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# Review: CFD Simulation of Heat Transfer In Air-Cooled Finned Four Stroke Engines

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***Abstract:*** *The heat transfer rate depends on the vehicle velocity, fin geometry and ambient temperature. Increase the heat transfer coefficient and surface area of object increase heat transfer. Effects of the number of fins, fin pitch and wind velocity on air-cooling were investigated using experimental cylinders for an air-cooled engine of a motor cycle. The purpose of this experimental work is to study the forced conjugate heat transfer process taking place in engine cylinder block with varying wind speeds ranging from 40 km/hr. to 80km/hr., varying environmental conditions, various fin pitch and fin width. ADC12 Material is used by the Engine developers of 4-stroke. ADC12 aluminum alloy has chemical composition of Al-Cu-Si-Mg. The density of ADC12 alloy is very less compared to cast-iron resulting less weight of the engine. We have to design 3D model of the actual engine cylinder block of 4-stroke bike Engine has been drawn in Ansys 15.0. The Average heat transfer coefficient for the surface of the engine cylinder block has been calculated with the help of commercially available CFD tool ANSYS Fluent.*

***Key Word:*** *Forced convection, Engine cooling, Fin geometry, Wind Speed.*

## I.INTRODUCTION

In an internal combustion engine the combustion of fuel (normally a petroleum products) take place with an oxidizer (usually environmentally air) in a combustion chamber. In an I.C. engine, the expansion of the high temperature and high-pressure gases generated by combustion which applies direct force to various component of the engine, i.e. pistons. This force moves the component i.epis tonovera distance, generated mechanical energy in the form of rotation. Air cooled engines in heavy vehicles and cars are phased out and are replaced by water cooled engines which are more efficient, but almost all two wheelers uses Air cooled engines, because Air-cooled engines are only option due to some advantages like lighter weight, lesser space requirement and lesser maintenance. The heat generation from combustion in IC engine should be maintained at higher level to increase thermal efficiency, but to prevent the thermal damage to the engine geometry some heat should be removed from the engine.

Fins are one of the heat transferring devices which are used to increase the heat transfer on engine cylinder walls. Therefore, it is necessary to study the heat transfer rate of the fins. The research has been done to increase fin efficiency by Changing fin material and fin geometry. The fins are generally extended surfaces of projections of materials on the Cylinder block and head. The fins are usually used to increase the heat transfer from the Cylinder to the surroundings air by increasing the heat transfer surface area.

The heat transfer rate depends upon the velocity of the vehicle and fin geometry and temperature of cylinder. The heat transfer also depends on air velocity and environmental temperature. If the surrounding temperature is low and wind velocity is high, it can result in over cooling of the engine, which can overcome the thermal efficiency of the engine. Whereas, If the surrounding temperature is high and wind velocity is low it can result in over heating of the engine, which can causedistortionoftheenginegeometryandbreakdownoftheenginefunctioning.Variousexperimentalmethodsare available in literature to study the effect of that factors on the heat transfer rate.

There are many methods available in industry to design the engine cooling system. Few of them are experimental, analytical and numerical methods. The experimental heat transfer study involves constructing various cylinder-fingeometryandconductthestudyinwindtunnel.Butthatprocessis time consuming and costly. In today's rapidly moving and competitive world, the industry doesn't have time to invest lot of time and money to conduct experiment. There is a powerful alternative way called CFD tools, which is used to study and design the cooling system in engine efficiently. There are numerous CFD package available in market, to simulate the heat transfer phenomenon in engine fin assembly. In present study Ansys Workbench 15.0 (Fluent) is used to conduct numerical study. The reliability of the methodology proposed in this study has been validated with the experimental results. First the parametric 3D model of the simple cylinder with circular fins is constructed using CREO.

### FINS

A fin is a surface that extends from an object to increase the rate of heat transfer to or from the environment by increasing convection. The amount of conduction, convection, radiation of an object determines the amount of heat it transfers. Increasing the temperature difference between the object and the environment, increasing the convection heat transfer coefficient, or increasing the surface area of the object increases the heat transfer. Sometimes it is not economical or it is not

feasible to change the first two options. Adding a fin to the object, however, increases the surface area and can sometimes be economical solution to heat transfer problems. Circumferential fins around the cylinder of a motor cycle engine and fins attached to condenser tubes of a refrigerator area few familiar examples.

