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Thermo Structural Analysis of Two Stroke Si Engine Cylinder

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Abstract: *Cylinder is the heart of internal combustion engine as combustion takes place inside the cylinder large amount of heat is produce inside the cylinder due to that heat distortion of cylinder wall may takes place. Due to inadequate heat transfer through the engine cylinder block the engine cylinder gets overheated, lead to knocking and some time result into structural failure. This also causes an increase in the thermal stresses in the liner wall which ultimately affects the strength of liner wall. The main objective of this paper is to carry out thermo structural analysis of combustion chamber (Liner) in Ansys workbench 15.0 to predict temperature distribution across the combustion chamber of scavenged engine. The design of 2 stroke engine cylinder is modeled in ANSYS workbench 15.0. Around 27 cases are considered of different fin thicknesses, gaps and materials. Then geometry for each case is modeled. The boundary conditions are applied to each case. For thermal the boundary conditions are convection at liner, fins and exhaust section of the cylinder. For structural, cylindrical support and pressure are applied. Each case is analyzed in the ANSYS workbench 15.0. The results of total heat transfer and stresses induced in the cylinder for each case are obtained.*

Keywords: *Engine cylinder, Fin thicknesses, gaps and materials, Thermo structural analysis, ANSYS workbench 15.0.*

I. Introduction

Heat transfer is a very wide field used in analysis of internal combustion engine heat transfer effect parameter such as performance, emission and also efficiency. It is said that for a given mass of fuel higher the heat transfer to the combustion wall will reduce the average combustion pressure and temperature, this indirectly reduces the work done by the piston per cycle and these effects the specific power. Temperature rise of the engine parts may cause a serious durability of the engine. The shape of isothermal lines and high temperature regions become more important in these studies. The experimental way will find these regions are costly and time consuming; Analytical methods are almost equally good for fast conformation of this region by using finite elements Measuring the actual dimension of various components of two-stroke S.I engine **(BAJAJ, 100cc)**. modeling of piston, liner along with combustion chamber are done using **Ansys 15** we analyzed the temperature distribution and thermal stresses on above component, compare that thermal stresses with theoretically calculated thermal stresses.

Ii. Specification Of The Problem

Objective of the paper is to design cylinder with fins for **BAJAJ 100cc** engine, by changing the fin thickness and distance between the fins to analyze the thermal properties of the fins. Analyzation is also done by varying the materials of fins. Present used material for cylinder fin body is cast iron .Our aim is to change the material for fin body by analyzing the fin body with other materials and also by changing the geometry distance between the fins and thickness of the fins. Thickness of fins are– 2, 2.5 and 3mm Distance between the fins –5.6, 6.6mm. Materials are considered for analysis –**Grey cast Iron, Mild steel ,Magnesium alloy and Aluminum alloy.**

2.1. Survey on air cooled engine cylinder fins, commercially:

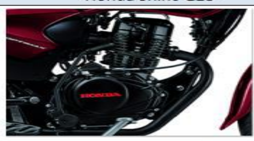
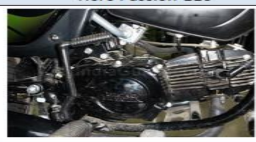
Bajaj pulsar-150		Honda Shine-125		Hero Passion-110	
					
No Of Fins	12	No Of Fins	12	No Of Fins	8
Pitch (mm)	10	Pitch (mm)	10	Pitch (mm)	9
Thickness (mm)	2	Thickness (mm)	2	Thickness (mm)	2
Height (max/min) in (mm)	35/10	Height (max/min) in (mm)	22/7	Height (max/min) in (mm)	38/7
Fin Material	Al.alloy	Fin Material	Al.alloy	Fin Material	Al.alloy
Position of Fins W.R.T. Cylinder Axis	Perpindular	Position of Fins W.R.T. Cylinder Axis	Perpindular	Position of Fins W.R.T. Cylinder Axis	Parallel

Fig 1: engine cylinder fins

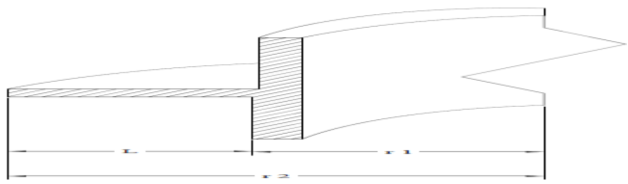
III.Design

3.1 Design parameters for selected model : Engine cylinder with fins is a complicated shape which was developed in professional software ANSYS Work bench 15.0.

