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Heat Transfer Analysis of Engine Cylinder Fins-A Review

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A B S T R A C T

One of the key parts of a car that is subjected to significant thermal stresses and high-temperature variations is the engine cylinder. To enhance the quantity of heat expelled by convection, fins are installed on the cylinder surface. In order to optimize the improvement in heat transfer efficiency, the current research described the enhancing assessments of heat dissipation and the consequent stress reductions across a flat surface in various motor cylinder types.Fins are positioned on the cylinder's surface to accelerate convectional heat transfer in order to cool the cylinder. Knowing how much heat is dissipated inside the engine cylinder by doing thermal analysis on the cylinder fins is useful. Designing such a massive, complex engine is exceedingly challenging since we know that increasing surface area would enhance the pace at which heat is dissipated.The thermal conductivity of the material and the geometry of the pins both promote heat transmission.The primary goal of the current article is to use the ANSYS workbench to alter the shape and thickness of cylinder fins in order to investigate the temperature distribution.

Keywords:Thermal Analysis, Heat transfer, Extended Surfaces, fins,ANSYS Software, SolidWorks.

1. Introduction

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. The heat from the cooling water, exhaust gas, lubricating oil, 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. 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 Ansys Workbench & CFD Fluent to validate the results in order to confirm them. This review essay was written after researching some international literature on a similar topic.

The automobile sector is one of the most exciting and fascinating in the world. The competition for developing new technologies with cutting-edge innovations that fulfill user requirements and expectations has expanded to many realms. The effectiveness of the engine has a major impact on how well the car performs. All of the parts connected to the combustion chamber are greatly impacted by the thermal stresses that the engine produces. It has become crucial to swiftly disperse the heat produced during combustion in order to maximize the engine's component lifespan and, as a result, the engine's efficiency. Fins or the expanded surfaces at the perimeter of typical air-cooled engines are utilized for this. Through conductive heat transmission to the fins and convective heat transfer from the fins to the surroundings, heat is transferred from the inside of the cylinder to the outside. Therefore, maintaining the appropriate engine temperature depends greatly on the heat transfer rate. An improved heat transfer rate has been achieved as a result of extensive effort done in the past. Software like Pro-E, ANSYS, and MATLAB, which are readily available, have tremendously aided in understanding the heat distribution for varied fin shapes with various material compositions, allowing for efficient fin optimization for a certain engine. Researchers studying engine cooling systems now have new avenues to explore thanks to recent developments in nanomaterials and their potential to expand engine applications.

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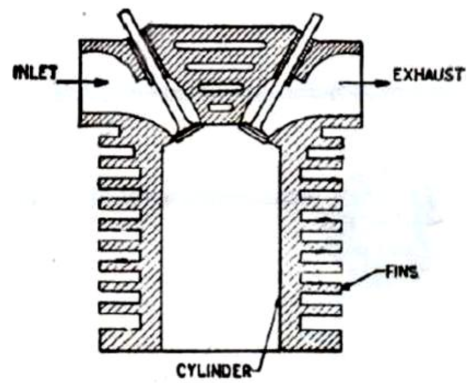

Figure 1: Engine cylinder [18]

2. Literature review

In a research paper on Heat transfer analysis and optimization of engine fins of varying geometry published by Pulkit Sagar et. al. [2] the air-cooled engine of a motorcycle elaborates the warmth of the surroundings by the method of forced convection. The fin permits the soothing wind to enter its ambiance. The technology involved in obtaining the influence of structure, different shapes, and unevenness of heat sinks on heat transfer. The main purpose of this article is to study heat transfer by changing the shape such as plane, concave, and convex, and surface stiffness roughness. Here the software used in this paper is INVENTOR 2015 and it has been simulated in Autodesk Nastran 2015. The main purpose of this article is to analyze heat transfer. They concluded that the heat transfer for the convex fin is better.

BN Niroop Kumar Gowd et. al. [3] analyzed the thermal performance by changing the geometry, material, and thickness of the cylindrical fins. A parametric model of the cylinder with fins has been developed to predict transient thermal behavior. Create models by changing geometric shapes, rectangles, circles, and curved fins. The current thickness of the fin is 3mm, reduced to 2.5mm. The 3D modeling software used is pro / Engineer and analysis is done in Ansys. Aluminum alloy 204 with the other three materials has more thermal conductivity than the aluminum alloy 204 used. These materials are aluminum alloy 7075, magnesium alloy, and beryllium. They conclude that the heat flux is more for beryllium and also for reducing the thickness of fin 2.5mm.

In the research carried out by G. Ashok Kumar et. al. [4] the main principle of execution is to increase heat loss by using hidden fluid in the air. It is well known that by increasing the surface area, the heat loss rate can be increased, 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.

In the research paper published by T. Uma Santhosh et. al. (2017) [5].the main goal is to investigate the heat features by changing the geometry, material, 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. It is observing the thermal analysis result; heat flux is more for aluminum than the other two materials.

Rajvinder Singh et. al. [8] 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. They concluded that by reducing the thickness of the fin, the heat transfer rate is increased.

In the paper by Sandhya Mirapalli et. al. [14] 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.

Bade Yellaji et. al. [15] 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 finite element method (FEM). It is a very crucial numerical approach used in engineering analysis.

In the thesis by G. Babu et. al. [18] 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 aluminum 6061, magnesium. 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.

In the paper by Divyank Dubey et. al. [19] the several automotive industries, fins are extended surfaces that help dissipate the heat generated in the engine, but the length of these extended surfaces is limited, which limits 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 50mm, 75mm, and 100mm. A comparative analysis of aluminium alloy 6061, aluminium alloy C443, and aluminium alloy 2014 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.

Deepak Gupta et. al. [21] discussed about the cooling technology based on air-cooled engines, which are mainly based on the structure of the cylinder head and cylinder block. 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 geometry, material, and thickness. A parametric model of the cylinder with fins has been developed to predict transient thermal behavior. 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.

Prof. Arvind S. Sorathiya et. al. [23] Discussed about the fins, geometry, and shape 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.

In the research paper of heat transfer analysis in annular fin with the tapered profile used in IC engine published by C Siva et. al.[24], the rate of heat transfer of the IC engine will be increasing with the help of changes in surface area and profile. 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.

In the paper by Dr. I. Satyanarayana et. al. [25] it is explained that in automobile parts, the engine cylinder is the main part, which bears high-temperature changes and thermal stress. To cool the cylinder, heat sinks are arranged on the surface of the cylinder to increase the heat transfer rate. 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.

In the article by Manish Kumar et. al. [26] 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 steady-state or transient according to the situation, and involves natural convection and forced convection to enhance heat transfer.

In the research paper by K. Sivaramakrishnan et. al. [27] 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.

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4. Conclusion

The engine cylinder, one of the most important components, is exposed to extreme temperature variations and heated loads. To improve heat exchange through convection on the outer layer of the engine cylinder, fins are installed on the bottom of the heat source layer. According to the literature review, the conductive and convective heat transfer rates of the fins depend on the material, the geometry of the profile, the number of fins, the pitches, the coating, etc. Thermal resistance is one of the distinctive features of the various heat executions. In the execution of fine designs, heat exchange, and the selection of the ideal final partition value, the impacts of geometric constraints, temperature generation within the cylinder, and heat dissipation structure in models with nearby temperature ranges were addressed.Altering the current fin profiles with complex geometry requires time-consuming procedures. The fins have been coated with nanomaterials, but no substantial study has been done on them too far.

Acknowledgements

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