HEAT TRANSFER ANALYSIS OF ENGINE CYLINDER OF FINS OF VARYING GEOMETRY AND MATERIAL

Rajneesh Kumar, Anurag Kumar, Shivangi Dixit, Aditya Veer Gautam
Faculty of Engineering and Technology, Rama University
rajkum2288@gmail.com

ABSTRACT

The Indian two-wheeler market ranks as the worlds second largest, comprising three main segments: motorcycles, scooters, and mopeds. In recent years, significant growth has been observed in the motorcycle segment, attributed to its ability to navigate rough road conditions effectively. Indian motorcycles commonly employ air-cooling for their engines, chosen for its lightweight and simple construction of the engine cylinder block. Air-cooled engines dissipate heat through cooling fins, which facilitate the transfer of heat away from the engine as air flows over them. However, the low rate of heat transfer through cooling fins presents a challenge in this cooling method. Engine cylinders, being subjected to high temperature variations and thermal stresses, utilize fins on their surfaces to enhance heat dissipation. Thermal analysis of these fins aids in understanding the heat dissipation within the cylinder. This project aims to improve heat dissipation rates by utilizing air, an invisible working fluid, to increase the surface area for cooling. Designing complex engines with extensive cooling fins presents challenges, making it essential to analyse thermal properties by varying fin geometry and materials.

Extended surfaces, such as fins, are commonly used in engineering applications to enhance heat transfer between a hot surface and a coolant. When fins experience significant temperature differences between the base and surrounding fluid, precise evaluation of their thermal performance requires consideration of the temperature-dependent thermal conductivity of the fin material. Rectangular profile fins are preferred in many systems due to their ease of manufacturing and cost-effectiveness. However, in applications prioritizing lightweight fin structures, such as airborne and space systems, curve parabolic profile fins, which result in lighter structures, are favoured over rectangular fins. Nevertheless, curve parabolic fins are challenging and costly to manufacture, and their sharp edges pose safety risks. Triangular fins, as a viable alternative to curve shapes, are also considered.

Keyword: fin, thermal conductivity of material, heat flux etc
DOI NUMBER: 10.48047/NQ.2021.19.6.NQ21108 **NEUROQUANTOLOGY2021;19(6):354-358**

MATERIAL AND METHODOLOGY

The following are the methodologies of the thesis work:

1- To design cylinder with fins for a 150cc engine by varying the geometry such as rectangular, circular and triangular shaped fins.
2- To determine transient thermal properties of the proposed fin models.
3- To identify material of the engine cylinder fins.

Sr. No.	Parameter	Forms
1	Type of fins	1. Rectangular 2. Circular 3. Triangular
2	Thickness of the fin	3 mm
3	Material of the fin	1. Aluminum Alloy 2. Magnesium Alloy

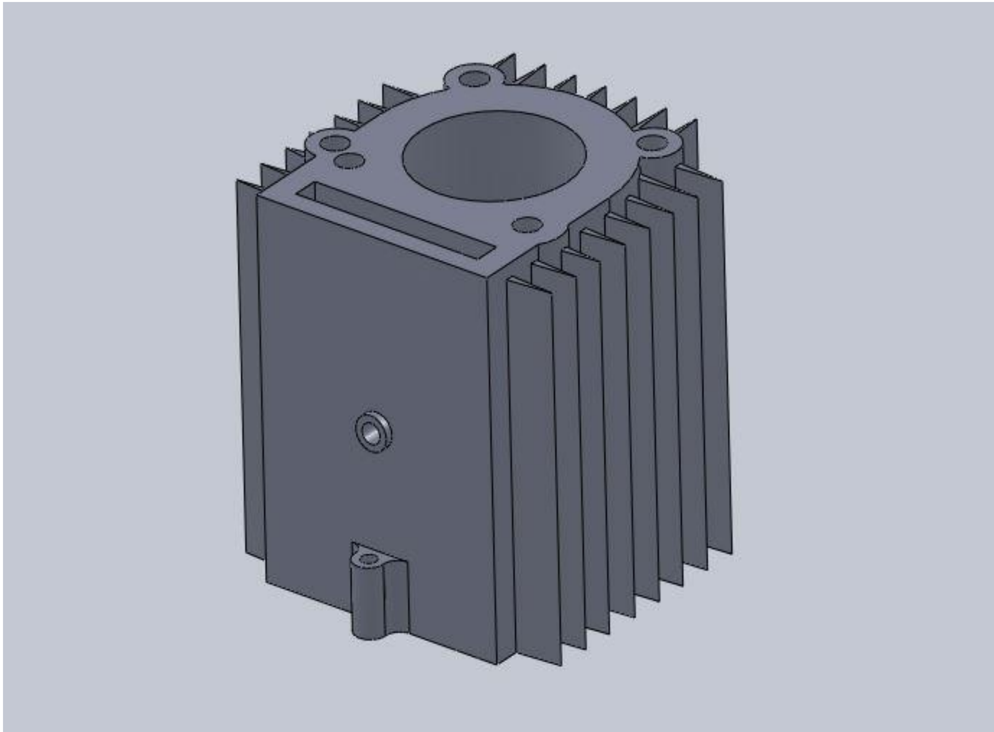
Material properties

Three different materials were selected which are as follows:
Aluminium Alloy- Cu = 4.50 wt. %, Ti = 0.22 wt. %, Mg = 0.20 wt. %, Si = 0.20 wt. %, Fe = 0.20 wt. %, Zn = 0.10 wt. %, Mn = 0.05 wt. %, Al = 94.53 wt. %.
Magnesium Alloy- Al = 16 to 19 wt. %, Zn = 1 to 6 wt. %, Mg = 75 to 83 wt. %.