*Figure1: Auto mobile/4strokeFin*

## II.LITERATURE REVIEW

**NamanSahuet. al** The engine housing is one of the essential components of the engine and is exposed to various high and high temperatures. Blades are installed on the outside of the chamber to increase heat retention due to convection. Thermal inspection of motor housing blades is increasingly useful for understanding the heat dissipated within the housing. The current survey was conducted to improve information on various recent surveys. This shows that blade heat transfer depends on balance composition, balance pitch, balance design, wind speed, texture and atmospheric environment. Written experiments have shown that the heat transfer is improved by the extended surface and the heat transfer coefficient is affected by changes in the equilibrium cross-section. This research helps identify geometries and materials that balance higher heat dissipation and engine cooling.

**Charanet. al.** We have broken down a broad surface that is commonly used to promote convective heat transfer in a wide variety of design applications. The holes in the parallel sides of the blades are suitable for improving the speed of heat transfer. As a result of the investigation, it was found that aluminum materials with three triangular holes had the lowest tip temperature and aluminum materials with three triangular holes had the highest heat transfer. As a result of the inquiry, it was found that the Nusselt number in the clamped scale increases when the blade is jammed in front of the blade that is jammed. Therefore, 3 aluminum triangles with horizontal holes are generally considered suitable for balance applications.

**K.Rama Chandra Manohar et al** The engine (SPLENDOR 150 CC) is one of the most important mechanical assemblies in a vehicle that is exposed to aircraft temperature and thermal instability. The balance, which changes as the operator cools down, is the basic expansion we're used to blowing expansion from our engines. The blades are used to reach the adjusted total from the plan to the environment. OPERATOR (SPLENDOR 150 CC) By achieving a calculated wind test on a cooled balance, currently in the Specialist Brilliance 150ccso, the balance is adjusted by inserting a modified type of tooth and is the aforementioned material. The capacity and balance capabilities are invaluable for competent Blade programming. The main point of our test is to activate the care breeze with the existing indentation and the test is completed by the ANSYS program.

**Beldaret. al.** Conducted continuous research with the help of CFD programming. Wind flow test and pressure drop test were done. The size of the points varies at 10%, 20%, and 30%, and the warm input varies from 25, 45, and 65 watts. In the uncompensated blade cluster region, the equilibrium surface is reduced, but the heat transfer enhancement is still reduced. The balance of payment cluster shows the focal substance of the balance again in the air of the virus, and the warm motion is increasing. Placing an indentation on the focal bit of the balance, after making a change to the conventional air flow example, significantly increases the peripheral velocity and changes the pneumatic stress across the channel, creating a tubular worm. The air temperature inside the sink channel will increase.

**Masao Yoshida et al.** In this research, Motorcycle engine releases heat to the atmosphere through the mode of force convection. To solve this, fins are provided on the outer of the cylinder. The heat transfer rate is defined depending on the velocity of vehicle, fin geometry and the ambient temperature. Increasing the temperature difference between the object and the environment, increasing the convection heat transfer coefficient, or increasing the surface area of the object increases the heat transfer. Many experimental methods are available in literature to analyze the effect of these factors on the heat transfer rate. The simulation of two type of engine block which is Modenas Kriss 110 and Yamaha Lagenda110z has been done accordingly to the requirement. The values of wind velocity have been determined to gain the heat transfer coefficients. This simulation is proving that the wind velocity is one important part that can affected the total of heat transfer and the value of heat transfer coefficient. Besides that, the design of motorcycle fins need to considered in order to measure total heat transfer, because fins are work to trap the air to maintain the heat of engine block, if the fins design are not too appropriate with the requirement, it can cause to overheating.

**K. Sathishkumar et al.** Fins are generally used to increase the heat transfer rate from the system to the surroundings. By doing computational flow analysis on the engine cooling fins, it is helpful to know about the heat dissipation rate and the Principle implemented in this project is to increase the heat transfer rate, so in this analysis, the fins are modified by putting different

types of notches and are of same material. The knowledge of efficiency and effectiveness of the fins are necessary for proper designing of fins. The main objective of their analysis is to determine the flow of heat at various notches available and the analysis is done by using ANSYS – CFD Fluent software. The fins with various configurations were modeled using CREO 2.0 and analyses are done by using CFD Fluent in order to find out the heat transfer rate. It is clear that the results from software and theoretically says that the fins with rectangular notch have greater heat transfer rate compared to that of the fins without holes, fins with holes and V shaped fins. Since the heat dissipation rate is more in rectangular notch so they conclude that the rectangular notch fins are most efficiency and best heat transfer notch among all types of notch.

