A Survey On Heat Transfer Of Air Cooled Internal Combustion Engine Various Fin Cutting Shape

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Abstract - *Indian two-wheeler market is the world's second biggest market. Among the 3 segments (motorcycles, scooters and mopeds) of the Indian two wheeler market, major growth trends have been seen in the motorcycle segment over the last four to five years due to its resistance and balance even on bad road conditions. In Indian motor-cycles, 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. 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, climate condition and material.*

Key Words: Air Cooling, ANSYS, CFD, Cylinder block, Engine Performance, Fins, Heat Transfer, Internal

1. INTRODUCTION

Engines are ineffective, so more heat energy enters the engine than comes out as mechanical power, the variation is waste heat which must be removed. Internal combustion engines eliminate waste heat through cool intake air, hot exhaust gases, and unambiguous engine cooling. Engines with higher efficiency have more energy leave as mechanical motion and less as waste heat. Some waste heat is necessary, it guides heat through the engine, much as a water wheel working only if there is some exit velocity (energy) in the waste water to carry it away and make room for more water. Thus, all heat engines require cooling to work. Cooling is also required because high temperature damage engine materials and lubricants. Internal-combustion engines burn up fuel hotter than the melting temperature of engine equipment, and hot adequate to set fire to lubricants. Engine cooling removes energy quick enough to keep temperatures low so the engine can survive.

Air Cooled System

Air cooled system is generally used in small engines say up to 15-20 kW and in aero plane engines. In this system fins or extended surfaces are provided on the cylinder walls, cylinder head, etc. Heat generated due to combustion in the engine cylinder will be conducted to the fins and when the air flows over the fins, heat will be dissipated to air.

The amount of heat dissipated to air depends upon :

(a) Amount of air flowing through the fins.
(b) Fin surface area.
(c) Thermal conductivity of metal used for fins.

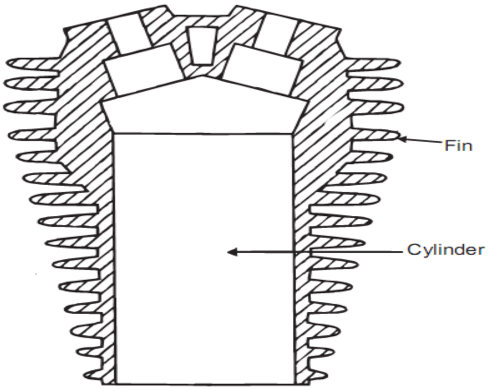


Fig.1 Cylinder with Fins

Advantages and Disadvantages of Air Cooled System

Following are the advantages of air cooled system :

- Radiator/pump is absent hence the system is light.
- In case of water cooling system there are leakages, but in this case there are no leakages.
- Coolant and antifreeze solutions are not required.
- This system can be used in cold climates, where if water is used it may freeze.

Disadvantages of Air Cooled System

- Comparatively it is less efficient.

- It is used in aero planes and motorcycle engines where the engines are exposed to air directly.

2. LITERATURE SURVEY

DenpongSoodphakdee et al. [1] compared the heat transfer performance of various fin geometries. These consist of plate or pin fins, which can be round, elliptical or square. The parallel plate fins can be continuous or staggered. The basis of comparison was chosen to be a circular array of 1mm diameter pin fins with a 2mm pitch. The ratio of solid to fluid thermal conductivity for aluminium and air is quite high, around 7000, permitting the fins to be modelled as isothermal surfaces rather than

conjugate solids. Fernando Illan et.al [2] simulated the heat transfer from cylinder to air of a two-stroke internal combustion finned engine. The cylinder body, cylinder head and piston have been mathematically analyzed and optimized in order to minimize engine geometries. The maximum temperature allowable at the hottest point of the engine has been adopted as the restrict condition. Starting from a zero-dimensional ignition model developed in previous works, the cooling system dimension 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.Bassam and K.Abu-Hijleh [3] investigated the problem of cross-flow forced convection heat transfer from a horizontal cylinder with several parts, equally spaced, high conductivity permeable fins on its outer surface numerically. The heat transfer characteristics of a cylinder with permeable versus solid fins were studied for several combinations of number of fins and fin height over the range of Reynolds number (5–200). Permeable fins resulted in much larger aerodynamic and thermals wakes which significantly reduced the effectiveness of the downstream fins, especially at $\theta < 90°$. A single long permeable fin tended to offer the best convection heat transfer from a cylinder.

