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Thermal Analysis of IC Engine Cylinder Fins Using ANSYS

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***Abstract**:*
The combustion processes in combustion process generates high heat which is dissipated using fins. The heat dissipation capacity of engine depends upon its fin design and dimensions. The objective of current research is to investigate the effect of fin diameter on heat dissipation and temperature distribution across engine cylinder fins. The design of engine cylinder and analysis is conducted in ANSYS FEA software. The effect of fin_dia on heat flux and temperature distribution is also evaluated using Taguchi Design of experiments. The fin diameter has significant effect on heat dissipation characteristics of engine cylinder. The critical regions of high temperature and heat flux are identified. The maximum heat flux was observed to be at fin_dia of 102mm and maximum temperature is observed for fin_dia of 107mm.

***Key Words:** Engine cylinder, fins, thermal analysis*

1. INTRODUCTION

The combustion in IC engine occurs at high temperature inside engine cylinder. The high temperature causes failure of piston ring, oil ring and compression ring. For air cooled engines (used in 2 wheelers) the heat is dissipated in to the atmosphere from engine fins. The heat transfer rate depends upon various factors which is "wind speed, geometry of the motor surface, internal surface area and temperature of the environment" [7].

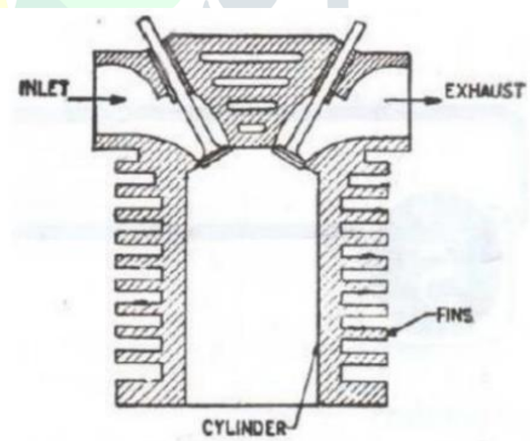

Figure 1: Engine cylinder [7]

2. LITERATURE REVIEW

R Ramachandra et al. (2016) [1] have the performance of engine by varying design of intake manifold configuration. The research findings have shown that by using helical spiral manifold an increase in "velocity component (W/Vp) inside the combustion chamber at the end of compression stroke" [1].

Bandi.Ramanjulu, et al. (2015) [2] have worked on improving engine performance of combustion chamber by varying engine cylinder fin geometry. The research findings have shown an increase in volumetric efficiency of engine by 10% when square filleted shape fins are used.

K.Raj Kiran, et al. (2017) [3] have worked on design and development of water cooled engine using experimental techniques. The research findings have shown reduction in cylinder pressure by 19% when modified flow condition is used and heat release reduced by 12.15%.

Lucas Konstantin off et al. (2017) [4] have investigated the performance of cylinder head having 2 different valve seat designs. The swirl flow coefficients are calculated on the basis of data from air flow rate and angular momentum. The results obtained from "static flow results were compared to results from PIV analysis conducted at an optical test bench for the visualization of flow and velocity patterns" [4].

Pankaj N. Shrirao et al. (2015) [5] have worked on the performance of engine by varying design configuration of cylinder head using 3 oval shapes. The research findings have shown an improvement of air-fuel mixing process when oval shape cylinder head is used by enhancing the turbulence in air/fuel flow inside combustion chamber.

J Benajes et al. (2004) [6] have investigated the performance of combustion chamber by optimizing swirl flow ratio under operating range. The combustion chamber geometry and fuel injection rate also has significant effect on efficiency of engine at different operating conditions.

3. OBJECTIVES

The objective of current research is to investigate the effect of fin diameter on heat dissipation and temperature distribution across engine cylinder fins. The design of engine cylinder and analysis is conducted in ANSYS FEA software. The effect of fin_dia on heat flux and temperature distribution is also evaluated using Taguchi Design of experiments.

4. METHODOLOGY

The thermal analysis of engine cylinder is conducted using techniques of finite element analysis. The CAD model of engine cylinder is developed using sketch and extrude tool. The fins are developed and pattern tool is used to create multiple copies.

