International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Modelling and Transient Thermal Analysis on IC Engine Cylinder Fins by using ANSYS Software

Vikram M [a], Dr. Sakunthala K [b]

[a] *PG Scholar of Thermal Engineering, Government College of Engineering, Salem-11, Tamilnadu, India.*
[b] *Faculty of Mechanical Engineering, Government College of Engineering, Salem-11, Tamilnadu, India.*

A B S T R A C T

Heat transfer is a very main phenomenon within the investigation of any inside combustion engine. Thermal efficiency of internal combustion engine is immediately linked with heat transfer. Consequently, heat transfer enhancement can make stronger thermal efficiency of inner combustion engine. In this case, we had regarded air cooled IC Engine. Heat Transfer through cylinder head consists of conduction through walls and convective heat transfer due to surrounding air flow. Design of multiplied surfaces is compulsory in air cooled IC engines to increase the heat transfer. Fins are the important component in an IC engine cylinder block which is responsible for heat removal during the combustion process through convection process. The efficient removal of heat transfer can always maintain the consistent efficiency of an IC engine. The fins are of different types which are generally used based on the heat transfer rate requirement. The main aim of this project is to find the best material for cooling fins to increase the heat transfer rate. The modelling of cylinder block with fins is done by using CATIA V5R20. The design specifications of the IC engine Cylinder block with fins are taken from IC engine analysis is done by using ANSYS Workbench 19.2. Thermal analysis is done through Transient Thermal which used to find out the total heat flux distribution and temperature distribution. Three different materials were selected and analysis is done by using them, to select the best material.

Keywords: Cylinder fins, Thermal analysis, Heat transfer

1. Introduction

Basically, the running of vehicles depends on the performance of engine. The choice of best engine modelling and assembling are basicallydepended upon the concluding of materials because internal ignition engines directly connected with the thermal conductivity of the materials.Thermal examination is the piece of material science that inquiries about the properties of materials that are engaged in with thermal examinationand moreover subjected to change with change in temperature. Thermal examination is furthermore every now and again used for streamlining of Heat transfer through the structures like internal ignition motors, moulding blocks and various more applications when heat exchange happens with conduction and convection modes.he thermal structures must be designed and evaluated to make, disperse the reasonable proportion of undesirable heat with the required interest.The effective working of thermal hardware's based upon different elements,significantly cooling or heating of its specific parts. The issue emerges when theheat exchanged by these fins are not sufficiently adequate to cool the heatproducing devices and makes harm the parts of the devices. The essentialarrangement accessible is that the state of fins can be optimized with the end goalthat the heat exchange thickness is greatest when the space and the materialsutilized for the finned surfaces are imperatives. The fundamental point of the task is to advance the thermal properties of fins by moving geometry and heatexchange rate.The main effort of the study is to increase the heat transfer rate of fin which could be achieved by modifying certain parameters and geometry of the same. Fins are normally investigated by expecting uniform heat exchange coefficient design on its surface. In any case, optimization by different researchers uncovered that it isn't steady, however shifts along the fin length. It is basically a direct result of non-uniform obstruction experienced by the fluid flow in the between fin area. Expanding the heat exchange region heat dissipation rate enhances, yet the expansion of resistance to fluid flow causing a decrease in heat exchange. With a specific end goal to the dissipation of heat of high heat flux densities, the required heat sink should regularly be higher than devices. Subsequently, the heat sink execution is decreased.The inner fin resistance might be lessened by including the notches or by adding the perforation to the fins. adding a cross-fin in the centre expands the heat transfer territory, however it forms the stagnant layer of hot air at the fin base. The fluid flow movement at the underside of the fin exhibit can be enhanced by adding holes to the fins.

