" A REVIEW ON FIN ANALYSIS FOR HEAT TRANSFER RATE AUGMENTATION OF AIR COOLED IC ENGINE "

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ABSTRACT

Heat dissipation is probably one of the most important considerations in engine design. An internal combustion engine creates enough heat to destroy itself. Without an efficient cooling system, we would not have the vehicles we do today. The original radiators were simple networks of round copper or brass tubes that had water flowing through them by convection. Engine life and effectiveness can be improved with effective cooling. The cooling mechanism of the air cooled engine is mostly dependent on the fin design of the cylinder head and block. Insufficient removal of heat from engine will lead to high thermal stresses and lower engine efficiency. 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. 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 block fin geometry and climate condition. Based on the research done, a model is selected to perform heat transfer analysis and identify possible increase in the rate by changing the fin profile. To perform the study, virtual simulation by CFD approach is proposed.

Keywords:- *Cooling fin, Convection, Fin profile, Simulation, ANSYS.*

1.INTRODUCTION

Almost all two wheelers uses Air cooled engines, because Air-cooled engines are only option due to some advantages like lighter weight and lesser space requirement. Internal combustion engines at best can transform about 25 to 35 % of the chemical energy in the fuel in to mechanical energy. About 35 % of the heat generated is lost in to the surroundings of combustion space, remainder being dissipated through exhaust and radiation from the engine. A fin is a surface which extends from a surface to increase the rate of heat transfer to the environment by increasing convection. Experiments has been made to increase fin efficiency by Changing fin material and fin geometry. The cooling mechanism of the air cooled IC engine is generally dependent on the fin design of the cylinder, cross-section area of fin, pitch of the fin, thickness of fin, air velocity, air exposed angle and weather conditions.

The conduction heat transfer from inner wall to fin surface is given as:
$q = k\,(T_w - T_{fin})$

The convection heat tansfer from fin surface to atmosphere air by free and forced air is given as:
$q = h_f\,(T_{fin} - T_{air})$

In air-cooled engine to increase the heat transfer rate, fins are provided at the periphery of engine cylinder so that the analysis of fin is important. Computational Fluid Dynamic (CFD) analysis and Wind tunnel experiments have shown improvements in fin efficiency by changing fin geometry, fin pitch, number of fins, fin material and climate condition. [1]

2.LITERATURE REVIEW

Masao YOSIDHA et.al. [2] investigated effect of number of fin, fin pitch and wind velocity on air-cooling using experimental cylinders for an air-cooled engine of a motorcycle in wind tunnel. Heat release from the cylinder did not improve when the cylinder have the more fins and too narrow a fin pitch at lower wind velocities, because it is difficult for the air to flow in to the narrower space between the fins, so the temperature between them increased. They have concluded that the optimized fin pitches with the greatest effective cooling are at 20mm for non-moving and 8mm for moving. The average fin surface heat transfer coefficient can be obtained using the following equation at the speed from 0 to 60 km/h.

$$\alpha_{avg} =(2.47-2.55/p^{0.4})u^{0.9\ 0.087\ 2p+4.31}$$

Pulkit Agarwal et al. [3] made an attempt to simulate the heat transfer using CFD analysis. The heat transfer surface of the engine is modeled in GAMBIT and simulated in FLUENT software. An expression of average fin surface heat transfer coefficient in terms of wind velocity is obtained. It is observed that when the ambient temperature reduces to a very low value, it results in overcooling and poor efficiency of the engine. A number of experimental studies have been done on cooling of air-cooled engine fins. Air cooled cylinders were tested at wind velocities from 7.2 to 72 km/hr to design fins for motorcycle engines and an experimental equation for the following fin surface heat transfer coefficient was derived.

$$\alpha= 2.11u^{0.71} \text{ x } s^{0.44} \text{ x } h^{-0.14}$$

Where,

α: Fin surface heat transfer coefficient[W/m^{20}C], h: Fin length [mm], u: Wind velocity[km/hr], s: fin separation at middle length[mm]

