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Thermal Analysis of Extended Surfaces (Fins) of the Air-Cooled IC Engine: A Review

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Abstract-In this research paper authors have investigated the research work of the previous researchers. One of the most significant issues in engine design is heat dissipation. The cooling process of an air-cooled engine is mostly determined by the cylinder head and block fin design. High thermal stresses and poorer engine efficiency will result from insufficient heat removal from the engine. Fins are extended surfaces used to transmit heat between two fluids, or between a solid and a fluid. Fins come in a variety of shapes and sizes, including angular, circular, and rectangular fins. The engine piston chamber is the most vulnerable portion of any car, as it is subjected to significant thermal shocks and thus thermal stresses. Mainly ANSYS has been used by various authors to evaluate the performance of fins in two-wheeler engines.

Keywords- IC Engine, Fins, Cooling, ANSYS.

I. INTRODUCTION

Two-wheeler engines are generally 2-stroke or 4-stroke petrol engines. Due to combustion of fuel inside an Internal Combustion engine, a large amount of heat is generated. This results in rise of temperature and may be in the range of 2350-2550°C. Such a high temperature may result in the combustion and burning of lubricating oil inside engine cylinder and engine may also seize.

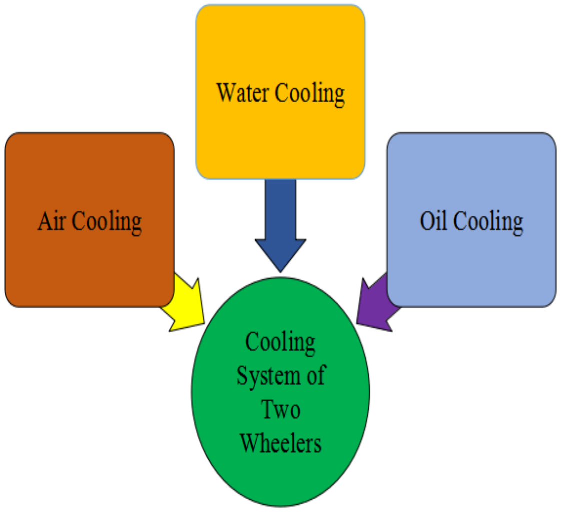

Fig 1. Types of Cooling System

In order to ensure efficient and smooth working of IC engine, it is imperative to reduce this temperature by using appropriate cooling system.Too much cooling should be avoided because it will result in lower thermal efficiency.

Cooling of engines is generally done in following three ways

1. Liquid Cooling:

This system of cooling is generally not employed in Indian bikes. Bike with such cooling have radiator and a coolant is circulated continuously just like engine of car.

2. Oil Cooling:

In this system a oil is used for the cooling purpose of the engine.

3. Air Cooling:

In this system ambient air is made to flow through the extended surfaces or fins of the engine. Excess heat of engine is carried away by the air flowing in the surroundings of the engine. In Air-cooled engines heat removal is done by the air which hits the engine when vehicle is moving. That's why fins are provided externally in order to provide more surface area over which air can flow.

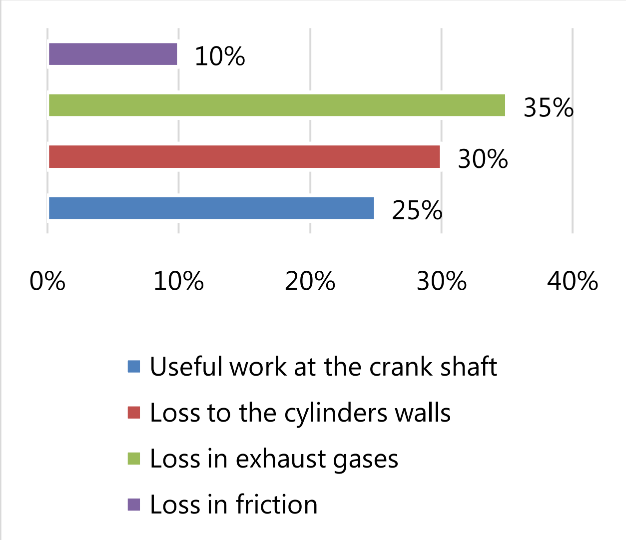

Fig 2. Typical Distribution of Fuel Energy.

This method of cooling is easy to operate and does not require any special device and also light weight. Main objective of cooling system must be to run the engine at most appropriate operating temperature. In heat engines, mechanical power is generated by conversion of heat into work.

As we know complete conversion of heat into work is not possible, therefore it is essential to minimize the heat losses for better efficiency of a heat engine. In internal combustion engines, some heat is removed by the cooling media but there are other losses too. Fuel energy can be typically distributed as follows.

