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Assessment of Effect of Perforated Fins on the Performance of Single Cylinder Engine

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Abstract: Change in heat transfer rate in different size of perforated fins has been studied in the present paper fins increases the heat transfer rate by increasing the surface area. Circular perforation in a single cylinder engine has been studied. ANSYS 15.0 has been used to done project analysis Al, Structural steel, Gray Cast Iron material have been considered to study heat transfer rate. Perforation has been done to see its effect on the heat transfer 2, 4, 6 mm perforation on the engine fins have been studied and compared by cylinder block without perforation. The time-temperature cooling curve has been plotted. From the result, it has also been noticed that gray cast iron shows largest heat transfer rate as compared to the fins is solid or without perforated. Weight analysis shows that engine made of Gray Cast Iron has Weight less than Structural steel but large than Al.
Keywords: Two Wheeler Single Cylinder Block, Fins, ANSYS 15.0.

I. INTRODUCTION

All most all the Electronic / Electrical/Mechanical devices generate a large amount of heat, which needed to be cool down for better performance. This heat can either be cool by passive ways or by active ways. Fins, also known as extended surface have been most widely used active ways studied and adopted for the cooling of engine blocks and many other heat generated systems. Perforations in the fins are the recent topic of research now a day.

A. In 2009 Kumbhar et al (1) find out the solution by the use of ANSYS and Calculate heat transfer expansion from a horizontal rectangular fin by triangular perforation under natural convection.
B. Shaeri & Yaghoubi (2, 3) in 2009 studied the fluid flow numerically & also Studied Turbulent convection of heat transfer from solid & Perforated Fins.
C. Nagarani el al (4) in 2010 analyzed heat removing rate for various environmental conditions.
D. Pise et al (5) in 2010 investigates the research with solid and pervasive fins to find the speed of heat transfer. Permeable fins are hard rectangular surface. With making 3 holes per fin.
E. Magarajan et al (6) in 2012 mathematically studied with the help of CFD tool net heat rejection of I.C. engine, the heat removing by an extended surface on an engine.
F. Paul et al (7) in 2012 in the research of internal burning fuel in engine & find the optimum solution of Extended fins and Also state that efficiency can be improved by using wider fins on the equation.
G. Raju et al (8) in 2012 studied the best solution for I.C. engine cylinder fins array by a binary coded genetic algorithm & also find the result of heat rejection & total heat transfer surface area of fins.
H. Dhumne and Farkade (9) in 2013 studied & analysis about the staggered arrangement of perforated fins cylindrically & also analysis the pressure drop. Considering the Reynold number which varying from 13500-42000.
I. Patil et al (10) in 2013 Studied about elliptically shaped fins for heat rejection parameters.
J. Tarvydas et al (11) in 2013 investigate about the performance for an electronic element. They use COMSOL for fem. process. They studied the result of the meshing processes on the time taken by COMSOL for a completed solution of the heat sink
K. Wange et al. (12) in 2013 conducted an experimental and computational investigation of fin array and given that the heat removing coefficient is high in indentation fin array than not including notch fin array. Designing limitations of fin effect on the working of fins, so proper collection of geometric parameter
L. Dhanawade et al. (13) in 2014 studied the effect of perforation during forced convection heat transfer considering square and circular perforation.
M. Ismail et al. (14) in 2014 numerically studied the heat transfer and flow of fluid inside the fins having lateral perforations. The governing parameter of their study was Reynolds number and they varied it from 2000-5000. They used k-ε and RANS model to calculate the fluid flow and heat transfer and found in good agreement.

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N. Wang et al. (15) 2014 studied the porous media approach for the plate-fin heat exchanger to study the hydrodynamic characteristics numerically. They developed a correlation between the Reynolds number, pressure drop, and flow distribution.

O. Warrier et al. (16) in 2014 conducted to design and modeling of perforated side walls in a micro-channel system and proposed a new model.

