A Review paper on Advanced design and analysis of engine fins for better cooling efficiency

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Abstract— *when fuel is burned in an engine, heat is produced. Additional heat is also generated by friction between the moving parts. Only approximately 30% of the energy released is converted into useful work while remaining 70% must be removed from the engine to prevent the parts from melting. In air-cooled I.C engine, extended surfaces called fins are provided at the periphery of engine cylinder to increase heat transfer rate. 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 different types of fins to improve heat transfer rate of cooling fins by changing cylinder fin geometry.*

Keywords—*Engine fins; Heat transfer rate; Cooling efficiency; serrated strip fins; Fins with holes*

Introduction

The internal combustion engine is an engine in which the combustion of a fuel (normally a fossil fuel) occurs with an oxidizer (usually air) in a combustion chamber. In an internal combustion engine, the expansion of the high-temperature and -pressure gases produced by combustion applies direct force to some component of the engine, such as pistons, turbine blades, or a nozzle. This force moves the component over a distance, generating useful mechanical energy.
Fins are the extended surfaces purposely provided at a place from where heat is to be removed. The amount of conduction, convection, or radiation of an object determines the amount of heat it transfers. Increasing the temperature gradient between the object and the environment, increasing the convection heat transfer coefficient, or increasing the surface area of the object increases the heat transfer. Fins are widely used for cooling of IC engines.

The different types of fin geometries that can be used for an IC engine are-

A.Pin Fins

A pin fin heat sink is a heat sink that has pins that extend from its base. The pins can be cylindrical, elliptical or square. A pin is one of the more common heat sink types available on the market. A second type of heat sink fin arrangement is the straight fin. Shapes of pin fin. A Pin Fin heat sink is a normal heat sink, but it differs from other heat sinks as it consists of pins that are extended from its base. These pins are in various shapes including elliptical, cylindrical and square shapes. It is the most common heat sink available in the market nowadays.

B.Rectangular Fins

Fins are projections on a surface used to promote heat transfer. To achieve this, the best way is to have a lot of thin fins with spacing in between them. If you were to look at a fin, it is obvious that the temperature distribution and the heat loss will not be strictly one dimensional. The material near the sides will be exposed to slightly more air than the material in the middle. But this is insignificant, so we go ahead and make the assumption of one dimensional heat flow. If we look at each fin, we see that the thickness (t), is very small compared to the other dimensions. This means that even though the middle layer would be at a higher temperature, it is not by much, because of how thin it is. Also because of how thin it is, the temperature will remain roughly constant throughout the width. There will be a difference, but it is negligible compared to the heat flow and temperature profile in the length wise direction. As a result, we can ignore the small differences, so we can make the assumption of one dimensional heat flow, starting from the base to the tip.

C.Triangular fins

Triangular fins are attractive, since for an equal heat transfer it requires much less volume than rectangular fin. Hence the fins have practical importance because it gives maximum heat flow per unit mass with ease of manufacture. In an air-cooled engine, rectangular and triangular fins are provided on the periphery of engine cylinder. Heat transfer analysis is carried out by placing rectangular and then triangular fins. In the Figure there is show the triangular fin. Fig shows the Length(L), Width(W) and Height(th) of fins. Application of triangular fins are same as the rectangular fins. only the shape of the fins are different from each other and also the triangular fins are more efficient then the rectangular fins.

D. Trapezoidal Fins

The trapezoidal fins are same as triangular fins. It mostly used in automobile industries and space applications. Most use of these fins is in rocket blades. This will hopefully reduce the rebuilt time when there is crash. It will reduce drag in the vertical position as there is less surface area cutting through the air. It will increase the surface area when the air is pushing the fin back to the vertical. So there are increases in the surface area of the fins so the heat transfer rate is also increase and its more as compared to rectangular fins and triangular fins.

E. Serrated Strip Fins

These types of fins are characterized by high degree of surface compactness, high reliability and substantial heat transfer enhancement due to the boundary layer re-starting at the uninterrupted channels. However there is on the other hand, an associated increment in large pressure drop consequently which leads to higher operation cost.
In fig show that there is typical serrated fin is shown in detail, in which the fin height(h), fin space (s), fin thickness (t), and interrupted length (l) are considered as the four optimization design parameters. Indeed it has become a necessary to find to fins a trade-off between the heat transfer enhancement and the pressure drop increment.

Literature Review

Sanjay Kumar Sharma and Vikas Sharma [1]: The results of computational numerical analysis of air flow and heat transfer in a light weight automobile engine, considering three different morphology pin fins(Cylindrical,drop,rectangular). A numerical study using Ansys fluent(Version 6.3.26) was conducted to find the optimum pin shape based on minimum pressure drop and maximizing the heat transfer across the Automobile engine body. There are three steps used in analysis- Temp control result, pressure plots and velocity plots. Result show that drop fin is most accurate from other fins because of its shape and surface area. The results indicate that the drop shaped pin fins show improved results on the

basis of heat transfer and pressure drop by comparing other fins. The reason behind the improvement in heat transfer by drop shape pin fin was increased wetted surface area and delay in thermal flow separation from drop shape pin fin.