Table 1: Properties of different materials

Parameters	Mild steel	Grey cast iron	Magnesium alloy	Alluminium alloy
E (Pa)	2E+11	1.1E+11	4.5E+10	7.1E+10
Poisson ratio	0.3	0.28	0.35	0.33
K (w/m 0 c)	60.5	52	156	165
α(/0c)	1.2E-05	1.1E-05	2.6E-05	2.3E-05
CP (J/Kg 0C)	480	420	1013	875
ρ(kg/m3)	7850	7272	1800	2770

3.2 Equations:



For a circumferential fin of rectangular cross section

$L=r2-r1$ $Lc=L+t/2$ $r2c = r1+Lc$ $Am = (r2c-r1)t$

Max Heat transfer $Q = 2\pi h(r_2^2-r_1^2)\theta_0$ $\theta_0 = (t_h-t_\infty)$

Heat transfer by the fin $Q_{fin}=\acute{\eta}_{fin}\times Q_{max}$

Effectiveness $\in = \sqrt{pk/hA}$

IV.Analysis & Optimization

4.1 Geometry of cylinder **4.2 Meshing of cylinder geometry**

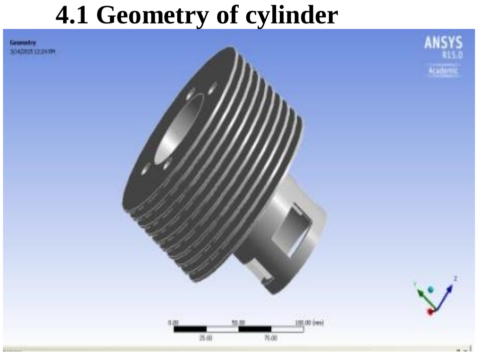


Fig 2: geometry of model

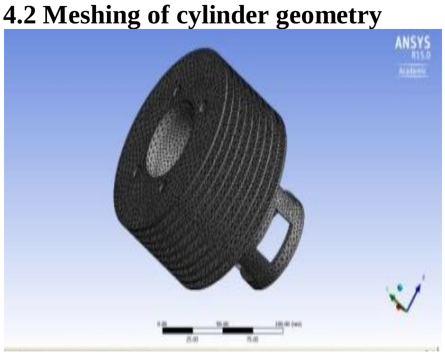


Fig 3: mesh model

4.3 Boundary conditions

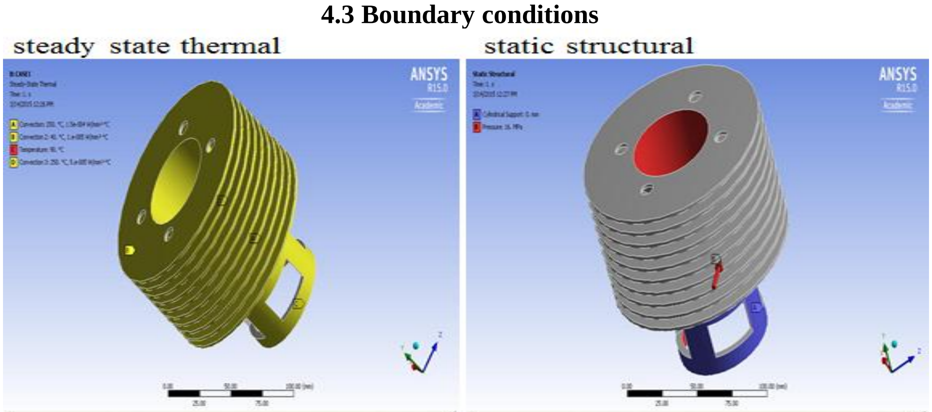
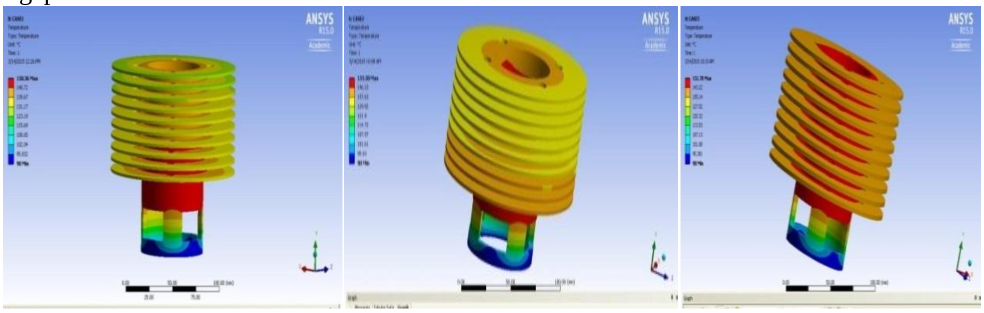


