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Effect of geometry, material and thickness of fin on engine cylinder fins

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Abstract – *The main of aim of this work is to analyze effect of material geometry and type of material used in two wheeler engine cylinder fins on temperature distribution and heat flux. For this purpose, we have used fins with two types of geometries rectangular, triangular geometry in variable thickness such as 2.5mm, 3mm and 3.5mm for both geometry three types of aluminum alloy, namely* Alloy 2014, alloy 6061 and alloy 2024 are used*. Depending on geometry, material type and thickness total 18 models developed in to ANSYS 16.2 version Then Finite Element Analysis (FEA) done on all models using ANSYS software for parameters like heat distribution and heat flux and results from each model are noted. Finally, to find out conclusions comparative study carried out between results obtained from total 18 models mention above.*

Key Word: **Finite Element Analysis (FEA), Aluminum Alloy, Temperature Distribution, Steady State Analysis.**

1. INTRODUCTION

Heat generated between Engines after fuel burned out, Extra heat generated by friction between the moving parts. Approximately 30% to 35% of the energy only released energy utilized for actual work. The remaining (65% to 70%) removed from the engine to prevent the parts from melting. For this purpose Engine contain of cooling mechanism in engine to take out this heat from the engine limited heavy vehicles uses water-cooling method and nearly all two bikes uses Air cooled engines, because of Air-cooled engines has rewards like lighter weight and smaller space requisite hence they are only option. Heat produced during combustion in Internal Combustion engine must be maintained at upper level to rise thermal efficiency, but to prevent engine parts from thermal damage some heat must be remove from the engine. In air-cooled engine, exterior stretched surfaces called fins and provided at the periphery of engine cylinder to increase heat transfer rate. Fins are widely used for cooling of IC engines. Engine cylinder fins are the outside stretched surfaces purposely provided on condition that it removes heat from place. The amount of conduction, convection and radiation of an object determines the amount of heat it transfers. Increasing the temperature gradient between the object and the environment, increasing the convection heat transfer coefficient and increasing the surface area of the object increases the heat transfer. The different types of fin geometries used in an IC engine are Rectangular fins, Triangular fins, Trapezoidal fins and Pin fins as shown in figure 1.

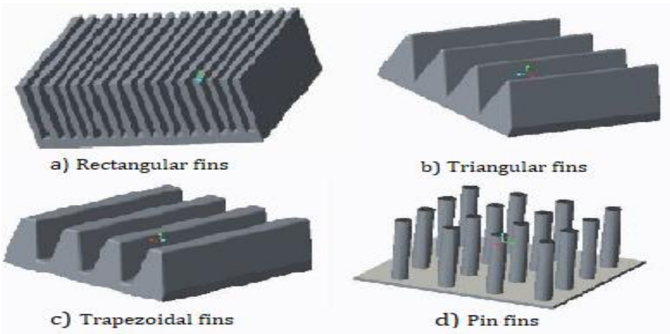


Fig-1: Different types of fin geometries

2. METHODOLOGY

To investigate the performance of the temperature distribution and heat flux through cylinder with fins first finite element analysis completed using ANSIS R16.2 to Redefining of design earlier in product development stage also comparing the various design alternatives through simulation. Reduce the amount of time and money required for prototype testing and create more reliable, better quality design, during FEA software model of a cylinder with *rectangular and triangular geometry Fins* of Aluminum Alloy 2024, 2014 and 6061 are implemented in ANSYS as shown in figure 1. After completion of finite elements model constrain and temperature has to apply to the model as shown in figure 2.