II. HEAT DISSIPATION IN THE FINS

Heat dissipation from the extended surfaces of the air-cooled engine takes place in three ways

- Conduction
- Convection
- Radiation

Fundamental governing equations of these modes are discussed below. Fourier's law of heat conduction is applied in conduction

$$\mathbf{Q \propto A\frac{dT}{dx}}$$

$$\mathbf{Q = -K.A\frac{dT}{dx}}$$

Where K is constant of proportionality and it is also known as thermal conductivity of the material. While $\frac{dT}{dx}$ is the rate of change of temperature with respect to the length or thickness of the body and it is called temperature gradient. Newton's law of cooling is used in heat dissipation by convection.

By Newton's law of cooling, heat dissipated from the hot surface is directly proportional to the area of surface exposed and temperature difference between hot surface and ambient air.

Mathematically,

$$\mathbf{Q \propto A(T_s - T_\infty)}$$

This equation can be written as

$$\mathbf{Q = h.A(T_s - T_\infty)}$$

Heat dissipation from the hot surface of fins in bike is not taking place by s single mode of heat transfer. All the three modes of heat transfer are involved in the heat dissipation from the fin.

Heat dissipated from the hot surface of fin to the surrounding air is given by the Stefan-Boltzmann law,

$$\mathbf{E = \sigma.A\varepsilon\left(T_s{}^4 - T_\infty{}^4\right)}$$

Where, E = Energy (heat) dissipated from the surface of fin by the radiation (in Watt)
A = Surface area of the body exposed and ε = Emissivity of the given surface.

III. THEORY OF EXTENDED SURFACE OR FINS

Fins are also called extended surfaces. Whenever the given surface area is not adequate for the dissipation of the required quantity of heat, then fins are provided on the surface for further increase of area.

Use of finned surfaces is mainly found in

- Economizers used in the steam power plants
- Automobile radiators
- Cylinder heads of air cooled I C engines
- Cooling coils of condensers of refrigerators
- Small size air compressors
- Body of electric motor
- Electronic equipment
- Body of transformers

IV. LITERATURE REVIEW

Deep N Patel &Maulik Modi, (2017) have used numerical simulation method for a better optimization of fin array parameters and fin material for a given thermal load. To elevate cooling of engine cylinder, number of fins can be increased. Thicker fins should be preferred in high-speed vehicles for maximizing efficiency.

Swirl of air is created by increasing thickness of fin which results in higher rate of heat transfer. Time for which flowing air is in contact with fin is also an important parameter.

ManirAlam, M.DurgaSushmitha, (2016) have used CATIA software for modeling of fin body of a motorcycle engine cylinder.Changes were made in the original model by changing the geometry of cooling fins, thickness of fins and average distance between two adjacent fins was changed. Generally, cast Iron is preferred as a fin material due to its high cast ability.Copper, Aluminum alloy 6082 and Cast iron have been taken in this study for the thermal analysis

Rajvinder et al. (2016) show how heat energy is transferred in two different materials: cast iron and aluminium alloy 6061. They concluded from the findings thatAluminium alloy 6061 has a higher heat flow rate thanthose made of different materials A review of the literature revealed that there are few fin-related research projects and there were no studies that looked at different fin parameters.Performing thermal transient analysis.

Mohankumar D et al, (2021) has investigated the fins by modifying the geometry of the fins, where they could observe that fins made from aluminum alloy 6061 and having circular notch were more efficient. This is because of the fact that differences of temperatures and rate of heat dissipation were found to be higher in this case. Even it was noticed that performance of stepped bar fins was better than the fins of normal bar of the same material.On a chamber.

Ajay Paul et al (2012) placed annular blades. Investigations were led by the product, and all information was handed to it. It was discovered that a specified blade thickness provides improved proficiency. In fast vehicles, a large number of thinner blades may be preferred over thicker balances with fewer blades.

Sujan Shrestha et. Al. (2019) has discussed that heat transfer from inner chamber of motor to outside air can be demonstrated with the help of an assortment of techniques. Techniques used may be very simple to complex one being used for the mutli-dimensional variable conditions. Outer surface of the chamber is equipped with equally spaced blades to enhance the heat dissipation by the convection. Using ANSYS.

Kumbhar [2009] investigated heat transfer enhancement from a horizontal rectangular fin by triangular holes with bases parallel to and towards the fin base under natural convection. They found that perforation enhances heat transfer rate when compared to fins of equal diameters without hole. The perforation of the fin improves heat dissipation rates while lowering fin material costs.

