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Design and Analysis of Engine Fins

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Abstract: *The Engine cylinder is one of the major automobile components, which is subjected to high temperature variations and thermal stresses. In order to cool the cylinder, fins are provided on the surface of the cylinder to increase the rate of Heat transfer. By doing thermal analysis on the engine cylinder and fins around it. It is helpful to know the heat dissipation rate and Temperature Distribution inside the cylinder. We know that, By increasing the surface area we can increase the heat dissipation rate, so designing such a large complex engine is very difficult. The main aim of the present project is to analyze the thermal properties like Directional Heat Flux, Total Heat Flux and Temperature Distribution by varying Geometry(Circular,Rectangular),material(AluminumAlloy,MagnesiumAlloy) and thickness of Fin (3mm, 2mm) of an approximately square cylinder model prepared in SOLIDWORKS-2022 which is imported into ANSYS WORKBENCH-2024 R1 for Transient Thermal analysis with an Average Internal Temperature and Stagnant Air-Simplified case as Cooling medium on Outer surface with reasonable Film Transfer Coefficient as Boundary Condition.*

Keywords: Dissipation, Thermal conductivity, Film transfer coefficient, Internal Temperature, Stagnant Air-Simplified case, Boundary Conditions

I. INTRODUCTION

Recently, there has been a massive interest for high-performance, airy, compact, and functional heat exchange parts. The plates are recognized as one of the best methods of increasing the heat distribution. The structure of plate is distinct for various applications, but the main concern is weight and cost. Therefore, it is hugely desirable to enhance the size of plate. The more significant measurements are those for which the maximum heat is scattered for a given weight or the mass of the plate.

The ultimate heat exchange improvement can be achieved by using plate as elements for heat exchange surface area expansion. The IC engine is a heat exchange liquid to occur in the engines themselves, typically the burning of fuel and the oxygen content of the air. Internal combustion engines use the warm conversion of the energy of the fuel. In IC engine fuel energy into motive force. And after converting the heating power supply excess heat should be removed from the loop. Heat will transfer to the atmosphere means a fluid with water and air.

The Cylinder is the one of the significant components in the Motor, which is why high temperature variations furthermore, warm burdens. To chill the cylinder, plates are given on the surface of the cylinder to increase the rate of heat Exchange rate. Plates are Basically Mechanical structures that are used to cool various structures through the process of convection and conduction. Extended razors are well-known for enhancing the heat transfer in IC engines. The evolution of the air cooling system is very simpler. Therefore, it is important for an air-cooled engine to use the razors efficiently to obtaina uniform temperature in the Engine cylinder. An internal combustion engine is an engine in which the combustion of a fuel occurs inside the combustion chamber or cylinder. Here, the expansion of the high-temperature and high-pressure gases produced by combustion applies direct force to the component of the engine, like a cylinder, turbine blades, or a nozzle. This force transfers the component over distance, producing useful mechanical energy.

When we run our motor vehicles, the air hits the motor vehicle engine at a certain speed and sweeps away its heat. The heat carried away by the air is due to natural air convection, therefore this method is known as Natural Air cooling. Our motor vehicles engine mostly cooling by natural air. Since heat dissipation is a function of the front cross-sectional area of the motor vehicle engines, the main need is to increase this contact area. If have engine with a large surface area this will be bulky & heavier. It also reduces the power-to-weight ratio. So, as with the new type of fins arrangement construction for improving the front-based cross-section area of our motor vehicle engine. Our motor vehicle Engine fin shape projection provides the surfaces of the motor engine block and cylinder head area. This will increase our vehicle cylinder head surface contact area between a vehicle cylinder and the air. Vehicle fin is normally identic cast.

II. LITERATURE REVIEW

Here be the chapter conveys the literature reviewing various papers, articles, books, and other sources (e.g. dissertations) that hath been considered during the research work. This literature review giveth an idea for existing research that is significance to the work that is being carried out.

