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RESEARCH ARTICLE

DESIGN MODIFICATION AND HEAT TRANSFER ANALYSIS OF AIR COOLED RECTANGULAR FIN ENGINE

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ABSTRACT

In this paper a CFD analysis of a rectangular fin engine is carried out. A two wheeler bike engine is chosen (e.g. Unicorn bike engine) and geometry is designed in Design Modeller in Ansys 16.0. Presently material used for is Al 6063 which has a thermal conductivity of 200 W/m K. A modification in design of engine is made by creating holes on fin. Transient and Steady state heat transfer simulation is carried out on the engine for a period of 400 seconds.

An Extensive analysis has been carried out to study the variation of temperature on creation of various diameters 2mm, 6mm, & 10mm holes on fin. In addition, a perforated fin was compared with an imperforate fin to observe the differences.

It is observed from the results that before a time period of 400 seconds Transient temperature of all fins has reached to steady state temperatures. However, Fin with a hole of 10mm dia has decrease the minimum temperature of 1036.5 K for an imperforated fin to a minimum temperature of 989.03 K.

INTRODUCTION

All Engines have cooling mechanism to remove the heat from the engine, some heavy vehicles uses water-cooling system and almost all two wheelers uses Air cooled engines, because Air-cooled engines are only option due to some advantages like lighter weight and lesser space requirement. In Engine When fuel is burned heat is produced. Additional heat is also generated by friction between the moving parts. Only approximately 30% of the energy released is converted into useful work. The remaining (70%) must be removed from the engine to prevent the parts from melting. For this purpose the heat generated during combustion in IC engine should be maintained at higher level to increase thermal efficiency, but to prevent the thermal damage some heat should remove from the engine. In air-cooled engine, extended surfaces called fins are provided at the periphery of engine cylinder to increase heat transfer rate. That is why the analysis of fin is important to increase the heat transfer rate.

Types of Cooling System

Air Cooled System

Air cooled system is generally used in small engines. In this system fins or extended surfaces are provided on the cylinder walls, cylinder head, etc. The amount of heat dissipated to air depends upon

- Amount of air flowing through the fins.
- Fin surface area.
- Thermal conductivity of metal used for fins

Water Cooled System

In water cooling system of cooling engines, the cylinder wall and heads are provided with jackets where water or a coolant is filled.

LITERATURE REVIEW

Kumbhar *et.al*. [1] They have concluded that the heat transfer rate increases with perforation as compared to fins of similar dimensions without perforation. The perforation of the fin enhances the heat dissipation rates at the same time decreases the expenditure for fin materials also.

Gulay Yakar and Rasim Karabacak [2] used heater whose fins had holes with an angle When Nu_d values were considered for the same air flow rate and the same Re_d, the Nu_d value of the heater with holes was found to be 2.43% higher than the Nu_d value of the heater without holes.

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A T Pise and U V Awasarmol [3] conducted the experiment to compare the rate of heat transfer with solid and permeable fins. Permeable fins are formed by modifying the solid rectangular fins with drilling three holes per fins incline at one half length of the fins of two wheeler cylinder block.

Matkar *et.al*. [5] Calculated the heat transfer rate and the temperature behavior for the same object with the different material (like copper and aluminium).

Pulkit Agarwal *et.al* [6] They have concluded that overcooling also affects the engine efficiency because of overcooling excess fuel consumption occurs. This necessitates the need for reducing air velocity striking the engine surface to reduce the fuel consumption.

Barhatte SH *et.al*. [7] Natural convection heat transfer from vertical rectangular fin arrays with and without notch at the center has been investigated experimentally and theoretically. In a lengthwise short array where the single chimney flow pattern is present, the central portion of fin flat becomes ineffective due to the fact that, already heated air comes in its contact.

Mishra AK *et.al*. [8] They carried out transient numerical analysis with wall cylinder temperature of 423 K initially and the heat release from the cylinder is analyzed for zero wind velocity. The heat release from the cylinder which is calculated numerically is validated with the experimental results.

Ajay Paul *et.al*. [9] Parametric Study of Extended Fins in the Optimization of Internal Combustion Engine they found for high speed vehicles thicker fins provide better efficiency. When fin thickness was increased, the reduced gap between the fins resulted in swirls being created which helped in increasing the heat transfer.

Raju G *et.al*. [10] They investigated maximization of heat transfer through fin arrays of an internal combustion engine cylinder, under one dimensional, steady state condition with conduction and free convection modes. They used non-traditional optimization technique.

Chandrakant SS *et.al*.[11] They conducted experiments for rectangular and triangular fin profiles for air velocities ranging from 0 to 11 m/s. Experimental and CFD simulated result proves that annular fins with rectangular fin profiles are more suitable for heat transfer enhancement as compared to triangular fin profiles.

