International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Design Optimization of Engine Fin's for Enhancement of Heat Dissipation Efficiency

Arpan Tharpal[1], Dr. Amit Bahekar[2]

[1]PG scholar, Department of Mechanical Engineering, SAGE University, Indore
[2]Associate Professor, Department of Mechanical Engineering, SAGE University, Indore

ABSTRACT

This study delves into the realm of engine cylinder fins with a primary objective of enhancing heat dissipation efficiency in internal combustion engines. Engine cylinders, central components in these engines, frequently endure extreme temperature variations and thermal stresses. To mitigate overheating, fins are strategically integrated onto cylinder surfaces to amplify heat transfer rates. This research introduces an innovative approach by harnessing air as an invisible working fluid while investigating the influence of different materials, geometries, fin distances, and thicknesses on overall cooling efficiency. Thermal analysis serves as the foundation of this investigation, involving a comprehensive examination of heat transfer mechanisms within engine cylinders and fins. Through simulations and computational models, temperature distribution patterns are scrutinized, potential hotspots identified, and the effectiveness of cooling fins assessed. By strategically augmenting surface area through well-designed fins, this project aims to significantly enhance heat dissipation, promising improved engine performance and longevity.

Additionally, alternative materials to the conventional cast iron for cylinder fin manufacturing are explored. This material exploration, in conjunction with an exhaustive examination of various geometries, fin distances, and thicknesses, offers insights into optimizing heat dissipation. A meticulous comparative analysis quantifies the impact of these design modifications on cooling efficiency, ushering in a new era of more efficient and resilient engine systems

Keywords – Creo, FEM, Cast Iron Cylinder fin and Ansys

Introduction

In the realm of internal combustion engines, maintaining precise thermal equilibrium is paramount to their efficiency, durability, and overall performance. Excessive heat, if left unchecked, can inflict a cascade of detrimental effects, ranging from diminished efficiency to catastrophic engine damage. At the heart of this thermal management challenge lie two fundamental choices: air cooling and liquid cooling systems. Each system represents a unique engineering approach, with its own set of advantages and limitations. This discourse delves into the intricacies of these cooling methods, elucidating their principles, applications, and comparative merits. Additionally, it explores the critical role of material selection in shaping the thermal behavior and mechanical prowess of engine components, shedding light on the multifaceted decisions that engineers face in the quest for optimal engine performance

Problem Statement

Internal combustion engines are the backbone of modern transportation and industry, converting fossil fuel's chemical energy into valuable mechanical work. However, this process generates substantial heat, resulting in high-temperature, high-pressure gases. Efficiently managing this heat is crucial to prevent overheating, ensuring optimal engine performance and longevity. The dissipation of excess heat lies at the core of this challenge, a complex interplay of engineering solutions and material choices. This exploration delves into the intricate world of heat management within internal combustion engines, illuminating the methods and materials that drive the engine's thermal equilibrium, ultimately shaping its efficiency and reliability.

Objective

Objective is to quantify the tangible performance improvements stemming from these fin modifications. This includes measuring efficiency gains, temperature reduction, and potential enhancements in engine longevity. By the culmination of this project, we aim to present actionable recommendations that can be readily implemented by manufacturers and engineers to harness the benefits of optimized fin designs and material choices in internal combustion engines. Furthermore, we envision contributing to broader sustainability objectives by exploring the potential for improved engine efficiency to reduce fuel consumption and emissions, aligning our efforts with the imperative of environmental responsibility. In essence, our project aspires to push the boundaries of internal combustion engine technology, paving the way for more efficient, reliable, and environmentally conscious engine systems.

Methodology

The methodology on fin design for IC engine on design software can be summarized as follows:

a. Gather the necessary information. This includes the dimensions of the engine, the materials available, and the desired cooling performance.

b. Select a design software. There are many different design software programs available, each with its own strengths and weaknesses. Choose one that is appropriate for the complexity of the design and your level of expertise.

c. Create a 3D model of the fin. This can be done by extruding a 2D fin shape or by using a more complex modeling technique.

d. Perform a thermal analysis of the fin. This can be done using a computational analysis will help you to determine the heat transfer characteristics of the fin and to identify any areas of concern. Optimize the fin design. This can be done by changing the geometry, material, or thickness of the fin. The goal is to find a design that provides the desired cooling performance with the minimum weight and cost.