2. Problem Statement

In the present Project investigation on thermal issues on IC engine fins were carried out. Investigation yields the temperature behaviour and Total Heat flux and Directional heat flux of the rectangular fins due to high temperature in the combustion chamber. ANSYS WORKBENCH-2019 is utilized for analysis. The analysis is done for different models of almost a IC engine and a comparison is thus established between them by changing geometry and Fin thickness. Also the material is changed so that better heat transfer rate can be obtained. It increments with the distinction of temperature between surroundings and the object, additionally expanding the convection coefficient of heat exchange, or expanding the surface region. But, increase of the area also causes increased resistance to the heat flow. Hence, coefficient of heat transfer is based on the total area (the base and fin surface area) which comes out to be less than that of the base. the temperature variations inside the fins made in three kind geometries (Trapezoid fins and Rectangular fins) and consistent state heat exchange examination has been studied utilizing a finite element software ANSYS to test and approve results. The temperature variations at various areas of fins are evaluated by compared Trapezoid fins and Rectangular fins with the results of fins obtained by ANSYS.

The following are the main objectives of the present work:

1. To design cylinder fins for an engine by varying the geometry such as rectangular and trapezoid of the fins.
2. To determine transient thermal properties of the proposed fin models.
3. To identify suitable alloy for the fabrication based on results obtained from finite element analysis and analytical method

Table-1 Fin geometry and its parameter

FIN GEOMETRY	PARAMETER FORMS
Type of Fins	1.Rectangular fins 2.Trapezoid fins
Thickness of the fin	1. 3mm 2. 2.5 mm
Material of the fin	1. Grey cast Iron 2. Aluminium Alloy 6061 3. Magnesium Alloy

3. Literature review

[1] Naman Sahu (2018) According to researcher, to overcome the problem of overheating, especially in thermal systems, fins are usually provided. Fins can be analysed in design phase only using Computational Fluid Dynamics as tool and assuming uniform heat transfer coefficient model on its surface.However, research investigators prove that heat dissipation is not constant, however varies along the fin length. It is mostly due to non-uniform resistance experienced by the fluid flow in the inter fin region.Also we can develop a model for the values of total heat flux and temperature distribution by using ANSYS.

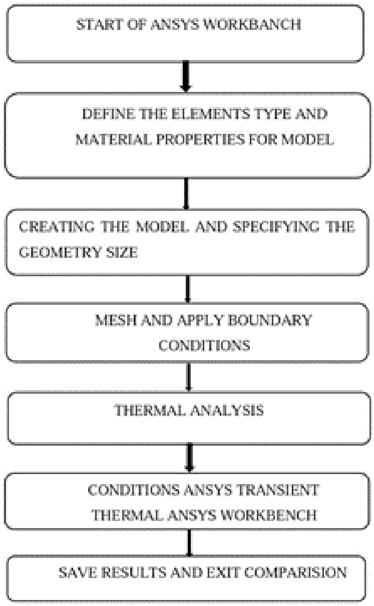
[2] Deepak Tekhre (2017) In this research studied to investigate heat dissipative effect of fins made up of different materials and different geometries. It's necessary to analyse the heat transfer rate of fins. Study will lead to the different experiments which have been made to increase fin efficiency by changing fin material properties, climatic condition around fins, using perforations and notches in fins and fin geometry. The main thermal analysis tool is CFD analysis with the help of computer modelling software. The main study is focused on a two wheeler engine (Honda unicorn 150cc). It also founded that change in environmental condition causes great change in heat transfer coefficient and in its efficiency.

[3] Reddy et. al. (2017) analysed the impacts of the fin shape of the heat sink on the thermal execution. The different kinds of Perforation on pin fin are utilized for powerful heat exchange rate under consistent thermal transition condition. Cooling is finished by constrained convection using fan. Air-based cooling advances have been broadly utilized for thermal administration of hardware. For low power CPUs, aluminium heat sinks are frequently fit for scattering the heat. In the event that better execution is required, copper heat sink might be utilized for higher heat sink execution, however aluminium is utilized in light of its lower weight and lower cost than copper. This numerical re-enactment is proficient by 3D demonstrating and investigation utilizing CATIA and ANSYS, 12.0.

4. Methodology

The ANSYS Design Modeller provides the following approaches for model generation: Creating a surface model within ANSYS Design Modeller.The engine cylinder setup the geometry of engine cylinder fin. The part of model was designed in ANSYS (Fluent) workbench 19.2software. The geometric dimension of the cylindrical block having circular fins.For simulating the cylindrical block have circular fins ANSYS 19.2 finite element control volume approach has been used.