2.1 Analysis of Various Work

Fernando Allan simulated the heat transferring from the cylinder to air of a two-stroke internal combustion finned engine In order to minimize engine dimensions, the cylinder body, cylinder head (which are both equipped with fins), and piston have all undergone numerical analysis and optimization. The maximum temperate admissible at the hottest point of the engine hath been adopted as the limiting condition. Starting from a zero-dimensional combustion model hath developed in prior works, cooling system geometry of a two-stroke air cooled internal combustion engine hath been optimized in this paper by reducing the total volume occupied by the engine. By decreasing the overall engine diameter D from90.62 mm to 75.22 mm and raising the overall height H from 125.72 mm to 146.47 mm, a total decrease of 20.15% has been accomplished. The aspect ratio varies from 1.39 to 1.95. In parallel with the total volume reduction, a slight increase in engine efficiency hath been achieved.

G. Babe and M. Lava Kumar analyzed the thermal properties by varying geometry, material and thickness of fins. The fin shapes rectangular, round, and curved as well as their thickness were varied to construct the models. Material used for manufacturing cylinder body was

Aluminum Alloy 204 which hath thermal conductivity of 110-150W/me and also using Aluminum alloy 6061 and Magnesium alloy which hath higher thermal conductivities. They came to the conclusion that the weight of the fin body decreases and efficiency increases when the thickness is decreased and the fin shape is altered to a curved form. Magnesium alloy reduces the weight of the fin body; round fins made of aluminum alloy 6061 with a thickness of 2.5 mm are preferable since they have a higher heat transfer rate and, in my opinion, are more effective because they lose less heat.

Ajay Paul et.al.Carried out Numerical Simulation to determine heat transfer characteristics of different fin parameters namely, number of fins, fin thickness at varying air velocities. A cylinder with a single fin mounted and explained it was tested experimentally also they did the numerical simulation of the same setup was done using CFD. Fin configurations of 1, 3, 4, and 6 were simulated for cylinders withthicknesses of 4 and 6 mm

In 2024, N. Phani Raja Rao et.al, Analyzed the thermal properties by varying geometry, material and thickness of fins. Various materials, such as magnesium alloy, aluminum alloy 6061, and aluminum alloy A204, with higher heat conductivities, were used to make the cylinder fin. These materials demonstrated that by making the fin thinner and more circular in shape, the weight of the fin body was reduced, which in turn increased the fin's efficiency and rate of heat transfer. The findings indicate that utilizing a circular fin made of aluminum alloy 6061 is preferable since it increases the fin's heat transfer rate, efficiency, and effectiveness.

In 2024, S.M. Wange and R.M. Metkar , have done experimental and computational analysis of fin array and shown that the heat transfer coefficient is more in notch fin array than without notch fin array in aspet.Fin performance is influenced by geometric characteristics, therefore choosing the right geometric parameters such as fin length, height, fin spacing, and notch depth is important in this regard.In 2023, PulkitAgarwal et.al. , simulated the heat transfer in motorcycle engine fan using CFD analysis. It has been noted that when the outside temperature drops to extremely low levels, the engine overcools and performs poorly. They have concluded that over cooling also gives the impact on the engine efficiency because over cooling excess fuel consumption occurs most of the times.

III. PROBLEM DEFINITION

In this section we review several previous works which gives a brief working scenario and problems with their work. After analyzing several research works in 2024, not a single method can provide better method. The engine's cylinder,

cylinder head, and piston all of which feature fins have all undergone numerical analysis in an effort to reduce the engine's size. The extreme temperature admissible at the combustion of fuel in the engine has been adopted as the limiting condition. This research presents the optimization of the cooling system of a 4-stroke air-cooled internal combustion engine, starting from a zero-dimensional combustion model created in earlier works, by lowering the overall volume occupied by the cylinder. By decreasing the overall cylinder diameter D from 89.26 mm to 74.21 mm and raising the overall height H from 124.79 mm to 145.87 mm, a total reduction of 19.15% has been accomplished. The aspect ratio changes from 1.29 to 1.89.Engine efficiency will rise if we reduce the cylinder volume.

The coefficient of heat transfer is more in notch fin array compare to without notch fin array. parameters of fin effects on the performance of fins, so proper selection of design parameter such as length of fin, height of fin, spacing between fins, depth of notch is needed.

