ISSN: 2455-6203
International Journal of Science Management & Engineering Research (IJSMER)
Volume: 08 Issue: 02 | July - 2023 www.ejournal.rems.co.in

Thermal Analysis of Engine Cylinder with Fins using ANSYS Workbench

Gaurav Verma[#1], **Hariom Khare** [#2]
[#1]*M.Tech scholar, Ojaswini Institute of Management and Technology, Damoh, Madhya Pradesh, India.*
[#2]*Assistant Professor, Mechanical Department, Ojaswini Institute of Management and Technology, Damoh, Madhya Pradesh, India.*
[1]verma.gaurav2211@gmail.com, 2hariom14071989@gmail.com

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 work is to analyze the thermal properties like Directional Heat Flux, Total Heat Flux and Temperature Distribution by varying Geometry (Circular, Rectangular), material (aluminum alloy, magnesium alloy) and thickness of Fin (3mm,2mm) of an approximately square cylinder model prepared in SOLIDWORKS which is imported into ANSYS WORKBENCH 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 Conditions.

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

I. INTRODUCTION

In recent times, there has been a significant demand for high-performance, lightweight, compact, and efficient heat exchange components. Among these, the use of fins has been recognized as one of the most effective methods for enhancing heat distribution. The design criteria for fins may vary depending on the application, but the primary concerns are weight and cost. Therefore, there is a strong desire to improve the efficiency of fins. The goal is to find the optimal dimensions that allow for maximum heat dissipation while minimizing the weight or mass of the fin.

One of the most effective ways to enhance heat transfer is by increasing the surface area using fins. In the case of internal combustion (IC) engines, heat transfer occurs within the engines themselves, typically during the combustion of fuel and air. IC engines convert the energy of the fuel into mechanical work, and as a result of this process, excess heat needs to be removed from the system. This heat is usually dissipated to the surrounding environment through a fluid medium like water and air.

The cylinder is a critical component in an IC engine, subject to high-temperature variations and thermal loads. To cool the cylinder efficiently, fins are added to its surface to increase the rate of heat transfer. Fins are essentially mechanical structures used for cooling various systems through convection and conduction. Enhanced fins are well-known for improving heat transfer in IC engines. Implementing an air cooling system with fins is relatively straight forward. Therefore, it is crucial to utilize the fins effectively in an air-cooled engine to achieve a uniform temperature distribution in the cylinder.

An internal combustion engine is an engine in which the fuel combustion takes place in a combustion chamber. As a result of this combustion, high-temperature and high-pressure gases are produced, which exert direct force on engine components such as pistons, turbine blades, or nozzles. This force is transferred to the components over a distance, generating useful mechanical energy.

1. Heat Exchange Components and Fins:

In various industries and applications, there is a growing demand for heat exchange components that are high-performance, lightweight, compact, and efficient. These components are used to transfer heat from one medium to another, such as from a hot fluid to a cooler fluid. One of the most effective heat exchange components is the fin. Fins are thin, elongated structures attached to the surface of a heat-conducting material (like a metal) to increase the surface area available for heat transfer. This design allows for more efficient heat dissipation, making fins crucial in applications where heat management is critical.

2. **Optimal Dimensions for Fins:**
   The goal in designing fins is to find the optimal dimensions that achieve maximum heat dissipation while minimizing weight and cost. By maximizing the surface area while keeping the weight and material usage in check, engineers can create efficient and cost-effective heat exchange systems. These considerations are particularly important in industries where weight and cost savings can lead to significant improvements in performance and overall efficiency.

3. **Heat Transfer in Internal Combustion (IC) Engines:**
   Internal combustion engines are commonly used in vehicles, power generation, and other applications. They work by igniting a fuel-air mixture within a combustion chamber, which generates high-temperature and high-pressure gases. These gases exert force on engine components, such as pistons, causing them to move and produce mechanical work. However, the combustion process also generates excess heat that needs to be managed to avoid damage to the engine and ensure optimal performance.