KM Sajesh, Neelesh Soni and Siddhartha Kosti [2]-:Transient and Steady state heat transfer simulation is carried out on the engine. A two wheeler bike engine is chosen and geometry is designed in Design Modeler in Ansys.CFD shows improvement in fin efficiency by changing fin geometry, fin pitch, number of fins, fin material and climate condition. A modification in design of engine is made by creating various diameter holes on fin. In addition perforated fin was compared with an imperforate fin to observe the differences.However, Fin with a hole of 2mm & 10mm dia has reached the steady state limits before a time period of 100 seconds when compared with other fins.

Prof. Arvind S. Sorathiya, Manankumar B. Joshi,Prof. (Dr.) Pravin P. Rathod[3]: Now-a-days motor cycles having higher capacity engine obtain liquid cooling. This takes place due to some limitation of air cooling with high capacity heat transfer process. As it is necessary to modify or design an advance air cooling system. For that computational, analytical and experimental studies are carried out for the fins geometry, material and its number and pitches. As per available literature surveyed there is a little work available on the wavy fins geometry pertaining to current research area to till date. So there is a scope of research in the field of heat transfer study on wavy fins on cylinder head –block assembly of 4 stroke SI engine.

Mohsin A. Ali and Prof. (Dr.) S.M Kherde[4]: Insufficient removal of heat from engine will lead to high thermal stresses and lower engine efficiency. The cooling fins allow the wind to move the heat away from the engine.For the analysis purpose existing Model of Bajaj discover is taken and same model is modified with different geometry of fins('s' shape fins and step shape fins) and comparison is plotted in results.Heat transfer rate increases after changing fin geometry and it is observed that HTC and turbulence are more in case of Step shape Fin model as compare to S shape Fin model. Due to non-uniformness in the geometry of Fins turbulence of flowing air increases which results in more heat transfer rate.

Abhishek Mote, Akshay Choukse, Atharva Godbole, Dr. Pradeep Patil, Avinash Kumar Namdeo[5]-:

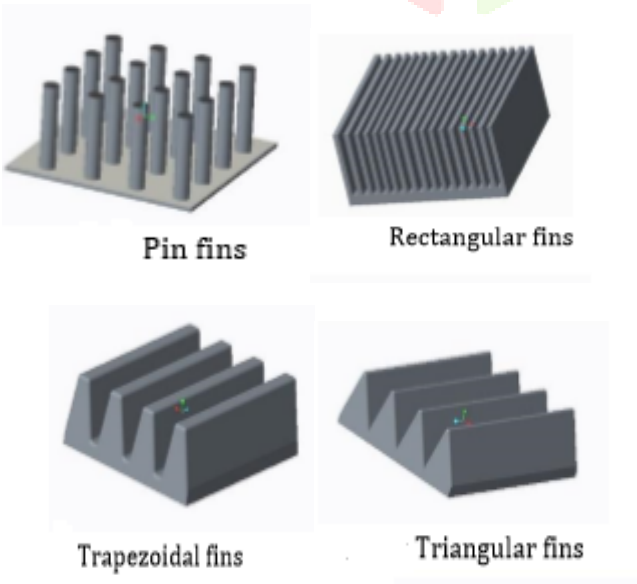

Fig.- Different types of fins

There are four different types of fins (rectangular, triangular, trapezoidal, pin) are taken and compare on CFD.If the length of fins is increased too much, the convective thermal resistance would increase thus reducing the heat transfer rate, fin efficiency and also; it adds unnecessary material and costs also. Conversely, if the length of fins is too short, the heat transfer rate and fin efficiency would decrease again. Hence the length of fin needs to be optimum in value.

JianWen, HuizhuYang, XinTong, KeLi, SiminWang, YanzhongLi[6] : The effect of fin design parameters on the performance of plate-fin heat exchanges was investigated in the paper.An ideal gas used as a working fluid and e-NTU methods is used to find heat transfer and pressure drop.There are used different types of factors, Compare it and find the different result from it.

Prof. Arvind S. Sorathiya, Hiren P. Hirpara, Prof. Dr. P.P. Rathod[7]: In IC engine there are planty of heat generate in combution chamber so the heat is carried away by exhaust gases. The aim of this review is to find out the effect of fin geometry and fin pitch on cooling of the engine. Fernando Illán et al-From the simulation they have concluded that a total reduction of 20.15% has been achieved by reducing the total engine diameter D and by increasing the total height H. S. H. Barhatte et al- He say that heat transfer rate should increase by provide different shape of notches on the engine surface.so this is the different technique for remove heat from the engine.

HongbinYan,ShangshengFeng,TianjianLu,GongnanXie[8]: In the disc break of vehicals,when we applied a break then planty of heat produced on disc,so we have to reduce the heat from disc. So we have to take standered disc break and disc break with cross drilled. And compare the heat transfer rate of both break.The cross drilled pin finned break disc provide 15-17% higher steady state cooling capacity to the standard pin finned break disc. So this is the best way to increase heat transfer rate in IC engine.

