International Journal of Scientific Research in Science, Engineering and Technology
Print ISSN: 2395-1990 | Online ISSN : 2394-4099 (www.ijsrset.com)
doi : https://doi.org/10.32628/IJSRSET23103147

# A Review on Thermal Analysis of Engine Cylinder Fins by Varying Geometry

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**ARTICLEINFO**

**Article History:**

Accepted: 01 June 2023
Published: 18 June 2023

**Publication Issue**
Volume 10, Issue 3
May-June-2023

**Page Number**
507-516

**ABSTRACT**

Heat transfer by convection between a surface and the fluid surrounding can be increased by attaching to the surface called fins. The heat conducted through solids, walls, or boundaries has to be continuously dissipated to the surroundings or environment to maintain the system in a steady state condition. The cylinder of the engine is one of the key components of the vehicle and is prone to maximum temperature variation and thermal stress. To cool the cylinder, the cylinder fin is designed to improve the heat transfer rate. Thermal analysis is done on the engine cylinder fins; it is very useful to understand the heat dissipation in the cylinder. The idea applied in this project is to increase the heat dissipation rate by using intangible working fluid, just air. It is understood that the heat dissipation rate is increased by changing the surface region; therefore, it is very challenging to design such a huge complicated engine. In this project, the analysis of the engine fin is carried out for different geometries such as Rectangular, Triangular, convex, and Tapered fin. A 3D model is created in SolidWorks and analysis is done using ANSYS Software in steady state condition. The material used for the fin body is Al6063. The result is compared to find the best geometry which gives the maximum heat flux.

**Keywords :** Thermal Analysis, Heat transfer, Fins, Varying Geometry, SolidWorks, ANSYS Software.

## I. INTRODUCTION

External and internal combustion engines are the two types of engines. Internal Combustion Engines use a cylinder to burn an air-fuel combination. A combustible mixture is heated from the outside by an external combustible engine. As a result, hot gases with temperatures ranging from 2300 to 2500°C are produced, which are extremely hot and may cause engine damage if not dissipated. In order for the engine to perform correctly, this temperature should be elevated to around 140-200°C. Cooling the engine more than necessary is wasteful since it reduces the engine's thermal efficiency [1][2][3][4]. As a result, a cooling system is designed to keep the engine cool and operational. In the case of vehicles, the power source is the IC engine. The burning of gasoline inside the combustion chamber is what gives the IC engine its power. About 30% of the total energy generated inside the engine is accessible at the crankshaft in the form of propelling power, while the other 70% is lost to exhaustion in the environment[5][6][7]. The heat from the lubricating oil, exhaust gas, cooling water, and fins dissipates energy into the environment. The expanded surfaces that are supplied on the cylinder surface's perimeter for heat dissipation are known as IC engine fins [6][8][9]. Convection is the mechanism used for heat transmission from the engine to the atmosphere through the fin. The surface area must be expanded in order to improve the rate of heat transmission by fin. But it is not practical owing to space constraints. Therefore, the goal of this project is to make a few changes to the fin geometry and form in order to create the best design of fin geometry that can aid in enhancing heat dissipation. We can concentrate on changing the fin design by keeping these things in mind. It is necessary to use CFD Fluent and Ansys Workbench to validate the results in order to confirm them. This research essay was written after researching some international literature on a similar topic[10][11][12][13][14].

The car industry is one of the most intriguing and thrilling in the world. The race to produce new technologies with cutting-edge breakthroughs that meet consumer needs and expectations has spread to many fields. The engine's efficiency has a significant impact on how well the automobile operates[15]. The thermal stresses produced by the engine have a significant influence on all of the parts related to the combustion chamber. It is therefore critical to quickly dissipate the heat generated during combustion in order to optimise the engine's component lifespan and, as a result, the engine's efficiency[16][17]. Fins or enlarged surfaces around the periphery of standard air-cooled engines are used for this. Heat is transmitted from the inside of the cylinder to the outside via conductive heat transmission to the fins and convective heat transfer from the fins to the surroundings. As a result, maintaining the proper engine temperature is heavily dependent on the heat transfer rate. An enhanced heat transfer rate has been attained as a result of previous efforts. Because of recent advances in nanomaterials and their potential to broaden engine applications, researchers investigating engine cooling systems now have new areas to examine [18][14][19].

