IJREAT International Journal of Research in Engineering & Advanced Technology, Volume 2, Issue 1, Feb-Mar, 2014
ISSN: 2320 - 8791
www.ijreat.org

Heat Transfer Augmentation of Air Cooled 4 stroke SI Engine through Fins- A Review Paper

Prof. Arvind S. Sorathiya[1], Manankumar B. Joshi[2], Prof. (Dr.) Pravin P. Rathod[3]

[1]Associate professor, Mechanical Engg. Dept.,Govt. Engg. College, Bhuj

[2]PG Student, Mechanical Engineering, Govt. Engg. College, Bhuj

[3]Associate professor, Mechanical Engg. Dept.,Govt. Engg. College, Bhuj

Abstract

As energy resources from this world are being depleted day by day in enormous amount. With keeping it as root cause engineers and scientists continually focus over inventing something better rather than existing. In case of automobile the fuel saving is the prime important with minimum emission and best performance. The phenomenon by which heat transfer takes place through engine fins must frequently be improved for these reasons. Fins are extended surface which 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. But still it may be enhanced by modifying certain design parameters of the fins. Hence the aim of this paper is to study from different literature surveys that how heat transfer through extended surfaces (fins) and the heat transfer co-efficient affected by changing cross-section, climatic conditions, materials etc.

Keywords: *Air Cooling, Engine Performance, Fins, Heat Transfer, Internal Combustion Engine, ANSYS*

1. Introduction

Now-a-days motor cycles having higher capacity engine obtain liquid cooling rather than air 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 which can also serve in high capacity bikes because of its some advantages like no pump, no leakage, easy maintenance and coolant and antifreeze solutions are not required. For that computational, analytical and experimental studies are carried out for the fins geometry, material and its number and pitches.

2. Literature Review

The literature reviews have been studied on the following aspects.

2.1 Fin Pitch, Design and Method

Mohammad A. Elyyan et al. [8] Direct and Large-Eddy simulations are conducted in a fin bank with dimples and protrusions over a Reynolds number range of ReH = 200 to 15,000, encompassing laminar, transitional and fully turbulent regimes. Two dimple-protrusion geometries are studied in which the same imprint pattern is investigated for two different channel heights or fin pitches, Case 1 with twice the fin pitch of Case 2. The smaller fin pitch configuration (Case 2) develops flow instabilities at ReH = 450, whereas Case 1 undergoes transition at ReH = 900. Case 2, exhibits higher Nusselt numbers and friction coefficients in the low Reynolds number regime before Case 1 transitions to turbulence, after which, the differences between the two decreases considerably in the fully turbulent regime. Vorticity generated within the dimple cavity and at the dimple rim contribute substantially to heat transfer augmentation on the dimple side, whereas flow impingement and acceleration between protrusions contribute substantially on the protrusion side. While friction drag dominates losses in Case 1 at low Reynolds numbers, both form and friction drag contributed equally in Case 2. As the Reynolds number increases to fully turbulent flow, form drag dominates in both cases, contributing about 80% to the total losses.

In conclusion, the dimple/protrusion combination as a heat transfer enhancement surface produced mixed results. While both geometries are viable and competitive with other augmentation surfaces in the turbulent regime, Case 2 with larger feature sizes with respect to the fin pitch is more appropriate in the low Reynolds number regime ReH < 2000, which makes up most of the operating range of typical compact heat exchangers.

Mishra A.K. et. al. [7] carried out transient numerical analysis ANSYS FLUENT 12.1 CFD code with wall cylinder temperature of 423 K initially and the heat release from the C. S. cylinder is analyzed for zero wind velocity. The heat release from the cylinder which is calculated numerically is validated with the experimental results. To increase the cylinder cooling, the cylinder should have a greater number of fins. However, the cylinder cooling may decrease with an increased number of fins and too narrow a fin pitch. The is because the air could not flow well between the fins, thus the overlapping of thermal boundary layers occurs at the upper and lower fin surfaces.