Vikash Kumar, Dr. S K Jain, Dr. Sukul Lomash[9]: When fuel is burned in an engine, heat is produced.Only approximately 30% of the energy released is converted into useful work while remaining 70% must be removed from the engine.In air-cooled I.C engine, extended surfaces called fins are provided at the periphery of engine cylinder to increase 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 by changing cylinder fin geometry and material.

B.Anoop ,C.Balaji,K.Velusamy[10]: Conjugate heat transfer from serrated fins on the outside of the tubes of a sodium to air tubular heat exchanger of sodium cooled fast breeder reactors, has been investigated by combined experimental and computational approaches. the RNG k–ε model, which is applicable for a wide range of Reynolds numbers, was used for turbulence closure. A detailed parametric study has been carried out to investigate the effect of serration depth, fin pitch, fin height and fin thickness.

A.Lemouedda, A.Schmid, E.Franz, M.Breuer, A.Delgado[11]: Helical serrated finned-tubes are well established in many thermal systems. This paper presents the results of numerical calculations carried out for the performance improvement of these devices. The work is divided into three main investigations conducted for Reynolds numbers between $Re = 600$ and 2600. The first investigation shows the effect of the fin serration, where a comparison between performances of finned tubes with and without fin serration is presented. Another main investigation is conducted on the effect of fin twisting of the outermost part of the fin on the performance of the serrated finned-tubes. Here, twisting angles considered are between $\beta = 0°$ and 25°. The third investigation deals with the effect of the number of fin segments per period.

Zhenping Wan, Yong Tang[12]: Most recently, energy and materials savings considerations have stimulated the demand for

high efficient and compact heat exchangers. Finned tube is a well-known technology that promotes heat transfer efficiency. This paper proposes a new method of manufacturing integral serrated outside finned tube—rolling and wedging/extruding method. In this method, surface material of workpiece is only split from workpiece body, but not removed. The split and inseparate "chips" can be used to integral outside fins. The wedging/extruding tool is designed. Comparing to conventional cutting tool, the secondary cutting edge is transformed into curve face and only primary cutting edge is remained in wedging/extruding tool. The forming process of integral serrated outside finned tube by rolling and wedging/extruding is analyzed. In addition, the main technical parameters which affect the fins height and pitch are also discussed.

G. Babu, M. Lavakumar[13]: The main aim of the project is to analyze the thermal properties by varying geometry, material and thickness of cylinder fins. Parametric models of cylinder with fins have been developed to predict the transient thermal behavior. The models are created by varying the geometry, rectangular, circular and curved shaped fins and also by varying thickness of the fins. The 3D modeling software used is Pro/Engineer. The analysis is done using ANSYS. Presently Material used for manufacturing cylinder fin body is Aluminum Alloy 204 which has thermal conductivity of 110-150W/mk. We are analyzing the cylinder fins using this material and also using Aluminum alloy 6061 and Magnesium alloy which have higher thermal conductivities.

Minsung Kim, Man Yeong Ha, June Kee Min[14]: In this study, the performance of a surface air–oil heat exchanger for an aero gas-turbine engine having plate- and pin–fin shaped geometries was investigated numerically. Basic heat-transfer and pressure-drop characteristics were examined using a simplified channel model. Performance of pin-shaped fins is compared with that of the plate fin as a baseline. Using a parametric study, optimal fin pitches of the pin–fin geometries in stream- and span-wise directions were determined.

Gui Lu, Jun Zhao, Lin Lin, Xiao-Dong Wang, Wei-Mon Yan[15]: A new design of wavy microchannel heat sink with porous fins is proposed to reduce simultaneously pressure drop and thermal resistance. A three-dimensional solid-fluid conjugate model with considering heat transfer and flow in porous media is adopted to validate the effectiveness of the new design. The results show that the wavy microchannel heat sink with porous fins reduce simultaneously pressure drop and thermal resistance compared with conventional wavy microchannel heat sinks with solid fins. The marked pressure drop reduction in the wavy microchannel with porous fins comes from the combination of permeation effect and the slip effect of the coolant fluids.

CONCLUSION FROM LITERATURE

- It was important to show that CFD tool is good approach to analysis thermal behavior of any thermal device. For future work refinement of mesh was good approach to refine results and validation of CFD results will give more benefit to users.
- Heat Flux of the fin varies on creation of holes. Heat lost by the body can be increased by increasing the surface area i.e. increasing the diameter of the hole created on the fin. Turbulence of flow of air is increased between the fins on creation of hole.
- There are used wavy fins in engines, because wavy fins are not used till date so its great scope for improvement in different way.
- Due to non-uniformness in the geometry of Fins turbulence of flowing air increases which results in more heat transfer rate.
- Length of fin is also play a major role, because if its too long or too short then there are bad effect on heat transfer rate.
- Large number of fins with less thickness can be preferred in high speed vehicles than thick fins with less number as it helps inducing greater turbulence and hence higher heat transfer possible. Wider spacing shorter fins are prefer than the longer fins.

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