5. Design of Fins

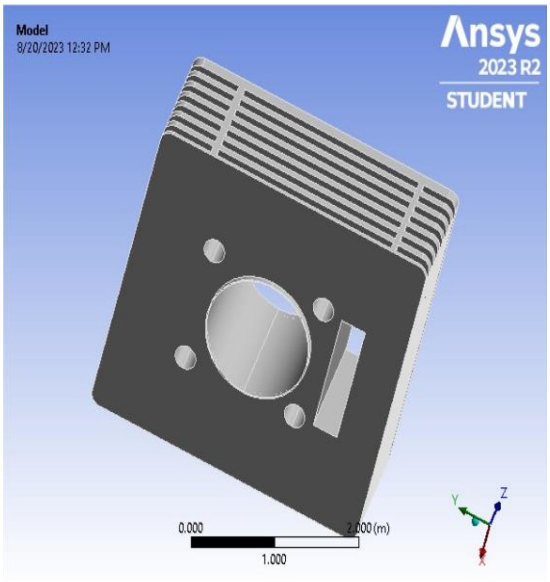

Fig.1 Design 1 Existing Cylinder Fin

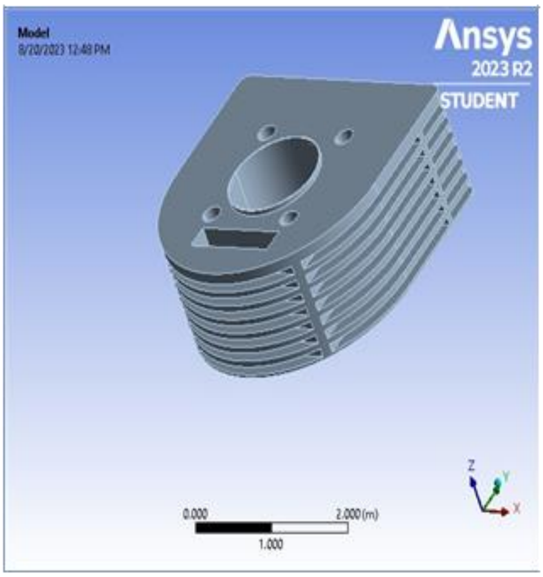

Fig.2 Design 2 Semicircular Cylinder Fin

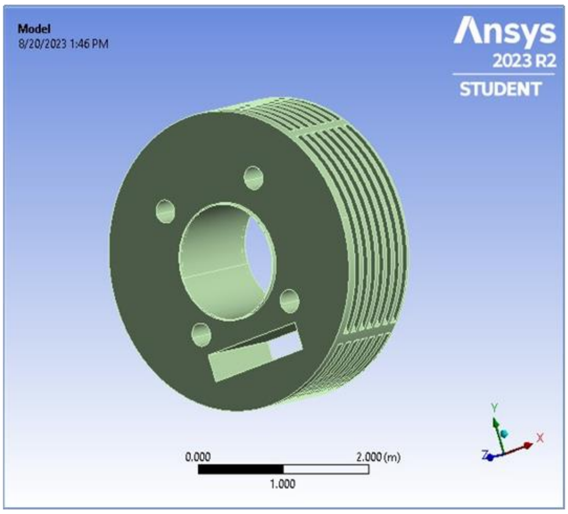

Fig.3 Design 3 circular Cylinder Fin

Fig.4 Design 4 Angular Cylinder Fin

6. Analysis

TABLE 1 Design Geometry

Object Name	Geometry
State	Fully Defined
Definition	
Source	C:\Users\admin\Desktop\Cylinder\design1.igs
Type	Iges
Length Unit	Inches
Element Control	Program Controlled
Display Style	Body Color
Bounding Box	
Length X	3.3026 m
Length Y	3.4296 m
Length Z	1.4732 m
Properties	
Volume	8.6773 m^3
Mass	62477 kg
Scale Factor Value	1.
Statistics	
Bodies	1
Active Bodies	1
Nodes	18379
Elements	9237
Mesh Metric	None
Update Options	
Assign Default Material	No
Basic Geometry Options	
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	No
Parameters	Independent
Parameter Key	ANS;DS
Advanced Geometry Options	
Use Associativity	Yes
Coordinate Systems	No
Reader Mode Saves Updated File	No
Use Instances	Yes
Smart CAD Update	Yes
Compare Parts On Update	No
Analysis Type	3-D
Mixed Import Resolution	None
Import Facet Quality	Source
Clean Bodies On Import	No
Stitch Surfaces On Import	Program Tolerance
Decompose Disjoint Geometry	Yes
Enclosure and Symmetry Processing	Yes

TABLE 2 Geometry > Parts

Object Name	design1-FreeParts| TRM_SRF
Definition	
Suppressed	No
Stiffness Behavior	Flexible
Coordinate System	Default Coordinate System
Reference Temperature	By Environment
Treatment	None
Material	
Assignment	Cast Iron
Nonlinear Effects	Yes
Thermal Strain Effects	Yes
Bounding Box	
Length X	3.3026 m
Length Y	3.4296 m
Length Z	1.4732 m
Properties	
Volume	8.6773 m^3
Mass	62477 kg
Centroid X	-3.6437e-016 m
Centroid Y	2.4051e-002 m
Centroid Z	2.3799e-002 m
Moment of Inertia Ip1	68626 kg·m^2
Moment of Inertia Ip2	67877 kg·m^2
Moment of Inertia Ip3	1.1644e+005 kg·m^2
Statistics	
Nodes	18379
Elements	9237
Mesh Metric	None