Figure 1: Engine cylinder [20]

## II. LITERATURE REVIEW

P. Teotia et al. The aforesaid research can be applied broadly when heat transmission is essential but space is limited. It may be utilised for stationary engines and motors in a variety of industries, machines, and other applications where space is limited and a high heat transfer rate is required. The aforementioned study may also be used to heat exchangers used in power plants, automotive radiators, CPU computer heat sinks, and other applications that require a high heat transfer rate in a small amount of area [3].

D. Srinivas et al. To demonstrate programming, I designed a recessed rectangular blade body for a Honda Unicorn Motorcycle and exhibited it in parametric 3D. For the balance body, Pro/Engineer Aluminium 2024 composite is now utilised. The balance is now rectangular; the shape has been adjusted to rectangular curved moulded. The standard blade thickness is 3mm, however it will be decreased to 2.5mm. By decreasing the thickness and altering the condition of the balance to bend generated, the heaviness of the blade body is lowered while the competence is raised. Furthermore, the weight of the blade body is lowered. They altered the shape and thickness of the balancing body in order to conduct a hot examination. The findings indicate that a Rectangular sunken balance manufactured of Aluminium composite 6061 with a width of 2.5mm works well since the heat exchange rate is higher. The weight of the blade body is reduced when rectangular curved balances are used. In terms of weight, bended blades are preferable to alternative geometries. As a consequence, we can infer that combining Aluminium 2024 is better, that decreasing width to 2.5mm is better, and that consuming a balance shape rectangular inward by inquiry and a blade form bent by weight is better. The results show that using curved blades enhances the quantity of heat emitted, as well as productivity and adequacy [6].

In the thesis by D. Srinivas et. al. uses CFD analysis to obtain thermal characteristics by changing the geometry, material, and thickness of the cylindrical fin. Model is developed of different geometric shapes using Pro-E software, such as rectangular, circular, and curved fins. The material used to manufacture the cylindrical fin body is aluminum alloy 204 with thermal conductivity of 110-150W/m K. It also analyzes different materials such as magnesium, aluminum 6061. They concluded that aluminum alloy 6061 is better, it is better to reduce the thickness to 2.5mm, and it is better to use round fins and fins that are bent by weight through analysis [8].

K. Angamuthu et al. A 100 cc motorcycle engine cylinder with grooves and holes is modelled and simulation tests are performed using Auto Desk Fusion360 to analyse the heat transmission rate. Aluminium cast alloy AA 1060, AA2014-T6, A356, cast iron with 2.0% magnesium alloy AM60A-F, nickel, and Sintered Aluminium Powder are used to make the cylinder block and fins. The groove widths are 2.50 mm, 5.0 mm, 7.50 mm, and 10.0 mm while the perforations in the fins have sizes of 2.0 mm, 3.0 mm, 4.0 mm. In all models, a thermal load of 350 °C is applied, and the temperature distribution is determined. The minimal temperature obtained in all models during the simulation trials suggests that the cylinder block with varied fin configurations has improved heat transmission capabilities [9].

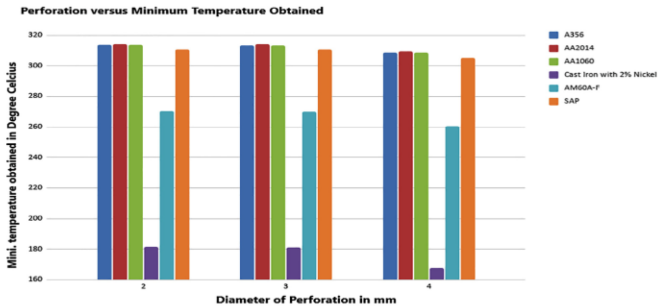


Figure. 2. Perforation versus minimum temperature obtained [9]