YosidhaMasao et.al. [4] investigated effect of number of fin, fin pitch and wind velocity on air-cooling using experimental cylinders for an air-cooled engine of a motor-cycle 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 velocity, because it is difficult for the air to pass into the narrower space between the fins, so the temperature is increased between them. They haveconcluded that the optimized fin pitches with the greatest effective cooling are at 20mm for non-moving and 8mm for moving.

D.G.Kumbhar et.al. [5] Heat transfer augmentation from a horizontal rectangular fin by triangular perforations whose bases parallel and towards the fin base under natural convection has been studied using ANSYS.The parameters considered are geometrical dimensions and thermal properties of the fin. The perforated fin heat dissipation rate is compared to that of solid fin. They have concluded that the heat transfer rate increases with perforation as compared to fins of similar dimensions without perforation. The perforation of the fin enhances the heat dissipation rates at the same time decreases the expenditure for fin materials also.

N. Nagarani et.al. [6] Analyzed the heat transfer rate and efficiency for circular and elliptical annular fins for different environment conditions. Elliptical fineffectiveness is more than circular fin. If space limitation is there along one particular direction while the perpendicular direction is relatively unrestricted elliptical fins could be a best choice. Normally heat transfer co-efficient depends upon the limit, time, flow conditions and fluid properties. If there are changes in environment conditions, there is alteration in heat transfer co-efficient and efficiency also.

Ashok TukaramPise and UmeshVandeoraoAwasarmol [7] conducted the experiment to compare the rate of heat transfer with solid and permeable fins. Permeable fins are formed by altering the solid rectangular fins with drilling three holes per fins incline at one half length of the fins of two wheeler cylinder block. It was found that permeable fins block average heat transfer rate improves by about 5.63% and average heat transfer coefficient 42.3% as compared to solid fins with reduction of cost of the material 30%.

Pulkit Agarwal, et al. [8] simulated the heat transfer in motor-cycle engine fins using CFD analysis. An air-cooled motorcycle engine releases heat to the atmosphere through the mode of forced convection. To improve this, fins are provided on the outer surface of the cylinder. The heat transfer rates depend upon the velocity of the vehicle, fin dimension and the ambient temperature. The temperatureand heat transfer coefficient values from fin base to tip are not uniform which shows the major advantage of CFD for analysis of heat transfer. Therefore the triangular fins are preferred than the rectangular fins for automobiles where weight is the main criteria. At wider spacing, shorter fins are more preferred than longer fins.

S.H. Barhatte et.al. [9] natural convection heat transfer from vertical rectangular fin arrays with and without notch at the center have been investigated experimentally and theoretically. The performance of heat transfer fins can be analyzed effectively by commercially available CFD software, Fluent 6.3 in specific. Computational analysis and subsequent experimental investigations have revealed fins can be used effectively to enhance the rate of heat transfer.

MatkarM.V et.al. [10] calculated the heat transfer rate and the temperature behaviour for the same object with the different material (like copper and aluminium). They have concluded that observe that heat flow rate of copper fin (19.2W) is less than the heat flow rate of the aluminum fin (56.99 W). The copper gets stable at the lowest temperature. And finally conclude that the copper is best material suitable for fin than the aluminum. Muhammad MahmoodAslamBhutta et.al. [11] used for to find various heat exchangers. CFD has been used for the following areas of study in various types of heat exchangers like fluid flow inefficient, fouling, pressure drop and thermal analysis in the design and optimization phase but not restrict to Plate, Shell and Tube, Vertical Mantle. CFD is an effective tool for the behavior and performance of a wide variety of heat exchangers. CFD has emerged as a cost effective alternative and it provides speedy solution to heat exchanger design and optimization.