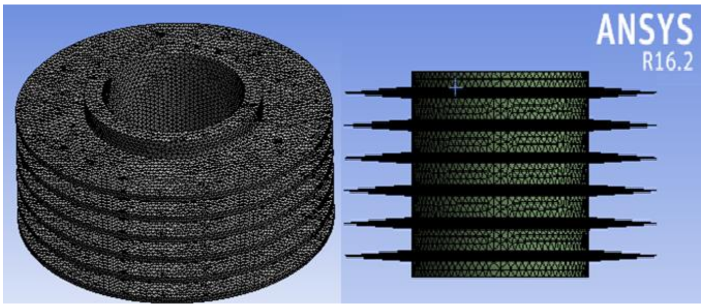


Fig- 1: Mesh Model of Cylinder with Rectangular Fins (right) and Triangular fins (Left)

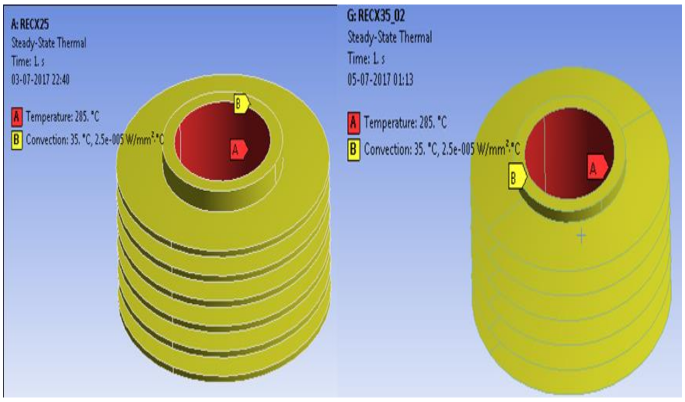


Fig- 2: Mesh Model of Cylinder with boundary conditions Rectangular Fins (right) and Triangular fins (Left)

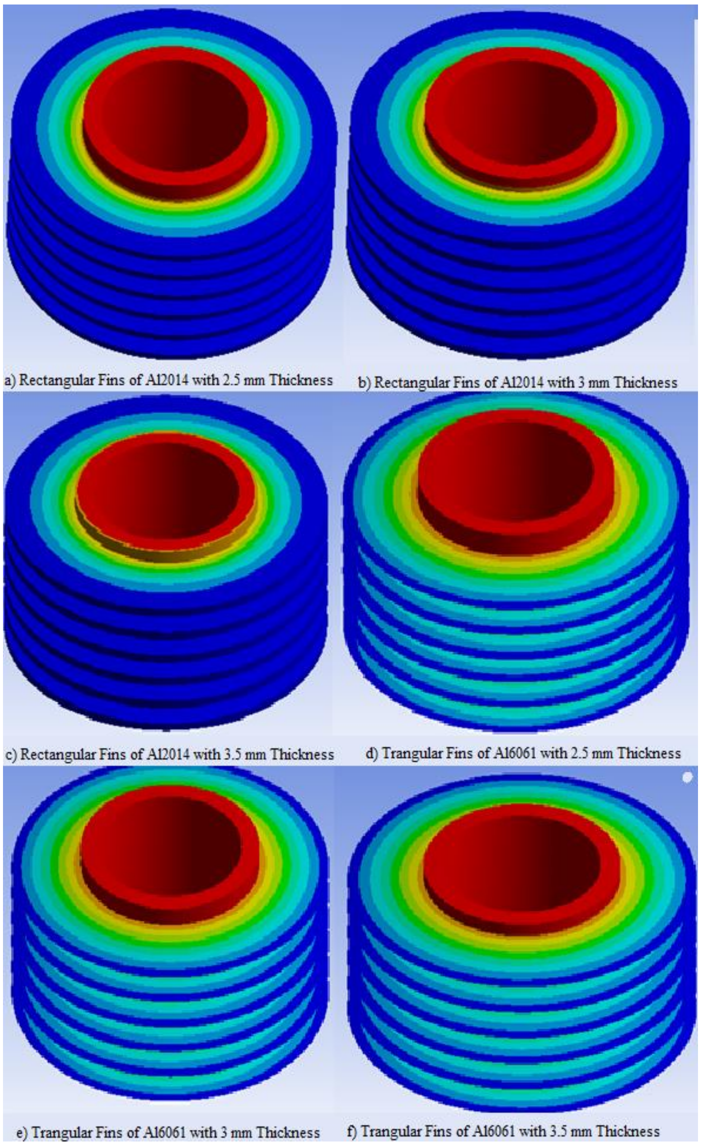


Fig- 3: Mesh Models of triangular and rectangular geometry fins Cylinder with Alloy 2024, 6061 and 2.5 m, 3mm, 3.5mm Fin Thickness