P. Yang and Li (17) in 2014 conducted the three-dimensional study of the hydraulic performance of plate-fin heat exchanger having strip fins.

Q. Damook et al. (18) in 2015 investigated the thermal performance of perforated heat sinks experimentally and numerically. They designed a perforated heat sink having perforation and studied the heat transfer and pressure drop both experimentally and numerically by CFD (computational fluid dynamics).

R. Nitnaware et al. (19) in 2015 find out the result of fin designs, a coefficient of heat transfer coefficient (h) and material (K) is studied for the heat loss for air cooling of an I.C. engine. Also, heat removes per unit mass of fin is higher for conical shape fin than a rectangular shape, therefore, tapering fins are favored over rectangular cross section fins.

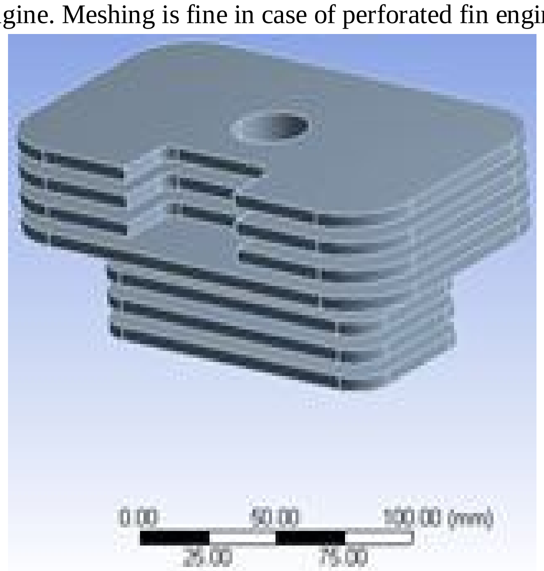
S. Liu et al. (20) in 2016 numerically studied the perforated finned tube heat exchanger having large fin pitches. They studied the air side heat transfer by varying the Reynolds number from 750-2350.

T. Stark et al. (21) in 2016 developed a numerical model for heat pipes having finned condenser to study the heat transfer rates. They solved three-dimensional Navier-stokes equation (mass, momentum, and energy). They validated the results of SST simulation with experimental results and found in good agreement.

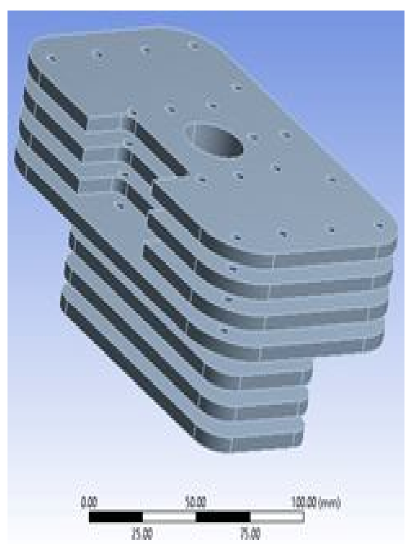
U. Prashant & Siddhartha (22) in 2016 Studied Heat transfer rate of Diff. Size of Perforated Fins by Using ANSYS 16.0 for Diff. Material AL6063, Nickle, and Copper. The result of this Study Show that the max transfer of heat has been formed in the largest perforation. Nickle shows largest heat transfer as compare to AL6063 & Cu. But Nickle shows Largest Weight that is not possible. Present paper here deals with analysis of temperature and heat flux distribution of single Cylinder engine with and without perforated fins. ANSYS 15.0 has been used in the present analysis. AL, Structural Steel and Gray Cast Iron as engine material have been studied. Time-temperature curve and weight analysis have also been conducted.

