multiple cylinders are commonly arranged side by side in a bank, or engine block, which is typically cast from aluminium or cast iron before receiving precision machine work. Cylinders may be sleeved (lined with a harder metal) or sleeveless (with a wear-resistant coating such as Nikasil). A sleeveless engine may also be referred to as a "parent-bore engine".

A cylinder's displacement, or swept volume, can be calculated by multiplying its cross-sectional area (the square of half the bore by pi) by the distance the piston travels within the cylinder (the stroke). The engine displacement can be calculated by multiplying the swept volume of one cylinder by the number of cylinders.

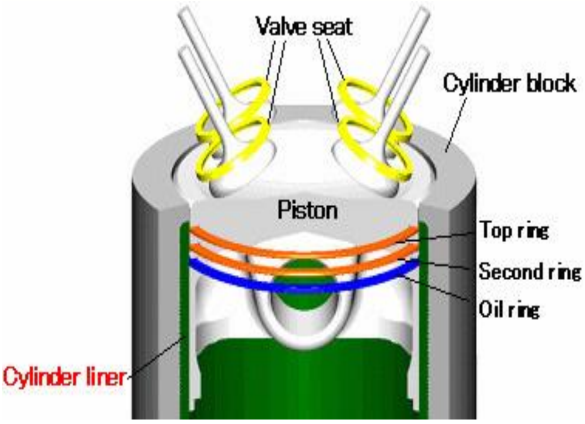


Fig1.1 Cross section of a cylinder in an internal combustion engine

Fig1.2 Cylinder block of kirloskar engine

1.1 CYLINDER BLOCK IN IC ENGINE

Cylinder block which is also called as engine block is the main structure of the engine which give the space for the cylinders, and it also give passages for the coolant, exhaust, and in take gases to pass over the engine and host for the crankcase and cam shafts. Engine block is the main housing of hundreds of parts found in modern engines. And it is the largest among the engine parts and it also constitutes 20% to 25% of the total weight of the engine. The first successful internal combustion engine which can be used in an automobile was built by Siegfried Marcus in about 1864. It was a upright single cylinder, two stroke petrol engine.

Today's engines has come to their maximum development and still being developed for the next years too. These developments have caused to increase the power, durability, resistance to wear, and efficient of the engine. Material used to build the engine block has being given the engine a higher strength with low weight which is more important for the power of the engine. For many years the engine block has being manufactured using cast iron alloys, it is due to its strength and low cost and its wear resistance. But as the engine become more complicated engineers found new materials to reduce its weight as well as to increase strength and wear resistance. A common alloy which is widely used is aluminium alloy, it is more popular due to its low weight but mostly within petrol engines.

1.2 MATERIAL USED IN ENGINE BLOCK:

GREY CAST IRON:

Grey cast iron is the first and most material used for manufacturing of engine blocks. Though the aluminum alloy also contain many similarities with low weight, it is still used in the manufacturing of diesel engine blocks because their internal stresses are higher. Grey cast iron contains 2.5 – 4 % of carbon, 1 -3 % of silicon, 0.2 - 1% manganese, 0.02 - 0.25 % of sulphur, and 0.02 - 1 % of phosphorus. It has a excellent damping absorption, good wear and thermal resistance, and it is easily machinable and less cost due to its availability.

STRUCTURAL STEEL:

Structural steel is a category of steel used as a construction material for making structural steel shapes. A steel shape is a profile, formed with a specific cross section and following certain standards for chemical composition and mechanical properties. It exhibits desirable physical properties that make it one of the most versatile material in use. Its greatest strength, uniformity, light weight, ease of use and many more desirable properties makes it the material of choice for numerous applications. The advantages of structural steel are high strength, uniformity, elasticity, ductility, toughness, thermal conductivity.

ALUMINIUM ALLOY

319 aluminum alloy contains 85.8 - 91.5 % of aluminum, 5.5 - 6.5 % of silicon, 3 - 4 % of copper, 0.35% of nickel, 0.25% of titanium, 0.5% of manganese, 1% of iron, 0.1% of magnesium, and 1% of zinc. This alloy has good casting features, corrosion resistance, and good thermal conductivity. Under the heat treatment of T5 process, it generates high strength and rigidity for the engine block

A356 aluminum alloy contains 91.1 - 93.3 % of aluminum, 6.5 - 7.5 % of silicon, 0.25 - 0.45 % of magnesium, 0.2% of copper, 0.2% of titanium, 0.2% of iron, and 0.1% of zinc. Although the mechanical properties are similar to 319, when it is under the heat treatment process T6 it gains higher strength than 319. But it has lower modulus of elasticity (72.4 GPa) than 319 with modulus of elasticity of 74 GPa.