S.K. Mohammad Shareef et al. Temperature and thermal stress vary throughout the engine cylinder. Fins are used on engines to increase the rate of heat transmission. To boost the heat transmission rate, fins are utilised on the surface of the engine cylinder. The rate of heat dissipation in engine cylinder fins may be increased by increasing their surface area. The primary goal of this numerical study is to evaluate the thermal characteristics of an engine cylinder by altering profile, material, and the geometry of the cylinder fins using Ansys workbench. SolidWorks was used to generate the models. In this study, three fin profiles for engine bodies were compared: angular profile, circular profile, and rectangular profile. An angular fin shaped engine body saves more than 60% of the weight of an original fin profile engine body. The highest heat flow value is attained for an angular profiled fin at the lowest feasible temperature [11].

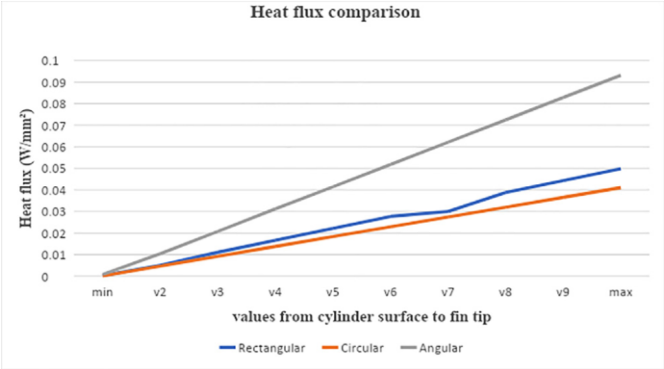


Figure. 3. Comparison of heat flux with different shapes [11].

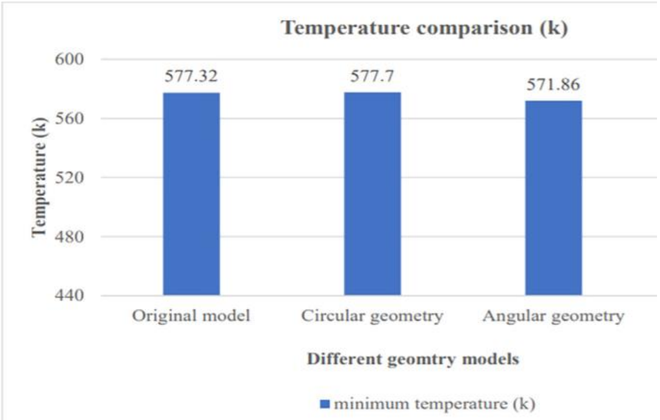


Figure. 4. Comparison of different fin profiles and temperature [11].

In the paper by Divyank Dubey et. al. Fins are extended surfaces that assist disperse heat created in the engine in numerous automotive sectors; however, the length of these extended surfaces is restricted, limiting the rate of heat dissipation. Various automotive industries strive to improve this heat dissipation rate, which can increase engine efficiency. This article is trying to increase the heat dissipation rate of these extended surfaces by increasing the tip thickness of the engine fins by about 3mm and providing the slot of 10.00cm, 7.5 cm, 5.0cm, and. A comparative analysis of aluminium alloy 2014, aluminium alloy C443, and aluminium alloy 6061, was carried out. Carried out 3D modelling on Solidworks and analyzed on ANSYS. They conclude that the heat dissipation rate is more for aluminium 2014 keeping the slot at 75mm [17].

In the paper by Sandhya Mirapalli et. al. heat is transferred between the surface and the enclosed fluid through a convection process, and the heat can be enhanced by joining to a surface called a fin. It is carried out the analysis of triangular fin by taking rectangular and triangular fin of length 6cm to 14cm and temperature varied from 2000C to 6000C. They concluded that the heat transfer for the triangular fin is higher as compared to the rectangular fin. But efficiency is decreased and effectiveness for the triangular fin is better, hence the preferred triangular fin over the rectangular fin [18].