Fig 3: boundary condition

[i- CAM2K16] DOI: 10.9790/1684-16053047280

4.4 Case 1:Material: Mild steel : Thermal analysis of cylinder

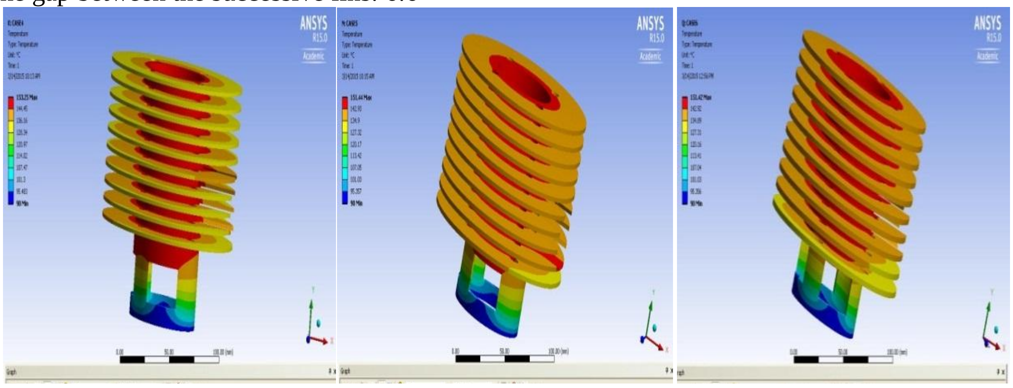
1. For the gap between the successive fins: 5.6mm



For Fin thickness:2mm For fin thickness:2.5mm For fin thickness:3mm

Fig 4

2. For the gap between the successive fins: 6.6



For Fin thickness:2mm For fin thickness:2.5mm For fin thickness:3mm

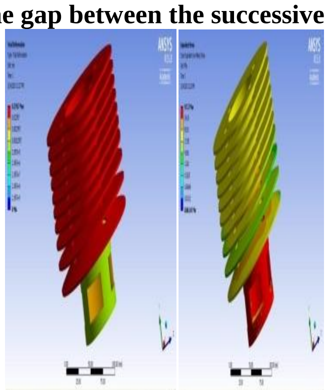
Fig 5

Table 2: Steady state thermal:

Material	Gap between fins(mm)	Fin thickness (mm)	Temperature (°C)
Mild steel	5.6	2	158.36
		2.5	155.38
		3	151.78
	6.6	2	153.25
		2.5	151.44
		3	151.42