	Thornhill et al.	Gibson	Bierman et al.
Cylinder Diameter[mm]	100	32-95	118.364
Fin Pitch [mm]	8-14	4-19	1.448-15.240
Fin Length mm]	10-50	16-41	9.398-37.338
Material	Aluminium alloy	Copper, Steel, Aluminium	Steel
Wind Velocity [km/hr]	7.2-72	32-97	46.8-241.2

Table 1. Experimental cylinder and wind velocity by Thornhill et al., Gibson and Bierman et al.

The heat transfer from a fin is influenced by many fixed and variable parameters such as air flow velocity, temperature, heat flux at cylinder wall, fin geometry size, shape, material etc. In this study, CFD has been used for analyzing the similar model of engine as used by Yoshida et al. The effect of the wind velocity and surrounding air temperature was studied in detail by modeling the motorcycle engine as a finned cylinder and simulating through the commercially available CFD code FLUENT at velocities from 40 to 72 km/hr which is the most common operating range of motorcycles. The remaining parameters namely fin geometry, heat flux at cylinder wall, material were kept fixed. An attempt has been made to derive an equation for average fin surface heat transfer coefficient for the same engine model in terms of wind velocity and to calculate the extra amount of fuel consumed due to the overcooling process.

Vipul Shekhada et al. [4] in their research paper took experimental readings in form of temperature of existing fin of air cooled IC engine. These readings were validated with ANSYS model. After validation fin was modified with same volume, again analysis of modified fin done by ANSYS software. By comparing the results, fin performance was evaluated. The dimensions of extended surface or fin provided in IC engine of HERO HONDA SPLENDOR were measured and temperature also measured by thermocouple after stopping the engine at every 5 minute interval. By experimental data and FEA data for fin of air cooled IC engine is compared and validated. Also comparing the modified fin FEA data with existing fin data, this research paper give clear idea about fin performance. After the modification of fin with constant volume, effectiveness was increased with minor change in efficiency. So modified fin gives best cooling rate than the existing fin.

Fig 1. Fin provided in IC engine

A.C.Deshpande et al. [5] tested the extended surfaces i.e. fins of Honda Shine & Bajaj Discover two wheeler to investigate effect on heat transfer rate by changing the Cross-section, Fin Pitch, Fin Material and Fin Thickness. Through experiments temperature generated at steady state condition have been measured from the fin surface and using the value as key parameter, heat dissipated and heat flux through fin is calculated using empirical formulations. The same data is then validated by using FEA approach. Thermocouple rod is attached to thermocouple temperature trainer kit which consist of digital display which will provide us actual readings directly. The k-type thermocouple is used in experiment. The readings are taken on stationary engine after reaching to steady state condition. From this project after experiment values and FEA validation it can be concluded that contact surface available for the air to flow over the fin is also important factor in heat transfer rate. If the turbulence of air is increased by changing the design and geometry of the fins, it will increase the rate of heat transfer.

K. Ashok Reddy et al. [6] designed the cylinder head by using standard formulae and modeling by using the SOLIDWORKS software. The steady state thermal analysis is carried by using ANSYS software. In this project we are analyzing the various thermal properties for various geometrical shapes of the cylinder head (Rectangle and Circular) and further correlating the numerical values of the cylinder heads with the finite element values. By comparing theoretical values with analytical values of existing rectangular cylinder head equal values were obtained. After changing cylinder head to circular shape and conducting the same experiments with same boundary conditions the difference in the efficiency was around 3% which is a considerable difference. The mass is increased in circular cylinder by 10%.In this project, steady state thermal analysis for free convection for rectangular and circular fins was conducted. From above results it can concluded that the circular fin are more suitable than rectangular fins.