Praful Date et. al. [13] proposed the novel approached toward the heat transfer enhancement of plate and fin heat exchanger using improved fin design facilitating the vortex generation. The vortex generator can be embedded in the plane fin and that too in a low cost with effect the original design and setup of the commonly used heat exchangers. The various design modifications like plate fin, wavy fin and compounded fin studied numerically and experimentally.

Sanjay Kumar Sharma et. al. [16] presented the results of computational numerical analysis of air flow and heat transfer in a light weight automobile engine, considering three different morphology pin fins. 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. 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.

S.H. Barhatte et. al. [15] By modifying the geometry of fin arrays natural convection heat transfer from vertical rectangular fin arrays with and without notch at the center have been investigated experimentally and theoretically. The fin flats were modified by removing the central fin portion by cutting a notch which was followed by simulation in CFD and experiment. It is proved beyond doubt that the heat transfer coefficient is highest for the set of fins with triangular notch. This has been shown by the CFD analysis as well as by the experimental analysis.

Magarajan U. et. al. [18] have studied heat release of engine cylinder cooling fins with six numbers of fins having pitch of 10 mm and 20 mm, and are calculated numerically using commercially available CFD tool Ansys Fluent. The engine was at 150 C and the heat release from the cylinder was analyzed at a wind velocity of 0 km/h. Their CFD results were mostly same as that of the experimental results. So, they concluded that, it is possible to modify the fin geometry and predict those results, changes like tapered fins, providing slits and holes in fins geometry can be made and the optimization of fins can be done with the help of CFD results.

2.2 Fin Thickness, Height and Method

L. Dialameh et. al. [5] have did numerical study to predict natural convection from an array of aluminum horizontal rectangular thick fins of 3 mm< t < 7 mm with short lengths (L 6 50 mm) attached on a horizontal base plate. The three-dimensional elliptic governing equations of laminar flow and heat transfer were solved using finite volume scheme. Based on the verified model, fluid flow and thermal structure around various fins were illustrated and two types of flow patterns in the channel of the fin arrays were observed. Effect of various fin geometries and temperature differences on the convection heat transfer from the array was determined for Rayleigh numbers based on fin spacing of 192–6784 and applied correlations are developed to predict Nusselt numbers with corresponding non-dimensional parameters. They concluded that natural convection heat transfer coefficient increases with increasing temperature differences and increases with fin spacing and decreases with fin length.

J.Ajay Paul et. al. [3] have done numerical simulations were carried out to determine the heat transfer characteristics of different fin parameters namely, number of fins, fin thickness at varying air velocities. The single cylinder air cooled engines was assumed to be a set of annular fins mounted on a cylinder. Cylinders with fins of 4 mm and 6 mm thickness were simulated for 1, 3, 4 &6 fin configurations. It was conclude regarding fin pitches and numbers that when fin thickness was increased, the reduced gap between the fins resulted in swirls being created which helped in increasing the heat transfer. Also, observed that 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.

2.3 Wind Velocity, Material and Methods

A. Mohammadi, M. Rashidi et. al. [1]. The computational fluid dynamics (CFD) code KIVA-3V is applied to simulate in cylinder flow in a four stroke single cylinder engine with pent roof combustion chamber geometry, having two inlet valves and two exhaust valves. In cylinder effect of change in engine speed on the instantaneous local heat transfer coefficient and Reynolds number on the wall surface of combustion chamber are studied and comparison between heat transfer coefficient and Woschni correlation that is general in experimental studies is made.

The ambient pressure was 0.87 bars and temperature was 300k and the temperature was taken as 485k for liner, 600k for cylinder head and piston, 450 for intake valves, and 700k for exhaust valves. They conclude that instantaneous local heat transfer coefficient is strongly affected by the gas flow and flame propagation and therefore, Reynolds number. Also, observed that with increasing, engine speed the value of heat transfer coefficient and Reynolds number increases.