Deepak Gupta et. al. discussed about the cooling technology based on air-cooled engines, which are mainly based on the structure of the cylinder block and cylinder head. Cooling is based on heat transfer and the effect that can be enhanced by cooling the engine. This article studies and compare with the Hero Honda motorcycle heat sink and analyzes the thermal performance by changing the thickness, material, and geometry. The shape of the fin is a rectangular, circle. The thickness of the heat sink is 3mm, 2.5mm. The software used here is ANSYS. They conclude that the heat dissipation is more for a circular fin with 2.5mm thickness [20].

R. Raveena et. al. this research looked at the thermal analysis of an engine block with fins. By doing thermal analysis on cylinder block caps, you may learn about heat dispersion inside the cylinder. Fins are mechanical devices that are utilised by the convection technique to cool various structures. The majority of their layout is largely constrained by system layout. Some characteristics and shape, however, might be altered to optimise heat transmission. In most cases, simple fin designs such as curved and rectangular fin are selected. Numerous experiments have been conducted in order to improve the fins and block were subjected to continuous thermal analysis to evaluate the transient state temperature variations with gaps. Thermal analysis is carried out using the ANSYS programme [21].

Mishra A.K. et al. The heat release from the cylinder was originally examined for zero wind speed using a temporary numerical simulation with a wall cylinder temperature of 423 K. The experimental results validate the heat escape from the numerically computed cylinder. To improve cylinder cooling, the cylinder must contain more pins. Yet, as the number of pins grows and the fin pitch narrows, cylinder cooling can be reduced [22].

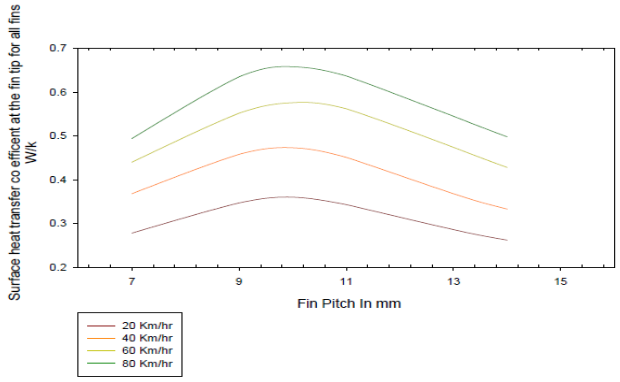


Figure 5. Heat dissipated by fins moving at varying speeds from the tip [23]

The air-cooled engine of a motorbike elaborates the temperature of the surroundings using the process of forced convection, according to a research study on Heat transfer analysis and optimisation of engine fins of different shape published by Pulkit Sagar et al. The fin allows the relaxing breeze to penetrate its environment. The technique used to determine the effect of heat sink structure, shape, and unevenness on heat transmission. The major goal of this article is to investigate heat transmission by varying the form, such as plane, concave, and convex, as well as the surface stiffness and roughness. INVENTOR 2015 was utilised in this work, and it was simulated using Autodesk Nastran. The primary goal of this paper is to examine heat transmission. They determined that the convex fin provides improved heat transmission [24].

In the research paper published by P. Harish. the main goal is to investigate the heat features by changing the material, geometry, and the major gaping between the fins. The parameter of the replica of the cylinder is to forecast the nature of thermal transient. The replica is presented by changing the shape circular and also by changing the geometry the size of the cylinder will be changed. The 3D modeling software is used Pro/Engineer and for thermal analysis in ANSYS. The thermal analysis is done through this software which obtains temperatures and other thermal constraints. The precise thermal simulation can be permitted through complicated construction a constraint which is to be recognized for enhanced lifestyle. Currently, the material which is utilized for the manufacturing of the fin of the cylinder is cast iron. In this research work, the copper and aluminum alloy materials to be tested are used. The heat detection is done through all the triple materials. The conductivity of copper is more than anyone others. The mass of aluminum is less as compared to other materials [25].

Magarajan U et al. Heat release from Internal Combustion engine cylinder cooling fin with six fins with pitch of 2.0 cm and 1.0 cm is computed numerically. The IC engine is initially set to 150 °C, and the heat emission from the cylinder is measured at 0 KM/hr. It has been discovered that CFD and experimental work are almost identical. CFD and experimental findings may be used to alter the fin geometry and anticipate the results. Changes in fin geometry, such as tapered fins with slits and holes[26].