Then we had done thermal analysis by putting the values of properties like thermal conductivity, specific heat, and coefficient of thermal expansion in ANSYS on all models. In thermal analysis, we have calculated temperatures distribution, total heat flux by changing geometry size 2.5mm, 3mm, 3.5mm thickness and materials mention above such as Al6061, Al2024 and Al2014. Figure 3 shows selected models of cylinders out of total models, subfigure a, b, c from fig. 3 shows Rectangular fins cylinder models from material Al2024 with 2.5 mm, 3mm, 3.5mm thickness respectively such as subfigure e, f, g from fig. 3 shows models of triangular fins cylinder from material Al6061 with 2.5 mm, 3mm, 3.5mm thickness respectively.

3. RESULTS AND RESULTS ANALYSIS

Simulation Results obtained for temperature distribution and heat flux from the Finite Element Analysis in ANSIS are shown in figure 6 and figure 7. All results are collected and made it in tabulated form as given in table 1 and table 2. Various graphs are plotted for experimental results as shown on figure 8 and ANSYS results in figure 9 and discussion is carried out on graphs.

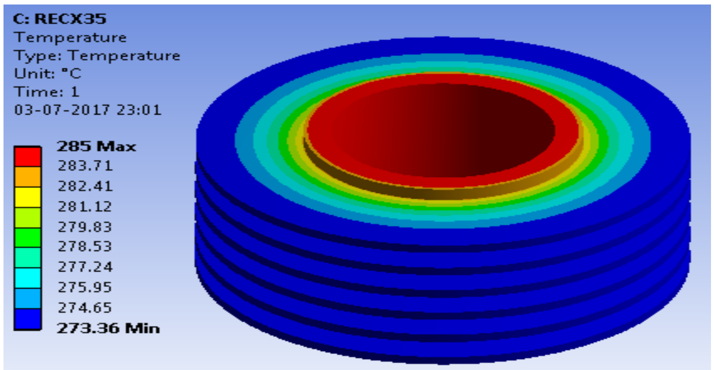


Fig-4: Temperature Distribution for Rectangular Fins of Aluminum Alloy 2014 with 3.5 mm Fin Thickness.

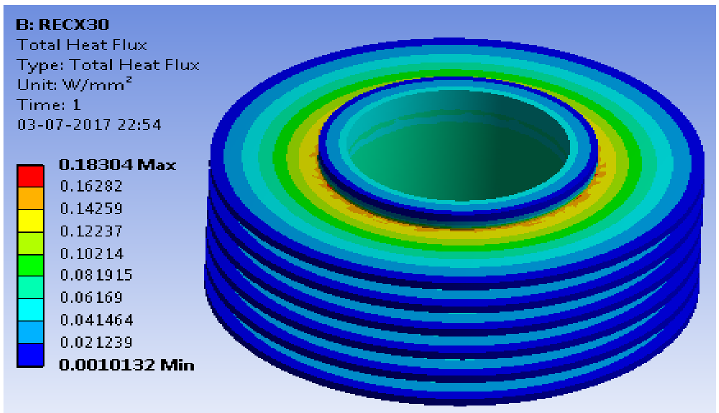


Fig-5: Total Heat Flux for Rectangular Fins of Aluminium Alloy 2014 with 3.0 mm Fin Thickness