**MohsinA.Alietal.** Engine life and effectiveness can be improved with effective cooling. The cooling mechanism of the air-cooled engine is mostly dependent on the fin design of the cylinder head and block. Insufficient removal of heat from engine will lead to high thermal stresses and lower engine efficiency. The cooling fins allow the wind and air to move the heat away from the engine. Low rate of heat transfer through cooling fins is the main problem in this type of cooling. The main of aim of this work is to study various researches done in past to improve heat transfer rate of cooling fins by changing cylinder block fin geometry and climate condition.

The conclusion of the present literature review is as follows, Design off in plays an important role in heat transfer. The fin geometry and cross-sectional area affects the heat transfer co efficient there is a scope of improvement in heat transfer of air-cooled engine cylinder fin if mounted fin's shape varied from conventional one. From the all the research and experiment that covered in this paper it can be conclude that Contact time for the air flows over the fin is also important factor in heat transfer rate. If they can increase the turbulence of air by changing the design and geometry of the fins it will increase the rate of heat transfer and it is found that Curve and Zig-zag fin shaped cylinder block can be used for increasing the heat transfer from the fins by creating turbulence of upcoming air. Improvements in heat transfer with new curve and Zig-Zag design fin can be compare with conventional one by CFD Analysis (Ansys Fluent).

**MushkBughioet. Al** investigated the potential reduction in indoor temperatures via energy-efficient ventilation through EAHEs in an existing architectural campus building (ACB) with an energy-efficient renovated building envelope in the hot and humid climate of Karachi, Pakistan. The building information modeling (BIM) program Autodesk Revit was used to develop a virtual ACB BIM model. An Energy Plus parametric analysis of the ACB BIM model in Design Builder facilitated quantification of the influences of operating parameters such as pipe installation depth and pipe diameter for EAHEs with similar total pipe lengths and air-exchange rates on the performance of the EAHEs during the cooling season. A 3 m deep and 0.1 m diameter pipe layout in open space significantly reduces indoor temperature via a specific duct layout in an exemplary ACB. The results show that a pipe diameter above 0.1 m is unsuitable because of the reduction in convective heat transfer due to the increase in the pipe's surface area and the decrease in pressure in the pipe. The findings of this study can be used to improve the indoor thermal comfort of buildings in climates with comparable properties.

**FabrizioAscioneet.al.** have worked on Earth-to-air heat exchangers for Italian climates by using an ETHE for an air conditioned have been evaluated for both summer and winter. It is observed in three Italian climates taken (cities of Milan, Rome, Naples). The energy required for the system is evaluated as a function of the boundary conditions (such as tube material, the typology of soil, velocity of the air crossing the tube, tube length and depth, control modes, ventilation airflow rates).In an experiment, earth soil should be homogeneous with constant temperature, the pipe has uniform diameter, surface temperature of the pipe is uniform and convective flow inside the pipe. During this experiment they concluded that it is save 44% of energy, about the length of pipe, depth of earth and velocity of air is calculated, the influence of the tube material such as PVC, metal, concrete.

**Girja Saranet.al.** have worked on Performance of single pass earth tube heat exchanger by using geothermal energy of the earth for cooling and heating. Specific aim of those investigations is to determine the operating characteristics of ETHE in heating and cooling mode and collect data of years. ETHE is made by parameter of 50 m long MS pipe,10 cm nominal diameter and 3 mm wall thickness. Buried 3 m deep underground surface. By the use of 400 W blower ambient air is pumped. Outlet air velocity in the pipe is 11 m/s. Air temperature measured in the inlet, middle (25 m), and at the outlet (50 m). They observed ETHE was able to reduce and increase the temperature of hot/cold ambient air.