4. **Cooling Pistons with Fins**:
   One critical component of an internal combustion engine is the piston, which undergoes significant temperature variations and thermal loads during engine operation. To prevent overheating and ensure efficient operation, fins are added to the piston's surface. The fins increase the surface area of the piston, facilitating more effective heat transfer to the surrounding environment. This cooling mechanism helps maintain a stable operating temperature for the engine and improves overall efficiency.

5. **Air-Cooled Engines and Uniform Temperature Distribution:**
   In some internal combustion engines, a simpler cooling system is employed, known as air-cooling. Air-cooled engines utilize the surrounding air to dissipate heat from the engine components. Fins play a crucial role in air-cooled engines, as they enhance the heat transfer process. Properly designed and positioned fins ensure a uniform temperature distribution in the engine, preventing localized overheating and potential damage to critical components.

6. **Mechanical Energy Generation**:
   The process of converting the high-temperature and high-pressure gases produced during combustion into useful mechanical energy is central to the operation of internal combustion engines. This mechanical energy drives the engine's components, leading to the rotation of crankshafts and power generation in various applications.

In summary, the effective use of fins in heat exchange systems, particularly in internal combustion engines, is essential for maintaining optimal operating temperatures, improving efficiency, and ensuring the reliable performance of various mechanical systems. Engineers continuously strive to optimize fin designs to achieve the best balance between heat transfer efficiency, weight, and cost, leading to advancements in numerous industries and applications.

II. COMPUTATIONAL FLUID DYNAMICS

Computational fluid dynamics (CFD) is a computer-based simulation method for analyzing fluid flow, heat transfer, and related phenomena such as chemical reactions. This project uses CFD for analysis of flow and heat transfer. Some examples of application areas are: aerodynamic lift and drag (i.e. airplanes or windmill wings), power plant combustion, chemical processes, heating/ventilation, and even biomedical engineering (simulating blood flow through arteries and veins). CFD analyses carried out in the various industries are used in R&D and manufacture of aircraft, combustion engines, as well as many other industrial products. It can be advantageous to use CFD over traditional experimental-based analyses, since experiments have a cost directly proportional to the number of configurations desired for testing, unlike with CFD, where large amounts of results can be produced at practically no added expense. In this way, parametric studies to optimize equipment are very inexpensive with CFD when compared to experiments.

1. CFD Computational Tools:

This section describes the CFD tools required for carrying out a simulation and the process one follows in order to solve a problem using CFD. The hardware required and the three main elements of processing CFD simulations: the pre-processor, processor, and post-processor are described. To run a simulation, three main elements are needed:

Pre-processor: A pre-processor is used to define the geometry for the computational domain of interest and generate the mesh of control volumes (for calculations). Generally, the finer the mesh in the areas of large changes, the more accurate the solution. Fineness of the grid also determines the computer hardware and calculation time needed. The open-source pre-processor used for this project is called Salomé.

Solver: The solver makes the calculations using a numerical solution technique, which can use finite difference, finite element, or spectral methods. Most CFD codes use finite volumes, which is a special finite difference method. First the fluid flow equations are integrated over the control volumes (resulting in the exact conservation of relevant properties for each finite volume), then these integral equations are discretized (producing algebraic equations through converting of the integral fluid flow equations), and finally an iterative method is used to solve the algebraic equations. (The finite volume method and discretization techniques are described more in the next sections)

Post Processor: The post-processor provides for visualization of the results, and includes the capability to display the geometry/mesh, create vector, contour, and 2D and 3D surface plots. Particles can be tracked throughout a simulation, and the model can be manipulated (i.e. changed by scaling, rotating, etc.), and all in full colour animated graphics. Para View is the open-source post-processor used for this project.

2. Basic Steps To Perform CFD Analysis:

CAD Modeling: Creation of CAD Model by using CAD modeling tools for creating the geometry of the part or assembly of which you want to perform FEA.CAD model may be 2D or 3D.

Meshing: Meshing is a critical operation in CFD. In this process, the CAD geometry is discretized into large numbers of small Element and nodes. The arrangement of nodes and element in space in a appropriate manner is called mesh. The CFD analysis accuracy and duration depends on the mesh size and orientations. With the increase in mesh size (increasing no. of element), the CFD analysis speed decrease but the accuracy increase.

Type of Solver*:* Choose the solver for the problem either Pressure Based or density based solver.