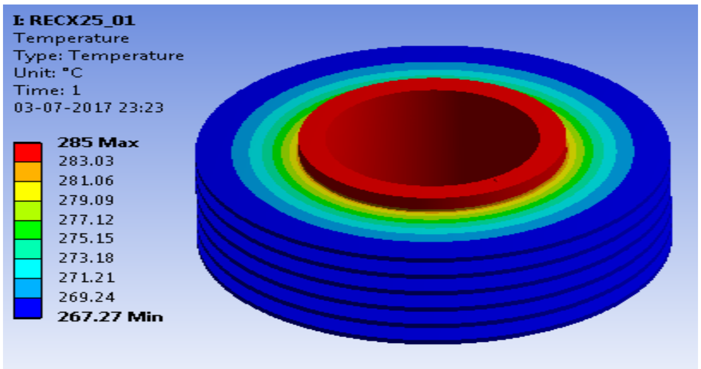


Fig-6: Temperature Distribution for Rectangular Fins of Aluminium Alloy 6061 with 2.5 mm Fin Thickness

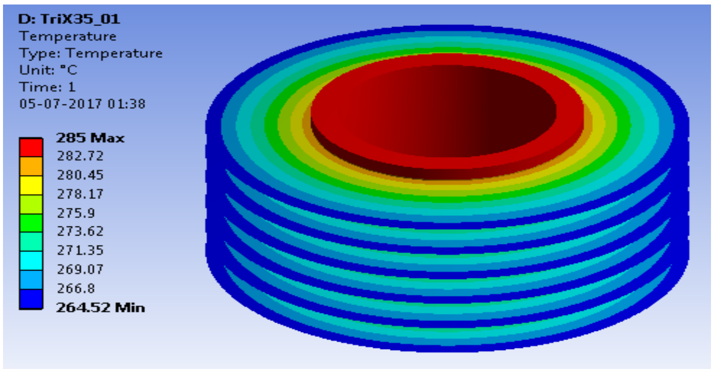


Fig-7: Temperature Distribution for Triangular Fins of Aluminium Alloy 6061 with 3.5 mm Fin Thickness

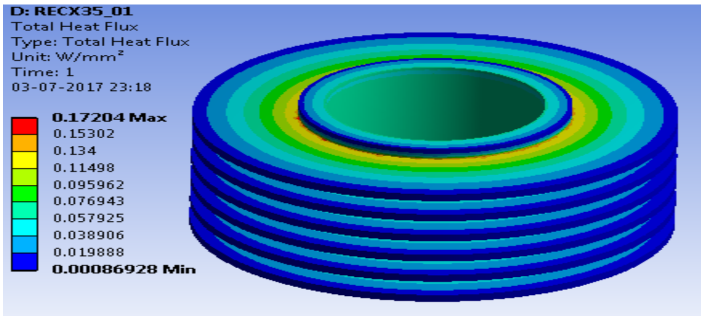


Fig-8: Total Heat Flux for Rectangular Fins of Aluminium Alloy 6061 with 3.5 mm Fin Thickness

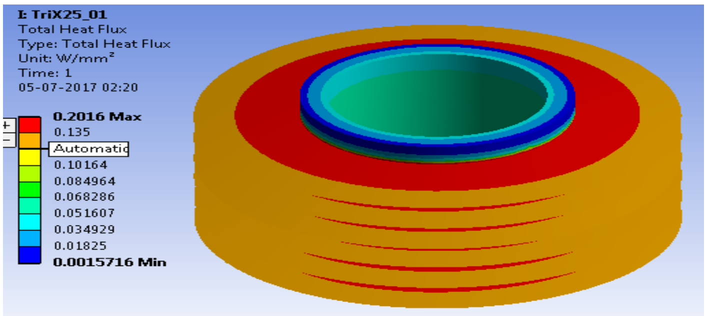


Fig-9: Total Heat Flux for Triangular Fins of Aluminium Alloy 6061 with 2.5 mm Fin Thickness

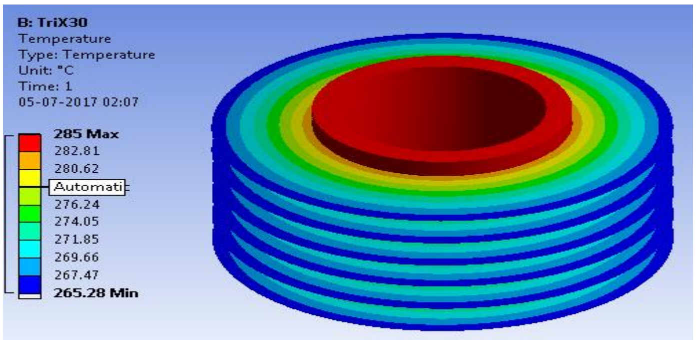


Fig-10: Temperature Distribution for Triangular Fins of Aluminium Alloy 2014 with 3.0 mm Fin Thickness