II. MODELING

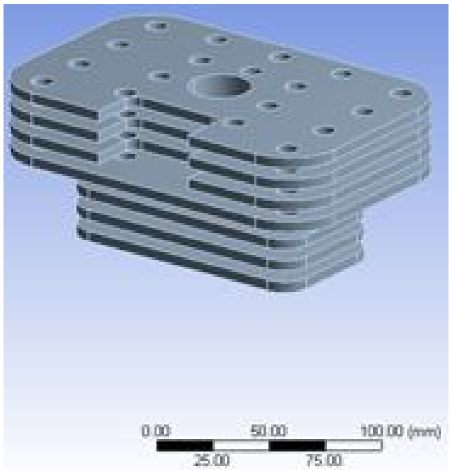
A two-wheeler engine Cylinder block has been chosen and modelled in the SolidWorks 2014. Circular perforation in the fins has been made. The figure shows the geometries of the engine with perforated fins of different diameter (2, 4 and 6mm). Figure 1 is without any perforation while figures 2 with 2mm, figure 3, 6mm and figure 4, 4mm perforation respectively. Automatic meshing has been adopted for the present work. One can observe the difference between the meshed view of the perforated fin engine and solid fin engine. Meshing is fine in case of perforated fin engine when compared with an engine with solid fins.



(1) Without Perforation



(2) 2 mm perforation



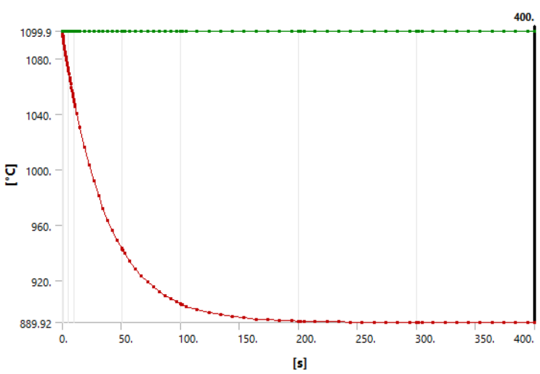
(3) 4mm perforation

(4) 6 mm perforation

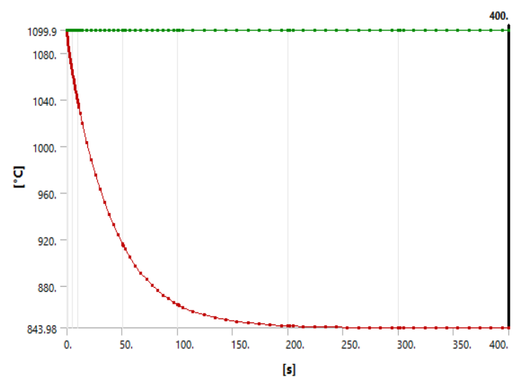
(4)

III. RESULT AND DISCUSSION

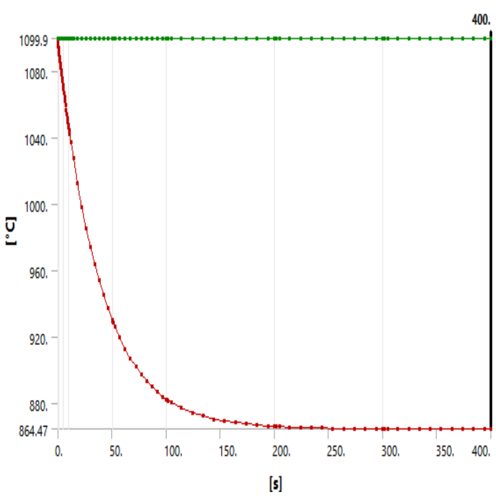
Figure 2, 3 and 4 represents the time-temperature cooling curves. Figure 1 represents Al material cooling curves for all three perforations considered in the present study. From the figures it can be noticed that with increment in the perforation size minimum temperature is decreasing, which represents that the heat transfer increases. The same behavior has been observed for Gray cast iron and Structural steel as well as shown in figure 2 and 3 respective.