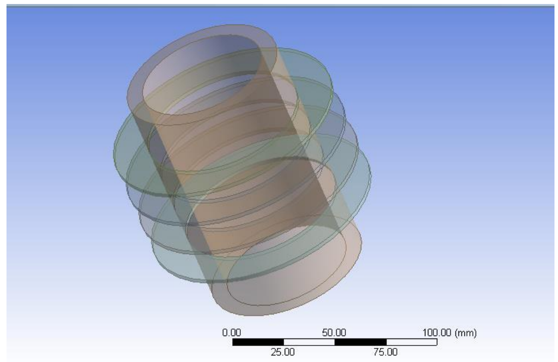

Figure 1: Engine cylinder design

The discretized model of engine fin is shown in figure 2 below. The inflation is set to normal, growth rate set to 1.3 and sizing set to fine. The model of engine cylinder has topological consistency and therefore the hexahedral element shape is achieved.

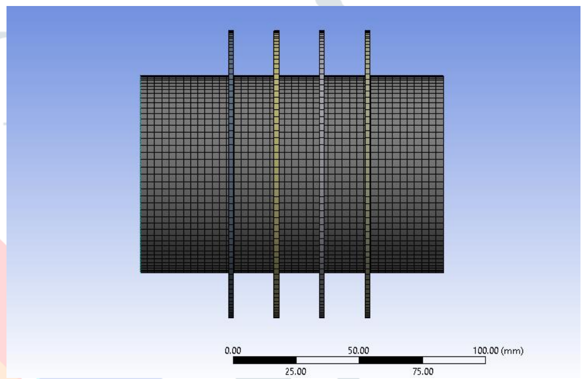

Figure 2: Engine cylinder design

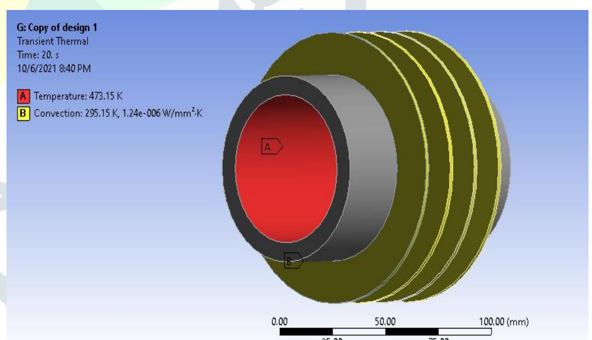

Figure 3: Loads and boundary condition

The thermal loads and boundary conditions are applied on the engine cylinder as shown in figure 3 above. The temperature is applied on the inner face of the cylinder and convection coefficient is applied on the fins of the cylinder as shown in yellow colour.

5. RESULTS AND DISCUSSION

The variation of temperature is obtained from the analysis is shown in figure 4 below. The temperature is high at the inner face with magnitude of 473K.

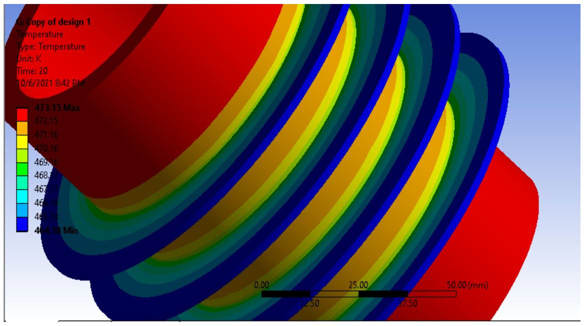

Figure 4: Temperature distribution across cylinder

The heat dissipation from the engine cylinder takes place through fins. The temperature at the fin cylinder interface is nearly 468K. The temperature reduces across the fins and temperature at the fin tip is nearly 4654K.

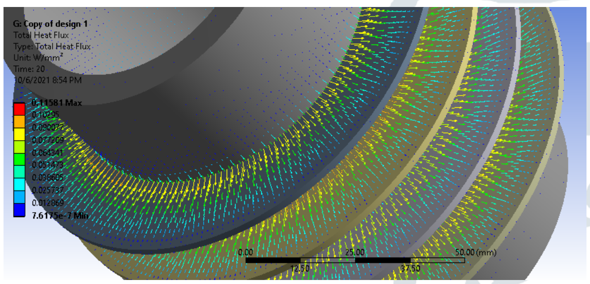

Figure 5: Total heat flux distribution across cylinder

The total heat flux vector plot obtained for engine cylinder is shown in figure 5 above. The heat flux is maximum at the interface fins and cylinder with magnitude of 115810W/m^2 and the heat flux is minimum at the fin tip with magnitude of .76W/m^2. The heat flux distribution is similar and uniform for all the fins attached to the cylinder.