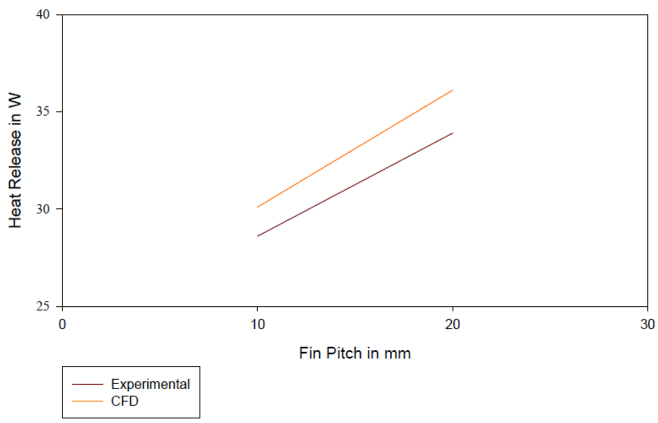


Figure. 6. Comparison between CFD and experimental results[26]

Bade Yellaji et. al. the majority of air compressors are either reciprocating piston or rotary vane screw. Centrifugal compressors are commonly used in big applications such as providing high-pressure clean air to fill gas cylinders and providing a huge volume of intermediate pressure air to operate pneumatic tools. Heat may be created in an air compressor in two ways: frictionally and by compressing air at high pressure. As a result, this heat will be transferred to the atmosphere via fins. Engineers are especially interested in learning how specific extended surfaces or fin configurations might optimise heat transmission from a surface to the surrounding fluid. Simulated the analysis by FEM. In this work the geometrical shapes were changed geometrical shapes of fins for analysis and choose most efficient cooling fin. The methodology used in this phenomenon is the FEM. It is a very crucial numerical approach used in engineering analysis [27].

G. Krishna Bharath et al. A 2-stroke IC finned engine's heat transport from the cylinder to the air was modelled. The body, head (both with fins), and piston have all been analytically evaluated and optimised for size. The limiting condition has been set to the greatest temperature allowable at the engine's hottest point. Based on a previous study's No-dimensional ignition model, the cooling structure design of a two-stroke air-cooled internal combustion engine was enhanced in this study by minimising the engine's total capacity [28].

In the research carried out by G. Ashok Kumar et. al. the main principle of execution is to increase heat loss by using hidden fluid in the air. Thereby complicating the structure of a complex engine. The main alloy which is extensively used is aluminium which is replaced by aerodynamic fins and sometimes it is replaced by magnesium alloy. The main software used here is UNI-Graphics (NX) software which is used for changing variations in temperature by changing the geometry and materials. This paper compares and analyzes the materials and heat fluxes of straight fins and pneumatic fins. They conclude that the heat flux and temperature distribution are more for aerodynamic fins[29].

Prof. Arvind S. Sorathiya et. al. Discussed about the fins, shape and geometry of the cylinder engines, automobiles, and the mechanism behind heat transfer. The study briefly explained the material cost of the heat sink. Compared with the solid heat sink of the same heat transfer rate, the cost of the heat sink in the permeable heat sink is 10-30% lower [30].

Rajvinder Singh et. al. performed an analysis on the heat sink of the vehicle depending on the surface area and transfers heat from the system to the surrounding environment by enhancing heat transfer. The transference of heat relies upon the speed of the vehicle and the geometry of the fin. The main purpose of this article is to enhance the heat transfer rate from enhanced fins to changed geometry and size of the fins with slot cut and the alloy of aluminum 6061. Which are assumed to be conducted in its surface area. The software used here is the ANSYS 16.0. [31].

C Siva et. al., by changing the fin profile from a rectangular ring fin to a tapered profile, the rate of conduction heat transfer can be increased. Research the performance of fins through experiments and theory. Use ANSYS WORKBENCH to conduct thermal analysis on the fin. They concluded that the rectangular profile to be better [32].