Table-3.2 Thermal Conductivity of material

S.R No.	MATERIAL NAME	THERMAL CONDUCTIVITY
1	ALLUMINUM ALLOY	167 W/m × K
2	MAGNESIUM ALLOY	156 W/m × K

Fins Specification
Length of the fin (L) = 130 (mm) = 0.13 (m)
Width of the fin (b) = 130 (mm) = 0.13 (m)
Thickness (y) = 3 (mm) = 0.003 (m)
Thermal Conductivity of fin material = K (W/m × K)
Heat transfer coefficient = 0.000025(W/mm^2 × K) or 25 (W/m^2 K) Ref [19]
Given condition
T_a = atmospheric temperature = 313 (K)
Heat flux= 0.25 (W/ mm^2)



ENGINE CYLINDER WITH TRIANGULAR FIN

RESULTS AND DISCUSSION

The above Solid Works 2010 model is analysed and solved by ANSYS 14.5 for different types of fins and materials. Material properties of the material are as:

Table-Material property of Al alloy

SR. NO.	MATERIAL PROPERTY of Al
1. DENSITY (10^{-6} Kg/mm^3)	2.77
2. SPECIFIC HEAT (J/g K)	0.875
3. COEFF. OF THERMAL EXP.(1E^{-6}/K)	23.2
4. TENSILE STRENGTH (M Pa)	310
5. YIELD STRENGTH (M Pa)	280
6. THERMAL CONDUCTIVITY (W/m K)	167
7. YOUNG MODULUS (G Pa)	71
8. POISSION'S RATIO	0.33

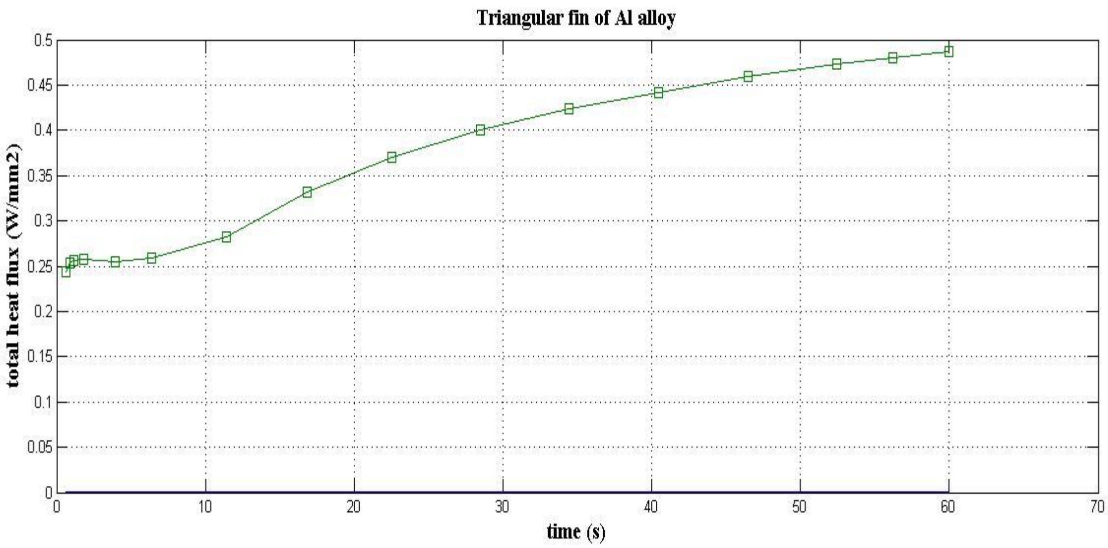
Table-Material property of Mg alloy

SR. NO.	MATERIAL PROPERTY of Mg
1. DENSITY (10^{-6} Kg/mm^3)	1.81
2. SPECIFIC HEAT (J/g K)	1.024
3. COEFF. OF THERMAL EXP.(1E^{-6}/K)	26
4. TENSILE STRENGTH (M Pa)	255
5. YIELD STRENGTH (M Pa)	193
6. THERMAL CONDUCTIVITY (W/m K)	156
7. YOUNG MODULUS (G Pa)	45
8. POISSION'S RATIO	0.35

