Investigation of temperature distribution of fin profiles: A Review

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ABSTRACT

The Engine is one of the important components in an automobile which is subjected to high temperature and thermal stresses. In order to cool the engine the fins are another component which are used to dissipate the heat from the Engine. Fins are generally used to increase the heat transfer rate from the system to the surroundings. The knowledge of efficiency and effectiveness of the fins are necessary for proper designing of fins. Application of the proposed method can be effectively extended to solve the class of similar non-linear fin problems in engineering and sciences. Fins are put on the cylinder surface to increase the quantity of convection-rejected heat. That is why the analysis of fin is important to increase the heat transfer rate. The main of aim of this work is to study various researches done in past to improve heat transfer rate of cooling fins. This review is to help understand how every mentioned parameters influences on improvement of thermal performance.

Keywords: Fins, CFD, heat exchanger, IC engine, fin material, heat transfer rate

INTRODUCTION

Heat transfer is a thermal energy which occurs in transits due to temperature difference. Cooling system is one of the important systems among all of the systems in automobile. Fins are responsible to carry out the produced heat inside the cylinder, for the heat transfer there are various modes like conduction, convection and radiation are taken place.(S Basavarajappa, G Manavendra 2020a) From these modes conduction is carried out in engine cooling fins. There are two different types of cooling system that are used in the automobiles, they are:

- Air Cooling
- Water cooling

Air-Cooling: Mostly automobile bikes using direct air cooling (without an intermediate liquid) were built over a long period beginning with the advent of mass produced passenger cars and ending with a small and generally unrecognized technical change (Pu et al. 2020).

Liquid Cooling: Liquid cooling is also employed in maritime vehicles. For vessels, the seawater itself is mostly used for cooling. In some cases, chemical coolants are also employed (in closed systems) or they are mixed with seawater cooling (Ndlovu and Moitsheki 2019). By doing the Computational Fluid Analysis the heat transfer rate of the fins with various types of notches are analyses by using ANSYS-14.5.(Jasim 2020)

Fins are the extended surfaces that are used to enhance heat transfer by the convection mode and are used in a wide range of industries as well as all domestic applications. Fins are generally used for heat control in electrical appliances such as computers, power stations, substation transformers, and widely used in IC engine cooling such in-car radiator. It is very important to predict the temperature distribution over the fin for choosing the fin geometry that offers maximum effectiveness and also economical.(Hameed and Khaleel 2019) So certain parameters are very important for the quality of the fin such of them is the effect of shape on fin effectiveness, efficiency, and temperature distribution.

Fins are commonly designed for enhancing heat transfer between base surface and its environment (Padmanabhan, Thiagarajan, Deepan Raj Kumar, et al. 2020). Convective heat transfer rate can be augmented by different methods such as increasing heat transfer surface area or heat transfer coefficient. Increasing the heat transfer surface area can be achieved by attaching the fins made of highly conductive materials on base surface.(Sathishkumar et al. 2017) Moreover, fin material should have high thermal conductivity to limit the temperature variation from base surface to the tip surfaces of the fin.

