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Thermal Analysis of Pins and Plate Fin Profiles by Using Ansys

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Abstract:
The engine compartment is one of the essential components of the engine exposed to excessive temperature differences and thermal stress. Fins are positioned on the surface of the cylinder to improve heat exchange by convection. The present study concerns the study of heat exchange between plate fins and pin fins. Pin fins assembled in two shapes (circular, rectangular) with tubular section to allow better improvement of the heat exchange rate. We have optimized the heat exchange rate and optimized all perspectives to achieve a higher heat exchange rate. In the present work, experiments were conducted to determine the temperature fluctuations inside the fins fabricated in three types of geometries (plate fins, circular pin fins, and rectangular pin fins) and study the coherent-state heat transfer was used using ANSYS finite element software to test and approve the results. Temperature fluctuations in different areas of the pin fins are evaluated using FEM, and the plate fin results are compared with the experimentally determined pin fin results in Ansys. The principle implemented in this design is to increase the heat dissipation rate by using wind flow. The main objective of the study is to improve the thermal properties by modifying the geometry, material and design of the fins.

Keywords: Heat Transfer, Extended surfaces, Pin Fins, FEM, and Heat Transfer Enhancement.

1. Introduction

Heating a component under different working conditions represents one of the main problems for engineering applications today, therefore rapid heat transfer from heated surfaces and reduction of material costs and weight have become a major challenge for component design of heat exchangers. Removing unnecessary heat from system parts is necessary to maintain a strategic distance from the harmful effects of burns or overheating. Therefore, improving heat transfer is a central topic in thermal engineering. Heat transfer from surfaces can generally be improved by increasing the heat transfer coefficient between a surface and its surroundings, by increasing the heat transfer zone of the surface, or both. In most cases the heat exchange area is expanded by using extended surfaces to compensate for the fins associated with walls and surfaces. Extended surfaces (fins) are often used in heat exchange devices to increase heat exchange between a substantial surface and the surrounding fluid. Various types of ribs have been used, from moderately simple to complex geometries. A form of regular fin geometry is rectangular, triangular, cylindrical, trapezoidal, etc. By conduction, convection and radiation of a set of fins, the amount of heat exchanged has been optimized, thus increasing the temperature contrast between the set of fins and the surrounding environment. A slight increase in the convective heat transfer coefficient or a slight increase in the surface area of the finned structure of the object improves heat exchange. Occasionally it is uneconomical or impossible to change the first two alternatives. In any case, adding a fin design to the fin pattern increases surface area slightly and can sometimes be an economical solution to heat transfer problems. The circumferential fins around the chamber, the square and rectangular fins of a motorcycle engine, and the fins connected to the condenser canisters of a refrigerator are some well-known precedents that appear only when there is a temperature difference, flowing faster when such fluctuation is greater, and they always move outwards from high to low temperatures, the larger the more pronounced the surface.

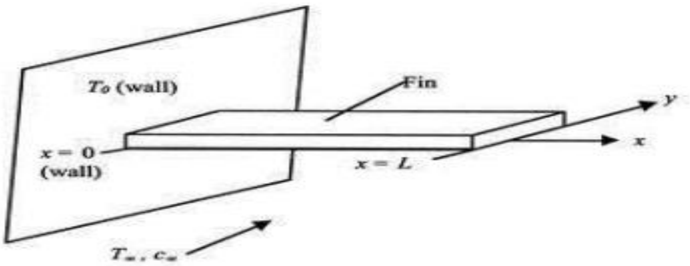
2. Extended Surfaces (Fins)

When studying heat exchange, the surface extruded from a base is called a fin. Fins are used to improve heat dissipation to or from the environment by increasing the rate of convection. The combination of convection, conduction or radiation functions of an object determines the rate of heat transfer. It increases with the temperature difference between the environment and the object, which increases the convection coefficient of heat exchange or increases the surface area. However, a larger surface area also means greater resistance to heat flow. Therefore, the heat transfer coefficient is based on the total surface area (the surface area of the base and fins) which is less than that of the base. In engineering applications, fins of different shapes and sizes are used to increase the heat transfer rate, e.g

- Rectangular fins
- Triangular fins
- Trapezium fins
- Circular segmental fins.

Different shape and designs of fins are used in different situations

Figure 1: diagram of heat transfer fin



(Source: Heat and Mass Transfer. Revised edition, R. K. Rajput).