Sukumar RS *et.al*. [12]. Presented CFD analysis of heat sinks which contain continuous rectangular fins, interrupted rectangular fins and above models with through holes for electronic cooling is investigated.

Sami *et al* [13]. They presented the application of a mathematical model for simulation of the swirling flow in a tube induced by elliptic-cut and classical twist tape inserts..

N. Phani Raja Rao and T. Vishnu Vardhan [14]. Al 6061 and Mg Al are used and compared with Al A204. The various parameters (i.e., shape& geometry) are considered in the study, 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.

G. Babu, and M. Lavakumar [15] Designed rectangular fin body made of Al 204 replacing with Al 6061 and Mg Al, changed the shape with circular and curve shaped. The default thickness of fin is 3mm; reduced it to 2.5mm. They had also done theoretical calculations to determine the heat lost effectiveness and efficiency of the fins.

Arvind SS *et.al*, [16].There is a scope of improvement in heat transfer of air cooled engine cylinder fin if mounted fin's shape varied from conventional one. Contact time between air flow and fin (time between air inlet and outlet flow through fin) is also important factor in such heat transfer.

Mohsin A. Ali and S.M Kherde [17]. There is a scope of improvement in heat transfer of air cooled engine cylinder fin if mounted fin's shape varied from conventional one. The fin geometry and cross sectional area affects the heat transfer coefficient..

Kamboj R *et.al*. [18] He had observed that the thermal enhancement factor tends to decreases at low values of Reynolds number and it increases at high values of Reynolds number.

Chaitanya S *et.al*. [19]. Presented work on a cylinder fin body. Al 6061 is compared with Al A204. The results showed that, by using circular fin with material Aluminium Alloy 6061 is better since heat transfer rate of the fin is more.

Deepak Gupta and Wankhade S.R [20] They designed a cylinder fin body of aluminum alloy fins and internal core with grey cast iron and replaced with Al 6063 and Grey cast iron separately for entire body. They concluded that using material Aluminum alloy 6063 is better.

Shabbani AL [21] found the accurate values of temperature with respect to the varying time. Applied principle of separable variables to heat conduction subjected in cylindrical fins.

PROPOSED METHODOLOGY

It is noticed from the above literature that the research work on cylinder fins with various geometry and materials was already carried out. Our effort will be to use Design Modeler in Ansys 16.0 to design an engine (e.g. Unicorn bike) and increase the surface area by creation of holes which in turn increases the heat transfer. A comparative analysis will be carried out to study the variation of temperature on creation of various diameters 2mm, 6mm & 10mm holes on fin.

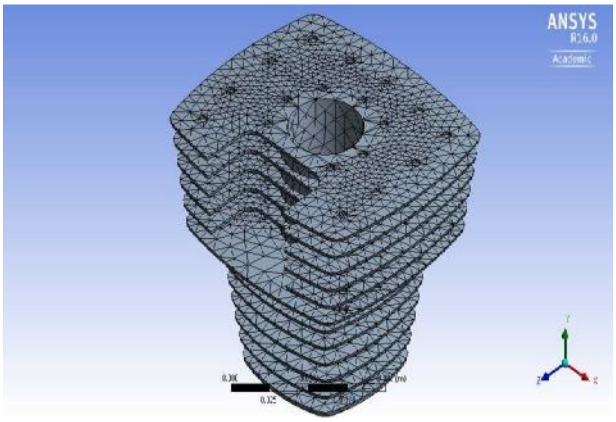


Fig-1 engine cylinder meshed

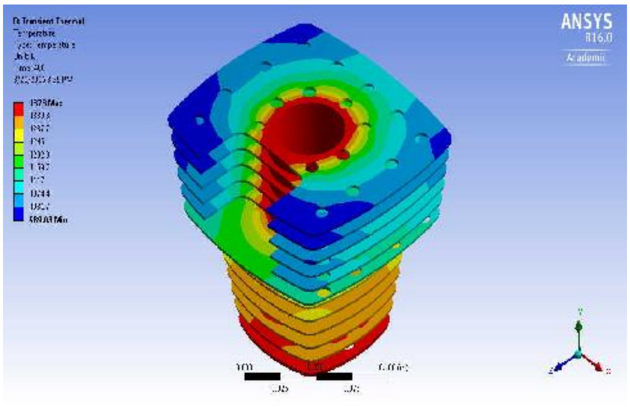


Fig-2 transient analysis of engine fin

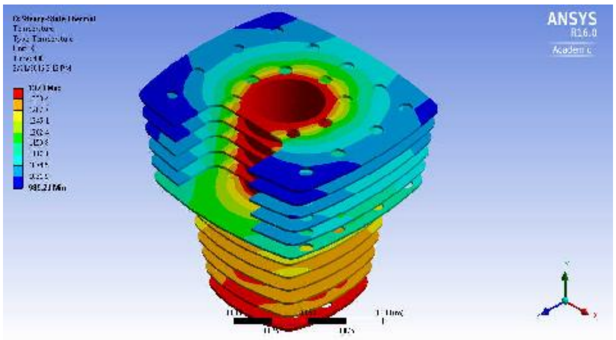


Fig-3 steady state analysis of engine fin
Simulation/experimental results

After simulation of Engine Fin in transient and steady state Thermal Analysis in Ansys 16.0. It was observed that the final temperature of fin varies with the diameter of the hole created. Transient & Steady State thermal Analysis of the fin is made and results are tabulated:-

