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EFFECT OF DIFFERENT VARIABLES ON HEAT TRANSFER RATE OF FOUR-STROKE SI ENGINE FINS - REVIEW STUDY

Hardik D. Rathod[1], Ashish J. Modi[2], Prof. (Dr.) Pravin P. Rathod[3]

[1](PG Student, Mechanical Engineering Department, GEC, Bhuj, India)
[2](Assistant Professor, Mechanical Engineering Department, GEC, Bhuj, India)
[3](Associate Professor, Mechanical Engineering Department, GEC, Bhuj, India)

ABSTRACT

To study of different papers related to heat transfer through extended surfaces (fins) and the effect on heat transfer co-efficient by changing cross-section, climatic conditions, materials etc.The fins are generally used to increase the heat transfer rate from the system to the surroundings by increasing the heat transfer area. The fins are generally extended surfaces or projections of materials on the system. It is necessary to study the effect of fin geometry, material, and climatic conditions to the behaviour of heat transfer through fins. So, this study is useful to know the better geometry and material for the fins for better engine cooling.

Keywords: Fins, Heat Transfer Rate, Perforations, CFD, ANSYS

1. INTRODUCTION

As the fossil fuel reserves are depleting day by day, increasing of fuel price raising the technology towards new inventions and research, which provides engines which are highly efficient and produces high specific power. Air cooled engines are phased out and are replaced by water cooled engines which are more efficient, but 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. The heat generated during combustion in IC engine should be maintained at higher level to increase thermal efficiency, but to prevent the thermal damage some heat should remove from the engine.

Extended surfaces (Fins) are one of the heat exchanging devices that are employed to increase the heat transfer on engine cylinder. It is necessary to analyse the heat transfer rate of the fins. Experiments has been made to increase fin efficiency by Changing fin material, climatic conditions around fins, varying pitch of the fins, using perforations and notches in fins and fin geometry. Many researchers analysed the fin heat transfer with the help of CFD also, better results were found in experiments using CFD.

2. EFFCT OF NUMBER AND THICKNESS OF FINS ON THE HEAT TRANSFER RATE

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. [1] The expression has been derived for the fin of the air cooled cylinder. The conclusion was that the optimized fin pitches with the greatest effective cooling area at 20mm for non-moving and 8mm for moving. [1]

For figure 1-4, it shows the variation of the heat Transfer with respect to velocity. The heat transfer was calculated directly from the fluent software. At zero velocity it is seen that the heat transfer from the 4mm and 6mm fins are the same. When the velocity is increased it can be seen that the heat transfer is increased with due to forced convection and also due to the swirl generated between two fins which induces turbulences and hence higher heat transfer. For a larger fin thickness, the corresponding fin spacing is comparatively small. As a consequence, the generated swirled flow may mingle with the main flow and result in a higher heat transfer performance. [2]

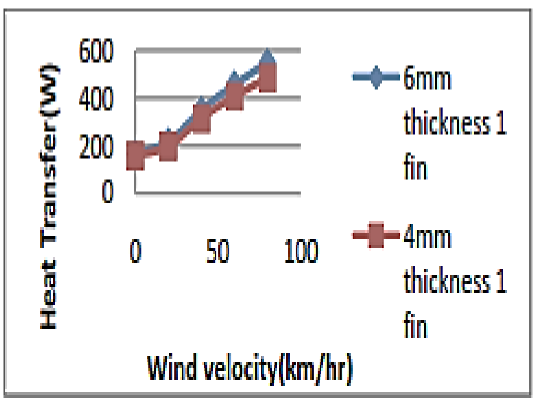


Fig.1. Heat transfer vs. air velocity for 6mm and 4mm thickness 1 no. of fin. [2]

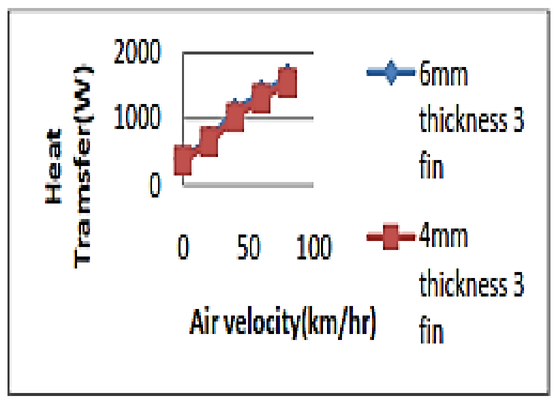


Fig.2. Heat transfer vs. air velocity for 6mm and 4mm thickness 3 no. of fin. [2].