3. Material properties of Fins material

Thermal analysis of Fins performed by using Aluminum alloy of the Fins material. Composition of Aluminum alloy is shown in Table 1

Table 1: Material properties of Fins Mode

Parameters	Unit	Aluminum alloy (6061)
Density	(Kg/m^3)	2700
Young's Modulus	(MPa)	69000
Coefficient of thermal expansion	(1/K)	2.32×10^{-5}

Poisson's Ratio	-	0.33
Elastic modulus	(GPa)	68.9
Ultimate Tensile Strength	(MPa)	310
Thermal conductivity	(W/m/0C)	167

4. Design and Analysis of Fins

a. Modeling of Fins Model

Fin models with 6061 aluminum alloy material selection and three fin models designed here, namely plate fins, circular pin fins and rectangular pin Fins. Model with plate fins and pin fins, circular and rectangular holes, pin fins to convey air through the fins. FEM analysis carried out via Ansys. The practical application of finite element modeling is called FEA and is best understood in solving real-world problems. FEA is widely used in the automotive industry. It is an extremely important tool for creating configurations in product development engineering. It is essential to understand the fundamentals of FEA and design engineering, demonstration systems, inherent errors, and their impact on the nature of the results to make FEA an effective design tool. FEA is also used as a computational tool to analyze engineering problems.

Figure 2: Plate Fins Designed Model in Ansys

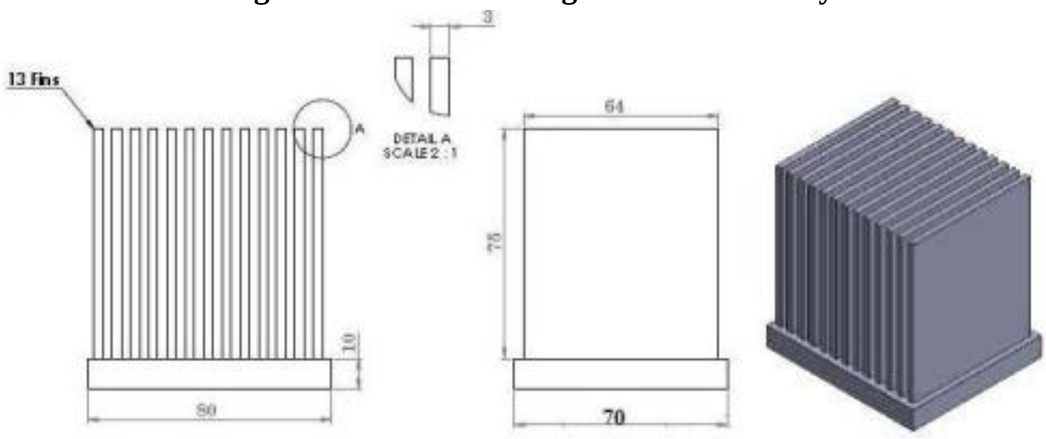


Figure 3: Rectangular Pin Fins Designed Model in Ansys

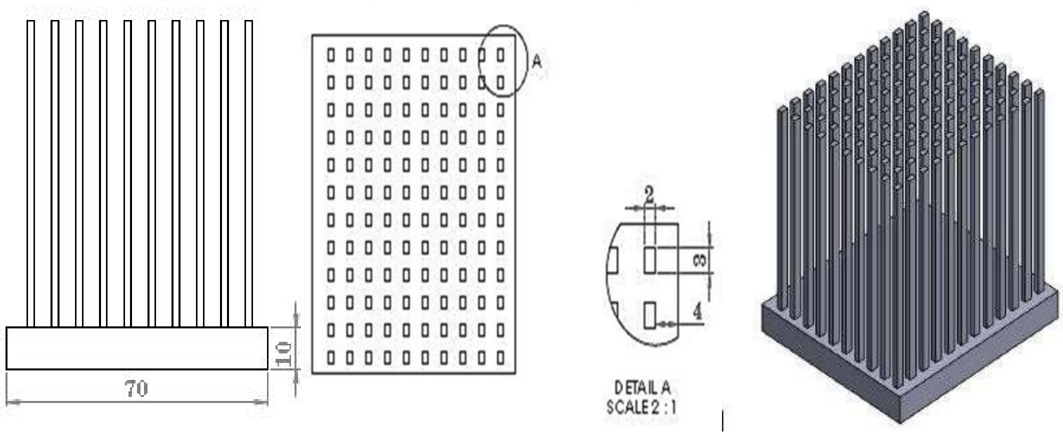
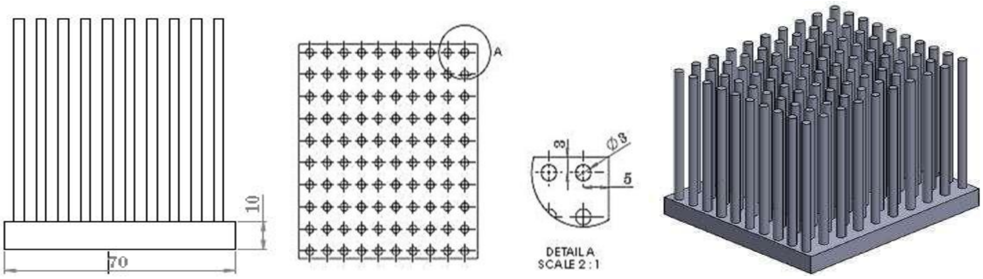


Figure 4: Circular Pin Fins Designed Model in Ansys Figure



b. Applying boundary conditions

The figure represents the boundary conditions applied to the fins. The model has a heat flux of 13W and convection conditions of 220°C, where convection has been applied on top of the fins to optimize the maximum and minimum temperature and also optimize the maximum heat flow for high heat transfer heat. The figure shows the applied boundary conditions of the Fins model.