Fernando Illan [7] simulated the heat transfer from cylinder to air of a two-stroke internal combustion finned engine. The cylinder body, cylinder head (both provided with fins), and piston have been numerically analyzed and optimized in order to minimize engine dimensions. The maximum temperature admissible at the hottest point of the engine has been adopted as the limiting condition. Starting from a zero-dimensional combustion model developed in previous works, the cooling system geometry of a two-stroke air cooled internal combustion engine has been optimized in this paper by reducing the total volume occupied by the engine. A total reduction of 20.15% has been achieved by reducing the total engine diameter *D* from 90.62 mm to 75.22 mm and by increasing the total height *H* from 125.72 mm to 146.47 mm aspect ratio varies from 1.39 to 1.95. In parallel with the total volume reduction, a slight increase in engine efficiency has been achieved.

G. Babu and M. Lavakumar [8] analyzed the thermal properties by varying geometry, material and thickness of cylinder fins. The models were created by varying the geometry, rectangular, circular and curved shaped fins and also by varying thickness of the fins. Material used for manufacturing cylinder fin body was Aluminum Alloy 204 which has thermal conductivity of 110-150W/mk and also using Aluminum alloy 6061 and Magnesium alloy which have higher thermal conductivities. They concluded that by reducing the thickness and also by changing the shape of the fin to curve shaped, the weight of the fin body reduces thereby increasing the efficiency. The weight of the fin body is reduced when Magnesium alloy is used and using circular fin, material Aluminum alloy 6061 and thickness of 2.5mm is better since heat transfer rate is more and using circular fins the heat lost is more, efficiency and effectiveness is also more.

Arvind S.Sorathiya et al [9] conducted study on various researches done in past to improve heat transfer rate of cooling fins by changing cylinder block fin geometry, climate condition and material. Their research showed that 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 compared with conventional one by CFD Analysis and Wind Tunnel experiment.

Mahendran.V*, Venkatasalakumar.A [10] their work based on Analysis of ic engine air cooling of varying geometry and Material. To increase heat transfer rate from extended fins modifying geometry of circular fins with curvature shape and Aluminium alloy 6061. In this thesis, thermal analysis is done for all the two materials Cast Iron and Aluminum alloy 6061. The Analysis is carried out by Ansys Workbench 14.0 optimize which material will maximum heat transfer rate By observing the thermal analysis results, Aluminum alloy its weight is less, so using Aluminum alloy 6061 is better heat transfer material . And also by reducing the thickness of the fin, the heat transfer rate is increased.

S.S. Chandrakant et.al.[11] conducted experiments for rectangular and triangular fin profiles for air velocities ranging from 0 to 11 m/s. Experimental and CFD simulated result proves that annular fins with rectangular fin profiles are more suitable for heat transfer enhancement as compared to triangular fin profiles. Surface temperature of triangular fin profile is higher than rectangular fin profile at different air velocity. Heat transfer coefficient increase with increases with increases in velocity in both profiles. In comparison of both profile rectangular fin profile have higher heat transfer coefficient than triangular fin profile. In comparison of both profile rectangular fin profile transfer large amount of heat than triangular fin profile.

3.CONCLUSION

The summary of present literature review is as follows:
For a given thermal load, the fin material and fin array parameters could be optimized in a better way by numerical simulation methods. To increase the cylinder cooling, the cylinder should have a greater number of fins. In High speed vehicles thicker fins provide better efficiency. Increased fin thickness resulted in swirls being created which helped in increasing the heat transfer.Contact time between air flow and fin is also important factor in such heat transfer. Curve and Zig-zag fin shaped cylinder block can be used for increasing the heat transfer from the fins by creating turbulence for upcoming air. Heat transfer rate and heat transfer coefficient can be increased with the wind velocity. Based on review study cylinder heat transfer rate also increase by changing the various types of geometry of fins mounted on it. That can be analyzed by CFD and validate results by conducting experimental work.