1. To design cylinder with fins for a IC engine by varying the geometry such as rectangular and Trapezoid shaped (parabolic) with different materials and temperatures.
2. To determine the heat transfer coefficient with help of CFD analysis.
3. To determine thermal properties of the proposed fin models.
4. To identify suitable alloy for the based on results obtained from finite element analysis and analytical method.



Methodology flow chart

5.Material selection

5.1.Aluminium Alloy 6061

Aluminium is selected for fin and cast iron for engine cylinder material. The thermal conductivity of aluminium is higher. Aluminium is the best material to manufacture many components because of its unique properties. Good strength and ductility with excellent corrosion resistance and superb machinability. Aluminium alloy 6061 material is used in this study, and the engine cylinder is one of the most important automotive products that is Subjected To High-Temperature Changes And Thermal Stresses

5.2. Magnesium Alloys

Magnesium alloys are well-known for being the lightest structural alloys. They are made of magnesium, the lightest structural metal, mixed with other metal elements to improve the physical properties. These elements include manganese, aluminium, zinc, silicon, copper, zirconium, and rare-earth metals. Magnesium alloys are materials of interest mostly due to their high strength-to-weight ratios, exceptional machinability and low cost..

5.3. Grey Cast Iron

Grey cast iron is a type of iron found in castings known for its grey colour and appearance caused by graphite fractures in the material. Specifically, the graphite flake structure that is created during the cooling process from the carbon that is in the component. Grey iron also experiences less solidification shrinkage than other cast irons that do not form a graphite microstructure. The silicon promotes good corrosion resistance and increased fluidity when casting. Grey iron is generally considered easy to weld.

Fins are placed on the surface of the cylinder to boost the rate of heat transmission, which helps to cool the cylinder down more quickly. It is beneficial to perform thermal analysis on the engine cylinder fins to determine the amount of heat dissipation occurring inside the cylinder. Because increasing the surface area results in an increase in the heat dissipation rate, developing a large complex engine is extremely difficult by altering the geometry of cylinder fins and analysing the results with the ANSYS workbench, the primary goal of this paper is to understand the thermal properties of cylinder fins.

6. ANSYS Analysis

ANSYS has advanced into multipurpose layout evaluation software program software, diagnosed around the area for its many capabilities. Today this system is extremely powerful and easy to use. Each release hosts new and more suitable competencies that make this system more flexible, extra usable and quicker. In this manner ANSYS enables engineers meet the pressures and demands current product improvement environment. To execute the finite element investigation of the Fins models whilst the engine temperature transfers to the air with the help of fins, a structural examination performed with the use of ANSYS Workbench19.2. At this step the research of the Fins is a steady state thermal analysis one, while minor modification in fins with designs provided. The model of the fins is designed in CADIA V5R20 and saved on this file and then imported in ANSYS Workbench.

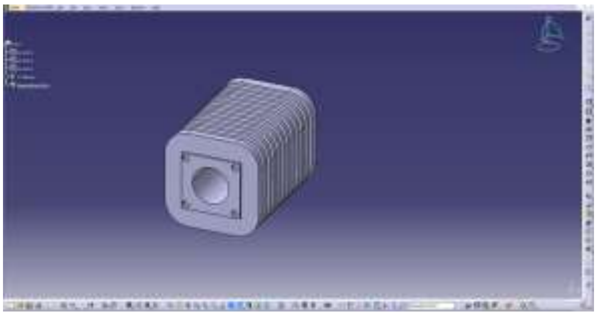
6.1. Transient Thermal Analysis:

The ANSYS thermal and analysis determines temperatures and other thermal quantities that vary over time. Engineers commonly use temperatures that a transient thermal analysis calculates as input to structural analyses for thermal stress evaluations. Many heat transfer application sheet treatment problems, nozzles, engine blocks, piping systems, pressure vessels, etc., involve transient thermal analyses.