If cooling of engine is more than it will be effect of the engine efficiency because excess fuel consumption occurs during more cooling process. In the show Project examination on warm issues on vehicle fins were carried out. Examination yields the temperature behavior and Total Heat flux and Directional warm flux of the Barrel balances due to tallTemperature in the combustion chamber. ANSYS WORKBENCH-2024 R1 is utilized for examination. The examination is done for distinctive models of nearly a square engine and a comparison is hence set up between them by changing geometry and Fin thickness. Moreover the fabric is changed so that superior heat exchange rate can be obtained.

IV. EXPERIMENTAL SETUP

The ANSYS Workbench interface comprises basically of a Tool stash locale, the Extend Schematic, the Toolbar, and the Menu bar. Depending on the investigation sort and/or application or workspace, you may moreover see other windows, tables, charts, etc. One way to work in ANSYS Workbench is to drag a thing such as a component or investigation framework from the Tool compartment to the Extend Schematic or to double-click on a thing to start the default activity. You can too utilize the setting menus, available from a right- mouse press, for extra choices. You will see your examination frameworks the components that make up your examination in the Venture Schematic, counting all associations and joins between the frameworks. The individual applications in which you work will show independently from the ANSYS Workbench GUI, but the comes about of the activities you take in the applications may be reflected in the Venture Schematic.

•A critical thought is the determination of the appropriate fin length L. Expanding the length of the fin past a certain value cannot be defended unless the included benefits exceed the included cost.

•The efficiency of most fins utilized in hone is over 90 percent.

The various kinds of data you can include in your project are shown in the ANSYS Workbench Toolbox. The Toolbox's contents may alter to reflect the components and actions that are available to you as you pick different things in the Project Schematic or other workspaces. This is because the Toolbox is context-sensitive. Clicking the Return to Project button on the Toolbar will bring you back to the Project Workspace after working in other workspaces like Engineering Data or Parameters.

The ANSYS Workbench Tool compartment presents the types of information that you can include to your extend. The Tool compartment is context-sensitive; as you select diverse things in the Project Schematic or other workspaces, the substance of the Tool compartment may change to reflect the components and activities accessible to you. When working in other workspaces, such as Designing Information or Parameters, you can return to the Project Workspace by clicking the Return Project button on the Toolbar.

4.1 Modeling of Cylinder Fin

SOLIDWORKS-2022 is use to model the cylinder and fin. The cylinder and fin measurements were obtained for a square engine with a stroke of the ratio is one. Fins featuring various geometries (round and rectangle) were created using SOLIDWORKS-2022 for modeling.

i. Examine and comprehend the top and font views of the provided, Model, as well as their proportions

ii. Modify SOLIDWORKS' Unit system to the SI-system,

iii. Visit Sketch,

iv. From the available viewpoints, choose the front view,
v. First, use the line command to draw the expected Center line distance,
vi. Next, sketch one front view side using the presumptive dimensions.
vii. Adjust the fin length, groove length, cylinder upward projection, and projection distance from the center line—the diameter of the fin flank—by using the smart dimension command. For both circular and rectangular fins, we use the fin flank's diagonal length.
viii. The cylinder's interior and external diameters are fixed in both scenarios.
ix. Next, revolute the sketched segment using the revolute command.
x. The fin model is ready for circular fins, but for rectangular fins, we must use the extrude cut option to do an extrude cut in a descending direction and perform a film cut to eliminate the surplus projections of the rectangle shape.
xi. Currently available are both circular and rectangular cylindrical fins however, each fin's specific dimensions must be adjusted by varying the fin thickness in accordance with the provided data.