Physical model*:* Choose the required physical model for the problem i.e. laminar, turbulent, energy, multiphase, etc.
Material Property: Choose the Material property of flowing fluid.

Boundary Condition*:* Define the desired boundary condition for the problem i.e. velocity, mass flow rate, temperature, heat flux etc.

3. Solution:

Solution Method: Choose the Solution method to solve the problem should be First order, second order.

Solution Initialization: Initialized the solution to get the initial solution for the problem.

Run Solution: Run the solution by giving no of iteration for solution to converge.

Post processing: For viewing and interpretation of result. The result can be viewed in various formats, graph, value, animation etc.

III. GEOMETRY SETUP AND MODELLING

The ANSYS Workbench interface consists primarily of a Toolbox region, the Project Schematic, the Toolbar, and the Menu bar. Depending on the analysis type and/or application or workspace, you may also see other windows, tables, charts, etc. One way to work in ANSYS Workbench is to drag an item such as a component or analysis system from the Toolbox to the Project Schematic or to double-click on an item to initiate the default action. a right analysis is the Project Schematic, including all connections and links between the systems. The individual applications in which you work will display separately from the ANSYS Workbench GUI, but the results of the actions you take in the applications may be reflected in the Project Schematic.

Assumptions for Analysis

- The temperature of the surrounding air does not change significantly.
- Constant heat transfer coefficient is considered at the air side.
- The heat generation is neglected.
- Loads are constant.
- Most of physical properties are constant

1. Modelling of Cylinder Fin

Cylinder along with fin was modeled in cylinder along ratio is unity. Fins with different geometries (circular and rectangular) were modeled.

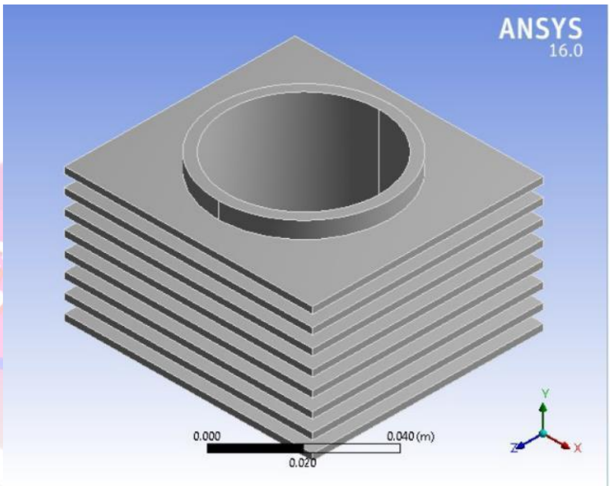


Fig. 1 Cylinder Fins.

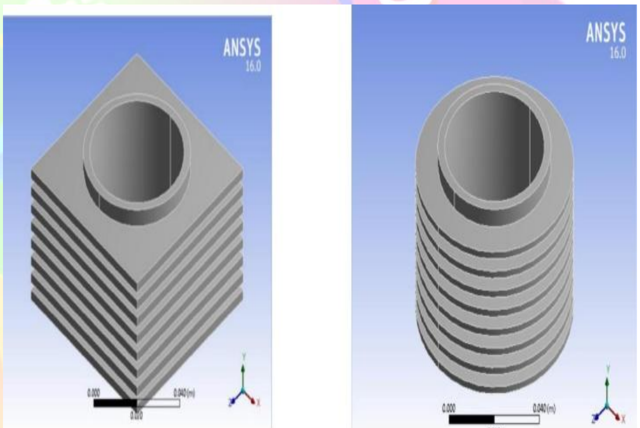
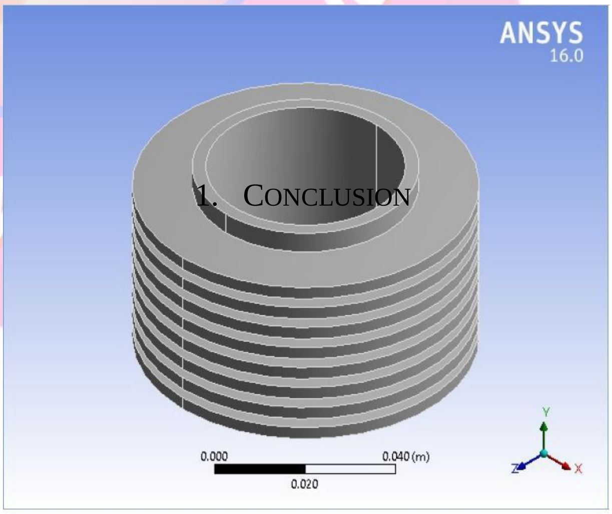


Fig. 2 Rectangular fins of 3mm and 2mm thickness.