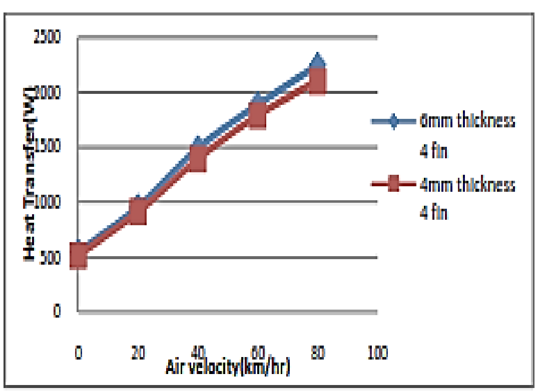


Fig.3. Heat transfer vs. air velocity for 6mm and 4mm thickness 4 no. of fin. [2].

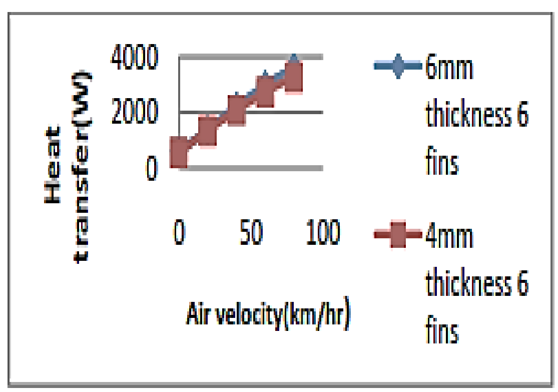


Fig.4. Heat transfer vs. air velocity for 6mm and 4mm thickness 6 no. of fin. [2].

The heat transfer from 6mm fins is found to be the higher at high velocities. For high speed vehicles thicker fins provide better efficiency. When fin thickness was increased, the reduced gap between the fins 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. [2]

Table-1

Experimental cylinders, fins and air velocities investigated by researchers [3]

	Gibson A.H	Biermann A.E. et al.	Thornhill D. et al		MasaoYoshida M. et al.
Cylinder diameter	32-95	118.36	86	100	78
Fin pitch	4-19	1.448-15.24	7-14	8-14	7-20
Fin length	16-41	9.398-37.33	25-65	10-50	35
Material	Copper, Steel , Al	Steel	Aluminium alloy		Al
Wind velocity	32-97	46.8-241.2	43.2-172.8		0-60

The comparisons of the experiments done are given in the above table which shows the different variations of pitch and no. of cylinders using for the fins. [3]

In the above studies, experiments are carried out on an IC Engine cylinder with fins using wind tunnel setup. The IC Engine is initially heated to 150°c and cooing rate of cylinder and fin is analyzed by varying the air velocity from 0 to 20 km/h using wind tunnel. This study is numerically extended for analysis of fin parameters using commercially available CFD code ANSYS Fluent. The numerically predicted results are validated with the experiments carried out in the laboratory. Hence the numerical study can also be extended to study the effect of fin pitch, fin thickness, normal and tapered fins, effect of holes and slits in fins etc. [3]

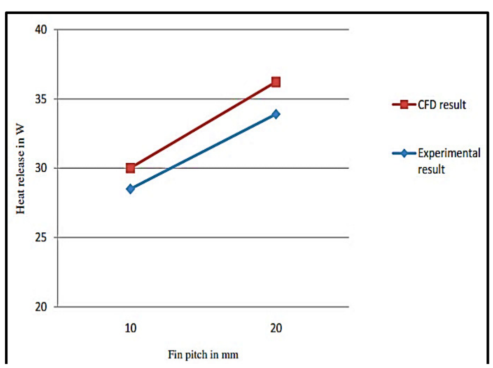


Fig.5. Comparison between experimental and CFD results [3]

From fig.5 it is seen the heat release by both experimental work and CFD work is approximately the same. [3]. so to analyze the heat transfer from the fins it is better to use the finite element method or CFD Tool for better results

3. EFFECT OF MATERIAL AND CLIMATIC CONDITION ON HEAT TRANSFER RATE OFFINS

Different materials are used to manufacture SI engine fins like Aluminium, copper, carbon steel etc. P. M. Ravanancalculated the heat transfer rate and the temperature behavior for the same object with the different material (like copper and Aluminium).