II.MODELLING OF IC ENGINE CYLINDER BY USIING CREO 3.0 CAD SOFTWARE:

Creo Parametric is a computer graphics system for modeling various mechanical designs and for performing related design and manufacturing operations. The system uses a 3D solid modeling system as the core, and applies the feature-based, parametric modeling method. In short, Creo Parametric is a feature-based, parametric solid modeling system with many extended design and manufacturing applications.

The cylinder is modeled in creo3.0 the model and the drawings are shown in figure.

2.1 GEOMETRY MODIFICATIONS

Fig 2.1 rectangular fins

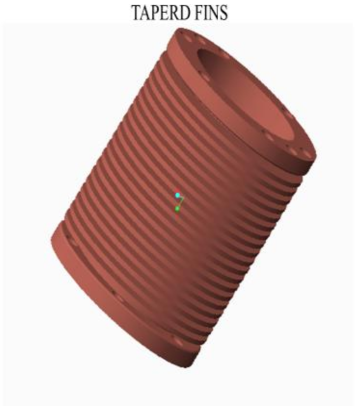


Fig 2.2 tapered fins

Fig 2.3 rectangular pin fins

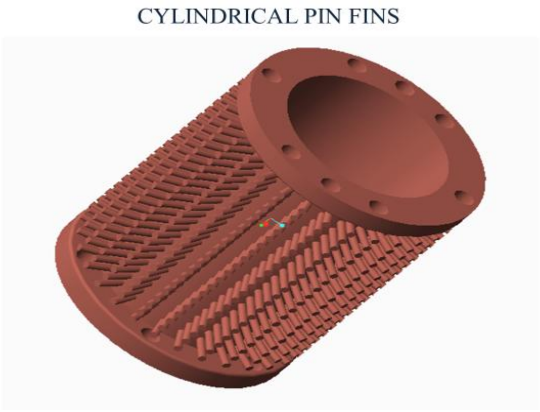


Fig2.4 cylindrical pin fins

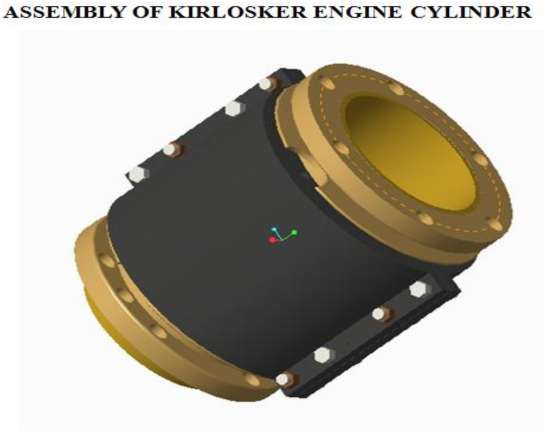
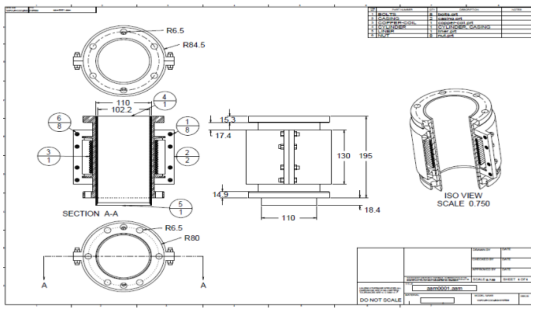


Fig 2.5 assembly of kirlosker engine



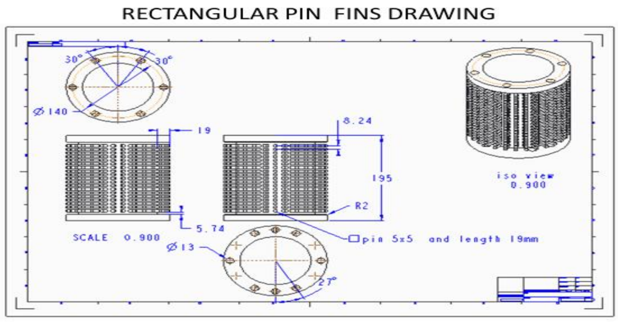


Fig2.6 Assembly drawing of engine cylinder

Fig2.7 part drawing of cylinder

2.2MODELLING PROCEDURE FOR THE RECTANGULAR PIN FINNED CYLINDER:

Software used: Creo parametric 3.0:

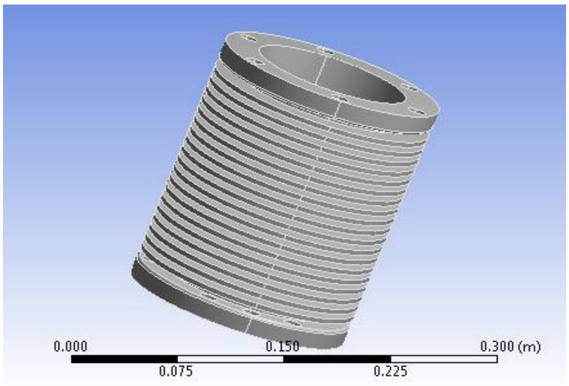
- Double click on Creo parametric 3.0 → set working directory → new → part → unit (mmns).
- Select the plane →Create rectangular pin fin →click on revolve option → draw the geometrical centre line → sketch the required part → click on the ok → the object is generated.
- Select the top surface of the part → click on the extrude option → sketch the required holes → click on the cut the material option → holes formation is done.
- Select the other side of the part → using the extrude option holes created.

Assigning model properties:

- Select the file → click on model properties → assign the material properties, system of units, accuracy → click on ok.

III. ANALYSIS OF IC ENGINE CYLINDER BLOCK

3.1 Thermal& Structural Analysis of Cylinder with different fin types and materials



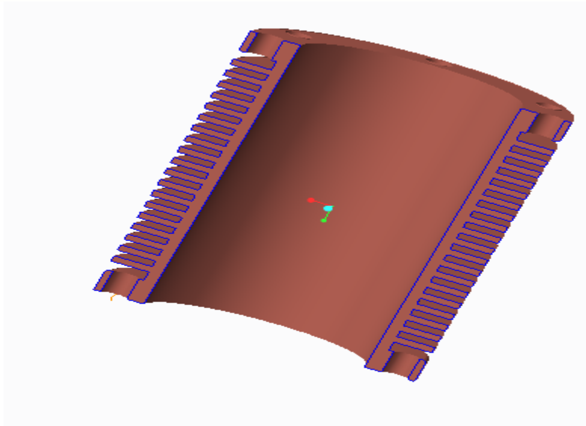
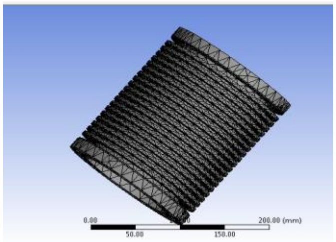


Fig 3.1 kirlosker engine Geometry

Fig 3. 2sectional view of taped fins

3.1.1 Structural analysis of rectangular geometry extension with structural steel material



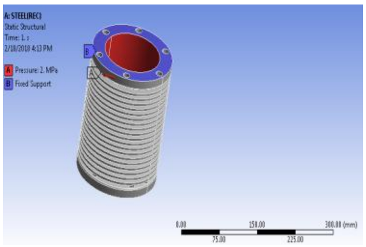
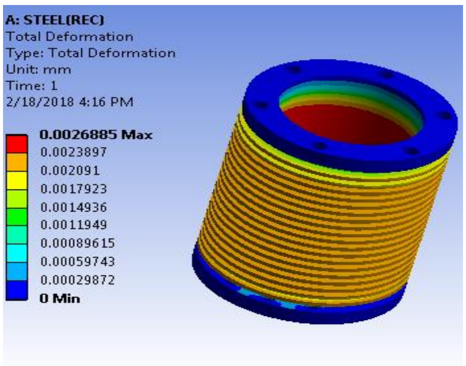