Figure 5: Applied Boundary conditions on Plate Fins

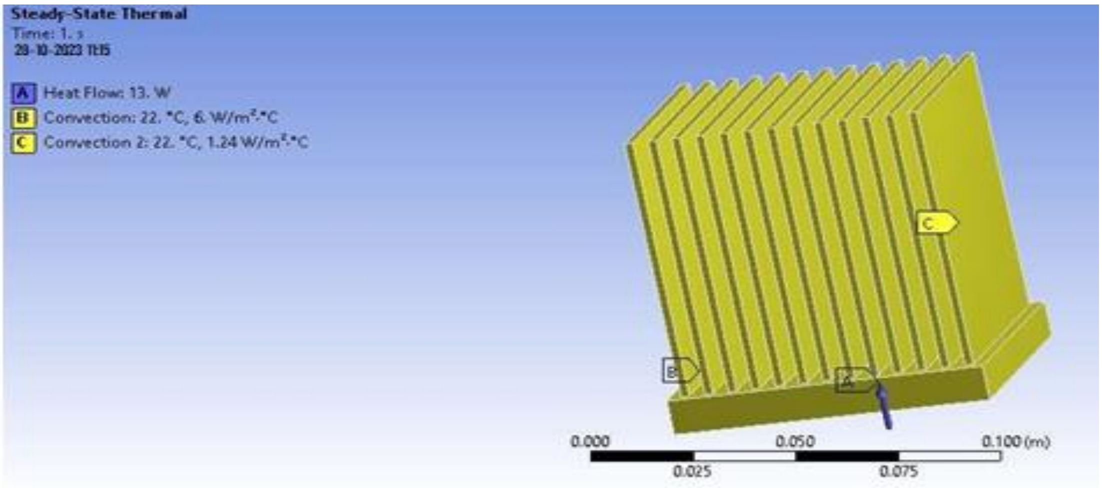


Figure 6: Applied Boundary conditions on Circular Pin Fins

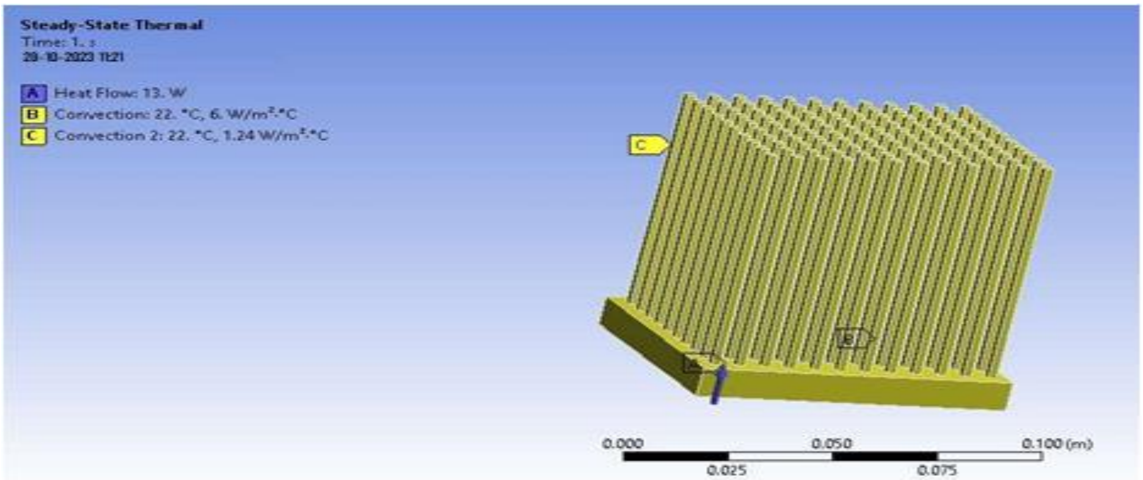
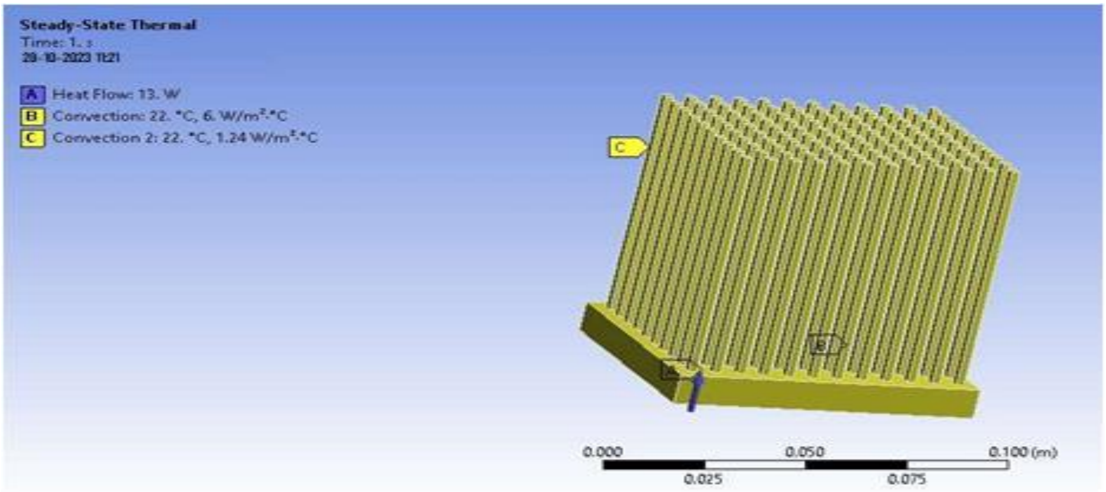