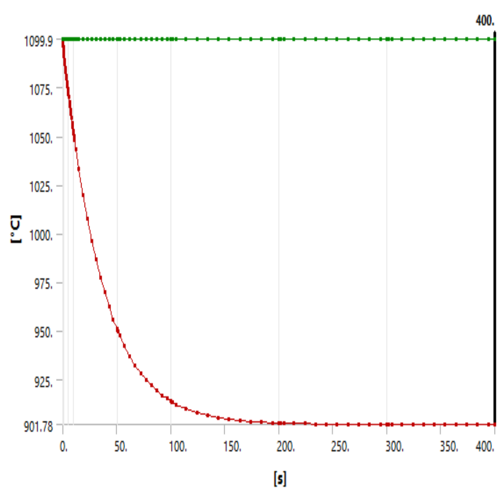
(1a) 2 mm hole



(1c) 6 mm hole



(1b) 4 mm hole



(1d) Without hole

Fig 1 :- Time-Temperature Cooling Curve for Al

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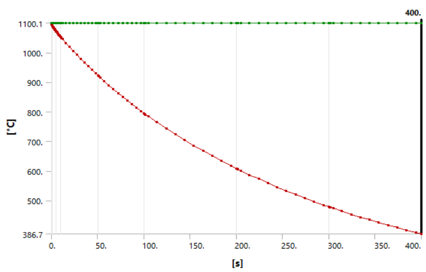
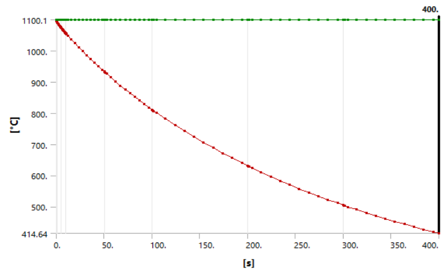
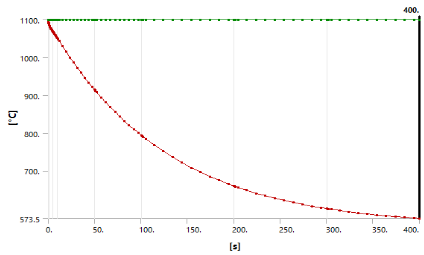