Table 1 Transient Min Temp of All Fins (K)

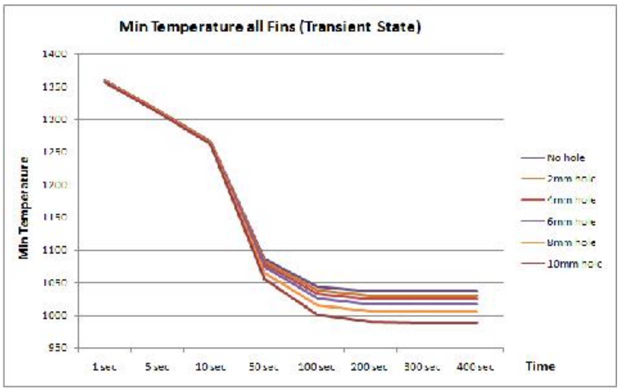
Hole / Time	No hole	2mm hole	6mm hole	10mm hole
1 sec	1359.2	1359.2	1359.2	1356.3
5 sec	1314.2	1314.0	1313.2	1311.0
10 sec	1265.7	1265.3	1264.2	1262.2
50 sec	1085.8	1081.9	1073.8	1055.7
100 sec	1043.6	1037.7	1025.6	1000.9
200 sec	1036.6	1030.2	1016.8	989.48
300 sec	1036.5	1030.0	1016.5	989.04
400 sec	1036.5	1030.0	1016.5	989.03

Table 2 Steady State Min Temp of All Fins (K)

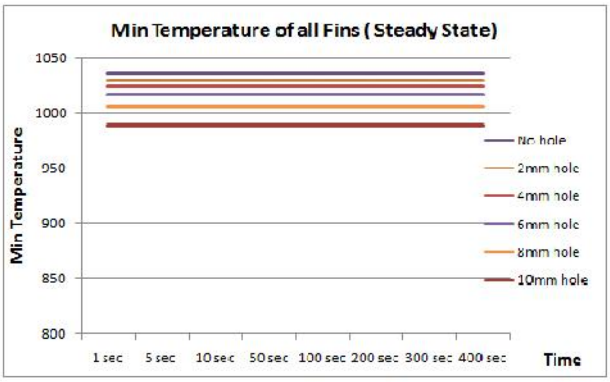
Hole / Time	No hole	2mm hole	6mm hole	10mm hole
1 sec	1036.4	1030.2	1016.3	989.21
5 sec	1036.4	1030.2	1016.3	989.21
10 sec	1036.4	1030.2	1016.3	989.21
50 sec	1036.4	1030.2	1016.3	989.21
100 sec	1036.4	1030.2	1016.3	989.21
200 sec	1036.4	1030.2	1016.3	989.21
300 sec	1036.4	1030.2	1016.3	989.21
400 sec	1036.4	1030.2	1016.3	989.21

Table 3 Time Taken By Fin To Reach Steady State From Transient State (Min Temp (K))

Sl No	Fin with hole size	Temp Max (K)	Temp Min (K)	Time to reach Steady State Min Temp (Sec)	Max Time Calculated (Sec)
1	No holes	1373	1036.5	217	400
2	2mm	1373	1030	227	400
3	6 mm	1373	1016.5	267	400
4	10mm	1373	989.03	305	400



Graph 1 Min temp v/s time for all fins (transient)



Graph 2 Min temp v/s time for all fins (steady)

CONCLUSION

On the basis of the study carried out in the rectangular engine fin by Transient and Steady State Thermal Analysis in ANSYS Workbench 16.0, the following conclusions have been drawn.

1. Turbulence of flow of air is increased between the fins on creation of hole.

2. Heat lost by the body can be increased by increasing the surface area i.e. increasing the diameter of the hole created on the fin.
3. Temperature of the fin can be reduced by creation of holes.
4. It is observed from the results that before a time period of 400 seconds Transient temperature of all fins has reached to steady state temperatures.
5. Fin with a hole of 10mm dia has decrease the minimum temperature of 1036.5K for an imperforated fin to a minimum temperature of 989.03 K.

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