1. CONCLUSION

Fig. 3 Circular fins of 3mm thickness.

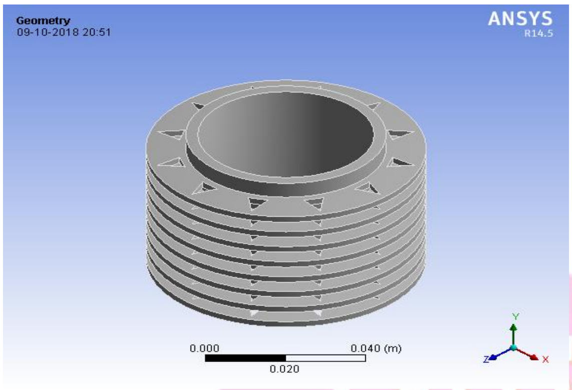


Fig. 4 Geometry Of Cylindrical Block Having Circular Fins With Triangular Holes.

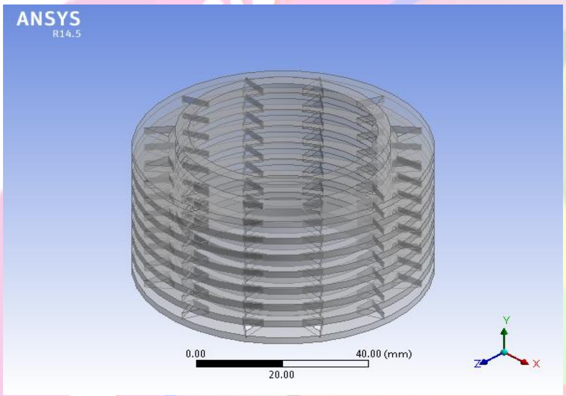


Fig. 5 Circular Cylinder FIN.

IV. RESULTS

A model of cylinder with fins mounted on it is used for analysis in the present project. This is imported into ANSYS workbench environment and boundary conditions were applied as mentioned above. Analysis is carried out for different geometry of fins (circular and rectangular)with various thicknesses and materials. The results are shown below:

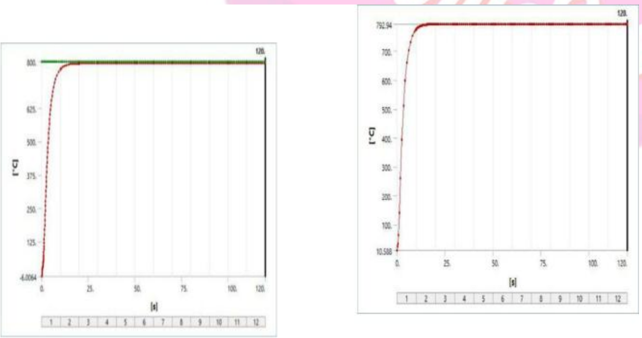


Fig 6. Time verses Temperature graph of Model_1 and Model_2.

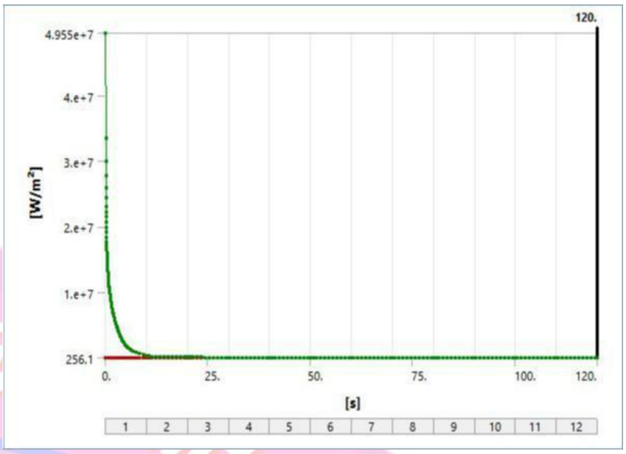


Fig7. Time verses Total heat flux graph of Model-1.

