

A Comprehensive Review On The Engine Cooling System With Fins

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Abstract

The cylinder of an automobile's internal combustion engine, for example, is one of the key components that endures extreme heat and cold. Fins or other protruding surfaces are seen on the inside of several cylinders of modern engines. Fins of varying materials and shapes may improve heat transmission from engine cylinders. To improve the rate of heat transmission, we may experiment with various fin materials as well as fin designs. In this paper, a literature survey has been conducted on the efficiency of the engine cooling system designed with fins on the cylinder and the different parameters affecting its efficiency.

Keywords

Internal Combustion Engine, Cylinder Fins, Thermal Strains, Rate Of Heat Dissipation

1.Introduction

More than 250 million highway transportation vehicles in the United States depend on internal combustion engines because of their exceptional drive ability and durability. They are not limited to conventional fossil fuels like gasoline and diesel (e.g., biodiesel, propane, natural gas, or ethanol). Hybrid electric powertrains and plug-in the hybrid electric systems may be used together to improve fuel efficiency and range, respectively. The term "combustion" refers to the chemical reaction between an air and fuel combination that results in the release of energy. The gasoline in an ICE is ignited and burned off within the engine itself. Then, the engine uses some of the energy released by the combustion to generate mechanical motion. In an internal combustion engine, a stationary cylinder houses a reciprocating piston. The crankshaft is turned by the piston, which is pushed by the expanding combustion gases. This motion ultimately powers the wheels of the vehicle through a transmission's gear system. Currently, two types of internal combustion engines (ICEs) are manufactured: spark ignition gasoline engines as well as compression ignition diesel engines. Most of them have what is called a four-stroke cycle engine, which means that each cycle of the engine requires four strokes of the piston. Intake,

combustion, compression and the power stroke, as well as exhaust are the four stages that make up the cycle. The fuel delivery and ignition systems of gasoline and diesel engines are fundamentally different. In a spark-ignition engine, the gasoline and air are blended together before being sucked into the cylinder. The compression of the fuel-air combination by the piston is followed by ignition by the spark plug. During the power stroke, the expanding combustion gases push the piston. Only air is taken in and compressed by a diesel engine. Diesel engines then spray a calculated amount of gasoline into hot compressed air, where it ignites.

2.Literature Review

(Kumar & Soni, 2021) The goal of this literature review is to familiarise yourself with the thermal analysis of fins of air-cooled internal combustion engines. The fins improve the system's heat dissipation efficiency by expanding the available heat sink area. Using convection, fins cool a variety of structures. The efficiency of fins as heat sinks is often capped by the system's engineering. Altering the cross-sectional area of fins, adding holes to fins, and doing thermal analysis of fins are all ways to modify the heat transfer effect. This work uses a literature review approach to learn more about the effects of cross sectional area on "heat transfer coefficient" and how it affects the efficiency of fins in an engine. (Abbood et al., 2021) The purpose of this effort was to enhance heat transmission in the motor engine cylinders by surrounding each cylinder with eight fins of varying forms. This process was performed out numerically the Fluent software (Ansys 19.0) for various Reynolds numbers (4, 6, and 8 x 10⁴) with constant heat flux (6, 12, 25 kw/m²). aluminium alloy, with a thermal conductivity of 237 W/m-k, was chosen for the fin bodies. Four forms of fin, circular, square, elliptical, as well as air foil, all with the same thickness (5 mm), gap between each fin (3 mm), pitch, and surface area (0.0745 m²) were tested. The working fluid utilised was air. According to the findings, the cylinder with square fins performed the best and had the maximum heat transfer coefficient. Heat transfer was shown to be proportional to Reynolds number, suggesting that as the latter rises, so does the rate of heat transmission.

(Kayal, 2021) The use of fins is crucial to the efficiency of any air conditioning or heating system. Its primary function is to enhance thermal conductivity. Research into the effects of fin properties including fin tip, fin array, base temperature, fin efficiency, as well as fin effectiveness was conducted so that a practical method could be proposed that could be utilised for adaptable analysis and design in appliances like refrigerators as well as transformers. Numerical calculations demonstrated an inverse relationship between fin length and heat transfer efficiency. While the efficacy of fins goes down as their thickness grows, their efficiency improves. The quantity of heat transported is proportional to the surface area, which is a function of the fin's size and form. Both the efficiency of the fins and the heat transmission were maximised in copper. Using a more conductive substance may boost fin efficiency.