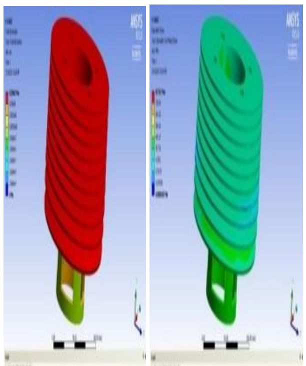
- **Structural analysis:**

3. For the gap between the successive fins: 5.6mm:



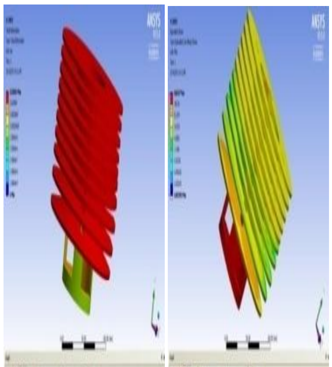
For fin thickness:2mm

Fig 6



For fin thickness:2.5mm

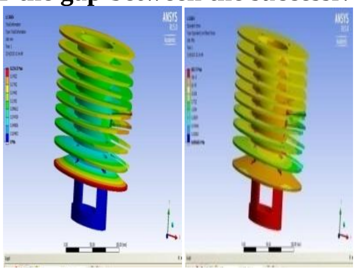
Fig 7



For fin thickness:3mm

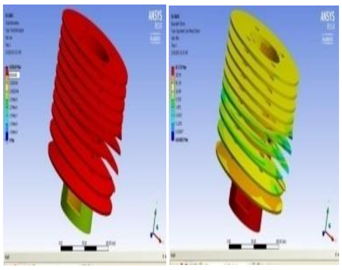
Fig 8

4. For the gap between the successive fins: 6.6mm:



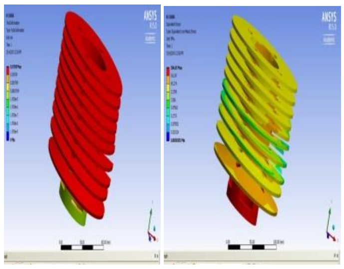
For fin thickness:2mm

Fig 9



For fin thickness:2.5mm

Fig 10



For fin thickness:3mm

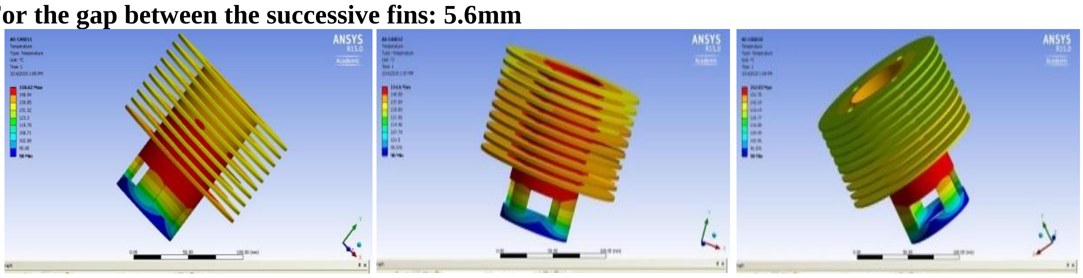
Fig 11

Table 3: static structural:

Material	Gapbetweenfins(mm)	Finthickness(mm)	Totaldeformation(mm)	Equalentstress(Mpa)
Mild steel	5.6	2	0.22957	917.57
		2.5	0.28668	827.62
		3	0.20869	660.87
	6.6	2	0.22413	682.71
		2.5	0.20446	617.75
		3	0.19769	584.65

4.5 . Material: Grey cast iron: Thermal analysis of cylinder:

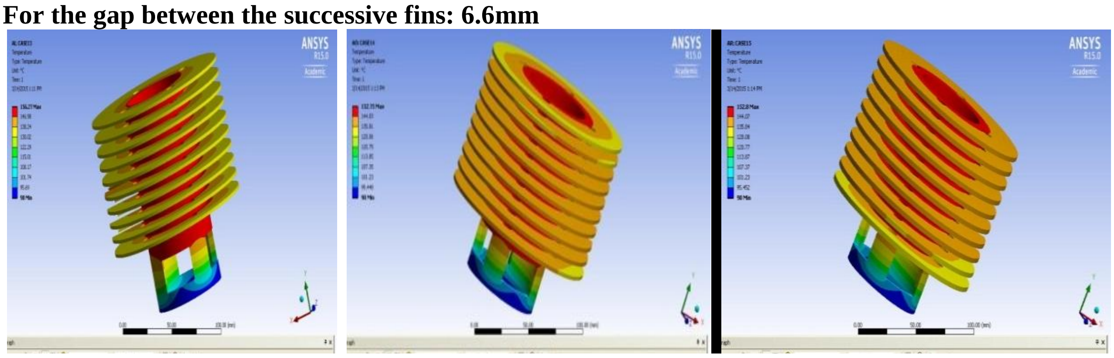
1. For the gap between the successive fins: 5.6mm



For Fin thickness:2mm For fin thickness:2.5mm For fin thickness:3mm

Fig 12

2. For the gap between the successive fins: 6.6mm



For Fin thickness:2mm For fin thickness:2.5mm For fin thickness:3mm

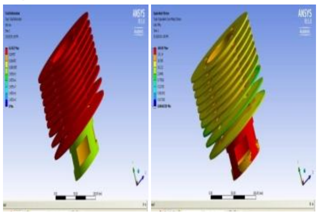
Fig 13

Table 4: Steady state thermal:

Material	Gap between fins(mm)	Fin thickness (mm)	Temperature (°C)
Grey cast iron	5.6	2	162.03
		2.5	158.62
		3	154.6
	6.6	2	156.27
		2.5	152.75
		3	152.8