NamanSahuet. al (2018) have discussed that the engine chamber is an important motor component that is subjected to extreme temperature variations and warm loads. Blades are placed on the outside of the chamber to increase the amount of heat that is transferred by convection. Knowing the warmth scattering inside the chamber is becoming increasingly important for warm inspection of the motor chamber blades.

Extended surfaces, which are commonly employed to improve convective heat transfer in a variety of design applications, were dismantled by **Charan et al. (2018).** The purpose of displaying holes on the blade's parallel surface is to improve heat transfer rate.

According to **K.Rama Chandra Manohar et al (2018),**The engine (SPLENDOR 150 CC) is one of the most important mechanical components in a car that is subjected to high temperatures and stresses during flight. In response to the operator's cooling, the balances are expanded fundamentals that are used to blast the calefaction from the Engine.

Blades are commonly used to calculate the amount of calefaction adjustment from the plan to the environment. By varying the geometry, material (Cu and Al amalgam 6082), separation between the balances, and thickness of chamber blades.

Rajesh et al. (2017) studied the warm characteristics. Fins models are created by altering the roundabout shape and varying the thickness of the balances for the two geometries. Pro/Engineer and UniGraphics were used for 3D showing programming.

By changing the shape of the warm warmth propagation of balances, **Jain et al. (2017)** were able to break it down. To predict the transitory warm conduct, parametric models of balances were developed. The geometry of the models was then varied, such as rectangular, circular, triangular, and blades with augmentation.

Warm investigation of chamber square was proposed by **Kummitha et al. (2017).** Warm investigations were carried out with several combinations to find the optimum material that provided the best warmth transfer rate, protected the motor from damage, and was of good quality and light weight.

Ravikumar et al. (2017) discussed the geometric aspects and structure of the warmth sink in order to improve the warm presentation. This project uses thermal analysis to find a cooling solution for a computer with a 5 W CPU. The frame could be cooled via a heat sink connected to the CPU, which was sufficient to cool the entire system.

The pace at which heat moves from the warming zone in an IC motor was investigated by **Sandeep Kumar et. al. (2017),** and a transient warm examination was carried out on the real structure of a Bajaj Find 125 CC single chamber motor. Transient warm tests were carried out on the actual and planned motor chamber plans in order to improve geometrical characteristics and warmth movement from the IC motor.

Mogaji et al. (2017) investigated the path of warmth through the balance of a rectangular profile surface with and without radiation heat misery. The effects of physical characteristics on the balancing warm execution, such as length, L, thickness, t, balance metal sort, and emissivity, have been nearly considered.

Arefin (2016) suggested an altered pin layout for a pin blade heat sink with pins extending outward. Warm assessment of the traditional pin balance heat sink and the adjusted pin blade heat sink has been directed numerically for normal convection for round form in inline course of action accepting consistent state condition from that point forward.

Balendra et al. (2016) tested and recreated a rectangular unnotched blade, which they certified for various thermal loads. The authors then focused on different sorts of stable zones, such as a changed indented blade. All of the foregoing aftereffects of temperature appropriation, speed vector plot, Nusselt number, and warmth move coefficient were assumed to expand consistently in all circumstances.

"Numerical look at on heat transfer IC Engine cooling by using enlarged fins the use of CFD," according to **Magarajan et al (2013).** In this study, the heat launch of six IC engine cylinder cooling fins with pitches of 10 mm and 20 mm is numerically computed using a commercially available CFD system. In Fluent ANSYS, The IC engine is set to 150 degrees and the heat released from the cylinder is measured at zero kilometers per hour.

Sayed and Viveksheel (2019) investigated fin thermal efficiency in Fluent (Ansys 15.2). For two metals (structural steel and aluminium alloy), the study was conducted at various air velocities (3, 4, 5, 6, 7 m/s). Three notched fin shapes (circular, trapezoidal, and square) were employed, as well as two unnotched fin shapes (rectangular and circular). The results showed that the rectangular fin provided better heat transfer outcomes than the other cases.

V. CONCLUSION

On the basis of the literature review in this research paper authors have concluded thatCooling fins are an integral part of the cooling system in air-cooled engines. They are used to improve performance of the engine.

Most of the authors have performed experimental work on the 100 CC and 125 cc motorcycle engines.
ANSYS have been used extensively by various authors for the investigation and evaluation of performance of the fins.Mainly Aluminium alloys, steel alloys and copper are the materials used in the fabrication of the extended surfaces. Copper has higher thermal conductivity gives better performance of the fins.

Design and geometry of the fins plays a significant role in the fabrication of the fins for an air-cooled engine.

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