(Thiagarajan et al., 2020) In IC engines, the cylinder liner is a hollow cylindrical shell inserted into the bore region to offer a suitable robust companion to the piston as well as to meet the demands of excellent sliding qualities, wear resistance, and thermal mechanical behaviour. There have been a lot of experiments done to increase the heat release rate by changing the fin design and the materials used. Also, the resistance to wear & corrosion may be affected by the temperature gradient between the combustion chamber's outside and interior. Cast iron's lubricating characteristics make it the material of choice for ic engines. Coatings for cylinders of various thickness and material have been taken into account in this study in order to provide the desired wear resistance, thermal stress, as well as corrosion protection. The cylinders for the two-wheelers were designed in Autodesk Inventor, as well as the steady-state thermal analysis was performed in ansys; the cast-iron cylinder liner was selected at first, but it was later compared to magnesium alloy as well as titanium, and its thickness was adjusted from 0.5 millimetres to 1.5 millimetres. The primary objective of this research is to examine a range of materials, varied in thickness, in order to do a thermal stress analysis under a variety of scenarios.

(Sathish et al., 2020) The research set out to identify several types of ideophones as well as ideophonic categories in Oromo. The research was done in the West Wellega, Ilu Abba Bor, and West Shewa zones of the Oromia Regional state. The goal of this research was to explore how Oromo speakers organise their language into ideophone as well as ideophonic categories. To define ideophones in Afan Oromo, distinguish them from ideographs in other word classes, explore Afan Oromo's onomatopoeia ideophones, and analyse how they are used in context

with other word classes. Qualitative methods were used because they were thought to be more effective in accomplishing the goals at hand. In all, 40 participants from three Zones were chosen using a purposive sample technique. Information was gathered using two methods: interviews and textual analysis. This research demonstrates that ideophones constitute a distinct word class with its own phonology, one that often makes use of onomatopoeia and innate reduplication to convey meanings of manner, sound, colour, odour, action, condition, and intensity. Ideophones stand out from other word families in each language due to their distinctive grammatical structure. Classifying words according to their formal and functional properties is a common practise in the field of linguistics. Therefore, it is reasonable to assume that ideophones constitute a coherent class of words in Afan Oromo. Word classes in general, however, allow for the creation of subclasses inside their larger umbrella.

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(Chandanshive & Pise, 2019) The expanded surfaces known as fins are responsible for releasing excess heat from the engine. To improve engine efficiency, several car sectors seek to boost heat dissipation rates. Maintaining the high thermal efficiency of the current model of IC engines necessitates the use of external heat sources such as garages and repair centres, but part of the heat produced during combustion must be removed to avoid thermal damage to the engine. When cooling an engine with

air, it's common practise to add fins, or protruding surfaces, to the cylinder's outside edge. The primary objective of this article is to examine how changing the shape and thickness of cylinder fins affects their thermal characteristics. In this work, a thermal analysis is performed on two different designs that include a slot, a thinner fin, and an increased number of fins to increase the rate of heat transmission. CAD and FEA tools are used to model and analyse the finned cylinder bloc.

(Ahirwar et al., 2018) The air-cooled engine's cooling process relies heavily on the fin configuration of the cylinder head as well as block. Adding cooling fins to a surface improves its ability to dissipate heat. Engine performance and longevity may be enhanced by proper cooling. The primary goal of this research is to investigate the thermal characteristics of different fin geometries, materials, and thicknesses, and to compare these findings with those obtained from a study of 100 cc Hero Honda motorcycles. There are parametric models of finned cylinders that may be used to predict their transient thermal behaviour. Presently The thermal conductivity of the aluminium alloy 6063 used to make the models is 200W/mk. There are three ways in which an internal combustion engine's combustion energy is lost after leaving the chamber. In order to improve geometrical parameters and increase heat transmission from the IC engine, transient thermal evaluations were done on both the existing and suggested designs of engine cylinders. The results of this study reveal that the suggested design of the IC engine has improved performance as well as heat transfer rate from the heating zone in the IC engine, which is why the focus of the current work is on this area as well as the replacement of the new design proposed by using the ANSYS 17.0 software. (Ranjan et al., 2017) The goal of this work is to improve the efficiency of heat transmission in an internal combustion engine by altering the shape of the fins. Both the current and new fin designs have been modelled in 3-dimensions using the CATIA V5 software package, and the "Finite Element Analysis" has been performed using the ANSYS workbench 17.0 programme. Previous studies have been used to compare and validate the findings.