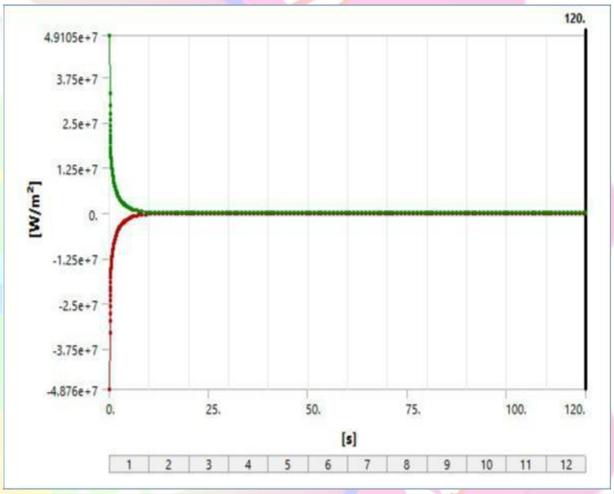


Fig 8. Time verses Directional heat flux graph of Model-1

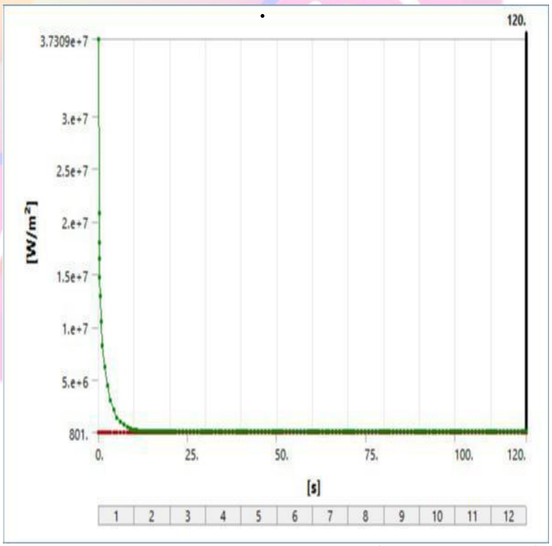


Fig 9. Time verses Total heat flux graph of Model-2.

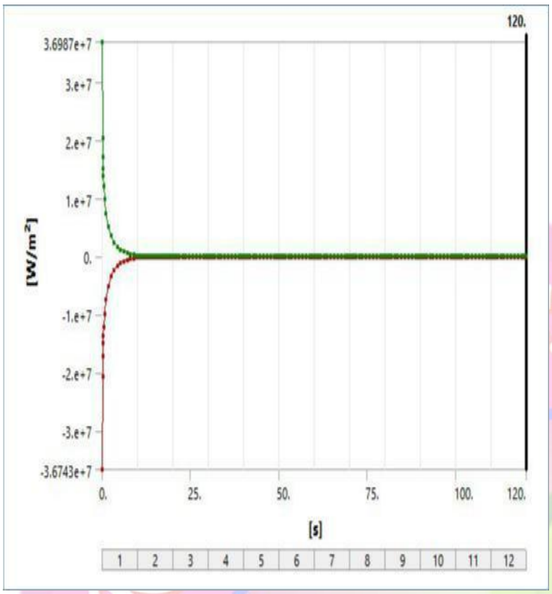


Fig 10. Time verses Directional heat flux graph of Model-2

V. CONCLUSION

We focused on modeling a cylinder fin body using SOLIDWORKS and conducting transient thermal analysis through ANSYS WORKBENCH.

These fins are intended for air cooling systems in two-wheelers. Specifically, we compared the performance of two different materials:
Aluminum alloy and Magnesium alloy.