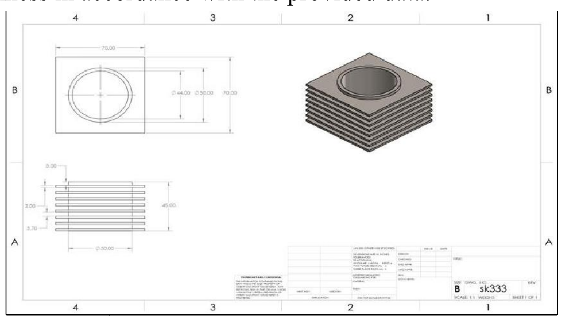

Fig-4.1 Rectangular fins of 2mm thickness

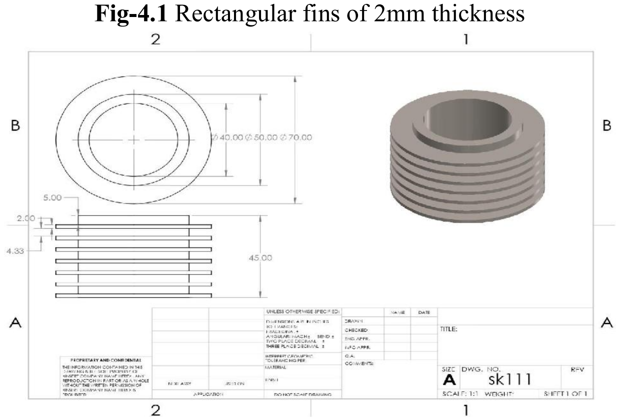

Fig-4.2 Circular fins of 2mm thickness

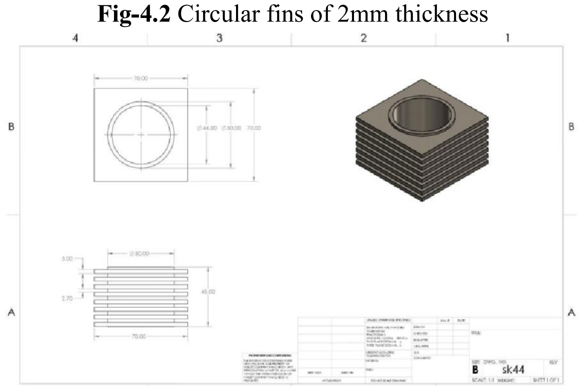

Fig-4.3 Rectangularfinsof3mmthickness

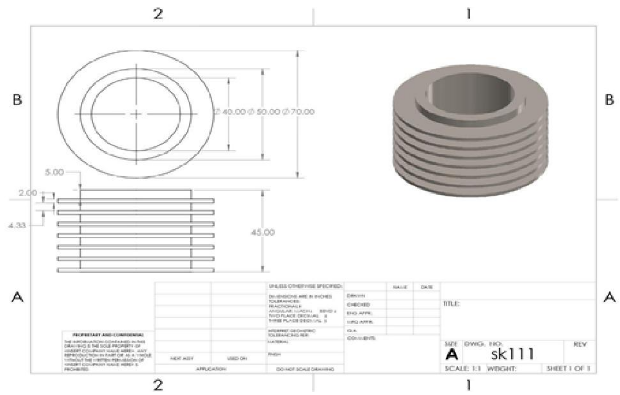

Fig-4.4 Circular fins of 3mm thickness

4.2 Experimental Details

The Boundary Conditions are:

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4.3 Material Data

Sl. No.	Loads	Units	Value
1	Inlet temperature	K	1073
2	Film coefficient	$W/m^2 K$	5
3	Ambient temperature	K	303
4	Material		Aluminium Alloy, Magnesium Alloy

1. Aluminium Alloy:

Density	2770 kg m^-3
Coefficient of Thermal Expansion	2.3e-005 C^-1
Specific Heat	875 J kg^-1 C^-1

Table: 4.1-Aluminium Alloy Constant

2. Magnesium Alloy:

Density	1800 kg m^-3
Coefficient of Thermal Expansion	2.6e-005 C^-1
Specific Heat	1024 J kg^-1 C^-1
Thermal Conductivity	156 W m^-1 C^-1
Resistivity	7.7e-007 ohm m

Table: 4.2-Magnesium Alloy Constants

V. METHODOLOGY

5.1 OVERVIEW

To initiate our study ahead a three dimensional model is developed with the help of simulation used, i.e. Ansys 2024 R1.

Our project's primary goals are to increase the engine cylinder's heat flow rate and examine the distribution of several attributes, including temperature, total heat flux, and directional heat flux, by adjusting the cylinder's material, geometry and linear dimensions.

