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Comparative Analysis of Heat Transfer of Engine Fins with different Materials in Steady State Condition

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Abstract: The engine of an automobile is exposed to elevated temperature variations and thermal stresses, which can lead to overheating and reduced performance. To mitigate this, fins of various materials and geometries are mounted on the engine c2ylinder surface to enhance heat transfer and reduce thermal stress. In this study, the thermal behavior of different fin geometries made of aluminum nitride, aluminum alloy 6063, and aluminum alloy 356 with varying thermal conductivity was analyzed using ANSYS. Three-dimensional models of the geometries were created using SOLIDWORKS 2020 and analyzed with ANSYS Workbench 2023 R1 to determine the optimal material and geometry for the fins. The results were compared with a conventional aluminum A204 material to identify the maximum heat transfer. The zigzag-type fins were used in this study. The analysis revealed that the material with the highest thermal conductivity produced the best heat transfer, and certain fin geometries were more effective than others. This study demonstrates the importance of selecting the right material and geometry for engine fins to improve thermal management and enhance engine performance.

Keywords: Thermal conductivity, Heat transfer, Aluminum nitride, Zig zag fins, ANSYS2023 R1, Heatflux

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1. Introduction

Heat transfer is a critical process that occurs in various mechanical systems, including automobile engines. Engine fins are used in automobile engines to facilitate heat transfer from the engine to the surrounding environment. Fins are extended surfaces that are attached to the exterior of the engine block, cylinder head, or other engine components. These fins help in increasing the Surface area of the engine, which improves the heat transfer rate. In this article, we discussed the heat transfer mechanism in automobile engine fins. The heat transfer in automobile engine fins occurs mainly through convection. Convection is the process by which heat is transferred from one fluid to another.

Through the motion of the fluid. In the case of engine fins, air is the fluid, and the fins provide a surface for heat transfer to occur. The engine fins are designed to have a large surface area, which enhances the transfer of heat to the air flowing around them.

The heat transfer rate in engine fins is influenced by various factors such as the fin shape, size, material, and the flow rate of the fluid. The shape and size of the fin affect the surface area of the fin, which determines the amount of heat that can be transferred. Materials with high thermal conductivity are preferred for engine fins to increase the rate of heat transfer. The flow rate of the fluid also affects the heat transfer rate, with higher flow rates resulting in higher heat transfer rates.

Engine fins are also designed to provide optimal cooling to specific engine components. For example, cylinder head fins are designed to provide cooling to the cylinder head, which is a critical component of the engine. The shape and size of the fins are tailored to the shape and size of the component being cooled to provide maximum heat transfer. The fins are also designed to provide a uniform flow of air over the surface to ensure that heat transfer is efficient. Heat transfer in automobile engine fins is a critical process that ensures the efficient operation of automobile engines.

Fins are designed to increase the surface area of engine components, which enhances the heat transfer rate through convection. The design of engine fins is critical to ensure that specific components are cooled optimally and that the flow of air over the fins is uniform. Understanding the heat transfer mechanism in automobile engine fins is essential in designing efficient and effective cooling systems for automobile engine.

2. Literature survey

TR Chinnusamy et. al. [2019]. It was researched to change the shape of the engine fins of the Honda unicorn motor cycle and the thickness of the shape used was reduced. Which made fin lose weight and there by increased efficiency. It the shapes and design of fins are changed, if the shape and design of the fins are changed, then the air turbulence will increase and there is an increase in heat transfer. By making this 3D model, thermal analysis has been done in CFD method in Ansys software.

Ambrish pandey et. al. [2021] Engine and machine heat zone studied. Fins are used to reduce heat. In which the heat transfer due to different shapes is more on which shape and the temperature is dropping. Total heat flux has been found out. Thermal analysis is finite element method, modelling in solid work.

K.N. Sai Sharan et. al. [2022] it has been studied that which material will be good for cooling this engine. For this, they have found out the best substances by comparing different substances. Analysis and design of heat flux distribution and temperature distribution of IC engine cylinder block with fin is completed. This work was modeled in Ansys software, solid work 2016 and thermal analysis was done in FEA method.

