Design Modification and Thermal Analysis of IC Engine Fin – A Review

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Abstract

To study different research papers related to thermal analysis of extended surfaces or projections of materials on the system (engine) called fins of air cooled IC engines. The fins are used to increase the heat transfer rate from the system to the surrounding by increasing the heat transfer area. Fins are used to cool various structures via the process of convection. Generally heat transfer by fins is basically limited by the design of the system. The heat transfer effect may be varied by changing material of different thermal conductivities, improvising engine geometry, increasing cross section area of fins, using perforations on fin and on CFD analysis of fins. Hence the aim of this paper is to study from different literature surveys that how heat transfer through extended surfaces and the heat transfer coefficient affected by changing cross-section this study is useful to know the better geometry and material for the fins for better engine cooling.

Keywords: Creo 3.0, ANSYS 15.0, CFD, Steady State, Transient State Heat Transfer

I. INTRODUCTION

In IC engine the combustion takes place inside the cylinder where the chemical energy of the fuel converts into mechanical energy. Only 25 to 35 percent of the total generated thermal energy converts into useful work and rest of it rejected into the surrounding. The generated energy causes the engine temperature up to 2300ºC which may result into burning of oil film between moving parts and may result into seizing or welding. Hence this temperature must be maintained up to safe temperature limits. The present study aims to investigate heat dissipative effect of fins made up of different materials and different geometries. It’s necessary to analyze the heat transfer rate of fins. Study will lead to the different experiments which have been made to increase fin efficiency by changing fin material properties, climatic condition around fins, using perforations and notches in fins and fin geometry. The main thermal analysis tool is CFD analysis with the help of computer modeling software. The main study is focused on a two wheeler engine (Honda unicorn 150cc).

II. LITERATURE REVIEW

KM Sajesh et al. [1] had studied that the heat lost by the body can be increased by increasing the surface area. The increment in surface area is done by creating holes of different sizes on the surface of fins. Increasing the diameter of hole created on the fin brings the overall temperature of the body lower than the lesser diameter model. By creating holes on fins the temperature of fins can be reduced. It also says that the turbulence of air also get increased by creation on holes. This result came by performing a CFD analysis of rectangular fin engine made up with AL 6063 having thermal conductivity of 200W/mK. This CFD is done on steady state and transient state both. This also shows that, the transient temperature of all fins reached to the steady state temperature within 400 seconds of time.

V. Karthikeyan et al. [2] have founded that heat transfer rate of rectangular fin arrays is analyzed by design with perforated and with extension, analysis is carried out using ANSYS Workbench. In that steady state thermal analysis, temperature variations with respect to distance at which heat flow occur through the fin is analyzed. Heat transfer through fin arrays with rectangular extensions higher than that of fin with other type of fins compared to it. Temperature at the end of fin arrays with rectangular extensions is minimum as compare to fin with extensions, without extension and with perforated. Fin arrays with rectangular extensions provide near about 13 % to 21% more enhancement of heat transfer as compare to other type of fins. This result may vary for forced convection heat transfer.

L. Natrayan et al. [3] Design of fin plays an important role in heat transfer. There is a scope of improvement in heat transfer of air cooled engine cylinder fin if mounted fin’s shape varied from conventional one. Contact time between air flow and fin (time between air inlet and outlet flow through fin) is also important factor in such heat transfer. Wavy fin shaped cylinder block can be used for increasing the heat transfer from the fins by creating turbulence for upcoming air. Improvements in heat transfer can be compare with all the four model of the engine fins geometry by CFD Analysis and its flow characteristics are studied for all the geometries it is found that the curved fins provide better result when compared with all the other geometries.

Pardeep Singh et al. [4] compared the heat transfer performance of fin with same geometry having various extensions and without extensions is in their thermal analysis, temperature variations with respect to distance at which heat flow occur through
the fin is analyzed. Fin with extensions provide near about 5% to 13% more enhancement of heat transfer as compared to fin without extensions also the heat transfer through fin with rectangular extensions higher than that of fin with other types of extensions. The temperature at the end of fin with rectangular extensions is lesser as compared to fin with other types of extensions. They also showed that the effectiveness of fin with rectangular extensions is greater than other extensions and choosing the minimum value of ambient fluid temperature provide the greater heat transfer rate enhancement.