Figure 7: Applied Boundary conditions on Rectangular Pin Fins



5. Results and Discussion

The Ends to fins model is broken down into a mesh of limited measured components of the basic framework. Displacement discrimination within each segment is assumed to be calculated from the basic polynomial profile capacities and node temperatures. Deformation and tension conditions are created up to the temperature of the dark node. From there, the equilibrium conditions are collected in an easily customizable grid. The steady-state temperature variation between different fin heights shows the applied boundary conditions shown in the figures. Maximum temperature above. After solution processing, the temperature and total heat flux are determined by thermal analysis compared to plate-fin and pin-fin models. These structural and thermal analysis results are obtained for all three conditions, i.e., plate fins, circular pin fins, and rectangular pin fins. The figures show the simulation study in Ansys of Fins models

a) Temperature distribution analysis of Fins Models

Figure 8: Temperature Distribution of Plate Fins

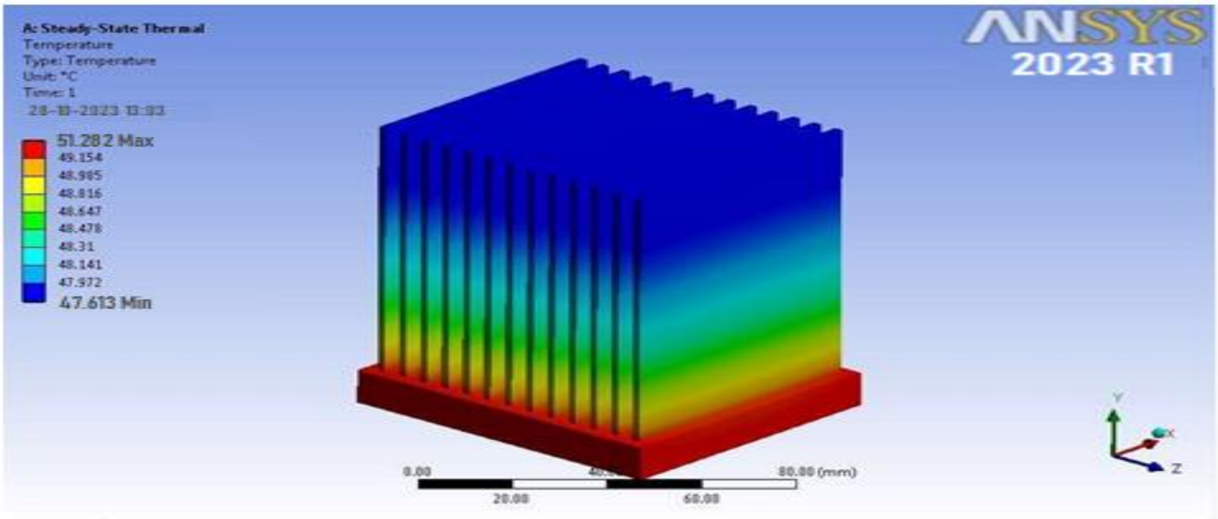


Figure 9: Temperature Distribution of Rectangular Pin Fins

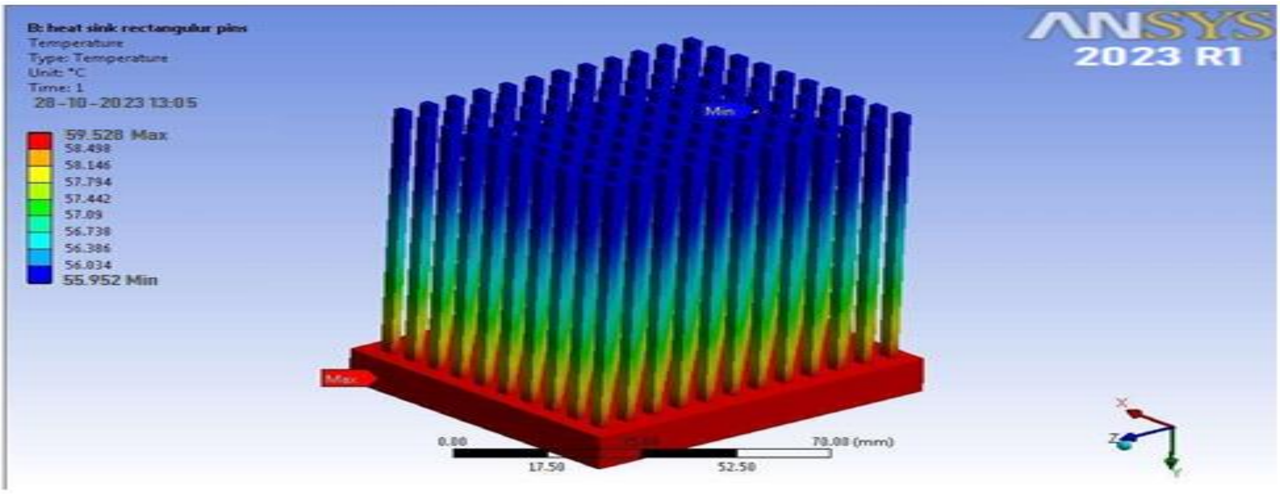
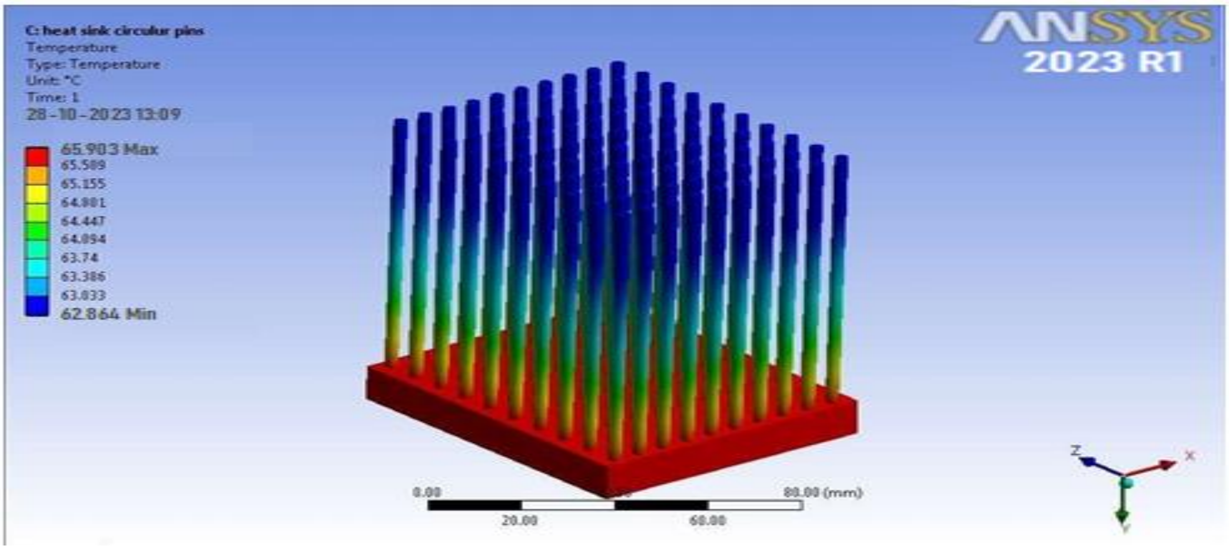