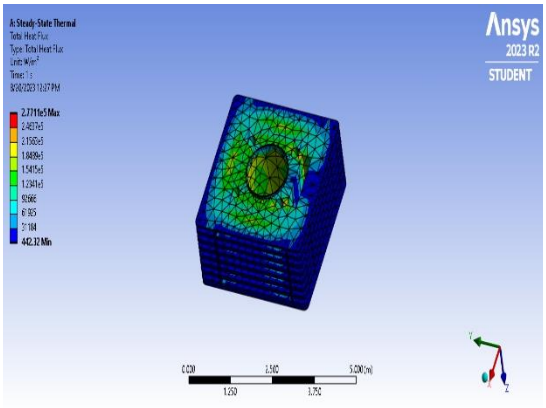

Fig.5 Total Heat Flux of profile 1

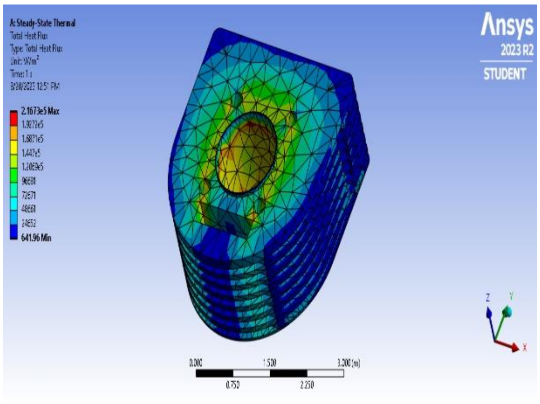

Fig.6 Total Heat Flux of profile 2

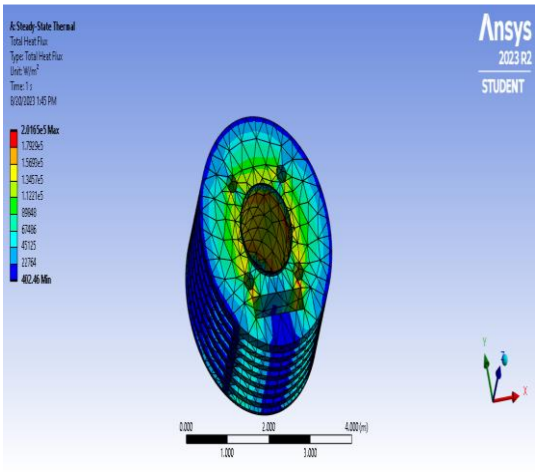

Fig.7 Total Heat Flux of profile 3

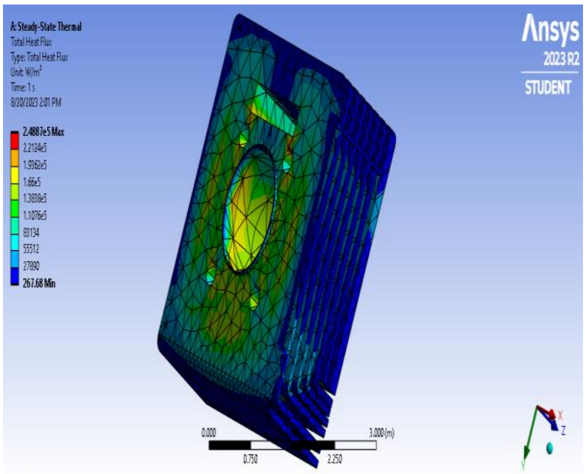

Fig.8 Total Heat Flux of profile 4

7. Result

Profile 1:

Profile 1 demonstrates temperature, total heat flux, directional heat flux, and thermal error values for a specific design. The temperature ranges from a minimum of 299.49 °C to a maximum of 2001.6 °C. The total heat flux varies with an average of 58508 W/m², and the directional heat flux averages 195.27 W/m². The design's thermal error is 3857.5, showcasing its accuracy in maintaining a relatively stable thermal performance.

Profile 2:

Profile 2 presents data for another design, showcasing key metrics such as temperature, total heat flux, directional heat flux, and thermal error. Temperature spans from 323.16 °C to 2001.6 °C, with an average of 1053.9 °C. The average total heat flux is 62944 W/m², and the average directional heat flux is -139.62 W/m². The design's thermal error is 3869.7, which indicates its precision in thermal management.

Profile 3:

Profile 3 provides insights into yet another design with temperature, total heat flux, directional heat flux, and thermal error measurements. Temperatures range from 407.17 °C to 2001.5 °C, with an average of 1207.5 °C. The average total heat flux is 62807 W/m², while the average directional heat flux is -543.61 W/m². The design's thermal error is 3961.1, highlighting its thermal performance in different conditions.