Mainly two ways to increase the rate of Heat transfer for dissipation of Heat from the Cylinder walls

1. Raising the coefficient of surface heat transfer (h value),
2. Increasing the components (the cylinder's) outside surface area that comes into touch with the surrounding air.

VI. RESULTS AND DISCUSSIONS

1. MODEL-1
Type: rectangular fin
Material: Aluminium alloy
Fin thickness: 2mm:

RESULTS			
Minimum	793.71 °C	2321.3 W/m²	-69934 W/m²
Maximum	800. °C	82965 W/m²	70639 W/m²
Minimum Value Over Time			
Minimum	-6.0064 °C	256.1 W/m²	-4.876e+007W/m²
Maximum	793.71 °C	9370.9 W/m²	-69934 W/m²
Maximum Value Over Time			
Minimum	800. °C	82965 W/m²	70639 W/m²
Maximum	800. °C	4.955e+007 W/m²	4.9105e+007 W/m²

Table 6.1: Results of Model-1

2. MODEL-2
Type: rectangular fin
Material: magnesium alloy
Fin thickness: 2mm

Results			
Minimum	795.33 °C	2328.6 W/m²	-49044 W/m²
Maximum	800. °C	63273 W/m²	48177 W/m²
Minimum Value Over Time			
Minimum	-2.875 °C	555.52 W/m²	-5.0515e+007 W/m²
Maximum	795.33 °C	9891.5 W/m²	-49044 W/m²
Maximum Value Over Time			
Minimum	800. °C	63273 W/m²	48177 W/m²
Maximum	800. °C	5.1579e+007 W/m²	5.1357e+007 W/m²

Table 6.2: Results of Model-2

3. MODEL-3
Type: rectangular fin
Material: aluminium alloy
Fin thickness: 3mm

RESULTS			
Minimum	795.33 °C	2328.6 W/m^2	-49044 W/m^2
Maximum	800. °C	63273 W/m^2	48177 W/m^2
Minimum Value Over Time			
Minimum	-2.875 °C	555.52 W/m^2	-5.0515e+007 W/m^2
Maximum	795.33 °C	9891.5 W/m^2	-49044 W/m^2
Maximum Value Over Time			
Minimum	800. °C	63273 W/m^2	48177 W/m^2
Maximum	800. °C	5.1579c+007 W/m^2	5.1357c+007 W/m^2

Table 6.3: Results of Model-3

4. MODEL-4
Type: rectangular fin
Material: Aluminium alloy
Fin thickness: 3mm

RESULTS			
Minimum	795.33 °C	2328.6 W/m^2	-49044 W/m^2
Maximum	800. °C	63273 W/m^2	48177 W/m^2
Minimum Value Over Time			
Minimum	-2.875 °C	555.52 W/m^2	-5.0515e+007 W/m^2
Maximum	795.33 °C	9891.5 W/m^2	-49044 W/m^2
Maximum Value Over Time			
Minimum	800. °C	63273 W/m^2	48177 W/m^2
Maximum	800. °C	5.1579e+007 W/m^2	5.1357e+007 W/m^2

Table 6.4: Results of Model-4

5. MODEL-5
Type: circular fin
Material: Aluminium alloy
Fin thickness: 2mm

Results			
Minimum	797.84 °C	1649.7 W/m^2	-46844 W/m^2
Maximum	800. °C	49178 W/m^2	45732 W/m^2
Minimum Value Over Time			
Minimum	-3.5016 °C	179.79 W/m^2	-4.8614e+007 W/m^2
Maximum	797.84 °C	4.1861e+005 W/m^2	-46844 W/m^2
Maximum Value Over Time			
Minimum	800. °C	49178 W/m^2	45732 W/m^2
Maximum	800. °C	4.9661e+007 W/m^2	4.8973e+007 W/m^2