Masao Yoshida [6] Effects of the number of fins, fin pitch and wind velocity on air-cooling were investigated using experimental cylinders for an air-cooled engine of a motorcycle. Experimental cylinders that had a various number of fins and fin pitches were tested in a wind tunnel at speed of 0 to 60 km/h. Then the temperature inside of the cylinder, on the surface of the fins and in the space between the fins was measured. Results indicated that the heat release from the cylinder did not improve when the cylinder had more fins and too narrow a fin pitch at lower wind velocities, because it was difficult for the air to flow into the narrower space between the fins, so the temperature between them increased. They also obtained the expression of average fin surface heat transfer coefficient derived from the fin pitch and the wind velocity. This expression is useful for the fin design of an air-cooled cylinder**.** They concluded that the optimized fin pitches with the greatest effective cooling are at 20mm for nonmoving and at 8mm for moving.

Mohd Faizal Mohideen Batcha et. al. [9] Mist cooling is a very efficient means for dissipating high heat fluxes with low coolant mass fluxes at low wall superheats. A feasibility study was conducted where the temperature distribution in an array of plate fins, similar to fins on an engine cylinder head, was measured. The fins were subjected to constant heat flux at the base and cooled by airflow, simulating actual conditions on a cylinder head. Experiments were conducted for several air velocities ranging from 21.5 m/s to 40.4 m/s. The temperature distribution in the fin was measured at several locations simultaneously to calculate the amount of heat being transferred. These experiments were repeated with the injection of mist to compare the augmentation of heat transfer. The heat transfer coefficients increased between 200 and 400% and the surface temperatures were depressed. This proves that mist-cooling can be adopted to enhance heat transfer and lower the temperatures in air-cooled systems during critical conditions.

Pulkit Agarwal et. al. [14] simulated the heat transfer in motor-cycle engine fins using CFD analysis at velocities from 40 to 72 km/hr which is the most common operating range of motorcycles. It is observed that when the ambient temperature reduces to a very low value, it results in overcooling and poor efficiency of the engine. It is observed that when the ambient temperature reduces to a very low value, it results in overcooling and poor efficiency of the engine. They have concluded that overcooling also affects the engine efficiency because of overcooling excess fuel consumption occurs. This necessitates the need for reducing air velocity striking the engine surface to reduce the fuel consumption. It can be done placing a diffuser in front of the engine which will reduce the relative velocity of the air stream thus decreasing the heat loss.

Benjamin pineel [2] have analyzed the heat-transfer processes of an air-cooled engine for the purpose of determining the manner in which the various engine and cooling conditions combine to determine the cylinder temperature. The cylinders on which the tests were made were a Pratt & Whitney 1535 and a Pratt & Whitney 1340H. The bore, stroke, and compression ratio for the 1535 cylinder were 5% inches, 53' inches, and 6.73 respectively, and for the 1340-H were 5% inches, 6 inches, and 5.6.

They conclude that the values of the effective gas temperatures were practically independent of the engine speed and brake mean effective pressure and for the normal range of operation were equal to 1,150° F. for the head and 600° F. for the barrel for both the Pratt & Whitney 1535 and the 1340-U cylinders. They also suggest turbulence devices in front of the cylinder to increase in the heat-transfer coefficient of the order of 30 percent for the same pressure drop.

Mr. A. Raj Kumar et. al. [10] performed the transient analysis with assumption that the engine is running at 6000 rpm for 60 seconds. First thermal analysis was done and analyzed the temperature distribution over the fin area. In the second stage structural analysis was carried out using the thermal loads obtained in the first stage. They found that for material A413.0, the maximum stress was 386.094 MPa. For material C443.0, the maximum stress was 363.354 Mpa. For material B390.0, the maximum stress was 242.236 Mpa and calculated the factor of safety for all three materials was 0.3367 for A413.0, 0.266 for C443.0 and 1.032 for B390. They concluded that the B390.0 was the best material among all because it has more Factor of Safety than other two and the FOS should always more than one.

Shinde Sandip Chandrakant et. al. [17] has conducted the feasibility study on engine test rig to suggest the optimum fin profile for heat transfer enhancement.
Experiments were conducted for rectangular and triangular fin profiles for several air velocities ranging from 0 to 11 m/s. The temperature distribution in the fin was measured for several locations simultaneously to calculate the amount of heat being transferred. Experiment was repeated for both fins, Similarly CFD simulation was carried out for both fins. Finally experimental and CFD simulated result are compared. From the comparison it proves that annular fins with rectangular fin profiles are more suitable for heat transfer enhancement as compared to triangular fin profiles.