A transient thermal analysis follows basically the same procedures as a steady-state thermal analysis. The main difference is that most applied loads in a transient analysis are functions of time. The main difference is that most applied loads in a transient analysis are functions of time. Transient thermal analysis is chosen for thermal analysis of the two models developed in CATIA V5R20 for a IC engine Fin. By changing the Material (Magnesium alloy, Aluminium alloy, Grey cast), Geometry is Rectangular and trapezoid Fin thickness(1.5mm,2mm) analysis is done and their effect on the time taken for reaching the steady state is plotted on a graph of time verses a property and the different properties analysed are as discussed above Temperature, Directional heat flux, Total heat flux.

6.2. Modelling Of Fins

Modelling of the Fins done using CATIA V5R20 has been explained in detail. Fins models designed with the material selection of aluminium alloy 6061, magnesium alloy, grey cast iron and Two Fins model designed here, Trapezoid fins and Rectangular fins. Fins model with type of Trapezoid and rectangular fins for passing heat through fins.



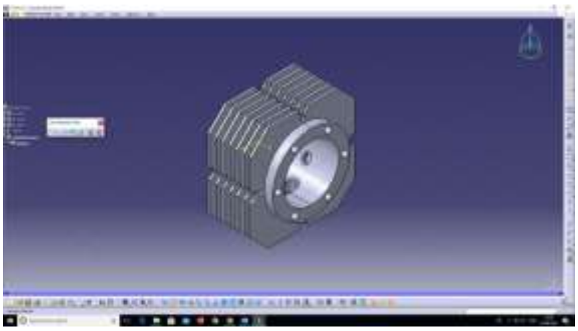


Fig-1 Modeling of rectangular fin

Fig-2 Modeling of trapezoidal fin

The model comprises all the nodes, elements, material properties, real constants, boundary conditions and additional features that are used to characterize the physical system. all models be generated then specific boundary conditions will be applied on the specific nodes then final analysis will be conducted.

7. Results and Discussion

Static thermal analysis performed to find out best design of Engine Fins for maximum heat transfer rate in Fins. There are two different shaped fins model

designed and analysed in ANSYS by assigning the Material properties of fins models. Thermal analysis is a collection of methods in which the deviation of a physical property of a material is calculated as a function of temperature. The most commonly used methods are those which calculate changes of mass or changes in energy of a model of a material. Temperature variation across various piston heights of piston in steady state condition shows and boundary conditions applied on fins models. After processing solution, the temperature variations in Trapezoid fins and Rectangular fins models studied and graph plotted for comparison. The main aim of the project is to analyse the thermal properties by varying geometry of Trapezoid fins and Rectangular fins using ANSYS workbench. The 3D model of the geometries is created using CADIAV5R20 and its thermal properties are analysed using ANSYS workbench 19.2. The variation of temperature distribution over time is of interest in many applications such as in cooling. The accurate thermal simulation could permit critical design parameters to be identified for improved life. Design of fin plays an important role in heat transfer. There is a scope of improvement in heat transfer of air cooled engine Rectangular fin if mounted fin's shape varied from conventional one. Contact time between air flow and fin (time between air inlet and outlet flow through fin)is also important factor in such heat transfer. Rectangular fins shaped Trapezoidal fins block can be used for increasing the heat transfer from the fins by creating turbulence for upcoming air turbulence for upcoming air.

7.1. Comparing The Results Of Rectangular Fins And Trapezoid Fins

The Fins model to research is subdivided into a mesh of limited measured components of the basic frame. Inside every segment, the distinction of displacement is thought to be computed by basic polynomial profile capacities and nodal Temperature.