Throughout the investigation, we explored various parameters, including the geometry and thickness of the fins. By reducing the fin thickness and altering the fin's shape from the conventional rectangular design to a circular one, we achieved a significant reduction in the weight of the fin body. This reduction in weight led to a substantial increase in the heat transfer rate and overall efficiency of the fin.

The findings of this study underscore the importance of optimizing the design of cylinder fins for air cooling systems. The use of lighter materials and improved geometries can enhance heat transfer capabilities, making the cooling system more effective and efficient for two-wheelers.

These results have practical implications for the automotive industry and highlight the potential for developing more advanced and efficient air cooling systems. By continuing to explore and fine-tune the design of cylinder fins, we can pave the way for improved performance, fuel efficiency, and sustainability in two-wheeler vehicles.

It is essential to note that the current study focused on a specific set of parameters and materials. Future research could expand the scope by investigating additional factors, such as different materials, fin shapes, and operating conditions, to gain further insights and advancements in the field of air cooling system design. By continuously pushing the boundaries of engineering and technology, we can contribute to a greener and more energy-efficient transportation landscape.

REFERENCES

[1]. Biermann, A. E. and B. Pinkel (1934). Heat Transfer from finnedmetal cylinders in an air stream, NACA Report No.488

[2]. J.C.Sanders, et al. (1942). Cooling test of an air-cooled engine cylinder with copper fins on the barrel, NACA Report E-103

[3]. Denpong Soodp hakdee, et al. (2001). "A Comparison of Fin Geometries for Heatsinks in Laminar Forced Convection Part 1 - Round, Elliptical, and Plate Fins in Staggered and In-Line Configurations."The International Journal of Microcircuits and Electronic Packaging 24(1).

[4]. Fernando Illan and M. Alarcon (2002)."Optimization of Annular Cylindrical and Spherical Fins in an Internal Combustion Engine under Realistic Conditions."Journal of Thermal Science and Engineering Applications 2.

[5]. A. Bassam and K. A. Hijleh (2003)."Enhanced Forced Convection Heat Transfer from a Cylinder Using Permeable Fins."ASMEJournal of Heat Transfer 125.

[6]. Yoshida Masao, et al. (2005). "Air-Cooling Effects of Fins on a Motorcycle Engine." Nippon Kikai GakkaiRonbunshu B Hen (Transactions of the Japan Society of Mechanical Engineers Part B) (Japan) 17(9): 2324-2330.

[7]. C. Han-Taw and C. Jui-Che (2006). "Investigation of naturalconvectionheat transfer coefficient on a vertical square fin of finned-tube heat exchangers." International Journal of Heat and Mass Transfer 49(17-18): 3034-3044.

[8]. A. Mohammadi, et al. (2008). "Analysis of local convective heat transfer in a spark ignition engine."International Communications in Heat and Mass Transfer 35.

[9]. D.G.Kumbhar, et al. (2009). Finite Element Analysis and Experimental Study of Convective Heat Transfer Augmentation from Horizontal Rectangular Fin by Triangular Perforations.Proc.Of the International Conference on Advances in Mechanical Engineering.

[10]. N.Nagarani and K. Mayilsamy (2010). "EXPERIMENTAL HEAT TRANSFER ANALYSIS ON ANNULAR CIRCULAR AND ELLIPTICAL FINS." International Journal of Engineering Scienceand Technology 2(7): 2839-2845.

[11]. A. T. Pise and U. V. Awasarmol (2010)."Investigation of Enhancement of Natural Convection Heat Transfer from Engine Cylinder with Permeable Fins." International Journal of Mechanical Engineering & Technology (IJMET) 1(1): 238-247.

[12]. P. Agarwal, et al. (2011). Heat Transfer Simulation by CFD from Fins of an Air Cooled Motorcycle Engine under Varying ClimaticConditions. Proceedings of the World Congress on Engineering.

[13]. S. Barhatte, et al. (2011). "Experimental and Computational Analysis and Optimization for Heat Transfer through Fins with Different Types of Notch." Journal of Engineering Research and Studies E-ISSN 976: 7916.

[14]. M. Matkar and P. M. Ravanan (2011).Thermal Analysis of Copper Fin by FEA.International Conference on Operations and Quantitative Management. Nasik, India.