6. MODEL-6
Type: circular fin
Material: magnesium alloy
Fin thickness: 2mm

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Results			
Minimum	797.58 °C	1648.7 W/m²	-46831 W/m²
Maximum	800. °C	49164 W/m²	45720 W/m²
Minimum Value Over Time			
Minimum	15.31 °C	190.17 W/m²	-3.6635e+007 W/m²
Maximum	797.58 °C	1.9031e+005 W/m²	-46831 W/m²
Maximum Value Over Time			
Minimum	800. °C	49164 W/m²	45720 W/m²
Maximum	800. °C	3.7454e+007 W/m²	3.6866e+007 W/m²

Table 6.6: Results of Model-6

7. MODEL-7
Type: circular fin
Material: aluminium alloy
Fin thickness: 3mm

Results			
Minimu m	797.78°C	2361.9 W/m²	-36746 W/m²
Maxim um	800. °C	36888 W/m²	36592 W/m²
Minimum Value Over Time			
Minimum	9.6088 °C	62.206 W/m²	-4.4034e+007 W/m²
Maximum	797.78 °C	4.2114e+00 5 W/m²	-36746 W/m²
Maximum Value Over Time			
Minimum	800. °C	36888 W/m²	36592 W/m²
Maximum	800. °C	5.367e+007 W/m²	4.4283e+007 W/m²

Table 6.7: Results of Model-7

8. MODEL-8
Type : circular fin
Material : magnesium
Fin thickness : 3mm

Results			
Minimum	797.52 °C	2360.8 W/m²	-36737 W/m²
Maximum	800. °C	36879 W/m²	36582 W/m²
Minimum Value Over Time			
Minimum	16.491 °C	226.89 W/m²	-3.5492e+007 W/m²
Maximum	797.52 °C	3.291e+005 W/m²	-36737 W/m²
Maximum Value Over Time			
Minimum	800. °C	36879 W/m²	36582 W/m²
Maximum	800. °C	4.0613e+007 W/m²	3.5796e+007 W/m²

Table 6.8: Results of Model-8

6.2. Discussion:

Temperature Distribution: According to the results above, the fifth model, which has circular circumferential fins that are 2 mm thick and composed of aluminum alloy, can reach the highest in the range of 797.84°C.which is also the highest among. The highest temperature values of every other model and It takes 14.8 seconds to reach this steady condition. However, the magnesium alloy model 6, which has the same dimensions as the model 5, including being 2 mm thick and having a round shape, is fiercely rivaling the model 5.Their maximum temperature of797.58 °C is lower than that of model-5, but it took them a relatively short time—10.9 seconds—to reach that temperature in comparison to all the other models.

The Model-8, which is composed of magnesium alloy and has circular circumferential fins that are 3 mm thick, has a rapid rate of temperature change. As a result, in the fins of circular geometry, both the reached maximum temperature and the temperature change with respect to time are considerable.

Total Heat flux: The variation seen when considering the overall heat flux conducted by the cylinder is as follows: Compared to all the other models, the model-1, which is composed of an aluminum alloy and has 2 mm rectangular circumferential fins, conducts a greater total heat flux.

Model-2, which is composed of magnesium alloy and has the same features as Model-1 with the exception of material change, conducts less total heat flux than Model-1 when material is the focus of interest. Therefore, aluminum alloy conducts more total heat flux. Another finding is that as a material's quantity grows, so does the total heat flux it conducts.

Because of this, its value is higher in rectangular geometry than in circular geometry, and it also gets smaller as fin thickness increases.

Directional Heat flux: All of the outcomes for Directional Heat Flux are comparable to those for Total Heat Flux. When compared to circular geometry, the directional heat flux conducted by the material is higher in rectangular geometry and decreases with fin thickness. It also increases with material amount.

Compared to magnesium alloy fins with the same geometry and thickness, aluminum alloy fins conduct more directed heat. The same effects apply in the opposite positive direction, the negative radial direction.

NOTE: Everything said above relates to the final data that was acquired via transient thermal analysis and after 120 seconds of operation.