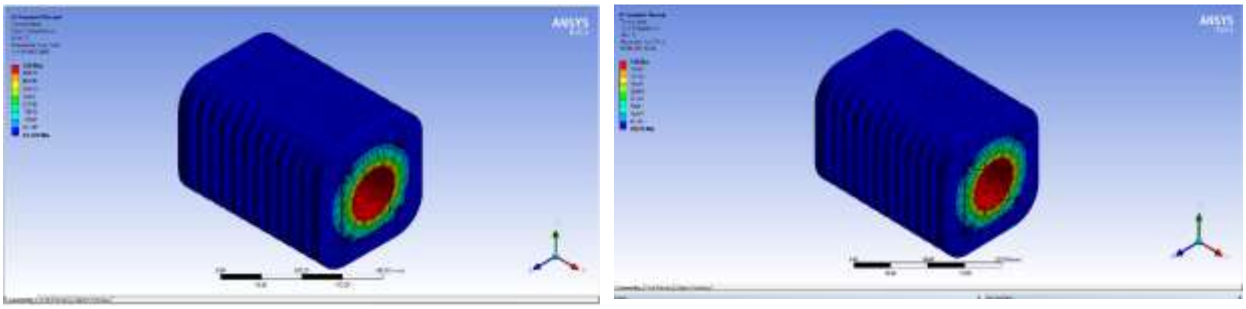


Fig-3 Temperature Distribution of Rectangular Fins

From this, the conditions of balance are collected in an engine fin shape which can be easily customized. After processing solution, the Temperature and Total Heat Flux in thermal analysis compared with the Rectangular fin and trapezoidal fin models.

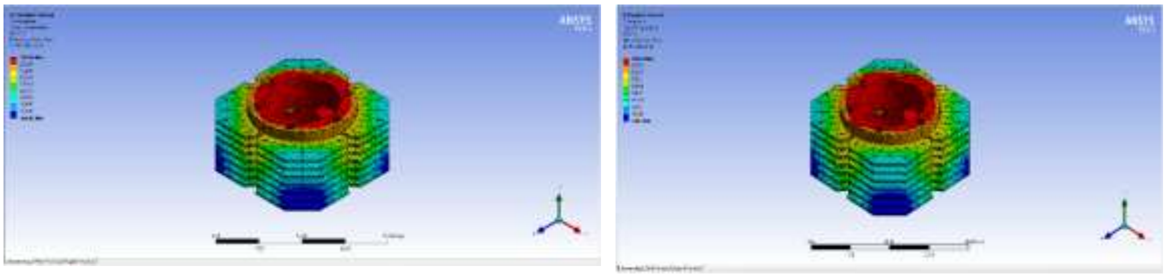


Fig 4 Temperature Distribution of Trapezoid Fins

These results as part of structural and thermal analysis are obtained for all three conditions i.e. Fins with trapezoid fins and Fins with rectangular fins. Figures shows the simulation study in ANSYS of Fins models.

7.2 Heat Flux Analysis of Fins Models

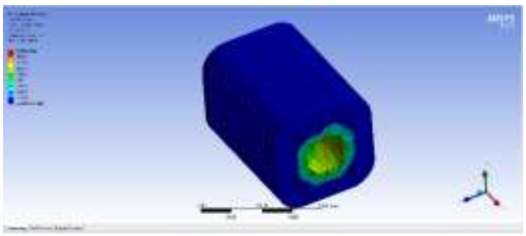


Fig-5 Heat Flux of rectangular Fins

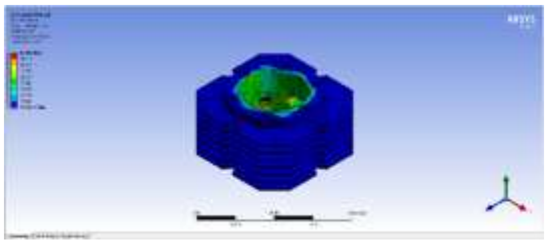
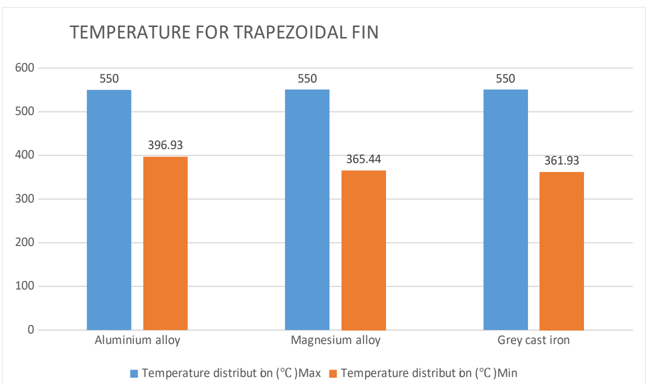
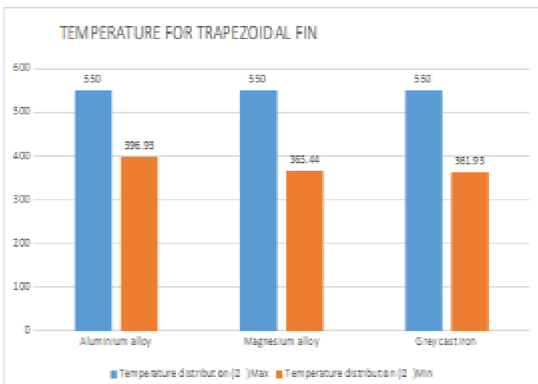