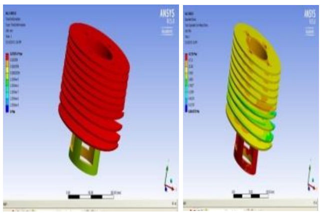
- **Structural analysis**

3. For the gap between the successive fins: 5.6



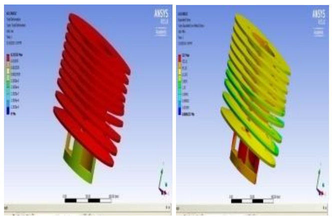
For fin thickness:2mm

Fig 14



For fin thickness:2.5mm

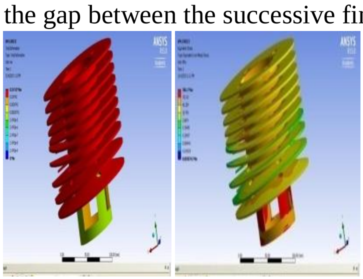
Fig 15



For fin thickness:3mm

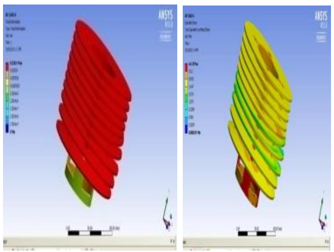
Fig 16

4. For the gap between the successive fins: 6.6mm



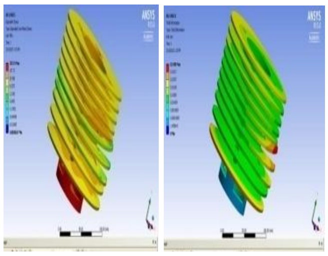
For fin thickness:2mm

Fig 17



For fin thickness:2.5mm

Fig .18



For fin thickness:3mm

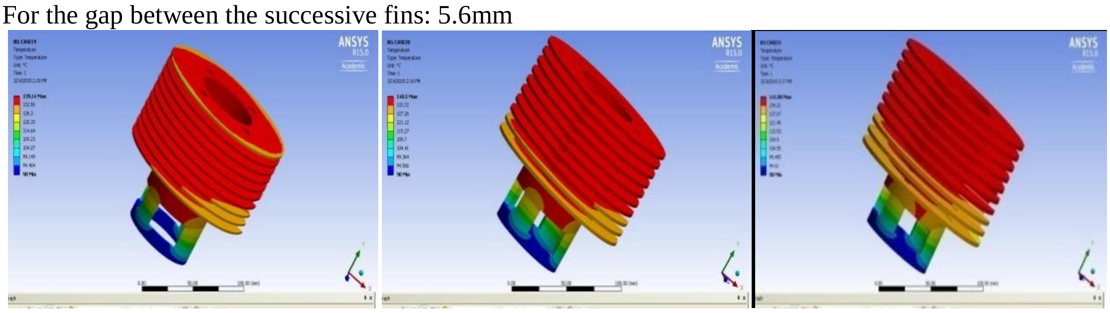
Fig.19

Table 5: static structural:

Material	Gap between fins(mm)	Fin thickness(mm)	Totaldeformation(mm)	Equalent stress(Mpa)
	5.6	2	0.24557	469.92
Grey cast iron		2.5	0.28354	412.94
		3	0.23535	521
	6.6	2	0.24742	566.1
		2.5	0.25024	444.78
		3	0.2490	387.19

4.6. Material: Magnesium alloy:Thermal analysis of cylinder

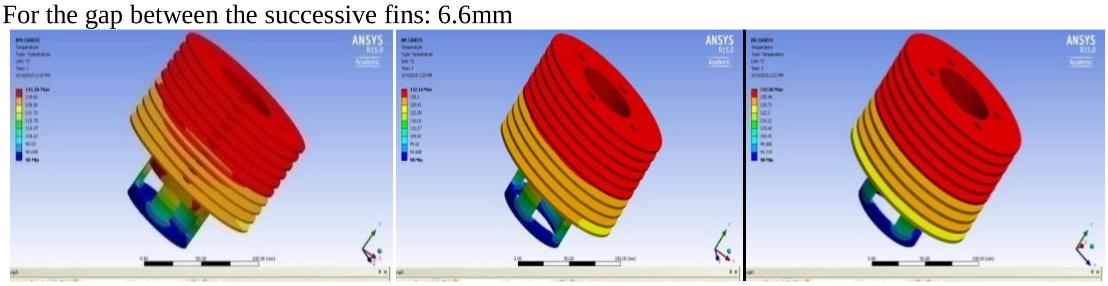
1) For the gap between the successive fins: 5.6mm