Sandeep gupta et. al. [2022] in this paper, a 3D model for a two wheeler engine was analyzed in the steady state condition by creating a 3D model in the Ansys software. Different shaped fins were used to block the flow of heat and reduce the temperature. In which rectangular, convex triangular and tapered etc. in which the maximum heat flux is in the convex fin and the temperature drop is in the tapered fin.

3. Methodology

Automobile engines generate a significant amount of heat during operation, and to prevent overheating, efficient heat transfer mechanisms must be employed. One common method is to use fins attached to the engine block that increase the surface area available for heat transfer. In this analysis, we will focus on the heat transfer performance of zigzag-shaped fins made from aluminum nitride, aluminum alloy 6063, and aluminum alloy 356.

The methodology for this analysis will involve conducting a thermal simulation using a computational fluid dynamics (CFD) software package. The engine block and the fins will be modeled using three-dimensional CAD software, and the model will be imported into the CFD software for analysis. The analysis will involve simulating the flow of coolant through the engine block, with heat being transferred from the engine to the fins. The fins will then dissipate the heat to the ambient air, and the simulation will calculate the temperature distribution across the fins and the engine block.

The simulation will be run for each of the three fin materials, and the heat transfer performance of each material will be compared. The analysis will also involve varying the spacing between the fins to determine the optimal spacing for each material. This analysis provide valuable insights into the performance of different fin materials and geometries for automobile engine cooling, which can be used to optimize engine design and improve energy efficiency.

3.1 Modeling of Fins model

Analysis of cylinder fins for different materials in steady state condition. Zigzag fins are used as there will be more heat transfer. Ansys is used for thermal analysis in Steady state condition. Steady state condition is a process in which there is no change in temperature with time. thermal investigation of steady state is used to find out temperature, thermal grades, heat movement rate, and heat fluxed in a body that are created by temperature affected loads in steady state condition. A steady state analysis evaluates effect of constant temperature affected loads on a body or object. To establish initial condition, engineers generally carry out a thermal analysis in steady state before a transitory heat analysis. A steady state heat analysis can be the major step of a transitory heat analysis; carried out after all transitory effects have reduced. Usually this type of analysis used to find out the maximum temperature generation in a product during the design.

Dimensions of the zig zag fin model

Cylinder Inner Diameter	=	56 mm
Cylinder Outer Diameter	=	60mm
Length of zig zag Fins	=	103mm
Width of zig zag fins	=	90 mm
Thickness of zig zag Fins	=	1mm
Pitch of Fin	=	10mm

3.2 Analysis in ANSYS workbench:

The zig zag fins model is for different materials are performed in ANSYS workbench .The analysis is carried out in steady state condition. Steady state condition is a process in which there is no change temperature with time.

Temperature variations are given below:

Table 1. Physical and thermal properties of materials.

Properties	Materials			
	Al alloy-A204	Aluminium Nitride	Al alloy 6063	Al alloy- 356
Density, kg/m^3	2780	3260	2700	2680
Ultimate tensile strength, MPa	300	450	145	221
Poisson' Ratio	0.34	0.25	0.33	0.33
Young's modulus, GPa	70	310	68.3	70.3
Coefficient of thermal Expansion /K	23.*10^{-6}	4.5*10^{-6}	23.2*10^{-6}	22.4*10^{-6}
Thermal conductivity k, W/m K	140	321	210	150