Fig 3.3 Meshing

Fig 3.4 boundary conditions



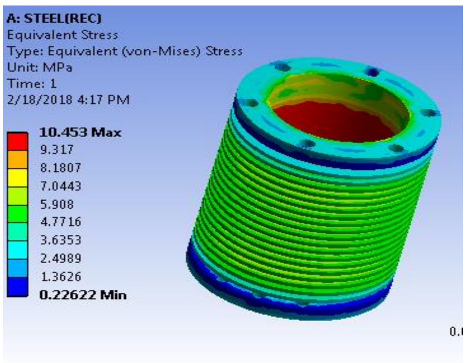
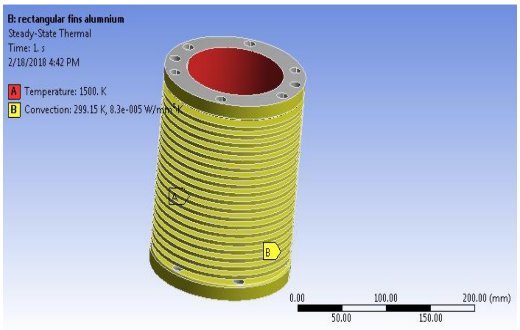


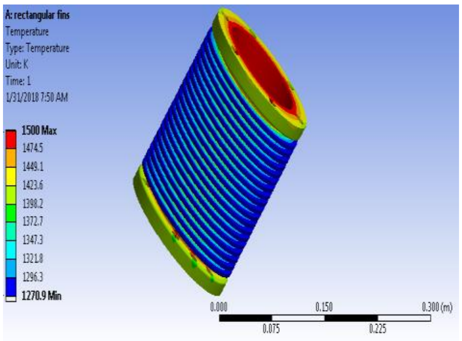
Fig 3.5 total deformation

Fig 3.6 von-misses stresses

3.1.2 Thermal analysis of rectangular geometry extension with structural steel material



3.7 Boundary conditions



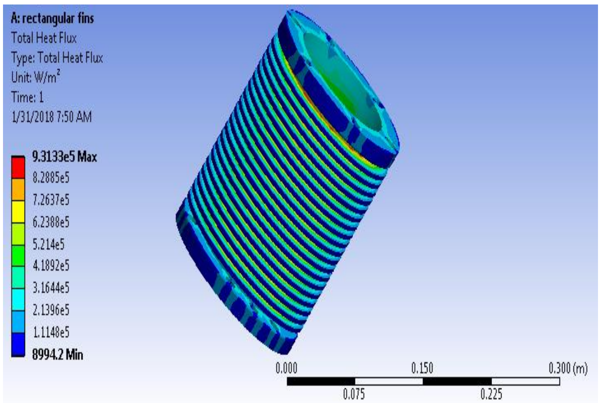
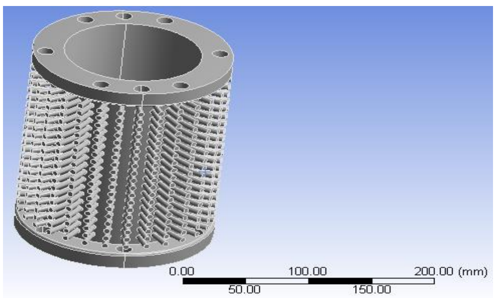