For Fin thickness: 2mm — For fin thickness: 2.5mm — For fin thickness: 3mm

Fig 20

2) For the gap between the successive fins: 6.6mm



For Fin thickness: 2mm — For fin thickness: 2.5mm — For fin thickness: 3mm

Fig 21

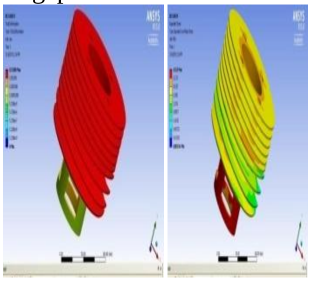
[i- CAM2K16] DOI: 10.9790/1684-16053047280

Table 6: Steady state thermal

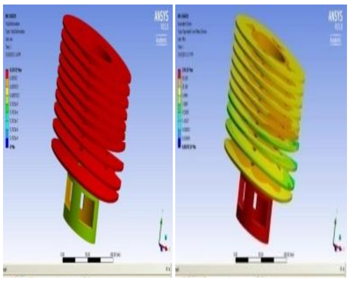
Material	Gap between fins(mm)	Fin thickness (mm)	Temperature (°C)
megnesium alloy	5.6	2	139.4
		2.5	140.5
		3	141.08
	6.6	2	141.56
		2.5	142.14
		3	142.56

- **Structural analysis:**

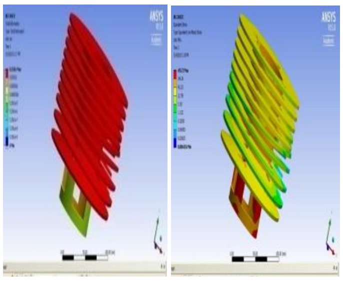
1) For the gap between the successive fins: 5.6mm



For fin thickness:2mm
Fig 22

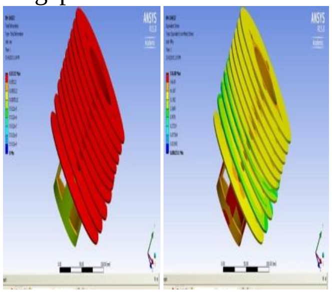


For fin thickness:2.5mm
Fig 23

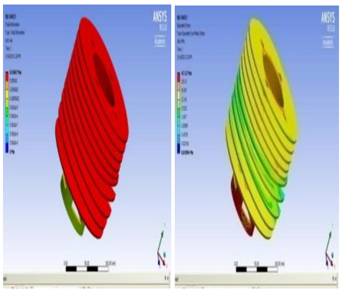


For fin thickness:3mm
Fig 24

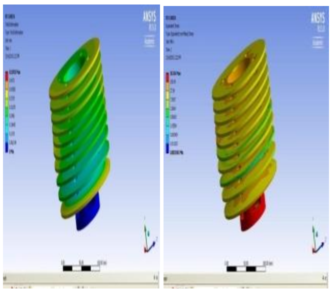
2) For the gap between the successive fins: 6.6mm



For fin thickness:2mm
Fig 25



For fin thickness:2.5mm
Fig 26



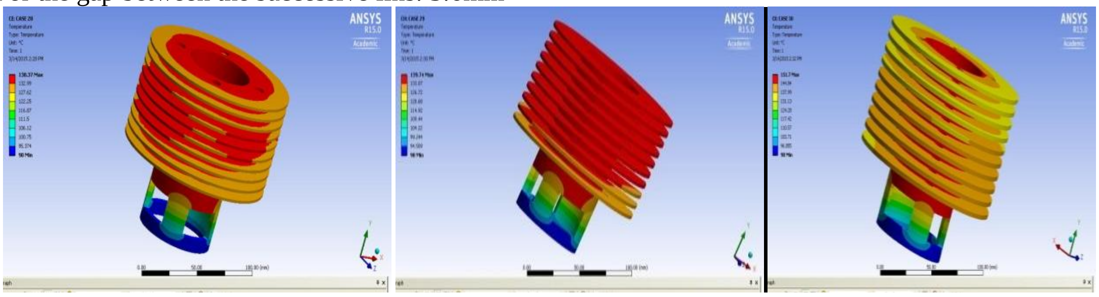
For fin thickness:3mm
Fig 27

Table 7: static structural

Material	Gapbetweenfins (mm	Fin thickness(mm)	Totaldeformation(mm)	Equalentstress(Mpa
Megnisium alloy	5.6	2	0.53388	415.35
		2.5	0.57672	339.35
		3	0.52561	495.72
	6.6	2	0.55122	516.08
		2.5	0.55602	421.12
		3	0.55935	367.04