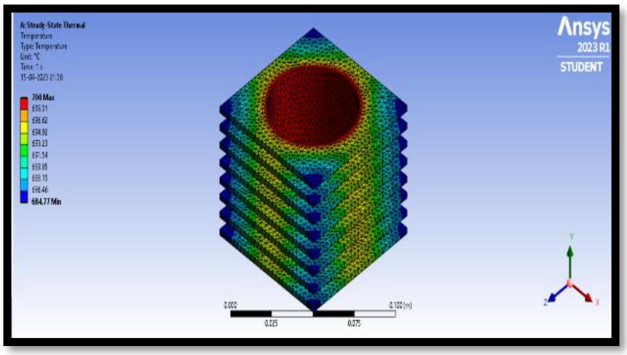

Figure 1: Temperature in Aluminium A204

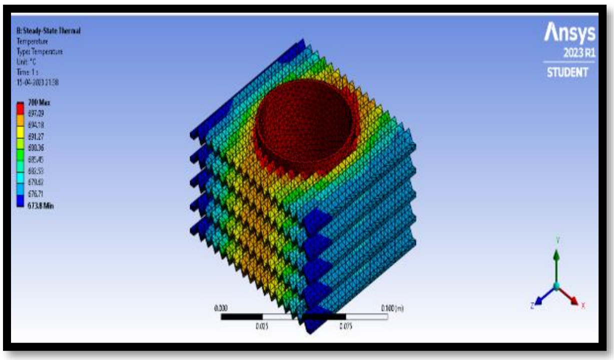

Figure 2: Temperature in Aluminium 6063

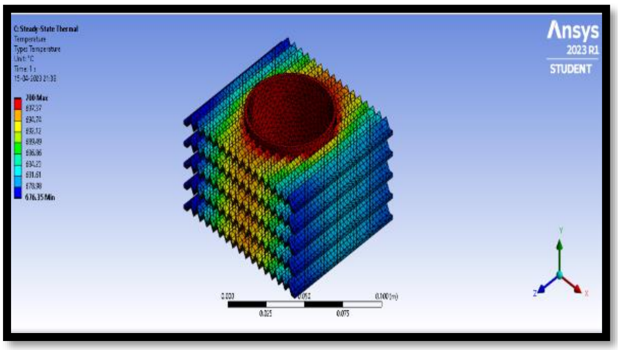

Figure 3: Temperature in Aluminium 356

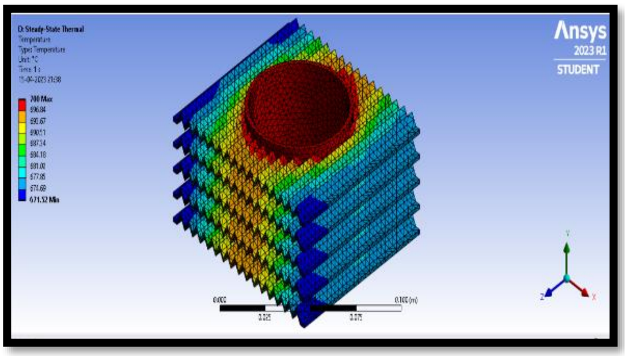

Figure 4: Temperature in Aluminium Nitride

Table 2. Minimum & Maximum temperatures of materials

Materials	Minimum temperature (°C)	Maximum temperature(°C)
Aluminium A204	684.77	700
Aluminium 6063	673.8	700
Aluminium 356	676.35	700
Aluminium Nitride	671.52	700

Heat flux for the model and materials are:

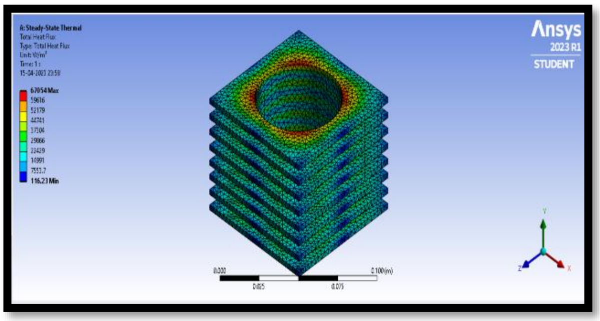

Figure 5: Aluminium 356

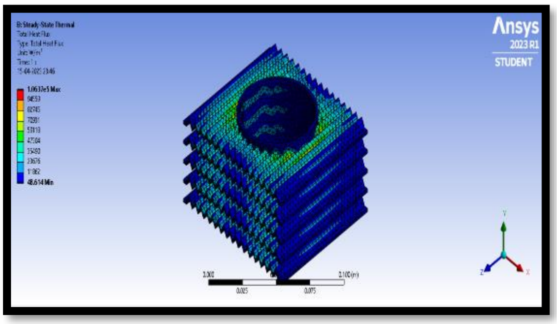

Figure 6: Aluminium Nitride

Table 3. Maximum & Minimum heat flux of materials

Materials	Total heat flux min.(W/m^2)	Total heat flux max.(W/m^2)
Aluminium A204	116.23	67054
Aluminium 6063	48.614	106370
Aluminium 356	43.757	95997
Aluminium Nitride	52.984	115660

Comparison of zig-zag fins materials with conventional fin material:

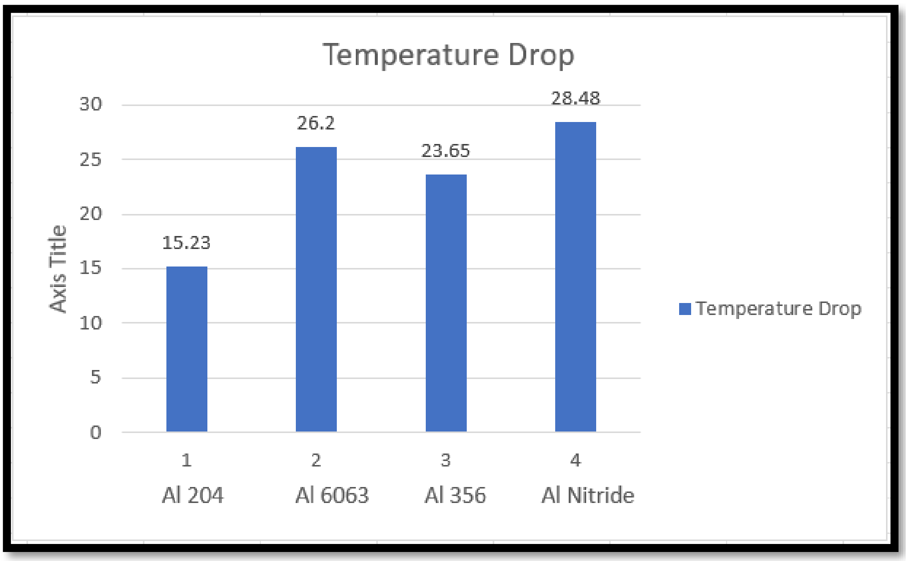

Figure 7: Temperature Drop among the different materials

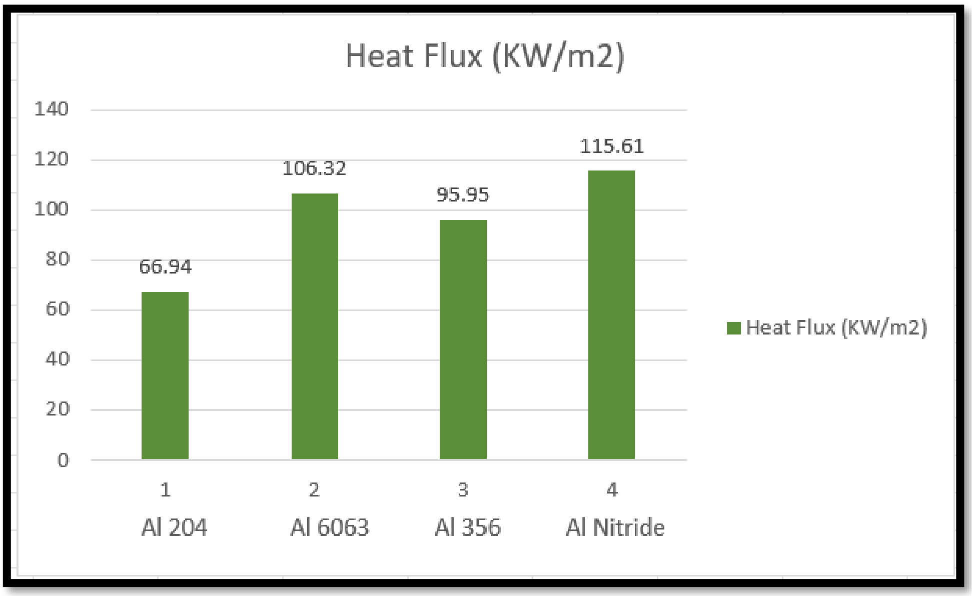

Figure 8: Heat flux between different materials

4. Result & discussion

The results obtained from the comparison show that the maximum heat flux and temperature range vary with different materials. The graphical representation presented above illustrates this observation. Specifically, it is evident from the two graphs that Aluminium Nitride generates the highest maximum heat flux, followed by the Aluminium 6063,Aluminium 356, and Aluminium A204 fins in that order. Furthermore, the Aluminium Nitride zig-zag fin experiences the largest temperature drop when compared to the conventional fins that is Aluminium A204. These findings suggest that the choice of fin geometry has a significant impact on heat flux and temperature range.