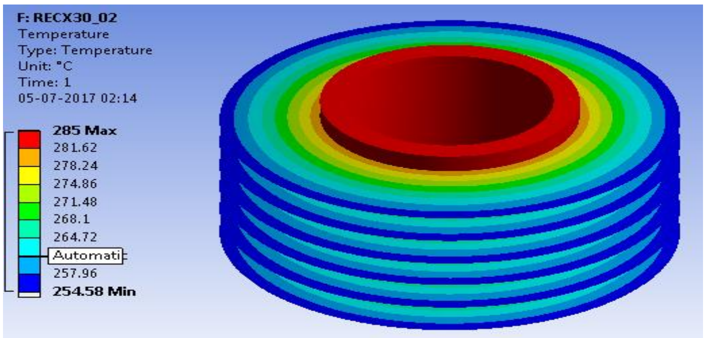


Fig-11: Temperature Distribution for Triangular Fins of Aluminium Alloy 2024 with 3.0 mm Fin Thickness

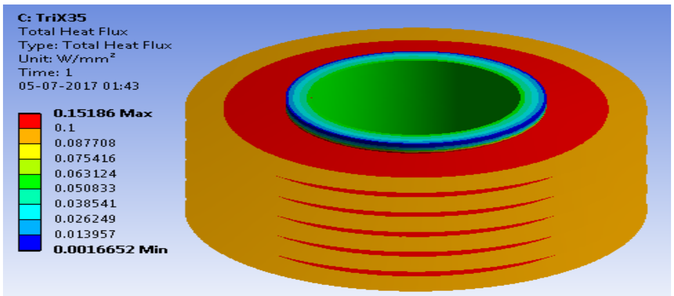


Fig-12: Total Heat Flux for Triangular Fins of Aluminium Alloy 2014 with 3.5 mm Fin Thickness

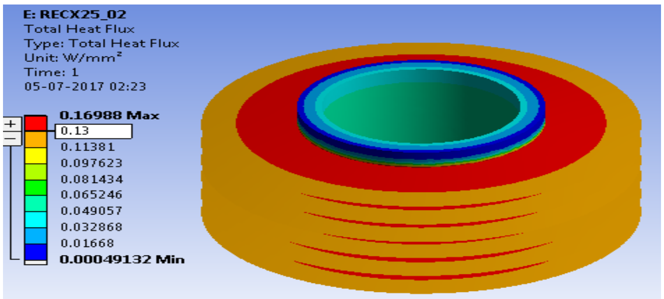


Fig-13: Total Heat Flux for Triangular Fins of Aluminium Alloy 2024 with 2.5 mm Fin Thickness

Ansys result for all cylinder models in tabular form are shown in table 1 to table 6. Table 1 to 3 shows ANSYS result Table for Cylinder with Rectangular Fins. ANSYS Results in table 3, 4 and 5 for Cylinder with Triangular Fins

Table 1: ANSYS Result table for Temperature Distribution

SR. NO.	THICKNESS	TEMPERATURE (°C)		
		Al 2014	Al 6061	Al 2024
1	2.5	270.07	267.27	261.83
2	3.0	271.96	269.5	264.69
3	3.5	273.36	271.14	266.82

Table 2: ANSYS Result table for Total Heat Flux

SR. NO.	THICKNESS	TOTAL HEAT FLUX (W/mm^2)		
		Al 2014	Al 6061	Al 2024
1	2.5	0.20751	0.20559	0.20186
2	3.0	0.18304	0.18154	0.17862
3	3.5	0.17333	0.17204	0.16951