G.Raju et.al. [12] investigated maximization of heat transfer through fin arrays of an internal combustion engine cylinder, under one dimensional, steady state condition with conduction and free convection modes. They used non-traditional optimization technique, namely, binary coded Genetic Algorithm to obtain maximum heat transfer and their corresponding optimum dimensions of rectangular and triangular profile fin arrays. They concluded 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 toolAnsysFluent.

U. Magarajan et.al. [13] have studied heat release of that when the ambient temperature reduces to a very low value, it results in overcooling and deficient efficiency of the engine. It is important for an air-cooled engine to utilize fins for effective engine cooling to maintain uniform temperature in the cylinder periphery. Many experiment has been done to improve the heat release of the cylinder and fin efficiency. It is observed that when the ambient temperature reduces to a very low value, it results in overcooling and deficient efficiency of the engine.

A.K. Mishra et.al. [14] carried out transient numerical analysis with wall cylinder temperature of 423 K initially and the heat release from the cylinder is analyzed for zero wind velocity. The heat liberation from the cylinder which is calculated numerically is validated with the experimental results. To increase the cylinder cooling, the cylinder should have a higher number of fins. Fins are basically mechanical structures which are used to cool various structures via the process of convection. Most part of their design is basically restricted by the design of the system. But still certain parameters and dimension could be modified to better heat transfer.

Mostafa H. Sharqawy et.al.[15]A numerical analysis is carried out to study efficiency and temperature distribution of annular fins of different fin profiles (constant and variable cross-sectional area) when subjected to simultaneous heat and mass transfer. The temperature andhumidity ratio differences are driving forces for heat and mass transfer. Actual psychometric relations are used in the present work instead of a linear model between humidity ratio and temperature that has been used in the literature.

J. Ajay Paul et.al. [16] carried out Numerical Simulations to determine heat transfer characteristics of different fin restrictions namely, number of fins and fin thickness at varying air velocities. A cylinder with a single fin mount on it was skilled experimentally. The mathematical recreation of the same setup was done using CFD. Cylinders with fins of 4 mm and 6 mm thickness were simulated 1, 3, 4 &6 fin configurations. They concluded that when fin thickness was enlarged, the condensed gap between the fins resulted in swirls being shaped which helped in increasing the heat transfer.

G. Babu and M. Lavakumar [17] analyzed the thermal properties by changeable geometry, material and thickness of cylinder fins. The models were shaped by changeable the geometry, rectangular, circular and curved created fins and also by changeable thickness of the fins. Material used for modern 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. Finally they fulfilled that by dropping the thickness and also by varying the shape of the fin to curve shaped, the weight of the fin body reduce thereby increasing the efficiency. By reducing the thickness and also by changing the shape of the fin to curve shaped, the weight of the fin body reduce thereby raising the efficiency.

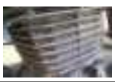
ShindeSandipChandrakant et.al.[18] conducted experiments for rectangular and triangular fin profiles for air velocities ranging from 0 to 11 m/s. In all engine two types of cool systems are utilize, liquid-cooling & air-cooling, among the two types of engine cooling system, liquid-cooling is broadly used due to its capacity to reject large amount of heat and air-cooling is preferred for small capacity engine in which the cooling system is much simple in design, light in weight and low in cost. In air-cooled engine annular fins with dissimilar fin profiles are used for heat transfer augmentation, therefore it is significant for an air-cooled engine to use fin profiles efficiently to obtain heat transfer enhancement.

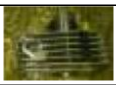
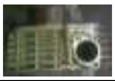
A. Raj kumar et.al [19] carried out the transient analysis with assumption that the engine is running at 6000 rpm for 60 seconds. The importance of heat transfer in design of four stroke engine is important to make sure the engine will perform to expectation during actual working conditions. For this a calculation is done on the various heat distributions that might occur during a normal operation of the engine. Heat transfer was model with conduction and convection as the main source of heat transfer and neglect radiation.