Table-2

Experimental cylinders, fins and air velocities investigated by researchers [4]

Properties	Cooper	Aluminium	Unit
Density	8933	2700	Kg/m²
Coefficient of thermal expansion	10	10	W/m²/k
Thermal conductivity	398	236	W/m/k
Specific heat	385	900	J/kg/k

Thermal analysis of cylindrical fin made of aluminium and cooper was made with the help of Transient analysis method. After comparing the both fin analysis, it is observed that heat flow rate of copper fin (19.2W) is less than the heat flow rate of the aluminium fin (56.99 W). Also the comparison of graph variables of both materials shows the steady state condition with respect to time. From the graph we know that the copper gets stable at the lowest temperature. And hence here conclude that the copper is best material suitable for fin than the aluminium. [4] But, now a day's aluminium is used as fin material because of its long life, good corrosion resistance characteristics and lighter weight.

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. [5]

Increase in wind velocity results in increase in excess fuel consumption due to overcooling. This variation increases steeply at velocities more than 60km/hr. This necessitates the need of reducing the air velocity striking the engine surface to reduce the fuel consumption. It can be done by placing a diffuser in front of the engine which will reduce the relative velocity of the air stream thus decreasing the heat loss. [5]

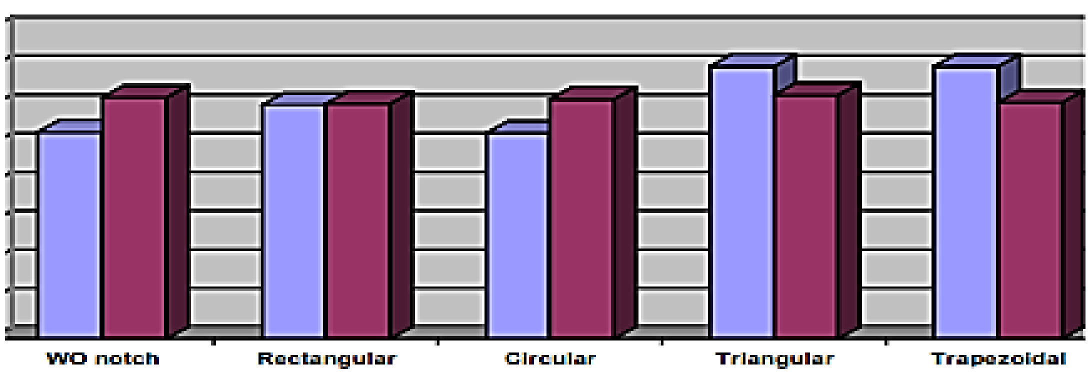
4. EFFECT OF PERFORATIONS, NOTCHES AND VARYING GEOMETRY ON HEAT TRANSFER RATE OF FINS

Due to the high demand for lightweight, compact, and economical fins, the optimization of the fin size is of greatimportance. Therefore, fins must be designed to achieve maximum heat removal, with the minimum material expenditure, taken into account, with the ease of manufacturing of the shape. The present study involves studying the effect of triangular perforations on rectangular fin. The study investigates the comparison of perforated fin with solid fin for temperature distribution along the fin and heat transfer rate. The analysis is done using ANSYS 9.0 version & also by experimentation. [6]

The analysis by ANSYS shows that thermal flux is more for the fins with perforations as compared to fin without perforations. Thus we can say that the heat transfer improves with the addition of perforations. It is also observed that the thermal flux increases with increase in perforation dimension increases up to certain dimension, then again it decreases. The analysis is also done for different materials of varying thermal conductivities, such as Mild steel & stainless steel. Results shown are similar to that of Aluminum fin. They show that as thermal conductivity increases thermal flux increases. As the thermal flux is more the rate of heat transfer would be more for the fins. [6]