Fig 3.8 Temperature distribution Fig 3.9 total heat flux

3.1.3 Thermal analysis of cylindrical pin fins geometry extension with aluminum alloy material



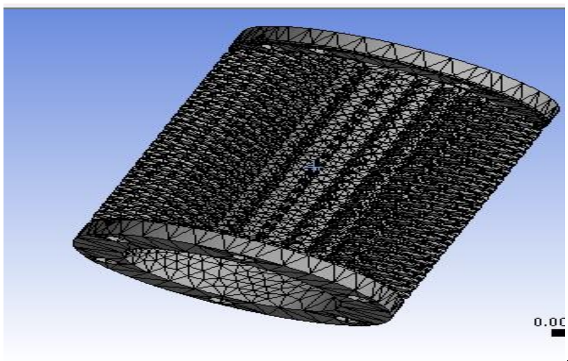


Fig 3.10 geometry Fig 3.11 meshing

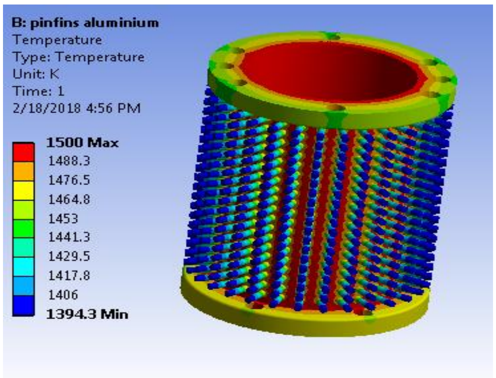


Fig 3.12 Temperature distribution

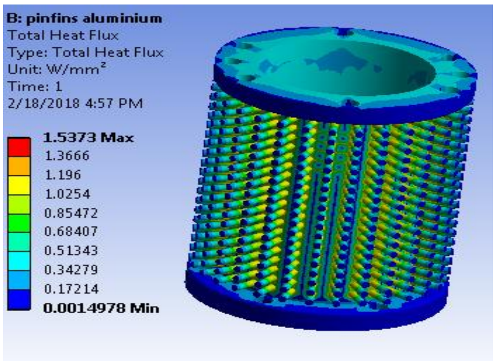


Fig 3.13 total heat flux

IV. RESULTS AND DISCUSSION

The cylinder block is analyzed in ANSYS 15.0 by importing the system in to the work bench. Both thermal and structural analysis are done on the cylinder block .

4.1 thermal analysis result tables

Table 4.1 shows temperature and total heat flux of rectangular fins with different materials

RECTANGULAR FINS			
S.NO	MATERIAL	TEMPERATURE DISTRIBUTION(1500K)	TOTAL HEAT FLUX(W/m2)
1	ALUMINIUM ALLOY	1411.4	1.03 X10^6
2	GRAY CAST IRON	1240	0.908X10^6
3	STRUCTURAL STEEL	1270	0.931 X10^6
4	S-GLASS EPOXY COMPOSITE	307	0.143 X10^6

Table 4.2 shows temperature and total heat flux of tapered fins with different materials

TAPERED FINS			
S.NO	MATERIAL	TEMPERATURE DISTRIBUTION(1500K)	TOTAL HEAT FLUX(W/m2)
1	ALUMINIUM ALLOY	1437.8	0.780 X10^6
2	GRAY CAST IRON	1310	0.717 X10^6
3	STRUCTURAL STEEL	1333.9	0.730 X10^6
4	S-GLASS EPOXY COMPOSITE	349	0.173 X10^6

Table 4.3 shows temperature and total heat flux of cylindrical pin fins with different materials

CYLINDRICAL PIN FINS			
S.NO	MATERIAL	TEMPERATURE DISTRIBUTION(1500K)	TOTAL HEAT FLUX(W/m2)
1	ALUMINIUM ALLOY	1394.3	1.53 X10^6
2	GRAY CAST IRON	1196	1.33 X10^6
3	STRUCTURAL STEEL	1231	1.36 X10^6
4	S-GLASS EPOXY COMPOSITE	518	2.50 X10^6

Table 4.4 shows temperature and total heat flux of rectangular pin fins with different materials

RECTANGULAR PIN FINS			
S.NO	MATERIAL	TEMPERATURE DISTRIBUTION(1500K)	TOTAL HEAT FLUX(W/m2)
1	ALUMINIUM ALLOY	1391.9	1.35 X10^6
2	GRAY CAST IRON	1191	1.16 X10^6
3	STRUCTURAL STEEL	1226	1.20 X10^6
4	S-GLASS EPOXY COMPOSITE	1191	1.16 X10^6

4.2 structural analysis result tables

Table 4.5 shows deformation and equivalent stresses of rectangular fins with different materials

RECTANGULAR FINS			
S.NO	MATERIAL	DEFORMATION(MM)	EQUIVALENT STRESSESS(N/MM2)
1	ALUMINIUM ALLOY	0.0075997	10.4
2	GRAY CAST IRON	0.004866	10.5
3	STRUCTURAL STEEL	0.002688	10.5
4	S-GLASS EPOXY COMPOSITE	0.0911	16.1

Table 4.6 shows deformation and equivalent stresses of tapered fins with different materials

TAPERED FINS			
S.NO	MATERIAL	DEFORMATION(MM)	EQUIVALENT STRESSESS(N/MM2)
1	ALUMINIUM ALLOY	0.00599	12.9
2	GRAY CAST IRON	0.003829	12.4
3	STRUCTURAL STEEL	0.0021146	12.5
4	S-GLASS EPOXY COMPOSITE	0.07163	13.7