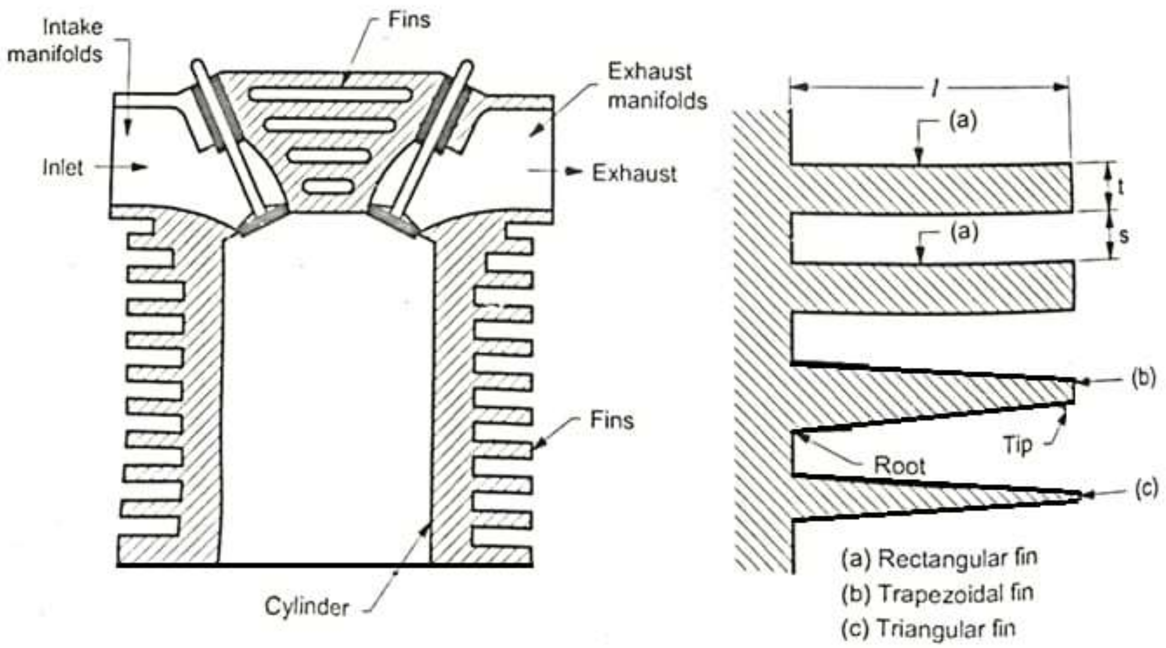

Figure 1: Engine with rectangular fins

Fins: In many engineering application large quantities heat has to be dissipated from small area. Heat transfer by convection between a surface and the fluid surrounding it can be increased by attaching to the surface thin strip of metal called Fins (He et al. 2020).

Different Configuration of FIN:

- Longitudinal fins
- Pin Fins or Spines
- Circumferential fins.
- Fins may be uniform or variable cross section.

Types of FIN geometry

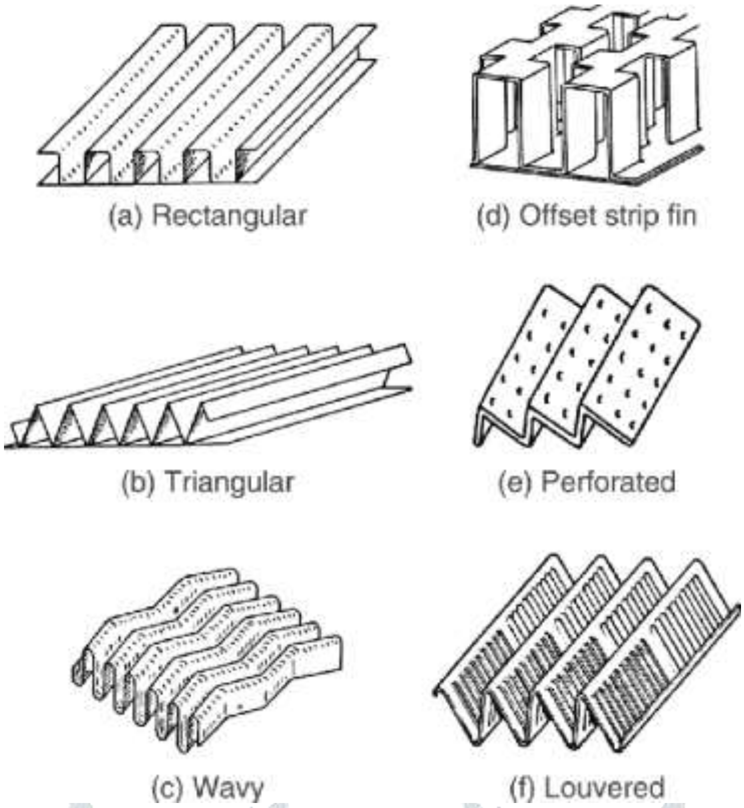

Figure 2: Types of FIN geometry

Some of the researches are previously described and the detailed information can be found in available literature. Most of the current scholar used to change the fin shape to improve the performance of the system (Thange et al. 2017)-(Wang et al. 2019).