3.TYPES OF COOLING SYSTEM IN ENGINE

Since internal combustion engines do all their fuel burning within the engine, they all need a cooling system. The engine's crankshaft does not transfer all the heat created by fuel combustion in the cylinders into usable mechanical energy. The conversion efficiency from heat to mechanical work is just about

30%. The exhaust takes up around 40%. The remaining 30% just releases heat into the environment without being of any value. The cylinder walls are subjected to a significant amount of heat, when this heat is not dissipated, several undesirable outcomes might occur, including piston seizure, excessive fuel consumption, lubricant burning, premature ignition, and so on. Given the above, it stands to reason that adequate provisions must be made for the removal of this surplus heat from cylinder walls in order to keep the temperature within acceptable parameters. A cooling system is what is used to remove the excessive heat from engine cylinder.

3.1Types of Cooling System In Engine

The two primary types of engine cooling systems are as follows:

- Air cooling system
- Water cooling system

1. Air cooling system

Small engines, up to around 15-20 kW in power, often employ air cooling. A variety of vehicles and installations employ the air system's engines, including motorbikes, scooters, aircraft, and even some permanent fixtures. Additionally, this mechanism is used in vehicle motors in nations with colder temperatures.

Through the walls of the cylinder, the heat is conducted directly into the surrounding air. Radiating fins as well as flanges are added to the cylinder as well as cylinder head to enhance the outside surface area and, hence, the rate of cooling. Larger units use fans to move air around the cylinder sides and head.

Advantages of Air Cooled System

The benefits of an air-cooled setup are as follows:

- The air cooled system is lightweight since it does not need a radiator or pump.
- There are leaks in a water cooling system, but none in this instance.
- Coolants and antifreeze are superfluous.
- If water is used, it may freeze in cold areas, but not with this technique.

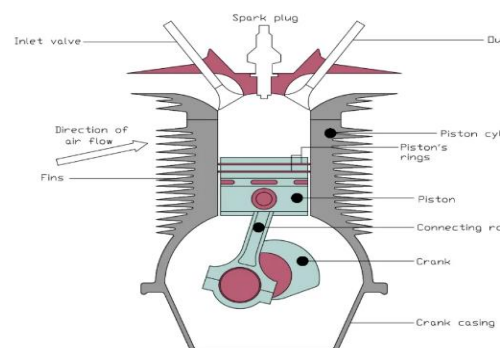


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Air Cooled IC Engines

Disadvantages of Air Cooled System

- As a result, its efficiency suffers in comparison.
- It's common in air-to-air applications, such as aeroplane and motorbike engines.

1. Water Cooling System

Vehicles such as automobiles, buses, trucks, etc. all employ engines that benefit from a water cooling system. Water jackets surround the cylinder, combustion chambers, valve seats, as well as valve stems, and the water is recirculated throughout the system.

A centrifugal water pump, powered by a V-belt from a pulley on the engine's crankshaft, maintains a constant flow of water. Having traversed the cylinder block as well as head jackets.

Currently, the radiator is functioning and water is flowing through it. Air is blown through the radiator to cool the water. Fan & water pump systems often share a driving shaft and mounting. The water is sent from the radiator to water pump through a cylinder intake route after it has been heated in the radiator. In the engine jackets, the water began to circulate once again.

Parts of Water Cooling System

- Radiator.
- Thermostat valve.
- Water pump
- Fan.
- Water Jackets.
- Antifreeze mixtures.