Table 3: ANSYS Result table for Directional Heat Flux

SR. NO.	THICKNESS	DIRECTIONAL HEAT FLUX (W/mm^2)		
		Al 2014	Al 6061	Al 2024
1	2.5	0.18065	0.17896	0.17569
2	3	0.15458	0.15332	0.15088
3	3.5	0.13765	0.13661	0.1346

Table 4: ANSYS Result table for Temperature Distribution

SR. NO.	THICKNESS	TEMPERATURE (°C)		
		Al 2014	Al 6061	Al 2024
1	2.5	261.93	257.71	249.65
2	3	265.28	261.63	254.58
3	3.5	267.75	264.52	258.27

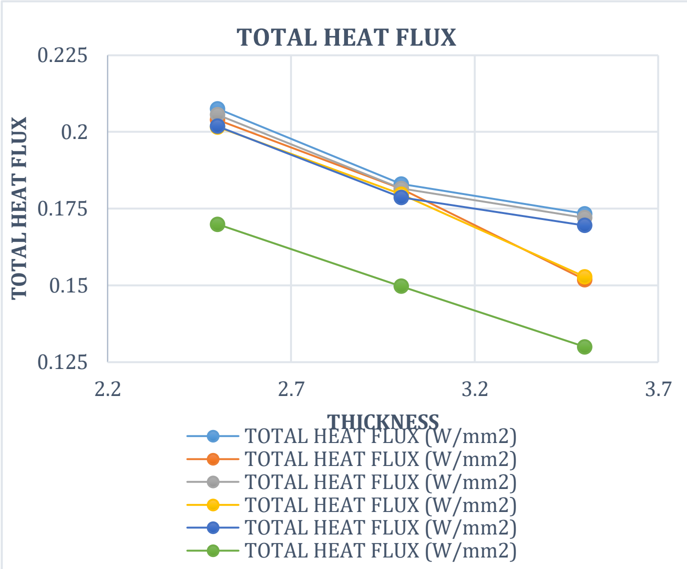
Table 5: ANSYS Result table for Total Heat Flux

SR. NO.	THICKNESS	TOTAL HEAT FLUX (W/mm^2)		
		Al 2014	Al 6061	Al 2024
1	2.5	0.20391	0.2016	0.16988
2	3	0.18145	0.17967	0.1497
3	3.5	0.15186	0.15277	0.12995

Table 6: ANSYS Result table for Directional Heat Flux

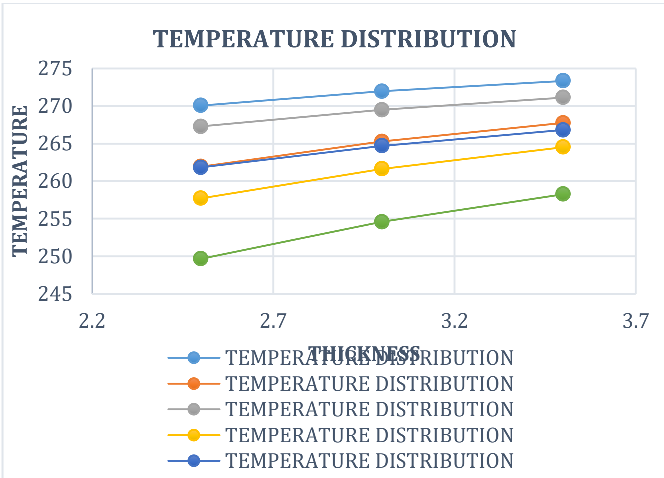
SR. NO.	THICKNESS	DIRECTIONAL HEAT FLUX (W/mm^2)		
		Al 2014	Al 6061	Al 2024
1	2.5	0.17299	0.17098	0.16191
2	3	0.14591	0.14444	0.14177
3	3.5	0.12784	0.12503	0.11917

Graph generated from above results are added next in this paper, Overall ANSYS Results for variation of Total Heat Flux with Thickness for Rectangular and Triangular Fins are plotted in line graph below.