Table 4.7 shows deformation and equivalent stresses of rectangular pin fins with different materials

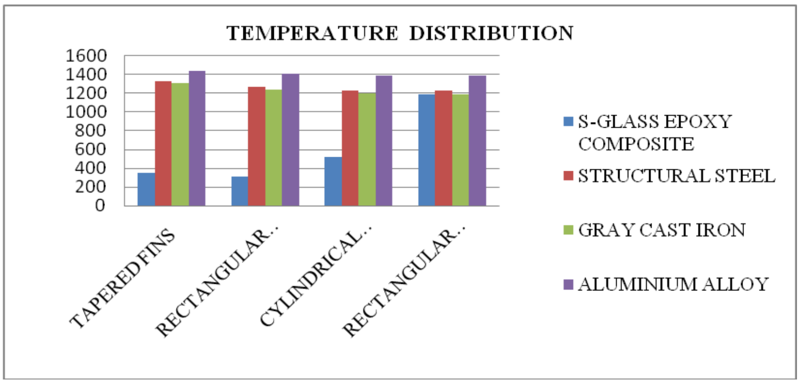
RECTANGULAR PIN FINS			
S.NO	MATERIAL	DEFORMATION(MM)	EQUIVALENT STRESSESS(N/MM2)
1	ALUMINIUM ALLOY	0.014966	21.4
2	GRAY CAST IRON	0.0098119	21.7
3	STRUCTURAL STEEL	0.005365	21.6
4	S-GLASS EPOXY COMPOSITE	0.1547	28.7

Table 4.8 shows deformation and equivalent stresses of cylindrical pin fins with different materials

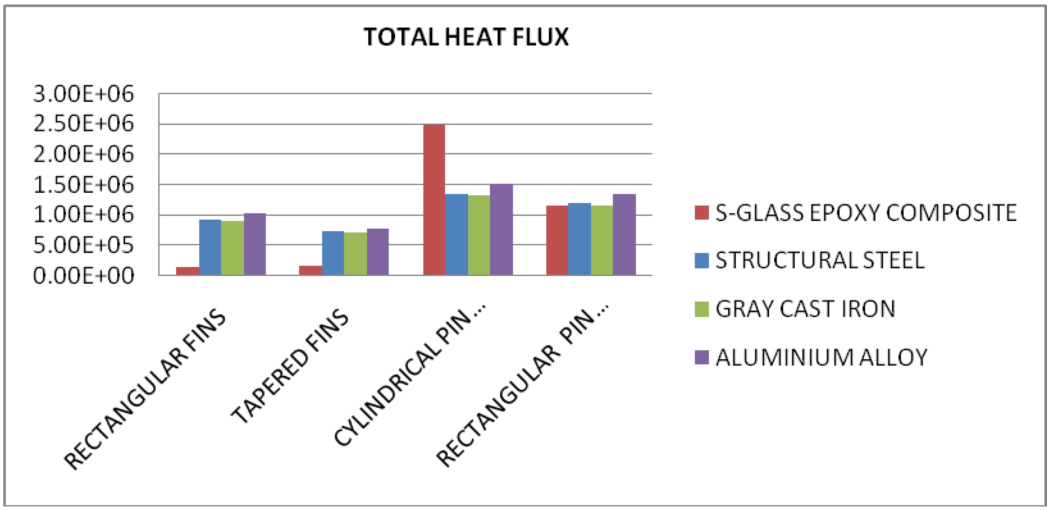
CYLINDRICAL PIN FINS FINS			
S.NO	MATERIAL	DEFORMATION(MM)	EQUIVALENT STRESSESS(N/MM2)
1	ALUMINIUM ALLOY	0.014878	21.5
2	GRAY CAST IRON	0.009755	21.8
3	STRUCTURAL STEEL	0.00533	21.7
4	S-GLASS EPOXY COMPOSITE	0.15356	27.7