Table 1: Temperature variation

Fin_dia (mm)	Temperature Minimum (C)
102.2679	191.3255614
106.0556	193.1494722
107.002525	193.3205223
107.94945	193.3673408
108.896375	193.2876557
115.52485	189.359157
118.365625	186.248583
119.31255	185.101792
120.259475	183.9231146
121.2064	182.7271104
122.153325	181.5285158
123.10025	180.3420265
124.047175	179.1820817
124.9941	178.0626532

Table 2: Total heat flux

Fin_dia (mm)	Total Heat Flux Maximum Minimum Value Over Time (W m^-2)
102.2679	292.8555387
103.214825	292.5296195
104.16175	291.8329685
105.108675	290.766402
106.0556	289.3332426
112.684075	269.8276502
113.631	265.8694936
114.577925	261.6793377
115.52485	257.2819084
122.153325	223.020811
123.10025	217.9834884
124.047175	213.0009909
124.9941	208.1029804

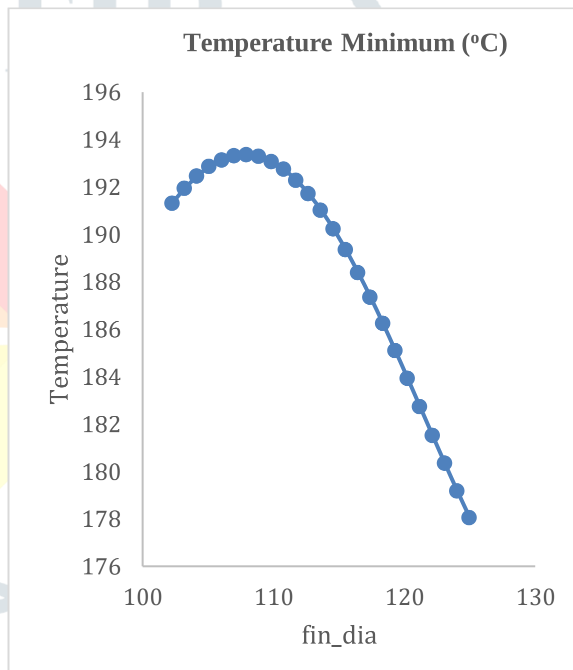

Figure 6: Temperature vs fin_dia

The effect of fin_dia on heat dissipation and temperature is investigated used Taguchi response surface optimization. Different design points are generated based on linear regression mathematical model. The variation of temperature with respect to fin_dia is shown in figure 6 above. The plot shows an increase in temperature upto 107mm fin_dia and then decreases linearly thereafter.

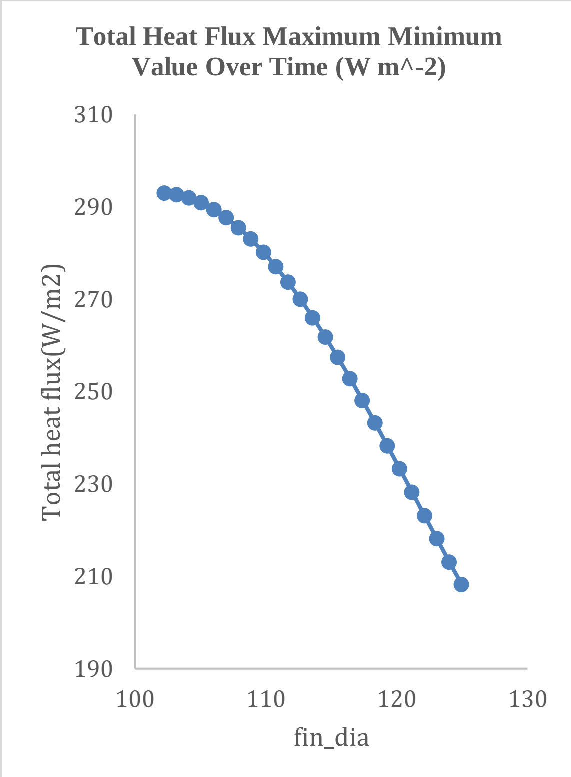

Figure 7: Total heat flux vs fin_dia

The effect of fin_dia on total heat flux is investigated used Taguchi response surface optimization. The total heat flux is maximum at fin_dia value of 102.2mm fin_dia and then heat flux decreases linearly thereafter. The minimum heat flux is obtained at fin_dia value of 124.9mm.

6. CONCLUSION

The FEA is a viable tool in determining heat transfer characteristics of engine cylinder. The fin diameter has significant effect on heat dissipation characteristics of engine cylinder. The critical regions of high temperature and heat flux are identified. The maximum heat flux was observed to be at fin_dia of 102mm and maximum temperature is observed for fin_dia of 107mm.

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