VII. CONCLUSION AND FUTURE WORK

7.1 Conclusion

In show work, a cylinder fin body is displayed by utilizing SOLIDWORKS-2022 and Transient thermal analysis is done by utilizing ANSYS WORKBENCH-2024 R1. These fins are utilized for air cooling systems for two wheelers. In present consider, Aluminum alloy is compared with Magnesium alloy. The different parameters (i.e., geometry and thickness of the fin) are considered, by decreasing the thickness and also by changing the shape of the fin to circular shape from the customary geometry i.e. rectangular, the weight of the fin body diminishes there by expanding the heat exchange rate and effectiveness of the fin.

7.2 Future Scope

The findings indicate that using a circular fin made of aluminum is preferable since the fin has a higher heat exchange rate. When compared to the current rectangular engine cylinder fin, the weight of the fin body is reduced by using circular fins.

The authors can acknowledge any person/authorities in this section. This is not mandatory.

REFERENCES

[1]. Biermann, A. E. and B. Pinkel (2024). Heat Transfer in an Airstream from Finned Metal Cylinders, NACA Report No. 488

[2]. J.C.Sanders, et al. (2024). NACA Report E-103: Cooling test of an air-cooled engine cylinder with copper fins in the barrel

[3]. Denpong, Soodphakdee, & associates, (2024). A comparison of fin geometries for heatsinks in laminar forced convection, part I: round, elliptical, and plate fins in staggered and in-line configurations, was published in the International Journal of Electronic Packaging and Microcircuits 24(1).

[4]. M. Alarcon and Fernando Illan (2024): "Optimization of Annular Cylindrical and Spherical Fins in an Internal Combustion Engine under Realistic Conditions" in Journal of Thermal Science and Engineering Applications.

[5]. A. Bassam and K. A. Hijleh (2024). "Enhanced forced convection heat transfer from a cylinder using permeable fins" ASME Journal of Heat Transfer 125.

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International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

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[6]. Yoshida Masao, et al. (2023). “Nippon Kikai GakkaiRonbunshu B Hen (Transactions of the Japan Society of Mechanical Engineers Part B) (Japan) 17(9): 2324-2330.”Air-Cooling Effects of Fins on a Motorcycle Engine."

[7]. C. Han-Taw and C. Jui-Che (2023). "Investigation of natural convection heat transfer coefficient on a vertical square fin of finned-tube heat exchangers." Heat and Mass Transfer International 49(17–18): 3034– 3044".

[8]. A. Mohammadi, et al. (2023). “Analysis of a spark ignition engine's local convective heat transfer "International Communications in Heat and Mass Transfer 35."

[9]. D.G.Kumbhar, et al. (2023) Utilizing Triangular Perforationsand Finite Element Analysis, this study examines the enhancement of convective heat transfer from a horizontal rectangular fin. Proceedings of the International Conference on Mechanical Engineering Advancements.

[10]. N.Nagarani and K. Mayilsamy (2023). " The article "ANNULAR CIRCULAR AND ELLIPTICAL FINS: AN EXPERIMENTAL HEAT TRANSFER ANALYSIS" was published in the International Journal of Engineering Science and Technology in 2007.

[11]. T. Pise and U. V. Awasarmol (2023)." The International Journal of Mechanical Engineering & Technology (IJMET) 1(1): 238-247, investigates "Enhancing Natural Convection Heat Transfer from Engine Cylinder with Permeable Fins."

[12]. P. Agarwal, et al. (2023). Through the use of CFD, heat transfer from the fins of an air-cooled motorcycle engine under various climate conditions is simulated. The World Congress on Engineering Proceedings.

[13]. (13)S. Barhatte, et al. (2023). " The article "Experimental and Computational Analysis and Optimization for Heat Transfer through Fins with Different Types of Notch" was published in the Journal of Engineering Research and Studies (E-ISSN 976: 7916)."

[14]. M. Matkar and P. M. Ravanan (2023).FEA thermal analysis of the copper fin.International Conference on Quantitative Management and Operations.India's Nasik.

[15]. M. H. Albana, H. L. Guntur, and A. B. K. Putra discuss the impact of grooves on an electric scooter's in-wheel motor cover to enhance the heat transfer process in the 2023 International Conference on Computer Science, Information Technology and Engineering (ICCoSITE), IEEE, Feb. 2023, pp. 84–89. 10.11691.2042.3076.2069.10127695