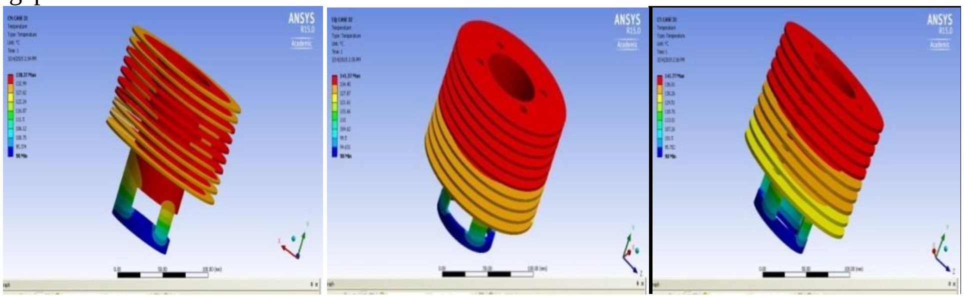
4.7 Material: Aluminium alloy:Thermal analysis of cylinder

1) For the gap between the successive fins: 5.6mm



For Fin thickness: 2mm For fin thickness: 2.5mm For fin thickness: 3mm
Fig 28

2) For the gap between the successive fins: 6.6mm



For Fin thickness : 2mm For fin thickness: 2.5mm For fin thickness: 3mm

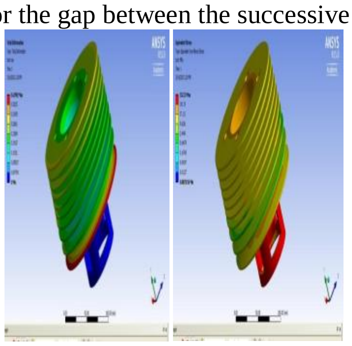
Fig 29

Table 8: Steady state thermal

Material	Gap between fins(mm)	Fin thickness (mm)	Temperature (°C)
Alluminium Alloy	5.6	2	138.37
		2.5	139.74
		3	151.7
	6.6	2	138.37
		2.5	141.37
		3	141.77