V. GRAPHICAL REPRESENTATION

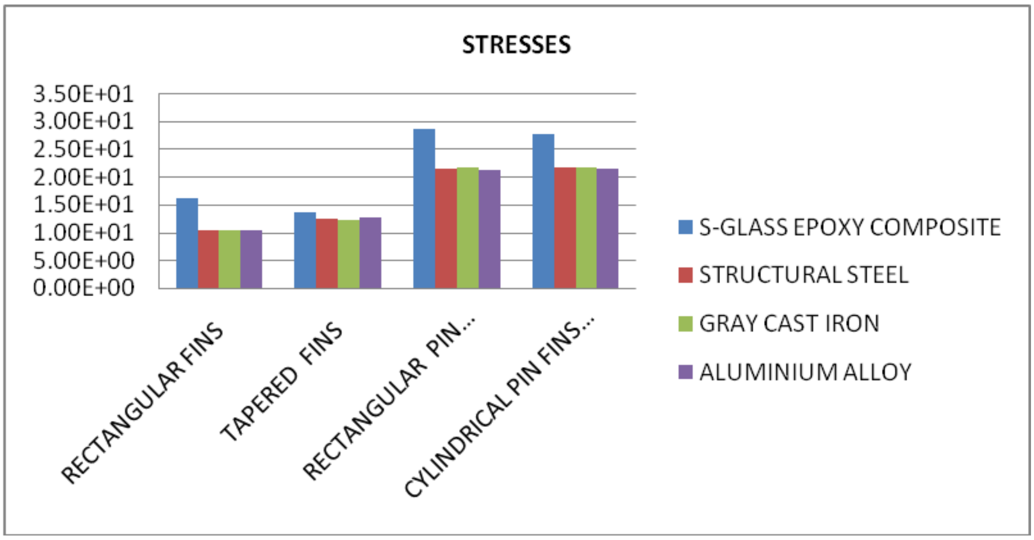
5.1 The graph shows the variations of temperature distribution of various geometries and materials



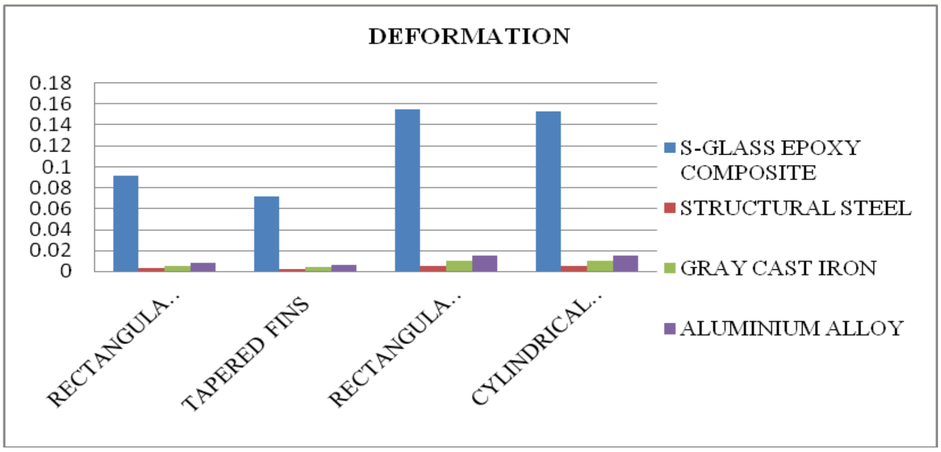
5.2 The graph shows the variations of total heat flux of various geometries and materials



5.3 The graph shows the stress of various geometries and materials



5.4 The graph shows the variations of deformations of various geometries and materials



VI.CONCLUSION

In this project the kirlosker engine is designed in CREO 3.0 software. The analysis is done on ANSYS workbench. In this analysis was done by changing the geometry of the engine fines and changing the materials of the cylinder material. The present used material for the engine cylinder is cast iron. In this project other materials are considered which have more heat transfer rate and strength from different extended geometry of engine fins.

- The material for the original model is changed by taking the consideration of their densities and thermal conductivity. Density is less for Aluminium alloy cylindrical pin fins compared with other three materials so weight of fin body is less using Aluminium alloy.
- By observing the thermal analysis results, thermal flux is more for Aluminium alloy than other three materials and also by using Aluminium alloy its weight is less, so using Aluminium alloy is better.
- From the above observations strength is taken into the considerations rectangular fin with structural steel having less deformation and more strength and less stresses are produced.
- S-glass epoxy composite material is not used for cylinder material because it has less strength and more deformation compared with other materials.

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