Result By the Present Work

Table-Value of thermal flux

Thermal flux(W/mm²)		**G.Babu and LavaKumar**		**Result by Present Work**	
	Al alloy 2024	Al alloy 6061	Mg alloy	Al alloy	Mg Alloy
Rectangular fin	0.529666	0.571051	0.463962	0.47422	0.47987
Circular fin	0.723258	0.738145	0.716357	0.69099	0.69565
Triangular fin				0.48752	0.49281



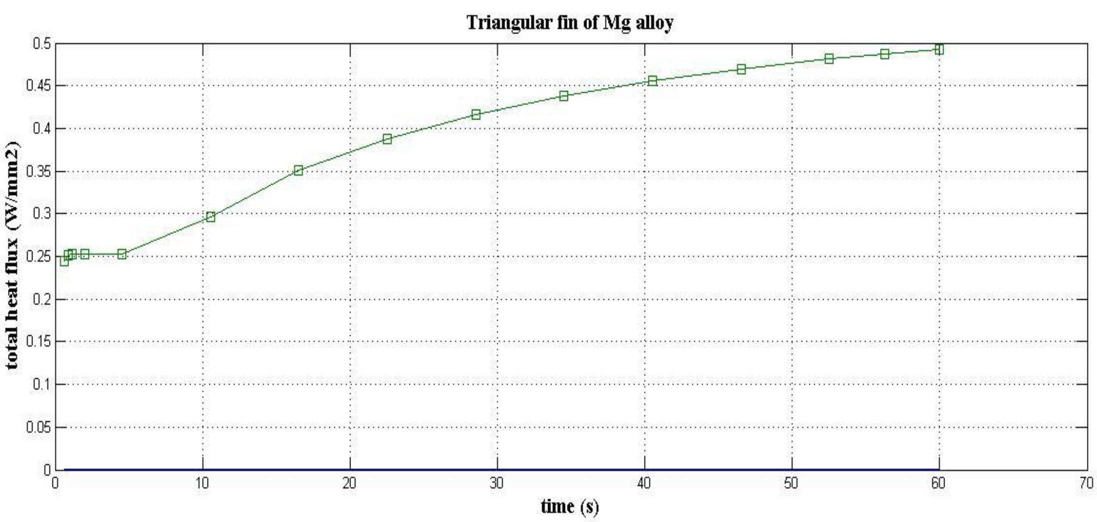


Table-Mass of Cylinder fin

Mass of cylinder fin(Kg)		**G.Babu and Lava Kumar**		**Result by Present Work**	
	Al alloy 2024	Al alloy 6061	Mg alloy	Al alloy	Mg Alloy
Rectangular fin	1.0100279	0.97395552	0.89459618	1.245	1.0487

Circular fin	1.1846582	1.1423490	1.0492687	1.3286	1.1532
Triangular fin				1.027	0.9071

Conclusion

In present work, a cylinder fin body is modelled with the help of Solid Works 2010 software and transient thermal analysis is done by using ANSYS 14.5. These fins are used for air cooling systems for two wheelers. In present study, Aluminium alloy and Magnesium alloy aroused and compared with G. Babu and M. Lava Kumar results. The various parameters (i.e., shape and geometry of the fin) are considered in the study, shape (Rectangular, Circular and Triangular), and thickness (3 mm) by changing the shape of the fin to triangular shaped, the weight of the fin body reduces thereby increasing the heat transfer rate and efficiency of the fin. The weight of the fin body is also reduced when Magnesium alloy is used. By using triangular fins the weight of the fin body reduces compare to existing engine cylinder fins.

REFERENCES

[1] Biermann, A. E. and B. Pinkel (1934). Heat Transfer from finnedmetal cylinders in an air stream, NACA Report No.488

[2] J.C.Sanders, et al. (1942). Cooling test of an air-cooled enginecylinder with copper fins on the barrel, NACA Report E-103

[3] DenpongSoodphakdee, et al. (2001). "A Comparison of FinGeometries for Heat sinks in Laminar Forced Convection Part 1 -Round, Elliptical, and Plate Fins in Staggered and In-Line Configurations." The International Journal of Microcircuits andElectronic Packaging 24(1).

[4] Fernando Illan and M. Alarcon (2002). "Optimization of AnnularCylindrical and Spherical Fins in an Internal Combustion Engineunder Realistic Conditions." Journal of Thermal Science andEngineering Applications 2.

[5] A. Bassam and K. A. Hijleh (2003). "Enhanced Forced ConvectionHeat Transfer from a Cylinder Using Permeable Fins." ASMEJournal of Heat Transfer 125.

[6] Yoshida Masao, et al. (2005). "Air-Cooling Effects of Fins on aMotorcycle Engine." Nippon Kikai GakkaiRonbunshu B Hen(Transactions of the Japan Society of Mechanical Engineers Part B)(Japan) 17(9): 2324-2330.

[7] C. Han-Taw and C. Jui-Che (2006). "Investigation of naturalconvectionheat transfer coefficient on a vertical square fin offinned-tube heat exchangers." International Journal of Heat andMass Transfer 49(17-18): 3034-3044.