LITERATURE REVIEW

(Padmanabhan, Thiagarajan, Raj, et al. 2020) suggested that in recent years, many researches on the fin material and geometry are carried out to enhance its application. In many applications, Fins are used to augment the rate of heat transfer from the system and rectangular, triangular and trapezoidal fin configurations were preferred. Fins are the expanded surfaces intentionally supplied in a position from which heat is to be extracted. The quantity of conduction, convection or radiation of parts determines the heat emitted by it. The temperature difference between the material and the atmosphere is increased, the thermal convection coefficient is rising or the ground surface area is increased, and the heat transfer increases. In this research paper, a numerical analysis is investigated for the different profile with the aluminium material. The temperature distribution at different lengths of the fin and the rate of heat transfer of these fin materials during each stroke of the compression engine for the steady-state are evaluated by analytical method, and results were validated with CFD analysis. The investigation is being made amongst the fin materials of rectangular and triangular geometries, and the best and optimal material is determined under the ambient conditions.

(Piccolo and Jaworski 2020) Heat transfer rates measurements by standard energy balance techniques and dynamic pressure measurements are used to assess the impact of the two heat exchangers on the engine performance. The gas-side heat transfer coefficient, expressed as Nusselt number, is also determined for the finned-tube heat exchanger. The resulting values are compared to the heat transfer coefficients estimated in analogous experimental studies and by predictive models. Results show that the circular-pore heat exchanger reduces the performance of the engine compared to the finned-tube heat exchanger by about 23%, being affected by higher thermal and viscous irreversibility.

(Hameed and Khaleel 2019) evaluated that seven different Aluminum fins under natural convection conditions were investigated experimentally and numerical. The first fin has a flat shape; while the second fin has a new proposed wavy shape. The rest have the same wavy shape but with different perforations distribution. 51 cm circular perforations were made on each of the five fins. Vertical cylindrical heat sink with 1000Wheater inside used. The difference in measurements between experimental and numerical study by ANSYS software was 2, 3, and 4% at a power supply of300, 500, and 700Wrespectively. Results show that the new proposed wavy configuration fin will give better heat transfer rate than the flat one with smaller space requirement. When the perforations were added to fins; better performance was obtained compared to solid fins (flat and wavy types) where a best heat transfer rate was obtained with minimum rig size, weight and cost which is the main object of most industrial applications. The effects of perforations distribution on wavy fins were also studied and the most success arrangement is indicated. Fin (5) showed more enhancement than other fin configurations.

(Salve, Koli, and Patil 2019) 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 and modification on the engine cylinder fins, it is helpful to know the heat dissipation inside the cylinder. Air-cooling is used due to reduced weight and simple in construction of engine cylinder block. As the air-cooled engine builds heat, 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. An attempt will be made to simulate the heat transfer using helical fin with parabolic cross section and analyze effects on rate of heat dissipation from fins surfaces. The heat transfer surfaces of Engine are modelled in CATIA and simulated in ANSYS software. The experimental analysis is done for rectangular and helical fin with parabolic cross section. The main of aim of this work is to compare various characteristic between these two fins.

(Sathishkumar et al. 2017) analyzed the Engine is one of the important components in an automobile which is subjected to high temperature and thermal stresses. In order to cool the engine the fins are another component which are used to dissipate the heat from the Engine. 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 our analysis is to determine the flow of heat at various notches available and the analysis is done by using ANSYS – CFD Fluent software.

(Sethuraman et al. 2015) presented that Convective heat dissipation from the standard surface can be significantly increased by the use of fins. Calculation of heat released from the fin involves a complex conjugate system of conduction and convection. The performance analysis is carried out using simulation and experimental method. Experiment carried out by using different geometry at different heat inputs. In this study, the enhancement of natural convection heat transfer from a horizontal rectangular fin embedded with rectangular perforations of aspect ratio of two has been examined using finite element technique. A fin experimental value set up is for designed developed and working procedure of the apparatus is simple. The results show that the rate of heat transfer is high for with insulated triangular fin, followed by without insulated triangular fin the results show that the rate of heat transfer is high for tapered pin fin, followed by pin fin.