Mr. N. Phani Raja Rao et. al. [12] did the transient thermal analysis to analyze the thermal properties by varying geometry, material and thickness of cylinder fins. Here in the analysis three material were used i.e. Aluminum Alloy A204, Aluminum alloy 6061 and Magnesium alloy. These different materials were tested with rectangular, circular and curve shaped (parabolic) fins. Finally as result shows that by using circular fin with material Aluminum Alloy 6061 is better since heat transfer rate, Efficiency and Effectiveness of the fin is more. By using circular fins the weight of the fin body reduces compare to existing engine cylinder fins

Wladyslaw Mitianiec et. al. [19] deals with calculation of the thermal loads and temperature distribution of the cylinder and cylinder head of the two-stroke engine 115 cm3 capacity cooled by air at mean engine load. The results of simulation carried out in ANSYS program with creation of the mesh in CATIA were verified by the experiment on the real engine. The results reveled that the cooling heat in the air-cooled two-stroke engine increases with the engine speed and cooling energy amounts above 30% of the total energy delivered with fuel. Also, observed that the highest temperature in SI two-stroke engine is in the area of the spark plug, and the outer ribs can be lessened in order to decrease the weight of the parts.

K.Shahril et. al. [4] the relation between wind velocity and heat transfer co efficient have been investigated by simulating of heat transfer of motorcycle fin under varying climatic condition. As the conclusion, the simulation of two type of engine block which was Modenas Kriss 110 and Yamaha Lagenda 110z has been done accordingly to the requirement and values of wind velocity have been determined to gain the heat transfer coefficients. This simulation has proved that the wind velocity is one important part that can affected the total of heat transfer and the value of heat transfer coefficient. Besides that, the design of motorcycle fins need to considered in order to measure total heat transfer, because fins are work to trap the air to maintain the heat of engine block, if the fins design are not too appropriate with the requirement, it can cause to overheating.

N.Nagarani et. al. [11] analyzed the heat transfer rate and efficiency for circular and elliptical annular fins for different environmental conditions. Elliptical fin efficiency is more than circular fin. If space restriction is there along one particular direction while the perpendicular direction is relatively unrestricted elliptical fins could be a good choice. Normally heat transfer co-efficient depends upon the space, time, flow conditions and fluid properties. If there are changes in environmental conditions, there is a change in heat transfer co-efficient and efficiency also.

Conclusion

A literature survey is carried out to review the performed research and development work for the engine cooling system, thermal management of vehicles, and the heat exchange in the vehicle. Based on the review work, it is to be noted that heat transfer of the fin can be augmented by modifying fin pitches, geometry, shape, and material and wind velocity. 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.

Acknowledgement

We would like to be thankful to the Government Engineering College, Bhuj. At the same time we could not forget the direct or indirect support of our colleagues and friends to make this paper successful.

References

[1] A. Mohammadi, M. Rashidi (2006), “Numerical analysis of heat transfer in a spark ignition engine”, *Proceeding of the 3rd BSME-ASME International Conference on Thermal Engineering, Dhaka, Bangladesh.*
[2] Benjamin pineel(1937), “Heat transfer process in air cooled engine”, *Langley Memorial aeronautical laboratory, National advisory committee for aeronotics, Langley Field*.
[3] J.Ajay Paul,Sagar Chavan Vijay, U.Magarajan & R.Thundil Karuppa Raj (2012), “Experimental and Parametric Study of Extended Fins In The Optimization of Internal Combustion Engine Cooling Using CFD”, *International Journal of Applied Research in Mechanical Engineering (IJARME)* ISSN: 2231 –5950, Volume-2, Issue-1, 2012