P. Sai Chaitanya et al. [5] had some work on a cylinder fin body modeled and transient thermal analysis is done by using Pro/Engineer and ANSYS. These fins are used for air cooling systems for two wheelers. In present study, Aluminium alloy 6061 is compared with Aluminium Alloy A204. The various parameters (i.e., geometry and thickness of the fin) are considered in the study. By reducing the thickness and also by changing the shape of the fin to circular shape from the conventional geometry i.e., rectangular, the weight of the fin body reduces thereby increasing the heat transfer rate and efficiency of the fin. The results show, by using circular fin with material Aluminium Alloy 6061 is better since heat transfer rate of the fin is more. By using circular fins the weight of the fin body reduces compared to existing rectangular engine cylinder fin.

Vignesh. P et al. [6] have changed flat structured fin to sinusoidal structure fin for increasing the heat transfer rate in the engine. Thus by simply changing the fin geometry from the flat fin to the sinusoidal wavy form the heat transfer rate is greatly improved leading to less thermal stress development. Also faster as well as uniform cooling can be possible in this type of fin geometry. The engine efficiency and effectiveness can be increased because of reduction in fin size and weight. Due to the development of wavy fins with projection on the convex area of the fins more turbulence and vorticity is formed which further improve the heat transfer rate. Thus manufacturing this type of fins will be economical and become a feasible product to our Country.

Mohsin A. Ali et al. [7] showed that the design of fin plays an important role in heat transfer. There is a scope of improvement in heat transfer of air cooled engine cylinder fin if mounted fin’s shape varied from conventional one. The fin geometry and cross sectional area affects the heat transfer coefficient. In high speed vehicles thicker fins provide better efficiency. Increased fin thickness resulted in swirls being created which helped in increasing the heat transfer. Large number of fins with less thickness can be preferred in high speed vehicles than thick fins with less numbers as it helps inducing greater turbulence and hence higher heat transfer. Heat transfer coefficient can be increased by increasing the surrounding fluid velocity by forced convection. Heat transfer depends on different stream velocities. The temperature and heat transfer coefficient values from fin base to tip are not uniform which shows the major advantage of CFD for analysis of heat transfer. Contact time between air flow and fin (time between air inlet and outlet flow through fin) is also important factor in such heat transfer. Curve and Zigzag fin shaped cylinder block can be used for increasing the heat transfer from the fins by creating turbulence for upcoming air. Improvements in heat transfer can be compared with conventional one by CFD Analysis.

Sachin Kumar Gupta et al. [8] had thermal analysis on the fin body by varying materials, geometry and slot sizes. And they concluded now a day’s material used for fin body of IC engine is Aluminium alloys. They have replaced older material with Aluminium alloy 6061, Aluminium Alloy C443 and Aluminium Alloy 2014. The shape of the fin remains the same with variable slots sizes. The default thickness of fin is 2.35mm. By slotting the weight of the fin body reduces thereby increasing the heat transfer rate but excess increase in slot sizes leads to decrease in heat transfer. By observing the analysis results they compared fin surface temperature of various sized slotted fins for different materials and founded that the cost of engine decreases due to reduction in the material requirement of cylinder. 75mm slotted fins have maximum heat transfer within different material slotted fin. The minimum surface provided for 75mm for fin surface temperature 75mm slotted fin engine of Aluminium 2014 material have maximum heat transfer As the slots size increase above 75mm heat transfer decreases.

Hardik D. Rathod et al. [9] had investigated that the fin geometry and cross sectional area affects the heat transfer coefficient. In high speed vehicles thicker fins provide better efficiency; the increased fin thickness resulted in swirls being created which helped in increasing the heat transfer. Large number of fins with less thickness can be preferred in high speed vehicles than thick fins with less numbers as it helps inducing greater turbulence and hence higher heat transfer rate. Heat transfer coefficient can be increased by increasing the surrounding fluid velocity by forced convection. Heat transfer depends on different stream velocities, but overcooling also leads to higher consumption of fuel, so it is necessary to maintain fluid velocities around the fins. Heat transfer coefficient depends upon the space, time, flow conditions and fluid properties. If there are changes in environmental conditions, there are changes in heat transfer coefficient and efficiency also. The temperature and heat transfer coefficient values from fin base to tip are not uniform which shows the major advantage of CFD for analysis of heat transfer.