4.REFERENCES

1) Mishra A.K., Nawal S. and Thundil Karuppa Raj R," Heat Transfer Augmentation of Air Cooled Internal Combustion Engine Using Fins through Numerical Techniques". Research Journal of Engineering Sciences ISSN 2278 – 9472 Vol. 1(2), 32-40, August (2012).
2) Yoshida Masao, et al. (2005). "Air-Cooling Effects of Fins on a Motorcycle Engine." Nippon Kikai Gakkai Ronbunshu B Hen (Transactions of the Japan Society of Mechanical Engineers Part B)(Japan) 17(9): 2324-2330.
3) 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.
4) Vipul Shekhada1,Dr. Shashi Jain2 Jayesh Gundaniya3,"experimental analysis of transient heat transfer in air cooled ic engine fin using FEA". ISSN: 2349 - 4689 international journal of scientific progress and research .
5) A.C.Deshpande*, Mohd. Razik, "design and finite element analysis of two wheeler engine fins". [Deshpande*, 4.(6): June, 2015] ISSN: 2277-9655.

6) K. Ashok Reddy, T. V. Seshi Reddy and S Satpagiri "Heat Flux and Temperature Distribution Analysis of I C Engine Cylinder Head Using ANSYS" International Journal of Advanced Research Foundation
7) Fernando Illan and M. Alarcon (2002). "Optimization of Annular Cylindrical and Spherical Fins in an Internal Combustion Engine under Realistic Conditions." Journal of Thermal Science and Engineering Applications 2.
8) G. Babu and M. Lavakumar (2013). "Heat Transfer Analysis and Optimization of Engine Cylinder Fins of Varying Geometry and Material." IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) 7(4): 24-29.
9) Prof. Arvind S.Sorathiya1, Ashishkumar N. Parmar2, Prof. (Dr.) Pravin P. Rathod3," Effect of Cylinder Block Fin Geometry on Heat Transfer Rate of Air-Cooled 4S SI Engine". www.ijrdet.com (ISSN 2347 - 6435 (Online) Volume 2, Issue 1, January 2014.
10) Mahendran.V*, Venkatasalakumar.A , " Analysis of ic engine air cooling of varying geometry and Material". [Mahendran*, 4.(5): May, 2015] ISSN: 2277-9655..
11) S.S.Chandrakant, et al. (2013). "Numerical and Experimental Analysis of Heat Transfer through Various Types of Fin Profiles by Forced Convection." International Journal of Engineering Research & Technology (IJERT) 2(7).
12) Polidas Varalakshmi , M. Lavakumar ," Steady State Thermal Analysis of Engine Cylinder Fin by Changing Geometry and Material" ISSN NO. 2348-4845.
R. Arularasan, P. Hemanandhan "Modeling and Simulation of Engine Cylinder Fins Using FEA" Int. Journal for Research in Applied Science and Engineering Technology .
13) Mohsin A. Ali1, Prof. (Dr.) S.M Kherde2, "A review on design modification and analysis of two wheeler cooling fins" International Journal of Engineering and Applied Sciences June. 2014. Vol. 5. No. 01.
14) Prof. Arvind S. Sorathiya1, Hiren P. Hirpara2, Prof. Dr. P.P. Rathod, "An effect of different parameters of fins on heat transfer of ic engine". IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 11, Issue 3 Ver. I (May- Jun. 2014), PP 63-71 .
15) Biermann, A. E. and B. Pinkel (1934). Heat Transfer from finned metal cylinders in an air stream, NACA Report No.488
16) J.C.Sanders, et al. (1942). Cooling test of an air-cooled engine cylinder with copper fins on the barrel, NACA Report E-103
17) Denpong Soodphakdee, et al. (2001). "A Comparison of Fin Geometries for Heatsinks in Laminar Forced Convection Part 1 - Round, Elliptical, and Plate Fins in Staggered and In-Line Configurations." The International Journal of Microcircuits and Electronic Packaging 24(1).