Profile 4:

Profile 4 outlines data for a distinct design, featuring temperature, total heat flux, directional heat flux, and thermal error values. The temperature range is from 95.421 °C to 2001.6 °C, with an average of 834.68 °C. The average total heat flux is 56656 W/m², and the average directional heat flux is -77.847 W/m². The design's thermal error is 3482.4, indicating its efficiency in managing thermal variations.

Each profile showcases a design's performance in terms of temperature, heat flux distribution, and thermal error, providing valuable insights for selecting the most appropriate design based on specific priorities and requirements.

8. Conclusion

Based on the provided data, Design 4 appears to be the most favorable choice among the four designs for the following reasons:

I. Average Temperature: Design 4 has the lowest average temperature of 834.68 °C, indicating better thermal management compared to the other designs. Lower temperatures generally contribute to improved engine efficiency and longevity.

II. Average Total Heat Flux: Design 4 exhibits a relatively lower average total heat flux of 56656 W/m², suggesting better heat dissipation capacity. Efficient heat dissipation is crucial for preventing overheating and maintaining engine performance. Overall, Design 4 demonstrates a balance between effective cooling and temperature management, making it the preferable option among the presented designs. However, it's important to consider other factors such as manufacturing feasibility and cost implications before finalizing the choice.

REFERENCES

1. Dubey, Divyank; Singh, Dinesh; Yadav, Abhishek; Pal, Satyajeet; Thakur, Harishchandra (2017). Thermal Analysis Of Engine Cylinder Having Thick Tip Fin With Varying Slot Sizes And Material. Materials Today: Proceedings, 4(8), 7636–7642. Doi:10.1016/J.Matpr.2017.07.097

2. Reddy Kummitha, Obula; Reddy, B.V.R. (2017). Thermal Analysis Of Cylinder Block With Fins For Different Materials Using ANSYS. Materials Today: Proceedings, 4(8), 8142–8148. Doi:10.1016/J.Matpr.2017.07.155

3. Srinivas, D.; Kumar, Thalla. R. Santosh; Suresh, V.; Eshwaraiah, R. (2019). Aip Conference Proceedings [Aip Publishing 1st International Conference On Manufacturing, Material Science And Engineering (Icmmse-2019) - Telangana, India (16–17 August 2019)] 1st International Conference On Manufacturing, Material Science And Engineering (Icmmse-2019) - Thermal Analysis And Optimization Of Engine Cylinder Fins By Varying Geometry And Material. , 2200(), 020011–. Doi:10.1063/1.5141181

4. Turkyilmazoglu, Mustafa (2018). Heat Transfer From Moving Exponential Fins Exposed To Heat Generation. International Journal of Heat and Mass Transfer, 116(), 346–351.

5. Sagar, Pulkit; Teotia, Puneet; Sahlot, Akash Deep; Thakur, H.C (2017). Heat Transfer Analysis and Optimization Of Engine Fins Of Varying Geometry. Materials Today: Proceedings, 4(8), 8558–8564. Doi:10.1016/J.Matpr.2017.07.202

6. S.K. Mohammad Shareef;M Sai Vikas;A.L.N Arun Kumar;Abhishek Dasore;Sanjay Chhalotre;Upendra Rajak;Trikendra Nath Verma; (2021). Design And Thermal Analysis Of Engine Cylinder Fin Body Using Various Fin Profiles . Materials Today: Proceedings, (), –. Doi:10.1016/J.Matpr.2021.04.116

7. Thiagarajan, C.; Prabhahar, M.; Prakash, S.; Senthil, J.; Kumar, M. Saravana (2020). Heat Transfer Analysis And Optimization Of Engine Cylinder Liner Using Different Materials. Materials Today: Proceedings, (), S2214785320346277–. Doi:10.1016/J.Matpr.2020.06.173

8. B.J. Patil;Vidyasagar Shetty; (2021). Thermal Analysis Of Two Wheeler Engine Fins. Materials Today: Proceedings, (), –. Doi:10.1016/J.Matpr.2021.03.160

9. Thiagarajan, C.; Prabhahar, M.; Prakash, S.; Senthil, J.; Kumar, M. Saravana (2020). Heat Transfer Analysis And Optimization Of Engine Cylinder Liner Using Different Materials. Materials Today: Proceedings, (), S2214785320346277–. Doi:10.1016/J.Matpr.2020.06.173

10. G. Babu, M. Lavakumar,Heat Transfer Analysis and Optimization of Engine Cylinder Fins of Varying Geometry and Material, Journal of Mechanical and Civil Engineering (IOSR-JMCE, Volume 7, Issue 4 (Jul. - Aug. 2013), PP 24-29