5. Conclusion

A zig zag shaped engine fins are created by using solid works software. Three different materials are chosen whose thermal conductivity is more than convention fin material. These 3D models are analyzed using ANSYS Workbench in steady state condition. In analysis it is observed that Aluminium Nitride gives highest temperature drop and heat flux due it's high thermal conductivity and zig -zag design after that Aluminium 6063,Aluminium 356, and Aluminium A204 fins are in that order. All the above comparison shows that Aluminium Nitride with zig-zag shaped fins is better in heat dissipation than conventional fin material.

References

[1] L. Prabhu, M. Ganesh Kumar, Prashanth M, Partha sarathy M, "Design and Analysis of Different Types of Fin Configuration Using ANSYS", 2018. http://dx.doi.org/10.48175/568
[2] Hiren kumar A Patel, Vinamra S Kale, Sanjeev U Joshi , "Comparative Thermal Analysis of Fins, 2018." http://dx.doi.org/10.1007/978-981-13-2490-1_18
[3] Rakesh Ramesh Poojari, Sandeep Pawan kumar Sharma, Akash Anil Deore, Rahid Riyaz Kazi, Sagar dinkar Vibhute, "Thermal Analysis of Fins, 2018." http://dx.doi.org/10.1007/978-981-13-2490-1_18
[4] Sujan Shrestha, Nitesh Kumar Yadav, Suman Bikram Bam, "Analysis of Heat Transfer Through Fins of IC Engine, 2019."
[5] Pooran Singh Dhkar, "Heat Transfer Analysis between Plate Fins and Pin Fins Using ANSYS, 2019." http://dx.doi.org/10.13140/RG.2.2.18888.88322
[6] T R Chinnusamy , E Balaji , V Vignesh, T Karthikeyan , M Krishnan , "Design Analysis of Cooling Fins for Two Wheeler Using ANSYS, 2019."
[7] Rajat Kumar, Devendra Singh, Ajay Kumar Sharma, "Static Tharmal Analysis of Fins Models Using ANSYS, 2020". https://www.doi.org/10.34218/IJMET.11.2.2020.002
[8] Kota Leela Sai Bharath, V Pradeep Kumar, "Design and Analysis of a Rectangular Fin with Comparing by Varying Its Geometry and Material ,With Perforation and Extension, 2021". https://doi.org/10.17762/turcomat.v12i2.2346
[9] Adil Abbas Mohammed, "Performance of Rectangular Pin -Fin Heat Sink Subject to Impinging Air Flow, 2021."https://doi.org/10.1016/j.icheatmasstransfer.2020.105044

[10] Mr. K. Manikandan, S. Thirumoorthi, S.J. Sabharinaath, R.Sugumar, P. Sabareswaran, "Design and Analysis of Fins Using Various Configuration, 2021." http://dx.doi.org/10.48175/568
[11] Shankar Durgam , Aniket Kale ,Nikhil Kene, Akshay Khedkar ,Sanket Palve and Nikita M. Gawai, "Thermal Analysis of Fin Material for Engine Cylinder Heat Transfer Enhancement, 2021." http://dx.doi.org/10.1088/1757-899X/1126/1/012071
[12] Ambrish Pandey, Vikash Dwivedi "to Investigate Optimum Design of Fins Model for Better Heat Transfer by Using ANSYS Software, 2021". https://doi.org/10.1016/j.matpr.2021.12.583
[13] K. N. Sai Sharan, Rohan Kumar Malla, Dr. P. Ravikanth Raju ,Kotha Nikhil ,Venkataraman Radha Krishan, "Modeling and Analysis of IC Engine Fins by Using Different Materials, 2022." http://dx.doi.org/10.46501/IJMTST0801033
[14] P.V. Ananth Subray , B. N. Hanumagowda , S. V. K. Varma , A. M. Zidan , Mohammed Kbiri Alaoui , C. S. K. Raju , Nehad Ali Shah and Prem Junsawang , "Dynamics of Heat Transfer Analysis of Convective -Radiative Fins with Variable Thermal Conductivity and Heat Generation Differential Transformation Method, 2022." https://doi.org/10.3390/math10203814
[15] Sandeep Gupta , Dheeraj Kumar ,Shailendra Kumar, "Heat Transfer Analysis of Engine Cylinder Fins by Varying Geometry, 2022." https://doi.org/10.1016/j.matpr.2017.07.202