Figure 10: Temperature Distribution of Circular Pin Fins



b) Heat Flux analysis of Fins Models

Figure 11: Heat Flux of Plate Fins

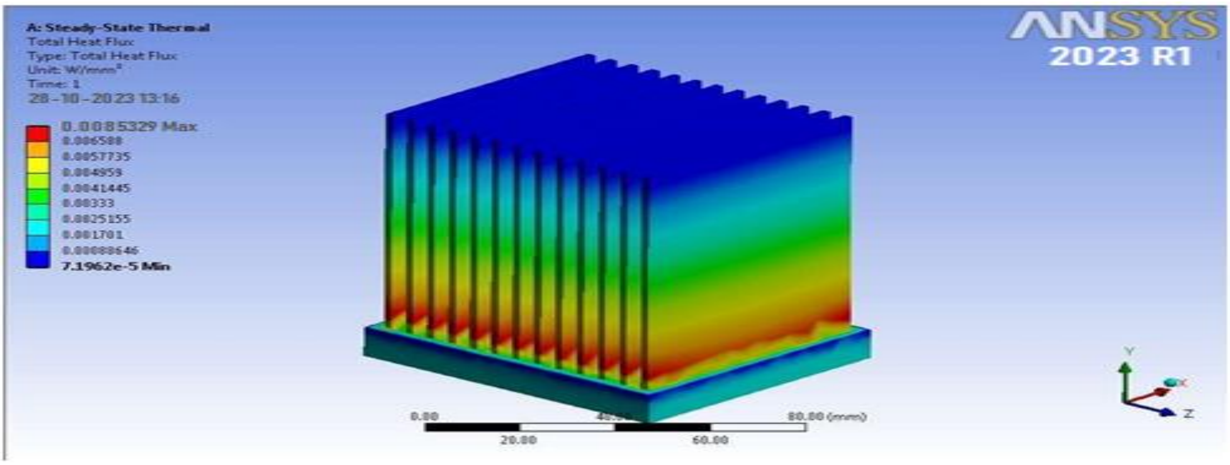


Figure 12: Heat flux of Rectangular Pin Fins

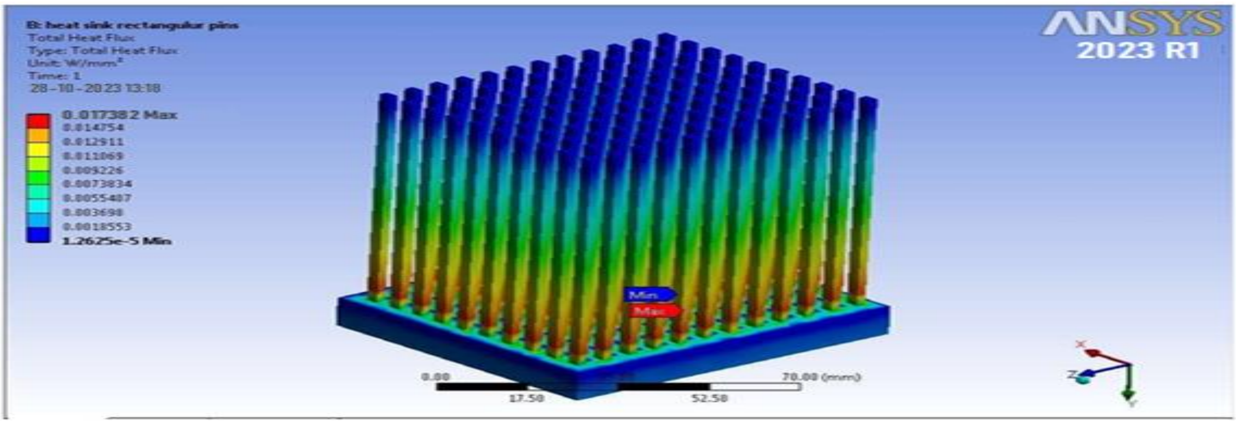


Figure 13: Heat flux of Circular Pin Fins

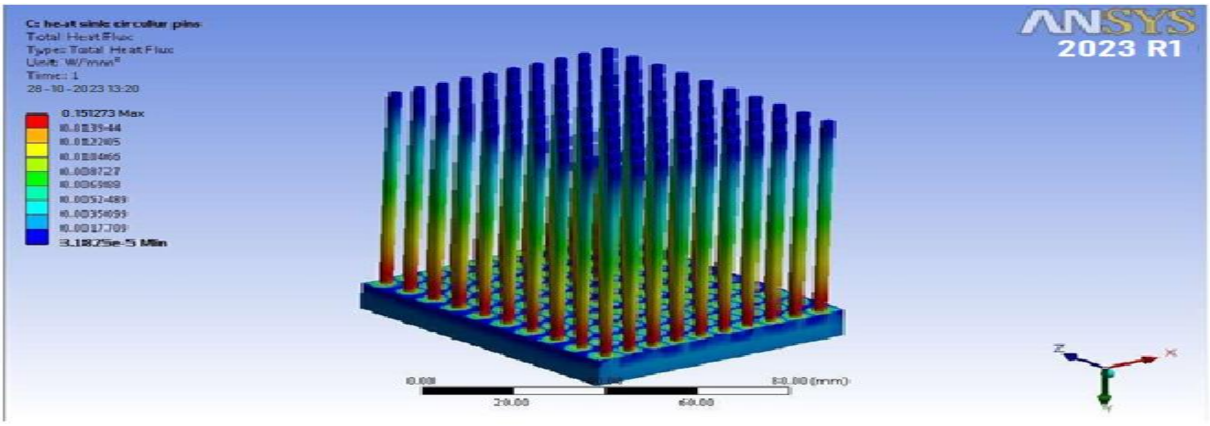


Table 2: Temperature Variations of Fins Models

Geometry Condition	Max Temperature (°C)	Min Temperature (°C)	Temperature drop(°C)
Heat Sink with Plate Fins	51.282	47.613	3.669
Heat Sink with Rectangular Pin Fins	59.528	55.952	3.576
Heat sink with Circular PinFins	65.903	62.864	3.039