Rajeev P.Patil and H.M.Dange [20] conducted CFD and experimental analysis of elliptical fins for heat transfer parameter, heat transfer coefficient and tube effectiveness by forced convection. The work includes analysis of heat transfer parameter, heat transfer coefficient and tube effectiveness of elliptical fin by forced convection. Also the experimental analysis was verified by computational fluid dynamics software.

N.Phani Raja Rao and T. Vishnu Vardhan [21] analyzed the thermal properties by changeable geometry, material and thickness of cylinder fins. The Engine cylinder is one of the major automobile apparatus, which is subjected to high temperature variation and thermal stresses. In order to cool the cylinder, fins are provide on the plane of the cylinder to increase the rate of heat transfer. By liabilitythermal analysis on the engine cylinder fins, it is helpful to know the heat indulgence inside the cylinder.

S.M. Wange and R.M. Metkar [22] have done, experimental and computational analysis of fin array and shown that the heat transfer coefficient is more in notch fin array than without notch fin array. Numerical parameter of fin affects on the performance of fins, so proper selection of geometric parameter such as length of fin, height of fin, spacing among fins, depth of notch is required.

Model	**CC**	**Stoke (mm)**	**Bore (mm)**	**No Of Fin s**	**Pitch (mm)**	**Thickness (mm)**	**Height**		**Fin Material**	**Position of Fins W.R.T. Cylinder Axis**
							Max (mm)	**Min (mm)**		
Hero Passion 	110	55.6	50	11-811	9	2	36	8	Aluminium alloy	Parallel
Honda Sine 	125	57.9	52.4	6	10	2	22	7	Aluminium alloy	Perpendicular
Bajaj Pulsar 	135	54	59	6	10	2	35	10	Aluminium alloy	perpendicular
Bajaj Pulsar	150	56.4	58	6	11	2	35	10	Aluminium alloy	Perpendicular

										
Honda Unicorn 	149	57.8	57.3	6	7	3	13	9	Aluminium alloy	Perpendicular
Yamaha Fazer 	153	57.9	58	7	10	3	24	5	Aluminium alloy	Perpendicular
Hero Karizma 	225	66.2	65.5	8	10	2	23	12	Aluminium	perpendicular

3. PROPOSED METHODOLOGY

A transient numerical analysis can be carried out with wall cylinder temperature of 423 K initially and the heat release from the cylinder can be analyzed for various wind velocity. The heat release from the cylinder which is calculated numerically can be validated with the experimental results. In the present paper an effort is made to study the effect of fin parameters on fin array performance which includes variation in pitch and fin. In addition, the current paper considers the effect of air flow velocity on different fin pitch. With the help of the available numerical results, the design of the internal combustion engine cooling fins can be altered for better efficiency.

Effect of Fin Pitch:Three different fin pitches of 7 mm, 10 mm and 14 mm can beeanalyzed for internal combustion engine cylinder with 80 mm length. The pitches can bee measured from fin surfaces. The number of fin varies with respect to the change in the fin pitch. The number of fins is 6 for a fin pitch of 7 mm and it is 5 for a fin pitch of 10 mm.four shapes (square, triangular, circular, diamond) which are fixed in heat sink. The pitch distance between the fins and these are arranged in staggered configuration which is better than inline configuration. From the heat transfer point of view as it is used by many references.

3. CONCLUSIONS

Design of fin plays an important role in 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. Wavy fin shaped cylinder block can beused for increasing the heat transfer from the fins by creating turbulence for upcoming air. Improvements in heat transfer can be compare with conventional one by CFD Analysis in ANSYS and Wind Tunnel experiment. 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 and improvement in heat transfer of air- cooled engine cylinder fin if mounted fin's shape varied from conventional one.

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