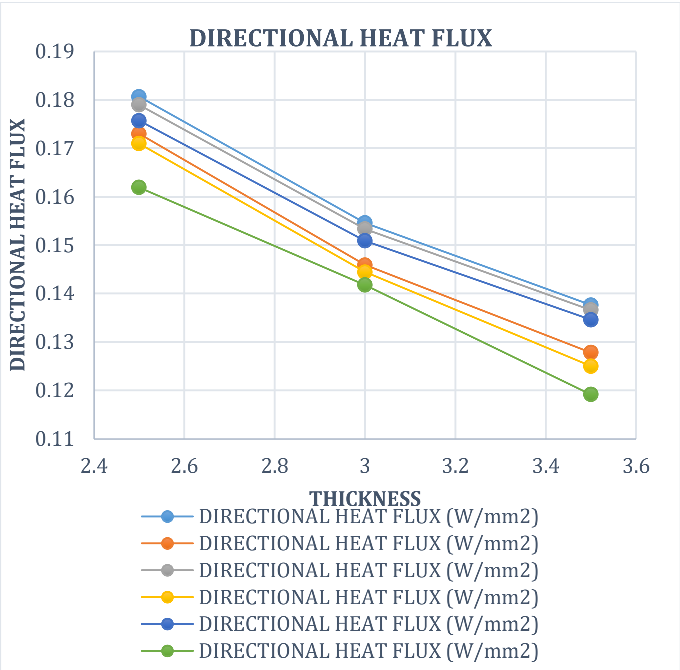


Graph 1: Overall ANSYS Result for variation of Total Heat Flux with Thickness for Rectangular and Triangular Fins.

Graph 1 shows the variation of total heat flux with thickness for cylinder with rectangular and triangular fins of varying fin thickness and materials. From this graph, it is clear that the total heat flux is maximum for cylinder with rectangular fins with 2.5 mm fin thickness and for the material aluminium alloy 2014. Same as graph 1 Overall ANSYS Result of Temperature Vs Thickness for Cylinder with Rectangular and Triangular Fins are plotted in graph 2.



Graph 2: Overall ANSYS Result for variation of Temperature with Thickness for Rectangular and Triangular Fins.



Graph 3: Overall ANSYS Result for variation of Directional Heat Flux with Thickness for Rectangular and Triangular Fins.

Graph 2 shows the variation of temperature with thickness for cylinder with rectangular and triangular fins of varying fin thickness and materials. From this graph, it is clear that the temperature distribution is maximum for cylinder with rectangular fins having 3.5 mm fin thickness and for the material aluminium alloy 2014, same as graph 2. Overall ANSYS Result of Thickness Vs Directional Heat Flux for Cylinder with Rectangular and Triangular Fins are combined in graph 3 for find out conclusion of overall work. Graph 3 shows the variation of directional heat flux with thickness for cylinder with rectangular and triangular fins of varying fin thickness and materials. From this graph, it is clear that the directional heat flux is maximum for cylinder with triangular fins with 2.5 mm fin thickness and for the material aluminium alloy 2014. With the help of analysis of obtained results, we finished this work in conclusion section.

4. CONCLUSIONS

Finite element analysis and experimental investigation on the thermal behavior of cylinder with different fins of varying fin thickness, geometry and material is carried out. Based on the finite element analysis and experimental investigation of different fins, following conclusions are drawn. The study shows that the temperature distribution is maximum for the cylinder with rectangular fin of 3.5 mm fin thickness for aluminium alloy 2014 and minimum for triangular fin of 2.5 mm thickness for aluminium alloy 2024. It also shows that the total heat flux is maximum for the cylinder with rectangular fin of 2.5 mm fin thickness for aluminium alloy 2014 and minimum for triangular fin of 3.5 mm fin thickness for aluminium alloy 2024 and directional heat flux is maximum for the cylinder with rectangular fin of 2.5 mm fin thickness for aluminium alloy 2014. Minimum for triangular fin of 3.5 mm fin thickness for aluminium alloy 2024. It can be seen that the temperature at the tip of fin increases with increasing fin thickness for both rectangular and triangular fins.

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