In the article by Manish Kumar et. al. described the phenomena of heat transfer circumstances by using various methods. Convection process in which heat is transferred through multiple methods, in the case of a motorcycle engine, the fins can be in different positions and can be fixed and in motion. The dependency of heat coefficient of any medium is the relation of various numbers fin with an aspect of the location of the body. Finned heat transfer is determined as transient or steady-state according to the situation, and involves forced convection and natural convection to enhance heat transfer [33].

Rajeev P Patil et al. the influence of forced convection on heat transfer coefficient, heat transfer parameter, and tube efficiency of elliptical fins has been studied using experimental methods and CFD methods in this work. The heat transmission parameter was investigated under various operating conditions. The experiment was conducted at various air flow rates [34].

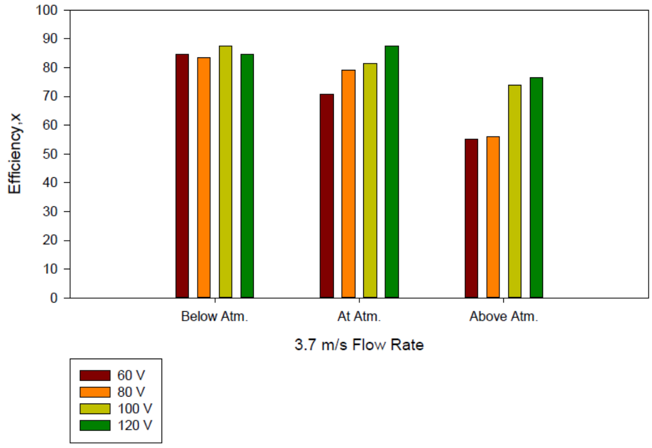


Figure 7. Efficiency at different environmental conditions [34]

In the paper by Dr. I. Satyanarayana et. al. it is explained that in automobile parts, the engine cylinder is the main part, which bears thermal stress and high-temperature chang. The principle of project implementation is to improve the heat dissipation rate by conducting thermal analysis and using the working fluid of air. Currently, the material used to manufacture the cylinder head fin body is aluminum alloy AL204, which is replaced by AL1060, AL6061, and magnesium alloys with higher thermal conductivity. The main purpose of this work is to improve heat transfer by changing the geometry such as rectangular, triangular, thickness, wind speed, and material of the cylinder block fins by using solid work and transient thermal analysis were done and it is concluded that triangular to be better [35].

In the research paper by K. Sivaramakrishnan et. al. it is investigated that thermal dissipation of heat from the engine cylinder fin for the high rate of cooling. It can be analyzed by changing the geometry applied different materials to it. The geometric shapes used in this analysis, such as rectangles, helical, circular, tapered, longitudinal, angular, and the materials used such as gray cast iron and aluminum alloy 6061. The model was created by Creo 3.0 and thermal analysis was performed on Ansys Workbench 16.1. Based on the analysis circular fin with Aluminum Alloy 6061 has the maximum thermal dissipation and high rate of cooling [36].

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## III. Conclusion

The engine cylinder is a critical engine component that is subjected to high temperatures and heated loads. To enhance heat exchange via convection, fins are placed on the surface of the heat source. Surveys on heat exchange change and proportionate weight decrease across a flat surface were conducted in the current study. Thermal resistance is one of the various thermal execution characteristics. In the heat exchange execution of fins models, the impacts of geometric limitations, fin length, fin breadth, and fin material with regard to surrounding temperature variation have been determined, as has the optimal fin partition value. It is explored how fin thickness affects heat exchange performance. The thermal conductivity of the material and the length of the fins further improve heat exchange.

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**Cite this article as :**

Rudra Devraja, Dr. Sumita Chaturvedib, " A Review on Thermal Analysis of Engine Cylinder Fins by Varying Geometry, International Journal of Scientific Research in Science, Engineering and Technology(IJSRSET), Print ISSN : 2395-1990, Online ISSN : 2394-4099, Volume 10, Issue 3, pp.507-516, May-June-2023. Available at doi : https://doi.org/10.32628/IJSRSET23103147
Journal URL : https://ijsrset.com/IJSRSET2310314