Types of Water Cooling System

Water cooling system has the following types:

- Thermosyphon cooling system.
- Impeller circulation system.
- Pump circulation system.
- Pressurised cooling system.

1. Thermosyphon Cooling System

Water convection is employed in this method. So, heated water rises because it's less dense than cold water. In this method, the hot water from the water jacket may reach the radiator at the top, where it can be radiated before making its way to the bottom tank, where it can be collected and used again.

Water is recirculated from bottom tank to the cylinder block's water jacket. This kind of natural circulation is employed in classic automobiles.

2. Impeller System

Thermosyphon cooling has been superseded by this method. And it's the same in every other way except

that it contains a little impeller unit operated by the engine itself to speed up the water's circulation.

3. Pump Circulation

A centrifugal pump powered by the engine's v-belt efficiently circulates water between the cylinder block and the radiator and vice versa, making this system the gold standard for contemporary water cooling.

4. Pressurised System

Compared to the traditional pump-based cooling circulation system, this is a major step forward. Specifically, this setup makes use of a spring-loaded pressure valve as well as vacuum valve on the particular radiator cap.

When engine is heated, water vapour is produced and is not permitted to escape since the cap is gas-tight. As a result, the engine's operating temperature increases, as does the boiling point of the water in the system, resulting in greater thermal efficiency.

When the internal pressure of the system reaches a specified threshold, say 0.5 kg cm², the pressure valve opens, allowing the steam to leave and preventing the buildup of excessive pressure. The engine's vacuum valve opens to make up for air or water loss when the engine is cooled.

Advantages of Water Cooling System

- Complete and even cooling throughout the cylinder, head, as well as valves.
- The use of a water cooling system reduces the engine's specific fuel consumption.
- Water cooling eliminates the requirement to place the engine at the very front of a vehicle in motion.
- The water in the cooling system helps to reduce the engine's noise compared to air-cooled models.

Disadvantages of Water Cooling System

- Water availability is a key factor.
- In order to keep the water flowing, a significant amount of energy is needed to run the water pump.
- When the engine's water cooling system breaks down, serious damage will occur.
- The water-based cooling system is more expensive since it requires more components. As an added downside, it has a higher component maintenance cost.

(a) Flat Plate Collectors

There is nothing fancy about these collectors. They are basically metal boxes with glass glazing on the top of a dark-colored absorber plate. In order to reduce heat loss to the collector's other sections, the sides as well as bottom are normally insulated. The absorber plate is struck by solar radiation that has

passed through the transparent glazing material. As the absorber plate warms up, the heat is transferred to the water or the air contained between absorber plate as well as the glazing. They may be coated with specific coatings meant to improve heat absorption and retention, as opposed to ordinary black paint. Copper or aluminium are the most common metals used to make these plates.

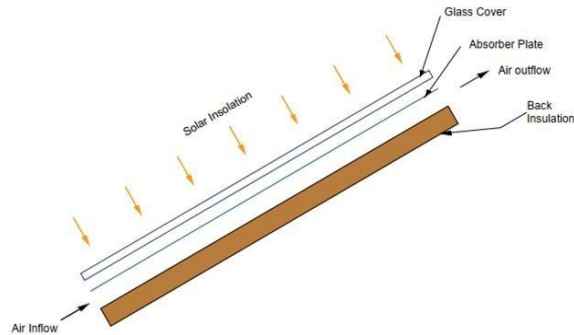


Figure 2 A Flat Plate Solar Collector

(b) Evacuated Tube Collectors

The water is heated by a series of evacuated tubes in this sort of solar collector. It is possible to catch the sun's rays while limiting heat loss with the use of vacuum tubes. Their absorber plate is an inner metal tube, which is attached to a heat pipe that transfers the sun's heat to water. The fluid in this heat pipe is under a very high pressure in a conduit of this kind.