A Sathishkumar et al. [10] had a research in which they designed cylinder fin body used in 100cc motorcycle. They replaced the engine fins with different materials such as Aluminium 6061, A2014, and C443. The various geometries of fins used are angular, curved and circular instead of rectangular fins. The observations from their research work are, Aluminium Alloy 2014 showing 17% higher temperature distribution compared to that of Aluminium Alloy 204 due to its material composition and higher thermal conductivity. All the materials are showing linear distribution of temperature along the length of fins and the circular fins increase the efficiency of the engine by reducing the weight of the engine. Also, observed that the engine with curved fins is shown better efficiency due to its less weight.

K. Sathishkumar et al. [11] had investigated that 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 we conclude that the rectangular notch fins are most efficiency and best heat transfer notch among all types of notch.
Ajay Sonkar et al. [12] had studied that the use of fin/extended surface with extensions, provide efficient heat transfer, temperature of Fin with extensions increases about 2% to 3% as compare to fin without extensions. Fin with extensions provide near about 4% to 13% more enhancement of heat transfer as compare to fin without extensions. Heat transfer through fin with trapezoidal extensions higher than that of fin with other types of extensions. By providing extensions in fin there is no improvement in thermal flux. From analysis they have got that the thermal flux decreases with extensions and concluded that using extension in fins surface is having better heat transfer rate as compared to normal fin.

Deepak Gupta et al. [13] had designed a cylinder fin body used in a 100cc Hero Honda Motorcycle and modeled in parametric 3D modeling software Pro/Engineer. Present used material for fin body is aluminum alloy fins and internal core with grey cast iron. We are replacing with Aluminum alloy 6063 and Grey cast iron separately for entire body. The shape of the fin is rectangular; we have changed the shape with circular shaped. The default thickness of fin is 3mm; they reduced it to 2.5mm. They have done thermal analysis on the fin body by varying materials, geometry and thickness. By observing the analysis results, using circular fin, material Aluminum alloy 6063 and thickness of 2.5mm is better since heat transfer rate is greater, but by using circular fins the weight of the fin body increases. So if we consider weight, using circular fins is better than other geometries. So they concluded that using material Aluminum alloy 6063 is better, reducing thickness to 2.5mm is better and using fin shape circular by analysis and fin shape curved by weight is better. By observing the results, using circular fins the heat lost is more, efficiency and effectiveness is also better.

G. Angel et al. [14] had investigated that these fins are used for air cooling systems for two wheelers. In their work, Aluminium alloy 6061 and Zinc alloy at different thickness has been studied. The various parameters (i.e., materials and thickness of the fin) are considered in the study, materials (Aluminum and Zinc alloys) and thickness (3 mm and 2.5 mm). By varying the thickness of the circular fin, aluminum alloy shows better results compared to Zinc alloy, since heat transfer of the circular fin is more.

III. SCOPE OF WORK

From the study it is clear that there is huge scope of designing cooling fins for air cooled engines. This can improve heat dissipation from engine which can be achieved by changing fin geometry, fin material. Thermal analysis of cooling fin can easily be done by CFD on ANSYS while the model could be prepared on any modeling software like Creo. In which the thermal analysis of the super meshed model take place very accurately. This study also tells that CFD analysis is better than the theoretical analysis of the model. It also says that in present time Aluminium alloys like AL6061, 6063 are used at the large scale for the manufacturing of cooling fins of IC engines and they shows better thermal conductivity than the conventional steel alloys.

IV. CONCLUSION

From detailed study of the papers it can be concluded that the geometry and cross section area of the fin is the most important criteria that decides the efficiency of the cooling fin. For increasing the cross section area making holes on the surfaces of fins also increases the heat rejection from fins faster than the plan rectangular fin. Increasing the hole size also improves the heat dissipation up to a limit as the hole size increases the minimum temperature on the fin gets reduced. Heat transfer coefficient depends on the time, space, flow condition and the fluid properties. It also founded that change in environmental condition causes great change in heat transfer coefficient and in its efficiency.

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