Fig-6 Heat Flux of Trapezoidal Fins



Graph-1. Rectangular fin Temperature distribution(K) and Thermal flow (W/m^2)



Graph-2. Temperature distribution (°C) with Trapezoidal fin

Table 2: Temperature Variations of Fins Models

Fin Geometry	Materials	Temperature distribution (°C)		Heat flux (W/mm$^{2)}$
		Max	**Min**	
Rectangular fin	Aluminium alloy	550	330.93	0.003735
	Magnesium alloy	550	223.44	0.0035436
	Grey cast iron	550	212.10	0.001692
Trapezoidal fin	Aluminium alloy	550	396.93	0.068270
	Magnesium alloy	556	365.81	0.064274
	Grey cast iron	552	361.93	0.051964

Conclusion

The main aim of the project is to analyse the thermal properties by varying geometry of engine finusing ANSYS work bench. The 3D model of the geometries is created using CATIA V5R20 and its thermal properties are analysed using ANSYS workbench 19.2. The accurate thermal simulation could permit critical design parameters to be identified for improved life. Contact time between air flow and fin time between air inlet and outlet flow through fin is also important factor in such heat transfer. Trapezoid fin shaped cylinder block can be used for increasing the heat transfer from the fins by creating turbulence for upcoming air. In present work, a rectangular fin body is modelled and transient thermal analysis is done by using ANSYS. These fins are used for air cooling systems for two wheelers. In present study, Aluminium alloy 6061 is compared with Magnesium alloy, Grey cast. The various parameters geometry and thickness of the fin are considered in the study, by reducing the thickness and also by changing the shape of the fin to shape from the conventional geometry i.e. rectangular, trapezoid shape the weight of the fin body reduces thereby increasing the heat transfer rate and efficiency of the fin. The results show, by using Trapezoid fin with material Aluminium Alloy 6061 is better since heat transfer rate of the fin is more. By using Rectangular fins, the weight of the fin body reduces compared to existing Trapezoid engine cylinder fin.

REFERENCES

[1] KM Sajesh, Neelesh soni, Siddhartha Kosti, “Design Modification and Heat Transfer Analysis of Air Cooled Rectangular Fin Engine”, International Journal of Recent Scientific Research, Vol. 7, Issue, 3, pp. 9653-9656, March, 2016.

[2] L.Natrayan, G.Selvaraj, N.Alagirisamy, M.S.Santhosh, “Thermal Analysis of Engine Fins with Different Geometries”, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, Issue 5, May 2016.

[3] Sachin Kumar Gupta, Harish Chandra Thakur, Divyank Dubey, “Analyzing Thermal Properties of Engine Cylinder Fins by Varying Slot Size and Material”, Open International Journal of Technology Innovations and Research, e-ISSN: 2321-1814, ISBN: 978-1-62951-946-3, Volume 14, April 2015.

[4] The effect of fin spacing and material on the performance of a heat sink with circular pin fins by A Dewan, P Patro, I Khan, and P Mahanta

[5] Nagarani N, Mayilsamy K, “Experimental Heat Transfer Analysis on Annular Circular and Elliptical Fins”, International Journal of Engineering Science and Technology, Vol. 2, No. 7, pp. 2839-2845, 2013.

[6] Ajay Paul J, Sagar Chavan Vijay, Magarajan R, Thundil Karuppa Raj, “Experimental and Parametric Study of Extended Fins in the Optimization of Internal Combustion Engine.