Figure 14: Temperature Variations in Models of Plate Fin and Pin Fin

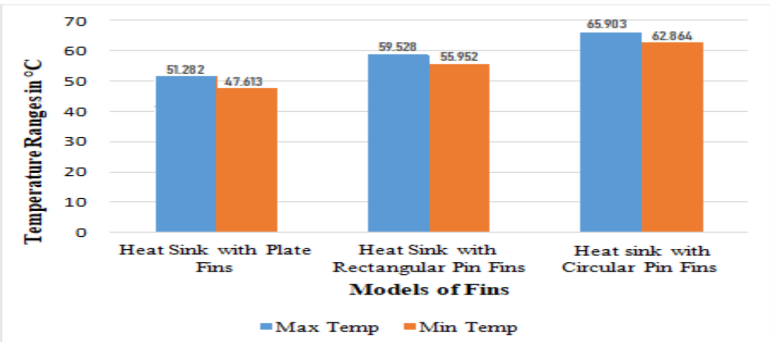


Figure 15: Total Temperature Drop in Plate Fin and Pin Fin Models

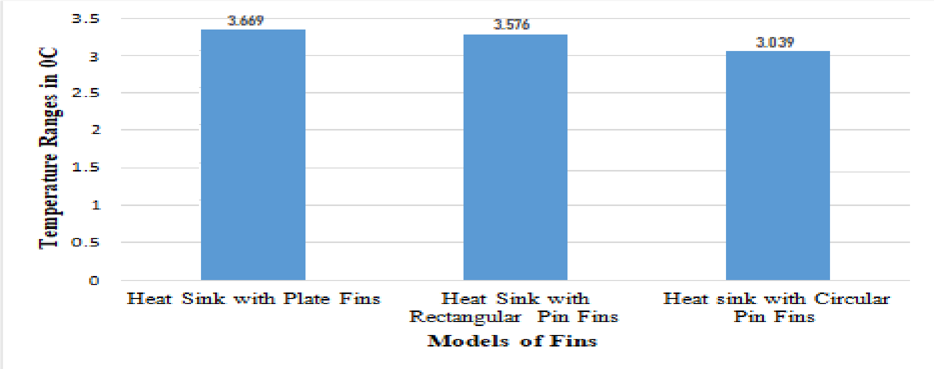
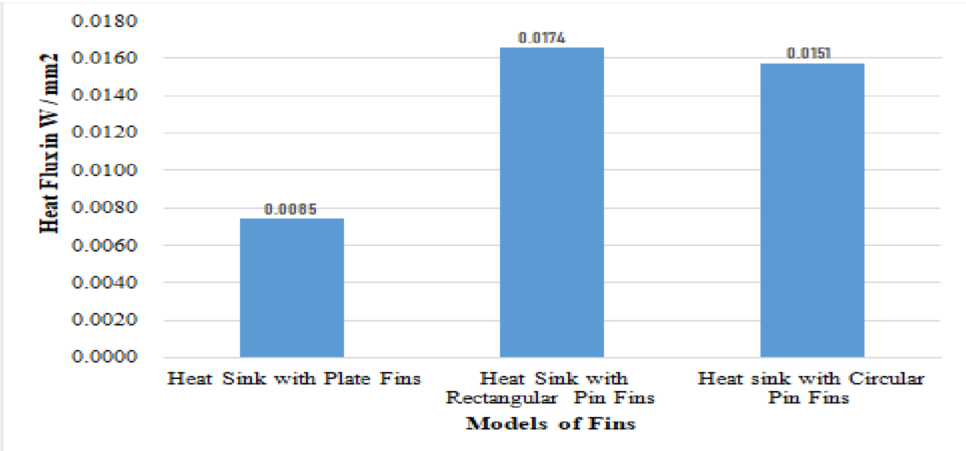


Table 3: Heat Flux Found on All conditions of Fin Models

Geometry Condition	Heat Flux(w/mm^2)
Heat Sink with Plate Fins	0.0085
Heat Sink with Rectangular Pin Fins	0.0174
Heat sink with Circular Pin Fins	0.0151