(Wais 2010) analyzed the optimization of finned tube heat exchanger is presented focusing on different fluid velocities and the consideration of aerodynamic configuration of the fin. It is reasonable to expect an influence of fin pro- file on the fluid streamline direction. In the cross-flow heat exchanger, the air streams are not heated and cooled evenly. The fin and tube geometry affects the flow direction and influences temperature changes. The heat transfer conditions are modified by changing the distribution of fluid mass flow. The fin profile impact also depends on the air velocity value. Three- -dimensional models are developed to find heat transfer characteristics be- tween a finned tube and the air for different air velocities and fin shapes. Mass flow weighted average temperatures of air volume flow rate are calculated in the outlet section and compared for different fin/tube shapes in order to optimize heat transfer between the fin material and air during the air flow in the cross flow heat exchanger.

(Ng, Johnson, and Watkins 2005) suggested that Heat exchangers used in modern automobiles usually have a highly non-uniform air velocity distribution because of the complexity of the engine compartment and under hood flow fields; hence ineffective use of the core area has been noted. To adequately predict the heat transfer performance in typical car radiators, a generalized analytical model accounting for airflow maldistribution was developed using a finite element approach and applying appropriate heat transfer equations including the e–NTU (effectiveness – number of heat transfer units) method with the Davenport correlation for the air-side heat transfer coefficient. The analytical results were verified against a set of experimental data from nine radiators tested in a wind tunnel and were found to be within +24 and −10 per cent of the experimental results. By applying the analytical model, several severe non-uniform velocity distributions were also studied. It was found that the loss of radiator performance caused by airflow maldistribution, compared with uniform airflow of the same total flow rate, was relatively minor except under extreme circumstances where the non-uniformity factor was larger than 0.5. The relatively simple set of equations presented in this paper can be used independently in spreadsheets or in conjunction with computational fluid dynamics (CFD) analysis, enabling a full numerical prediction of aerodynamic as well as thermodynamic performance of radiators to be conducted prior to a prototype being built.

Some Noteworthy Contributions

AUTHOR	OBJECTIVE	THEIR CONTRIBUTION
(S Basavarajappa, G Manavendra 2020b)	A review on performance study of finned tube heat exchanger	The purpose of this paper is to provide an overview of research works carried out to improve the thermal performance of a heat exchanger by using different parameters like type of fins, orientation, shapes and locations.
(Sushma and Chandrashekar 2019)	A Review on Enhancement of Heat Transfer through Fins	The main aim of this review paper is to analyse the thermal properties of fin by varying its certain parameters like geometry of fins, material used, number of fins, thickness of fins etc.
(Chala 2019)	Influence of fins designs, geometries and conditions on the performance of a plate-fin heat exchanger-experimental perspective	The performances of the fin heat exchanger with respect to different attributes including designs, qualities and conditions of the fin were investigated experimentally.
(Yuan Xue, Zhihua Ge , Xiaoze Du and Yang 2018)	On the Heat Transfer Enhancement of Plate Fin Heat Exchanger	Three new kinds of wavy plate fins, namely perforated wavy fin, staggered wavy fin and discontinuous wavy fin, are proposed and investigated by numerical simulation.

(A.V. Zoman 2016)	Heat Transfer Enhancement using Fins with Perforation: A Review	This paper focuses on studies which deal with heat transfer enhancement by using perforated fin.

CONCLUSION

From the literature review, it is clear that the design of fin plays an important role in heat transfer. To enhance the heat transfer various types of fins were used in this review paper. Different fin geometries like rectangular, triangular, trapezoidal fins, Pin fins, wavy fins, offset strip fins, louvered fins and perforated fins are used in order to analyse the heat transfer rate and pressure drop measurement, various parameters like fin pitch, orientation, height and different types grooves used to study heat transfer rate, Pressure drop, Nusselt number friction factor Rayleigh number. Research works on variety of fins showed that, it improves the heat transfer by increasing the exposed area to allow more heat transfer and as well as disturbing the flow to produce turbulence and causing bulk fluid mixing. In future, new fin configurations can be proposed and compared with the present configurations.

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