It is observed that heat transfer rate increases with perforations as compared to fins of similar dimensions without perforations. It is noted that in case of triangular perforations optimum heat transfer is achieved. It is also concluded that heat transfer rate is different for different materials or heat transfer rate changes with change in thermal conductivity. The perforation of fins enhances the heat dissipation rates and at the same time decreases the expenditure for fin materials also. [6]

S.H. Barhatte et al. modified the fin flats by removing the central fin portion by cutting a notch of different geometrical shapes and adding it at the arrays entrance on the two sides, where it is more effective and thereby keeping fin surface area same. [7] Notches of different shapes like rectangular, triangular, circular, trapezoidal were made on the fin surface and analyzed with the help of ANSYS Tool. Computational analysis involves three steps mainly modeling, preprocessing and post processing. The discretization schemes used for this purpose are structured hexahedral grid mesh. With the hexahedral grid mesh the solution becomes more accurate. Scheme of tetrahedral grid mesh can also be used but it is less accurate. Moreover for regular geometry it is possible to use hexahedral grid mesh more efficiently and get more accurate results. [7]



Base Temp of 60 Deg.	Average Heat Transfer Coefficient				
	Wo. Notches	Rectangular	Circular	Triangular	Trapezoidal
CFD	5.3434	6.039	5.31779	7.03509	7.0260
Experimental	6.231	6.07	6.18882	6.29172	6.1004

Fig.6. Comparison of heat transfer coefficient (HTC) by CFD and HTC by experiment [7]

5. CONCLUSION

The summary of the present literature review is as follows:

1. The fin geometry and cross sectional area affects the heat transfer co efficient.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.
2. Heat transfer coefficient can be increased by increasing the surrounding fluid velocity by forced convection. Heat transfer dependence on different stream velocities.
   But overcooling also leads to higher consumption of fuel. So it is necessary to maintain fluid velocities around the fins
3. Heat transfer co-efficient depends upon the space, time, flow conditions and fluid properties. If there are changes in environmental conditions, there are changes in heat transfer co-efficient and efficiency also
4. 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.

6. REFERENCES

[1] Masao Yoshida, SoichiIshihara,Yoshio Murakami, Kohei Nakashima, Masago Yamamoto, "Air cooling Effects of fins on a Motor cycle Engine", JSME International Journal, Series B,Vol.49,No.3,2006

[2] J.Ajay Paul, SagarChavan Vijay, U.Magarajan&R.ThundilKaruppa Raj, "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,pp.81-90, 2012

[3] Magarajan U., Thundilkaruppa Raj R. and Elango T., "Numerical Study on Heat Transfer of Internal Combustion Engine Cooling by Extended Fins Using CFD", Research Journal of Recent Sciences ISSN 2277-2502 Vol. 1(6), pp.32-37, June (2012).

[4] Matkar M.V. ,P. M. Ravanan, "Thermal Analysis of Copper Fin by FEA", ICOQM-10, pp.1229-1236, June 28-30, 2011

[5] PulkitAgarwal, MayurShrikhande 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

[6] Kumbhar D.G., Dr. N K Sane, Chavan S.T., "Finite Element Analysis And Experimental Study of Convective Heat Transfer Augmentation from Horizontal Rectangular Fin By Triangular Perforations",Proc. of the International conference on Advances in Mechanical Engineering,pp.376-380,August 2009 S.V.N.I.T-SURAT.

[7] S.H. Barhatte, M. R. Chopade, V. N. Kapatkar, "Experimental And Computational Analysis and Optimization For Heat Transfer Through Fins With Different Types of Notch", JERS, Vol-2, pp.133-138, Issue I, January-March 2011.

[8] Shri. N.V. Hargude and Dr. S.M. Sawant, "Experimental Investigation of Four Stroke S.I. Engine using Fuel Energizer for Improved Performance and Reduced Emissions", International Journal of Mechanical Engineering & Technology (IJMET), Volume 3, Issue 1, 2012, pp. 244 - 257, ISSN Print: 0976 – 6340, ISSN Online: 0976 – 6359.

[9] Ashok Tukaram Pise and Umesh Vandeorao Awasarmol, "Investigation of Enhancement of Natural Convection Heat Transfer from Engine Cylinder with Permeable Fins", International Journal of Mechanical Engineering & Technology (IJMET), Volume 1, Issue 1, 2010, pp. 238 - 247, ISSN Print: 0976 – 6340, ISSN Online: 0976 – 6359.