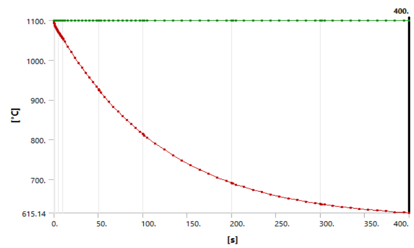
(2a) 2 mm hole



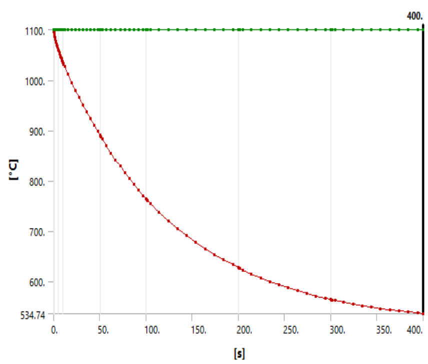
(3a) 2 mm hole



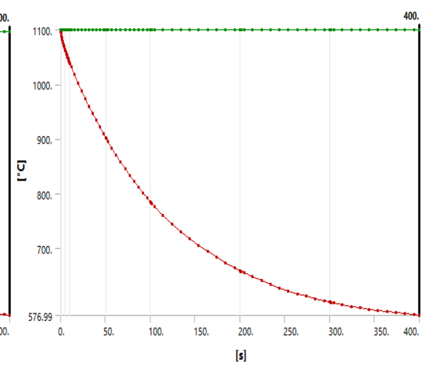
(2b) 4 mm hole



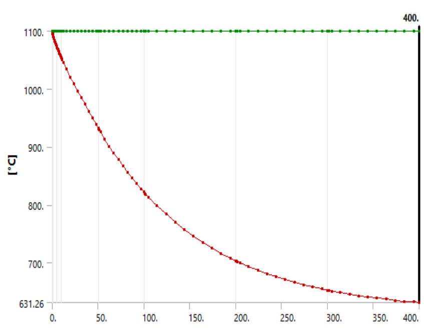
(3b) 4 mm hole



(2c) 6 mm hole

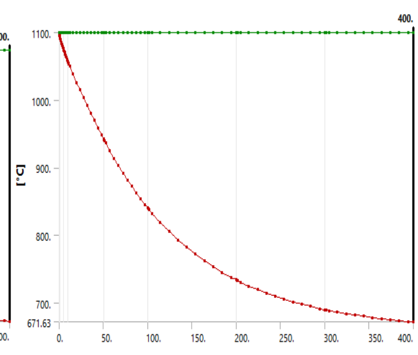


(3c) 6 mm hole3c



(2d) Without hole

Fig 2 :- Time-Temperature Cooling Curve for G.C.I.



(3d) Without hole

Fig3 :- Time-Temperature Cooling Curve for Structrual Steel

Table 1, 2, 3 and 4 represents the maximum and minimum values of heat flux and temperature for all the perforation considered. Table 1 is for without perforated fin engine. Table 2 is for 2mm perforation, Table 3 is for 4mm perforation, Table 4 is for 6mm perforation Difference between the values can be easily observed.

Table -1 – Maximum & Minimum Values for Temperature in Without Perforation

Material with Without hole	Heat flux(max)	Heat flux (min)	Temperature(max)	Temperature(min)
Al	1.24127w/mm^2	.018402 w/mm^2	1099.8	901.78
Structure Steel	.8930 w/mm^2	.01409 w/mm^2	1099.8	671.63
Gray Cast Iron	.8364 w/mm^2	.01333 w/mm^2	1099.8	631.26

Table -2 – Maximum & Minimum Values for Temperature in 2mm Perforation

Material with 2mm hole	Heat flux(max)	Heat flux (min)	Temperature(max)	Temperature(min)
Al	2.3031 w/mm^2	.01617 w/mm^2	1099.8	889.92
Structure Steel	8.5117 w/mm^2	.00246 w/mm^2	1099.8	414.64
Gray Cast Iron	7.7034 w/mm^2	.00210 w/mm^2	1099.8	386.7

Table -3 – Maximum & Minimum Values for Temperature in 4mm Perforation

Material with 4mm hole	Heat flux(max)	Heat flux (min)	Temperature(max)	Temperature(min)
Al	7.1225 w/mm^2	.00412 w/mm^2	1099.8	864.47
Structure Steel	4.7054 w/mm^2	.00429 w/mm^2	1099.8	615.14
Gray Cast Iron	4.4458 w/mm^2	.00432w/mm^2	1099.8	573.5

Table -4 – Maximum & Minimum Values for Temperature in 6mm Perforation

Material with 6mm hole	Heat flux(max)	Heat flux (min)	Temperature(max)	Temperature(min)
Al	4.0490 w/mm^2	.00314 w/mm^2	1099.8	843.98
Structure Steel	2.0589 w/mm^2	.00613 w/mm^2	1099.8	576.99
Gray Cast Iron	1.90916w/mm^2	.00601 w/mm^2	1099.8	534.74

Table 5: Weight comparison

Material	Total weight with 2 mm hole	Total weight without hole
Al	1.5779 Kg	1.6009 Kg
Structure Steel	4.4718 Kg	4.5369 Kg
Gray Cast Iron	4.1015 Kg	4.1612 Kg

IV. CONCLUSION

The present paper here deals with an analysis of temperature and heat flux distribution of single Cylinder engine with and without perforated fins. ANSYS 15.0 has been used in the present analysis. AL, Structural Steel and Gray Cast Iron as engine material have been studied. Time-temperature curve and weight analysis have also been conducted. Time Temperature Cooling Curve has been plotted and results, reveals that perforation increases the heat transfer. Gray Cast Iron Shows Larger Heat Transfer as compare to Al & Structural steel. The engine having perforated fins weigh less when compared with an engine having solid fins.

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