**VikasBansalet.al.** have worked on Performance evaluation and economic analysis of integrated earth air tunnel heat exchanger evaporative cooling system by applying implicit model based on CFD. For use of ETHE system integrated with evaporative cooling to be determine for evaluating the energy saving obtained. Four base cases of existing systems, i.e. electric heater and air-conditioner. Moreover, three different types of blower (i.e. standard blower, energy efficient blower and inefficient blower) are considered for evaluating the financial viability and energy saving of the proposed system.

**Nayak and Tiwariet.al** researched out theoretical performance of an integrated photovoltaic and earth air heat exchanger greenhouse using energy and energy analysis methods. A simplified mathematical model was developed to study round the year effectiveness of photovoltaic/thermal and earth air heat exchanger integrated with a greenhouse, located at IIT Delhi, India. The solar energy application through photovoltaic system and earth air heat exchanger for heating and cooling a green house is studied with the help of this simplified mathematical model. They compared greenhouse air temperatures when it is operated with photovoltaic/thermal and earth air heat exchanger integrated, for 24 hour. The results reveal that air temperature inside the green house can be increased by round 7-8$^{o}$C during winter, when the system is photovoltaic/thermal and earth air heat exchanger integrated operated.

**Mihalakakouet al.** investigated the heating potential of a single ground to air heat exchanger and also multiple parallel tube system. An accurate numerical model was used to investigate the dynamic thermal performance of the system during the winter period in Dublin. The model has been successfully validate against an extensive set of experimental data. The results showed that the heating potential of the system during winter is significantly important. To obtained results showed that that the effectiveness of the ground to air earth air heat exchanger increases with an increase in pipe length (checked rang 30-70 m). Also, there is increase in effectiveness when the pipe is buried in greater depths (3 m instead of 1.2 m). By increasing the pipe diameter from 100 to 150 mm, the heating capacity of the system was reduced. This is due to a reduction in convective heat transfer coefficient and an increase in the pipe surface, therefore, providing a lower temperature at the pipe outlet. Finally a higher velocity in the pipe (range 5-15 m/s) leads to a reduction of the system hearting capacity, mainly because of the increased mass flow rate inside the pipe.

## III.PROBLEM FORMULATION

The previous researchers have focused on effect of fin geometry, but the opted chosen was simple cylinder with circular fins. But in real life application round fins are non-realistic. Have a better H.T. and temperature distribution the fin geometry has to be changed. The fins can be straight in vertical or horizontal orientation to account the various direction of the wind. In this study the effect of fin pitch i.e. distance between two fins and effect of fin width (or Fin Length) is studied. The variation in fin spacing i.e. (distance b/w two fin) and fin width significantly affects the heat transfer phenomenon. Some problem are finding in previous research.

(a) In the previous research some Al alloy used (suchas-A5052, A204)and cast iron are used which density more so the wait increasing problem faced.
(b) The specific heat is low, so heat transfer rate is low.
(c) Thermal conductivity also low so it affects the heat transfer rate at high temp.
(d) The fin thickness is small, compared with its height and length, so that temperature gradient cross the fin thickness and heat transfer from the edges of the fin may be neglected.
(e) In internal combustion engine the combustion of fuel take place with an oxidizer in a combustion chamber.
(f) InanI.C.engine, the expansion of the high temperature and high-pressure gases generated by combustion which applies direct force to various component of the engine, i.e. pistons. This force moves the component i.e. piston over a distance, generated mechanical energy in the form of rotation.
(g) Air cooled engines in heavy vehicles and cars are phased out and are replaced by water cooled engines which are more efficient, but almost all two wheelers uses Air cooled engines, because Air-cooled engines are only option due to some advantages like lighter weight, lesser space requirement and lesser maintenance.
(h) The heat generation from combustion in IC engine should be maintained at higher level to increase thermal efficiency.

## IV.CONCLUSION

This work is done to study the heat transfer from the engine cylinder block of 4-stroke motor bike. The following conclusions can be drawn from the present work: The modeling of an automotive air-cooled engine cylinder block is done. The effect of surrounding environment temperature and wind velocity on heat transfer through the extended surfaces is analyzed with computational package. It is observed that the surface heat transfer coefficient increases as the wind velocity increases. Reduction in surrounding environmental temperature also results in excessive convective heat loss. The turbulence of wind flow increases with higher wind speed, which results in higher convection. The turbulent kinetic energy is also calculated.

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