[4] K.Shahril, Nurhayati Binti Mohd Kasim, and M.Sabri, "Heat transfer simulation of motorcycle fins under varying velocity using CFD method", *2nd International Conferenceon Mechanical Engineering Research (ICMER2013)*, doi:10.1088/1757 899X/50/1/012043

[5] L. Dialameh, M. Yaghoubi, O. Abouali (2008), "Natural convection from an array of horizontal rectangular thick fins with short length", *Applied Thermal Engineering* 28 (2008) 2371–2379 – 2008

[6] Masao Yoshida, Soichi Ishihara, Yoshio Murakami, Kohei Nakashima and Masago Yamamoto (2006), "Air-Cooling Effects of Fins on a Motorcycle Engine" , *JSME International Journal*, Series B, Vol. 49, No. 3, 2006

[7] Mishra A.K., Nawal S. and Thundil Karuppa Raj R. (2012), "Heat Transfer Augmentation of Air Cooled Internal Combustion Engine Using Fins through Numerical Techniques", *Research Journal of Engineering Sciences*, Vol. 1(2), 32-40, August (2012), ISSN 2278 – 9472

[8] Mohammad A. Elyyan, Ali Rozati, Danesh K. Tafti (2008), "Investigation of dimpled fins for heat transfer enhancement in compact heat exchangers", *International Journal of Heat and Mass Transfer* 51 (2008) 2950–2966

[9] Mohd Faizal Mohideen Batcha, Amer Isyraqi Hussin, and Vijay R. Raghavan, Engine cylinder head cooling enhancement by mist cooling- A simulation study, Proceedings of International Conference on Mechanical & Manufacturing Engineering (ICME2008), 21– 23 May 2008, Johor Bahru, Malaysia, ISBN: 97–98 –2963–59–2

[10] Mr. A. Raj Kumar Dr. G.Janardhana Raju Dr. G. Amarendar Rao, Heat Transfer Analysis In The Cylinder Head Of A Four-Stroke Si Engine, International Journal of Engineering Research & Technology (IJERT), Vol. 2 Issue 5, May – 2013, ISSN: 2278-0181

[11] N.Nagarani and K. Mayilsamy, Experimental heat transfer analysis on annular circular and elliptical fins, International Journal of Engineering Science and Technology **2**(7): 2839-2845

[12] N.P.R. Rao and T. V. Vardhan, Thermal Analysis of Engine Cylinder Fins By Varying Its Geometry and Material, International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 8, August – 2013, ISSN: 2278-0181

[13] Praful Date and V. W. Khond, Heat transfer enhancement in fin and tube heat exchanger, ARPN Journal of Engineering and Applied Sciences, VOL. 8, NO. 3, MARCH 2013, ISSN 1819-6608

[14] Pulkit Agarwal, Mayur Shrikhande and P. Srinivasan, Heat Transfer Simulation by CFD from Fins of an Air Cooled Motorcycle Engine under Varying Climatic Conditions, Proceedings of the World Congress on Engineering 2011 Vol III WCE 2011, July 6 - 8, 2011, London, U.K.

[15] S. Barhatte, et al., Experimental and Computational Analysis and Optimization for Heat Transfer through Fins with Different Types of Notch, Journal of Engineering Research and Studies E-ISSN 976: 7916.

[16] Sanjay Kumar Sharma and Vikas Sharma, Maximizing the heat transfer through fins using CFD as a tool, International Journal of Recent advances in Mechanical Engineering (IJMECH) Vol.2, No.3, August 2013

[17] Shinde Sandip Chandrakant, Prof. Shinde Sunilkumar, Nitin Gokhale, Numerical And Experimental Analysis Of Heat Transfer Through Various Types Of Fin Profiles By Forced Convection, International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 7, July – 2013, ISSN: 2278-0181

[18] U. Magarajan, et al., Numerical Study on Heat Transfer of Internal Combustion Engine Cooling by Extended Fins Using CFD, International Science Congress Association **1**(6): 32-37.

[19] Wladyslaw Mitianiec, Konrad Buczek, Analysis of thermal loads on air cooled engine, Journal of KONES Powertrain and Transport, Vol.14, No. 3 2007