Figure 16: Comparison of Heat flux of Fin Models



6. Conclusion

From the comparative analysis of the plate fin and pin fin study, it was concluded that the total heat flux reached a maximum of 0.0174W/mm2 for the rectangular pin fin. The maximum temperature measured in the circular fins is 65.90°C and the minimum temperature measured in the plate fins is 51.2820°C. Therefore, in this analysis, it was concluded that rectangular profile fins had better heat transfer properties. Therefore, better heat transfer for fins or experimental results show that rectangular fin profiles perform better than plate fins. The overall analysis is carried out using the FEM analysis tool ANSYS 23.0 R1. Therefore, deeper investigations can be carried out using advanced materials and various design and analysis tools. The following conclusions were drawn from the above study:

- The thermal analysis of the ribs was completed by modifying some parameters such as the geometry and ribs of the plate and pins.
- This can be easily determined from the analysis results. It is better to use rectangular fins with 6061 aluminum alloy material because the temperature drop and heat transfer rate of rectangular pin fins

are much higher than plate fins.

7. REFERENCES

1. Arjun Vilay, Prem Shankar, Vivek Tiwari, Sourabh Khambra, "CFD analysis of engine cylinder fin with various materials", International Journal of Advance Research, Ideas and Innovations in Technology, Volume 4, Issue 3, 2018.
2. Arun Eldhose, Benny Paul, Sebastian, "Numerical Analysis of Pin Fin by Varying Shape and Materials", International Research Journal of Engineering and Technology (IRJET), Volume 5 Issue 4, Apr-2018.
3. Karan Sangaj, Sudarshan Shinde, Rameez Shanediwan, "Thermal and Parametric Analysis of Pin-Fin: Vol 2", International Research Journal of Engineering and Technology, Volume 05 Issue 02, Feb-2018.
4. L.Prabhu, M. Ganesh Kumar, Prasanth M, "Design and Analysis of Different Types of Fin Configurations Using Ansys", International Journal of Pure and Applied Mathematics, Volume 118 No. 5 2018, 1011-1017.
5. Hari Raghvan, Rangu P., "A Study and Analysis on the Thermal Performance of a Pin Fin Heatsink for Natural Convection using CFD", International Journal of Engineering Research & Technology (IJERT), Volume 6, Issue 5, 2017.
6. M. Rajesh, "Design and optimization of engine cylinder fins by varying Geometry and material with thermal analysis", International Journal of Core Engineering & Management, IJCEM, PP. 424-432.
7. Malakappa Pujari, Imran Quazi, Shriramshastri Chavali, "Experimental and Numerical Analysis of Cylindrical Pin Fins having Square Thread with and without Perforations by Forced Convection", International Journal of Trend in Researchand Development, Volume 4, 2017.
8. Manoj Dange, M S Deshmukh, "Experimental Analysis of Cylindrical Staggered Pin Fin Heat Sink for Force Convective Heat Transfer Variation and its Enhancement", International Journal of Latest Engineering Research and Applications (IJLERA), Volume 02, Issue 08, August 2017, PP – 128-133, ISSN: 2455-7137.
9. Mayank Jain, Mahendra Sankhala, Kanhaiya Patidar, "heat transfer analysis and optimization of fins by Variation in geometry", International Journal of Mechanical and Production Engineering, Volume- 5, Issue-7, Jul.-2017.
10. R. Sudheer kumar Reddy, k. Govinda Rajulu, S.M. Jameel Basha, "Thermal Analysis of Pin Fin with Different Shape Forms using ANSYS”, International Journal of Engineering Science and Computing, Volume 7 Issue No.5, 2017.
11. S. Ravikumar, Subash Chandra, Remella Harish, "Experimental and Transient Thermal Analysis of Heat Sink Fin for CPU processor for better performance", Frontiers in Automobile and Mechanical Engineering, 197, 2017, doi:10.1088/1757-899X/197/1/012085.
12. Sandeep Kumar, Nitin Dubey, "Investigation and Thermal Analysis of Heat Dissipation Rate of Single Cylinder SI Engine", IJEDR, Volume 5, Issue 2, 2017.
13. Taye Stephen Mogaji, Folashade Desola Owoseni, "Numerical Analysis of Radiation Effect on Heat Flow through Fin of Rectangular Profile", American Journal of Engineering Research (AJER), Volume-6, Issue-10, pp-36-46.
14. Farhat Shaikh, Jayaramulu Challa, "CFD Analysis of Circular Pin Fin", International Journal of Scientific Engineering and Research (IJSER), Volume 4 Issue 5, May 2016.

15. Piyush Laad, Bhushan Akhare, Praveen Chourasia, "Thermal Analysis of Heat Sink with Fins of Different Configuration Using Ansys Workbench 14.0", International Journal of Engineering Sciences & Research Technology, Volume 5, Issue 6, 2016.