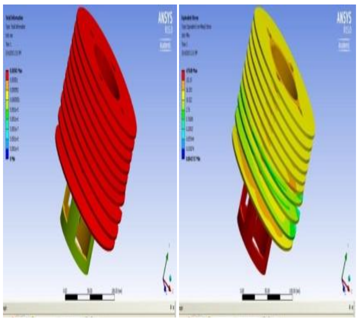
- **Structural analysis**

3) For the gap between the successive fins: 5.6mm



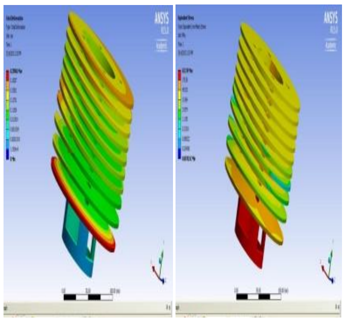
For fin thickness:2

Fig 30



For fin thickness:2.5mm

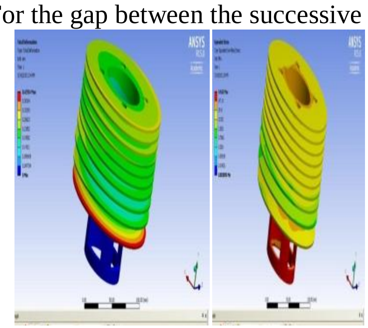
Fig.31



For fin thickness:3mm

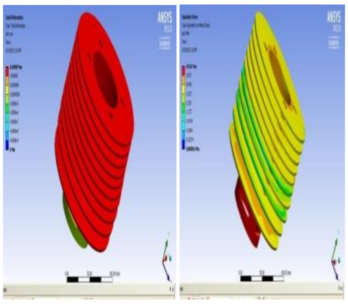
Fig 32

4) For the gap between the successive fins: 6.6mm



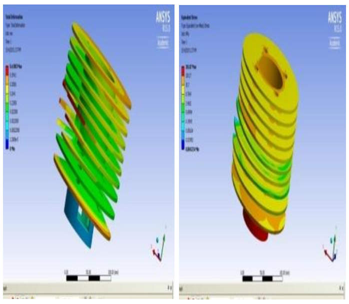
For fin thickness:2mm

Fig 33



For fin thickness:2.5mm

Fig 34



For fin thickness:3mm

Fig 35

Table 9: static structural

Material	Gapbetweenfins(mm)	Finthickness(mm)	Totaldeformation(mm)	Equalentstress(Mpa)
Alluminium alloy	5.6	2	0.42992	552.33
		2.5	0.50501	479.88
		3	0.20966	622.59
	6.6	2	0.42934	549.65
		2.5	0.40898	429.01
		3	0.41003	381.87

V. Results

The geometry of the original model is imported into ANSYS workbench 15.0 environment and boundary conditions were applied. Analysis is carried out for different geometry of fins (circular) with various thicknesses and different materials. The results are shown below

Table 10: Analysis Results

Material	Gap between fins (mm)	Fin thickness (mm)	Temperature (°C)	Total deformation (mm)	Equalent stress(Mpa)
Mild Steel	5.6	2	162.03	0.22957	917.57
		2.5	158.62	0.28668	827.62
		3	154.6	0.20869	660.87
	6.6	2	156.27	0.22413	682.71
		2.5	152.75	0.20446	617.75
		3	152.8	0.19769	584.65
Grey Cast iron	5.6	2	162.03	0.24557	469.92
		2.5	158.62	0.28354	412.94
		3	154.6	0.23535	521
	6.6	2	156.27	0.24742	566.1
		2.5	152.75	0.25024	444.78
		3	152.8	0.2490	387.19
Magnesium Alloy	5.6	2	139.4	0.53388	415.35
		2.5	140.5	0.57672	339.35
		3	141.08	0.52561	495.72
	6.6	2	141.56	0.55122	516.08
		2.5	142.14	0.55602	421.12
		3	142.56	0.55935	367.04
Alluminium alloy	5.6	2	138.37	0.42992	552.33
		2.5	139.74	0.50501	479.88
		3	151.7	0.20966	622.59
	6.6	2	138.37	0.42934	549.65
		2.5	141.37	0.40898	429.01
		3	141.77	0.41003	381.87

Table 11: Theoretical Results

Material	Finthickness(mm)	Heat lost (w)	Effectiveness (E)	Efficiency (η)
Mild Steel	2	83.72	16.05	82
	2.5	86.52	16.05	84
	3	89.35	16.05	86
Grey Cast iron	2	83.72	14.88	82
	2.5	86.52	14.88	84
	3	89.35	14.88	86
Magnesium Alloy	2	83.72	25.7	82
	2.5	86.52	25.7	84
	3	89.35	25.7	86
Alluminium alloy	2	83.72	26.51	82
	2.5	86.52	26.51	84
	3	89.35	26.51	86

VI. Conclusion

In this paper we have designed a cylinder fin body used in a 100cc Bajaj Motorcycle and modeled in ANSYS workbench 15.0 modeling software. Present used material for fin body is Aluminum alloy 204. We are replacing with Mild steel, grey cast iron, magnesium alloy, aluminum alloy. The shape of the fin is circular with rectangular cross section shaped. The default thickness of fin is 3mm; we are reducing it to 2, 2.5mm. By reducing the thickness and also by changing the gap between the successive fins. thereby increasing the efficiency. The weight of the fin body is reduced when Magnesium alloy is used. We have done thermal analysis on the fin body by varying materials, geometry and thickness. By observing the analysis results, using circular fin, material Aluminum alloy and thickness of 2.5mm is better since heat transfer rate is more. But by using circular fins the weight of the fin body increases.. So we can conclude that using material Aluminum alloy is better, reducing thickness to 2.5mm is better and using fin shape circular by analysis By using circular fins the weight of the fin body reduces compared to existing rectangular engine cylinder fin. We have also done theoretical calculations to determine the heat lost, effectiveness and efficiency of the fins. By observing the results, using circular fins the heat lost is more, efficiency and effectiveness is also more

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