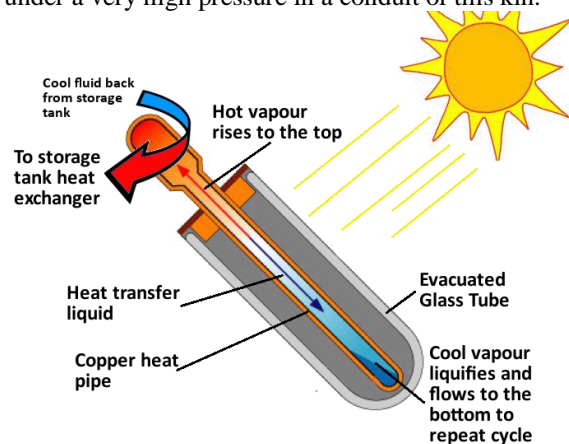


Figure 3 Evacuated Tube Collectors

Boiling liquid may be found at the "hot" end of the pipe, whilst condensing the vapour can be found at the "cold" end of pipe. A more efficient transfer of heat between the pipe's two ends is made possible. It's only when the Sun's heat flows from one end of heat pipe to the other that the water may be heated for the use.

(c) Line Focus Collectors

Reflective materials are used to capture and concentrate the heat energy from the solar radiation in these collectors. A lengthy trough connects a series of parabolically curved reflecting portions that make up these collectors. Reflective material is put in the middle of this trough to direct sunlight toward a water pipe, causing the water to heat up. "Solar thermal power plants" employ these collectors to create steam, which is why they aren't suitable for household usage because of their high power. These troughs, especially those that can swivel to follow the Sun's path in the sky, may be incredibly successful at producing heat from the Sun.

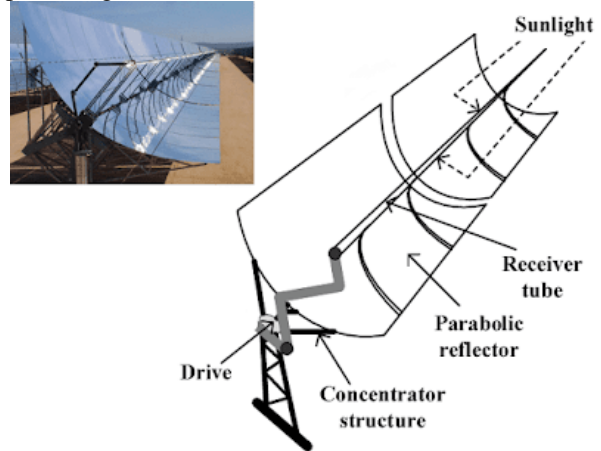


Figure 4 Line Focus Collectors

(d) Point Focus Collectors

Large parabolic dishes made of reflecting material concentrate the energy of the Sun into a single point in these collectors. It is most often utilised to power Stirling engines using the heat from such collectors. Even though they are very efficient at capturing sunlight, they should be constantly monitored to be of any use. Each of these dishes may be used on its own, but they can also be connected into a larger array to capture even more solar power. Concentrated photovoltaics may make use of point focus collectors as well as other similar devices to concentrate the solar energy. High-efficiency photovoltaic cells, particularly developed to capture the concentrated solar energy, convert the solar

energy directly into electricity rather than heat in this application.

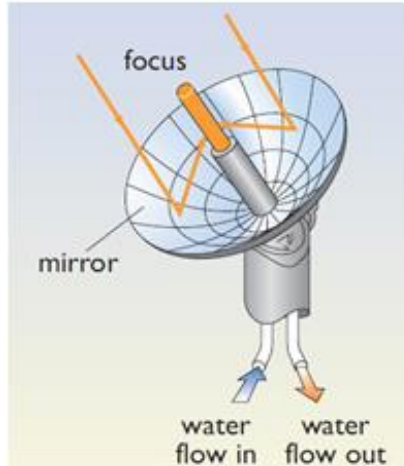


Figure 5 Point Focus Collectors

4. Conclusion and future work

The fins on an internal combustion engine are crucial for the efficient flow of cooled air to the engine. The primary function of these cooling fins is to direct airflow over the engine cylinder to keep it at a manageable temperature. Typically, fins are made in a rectangular form, but for this project, we decided to try something new. Extreme heat and cold, as well as thermal strains, are experienced by fins. Engine heat dissipation may be better understood by thermal analysis of the cylinder fins. The goal of this work is to boost the "rate of heat dissipation" by increasing the exposed area.

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