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Design Optimization of an Air Cooled Internal Combustion Engine Fin Using CFD

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Abstract: In internal combustion engines, the energy is generated by converting chemical energy of fuel into mechanical energy of reciprocating piston at the time of combustion of fuel and air. As a result of combustion of fuel in an IC engine the lubricant oil film starts burning due to very high temperatures of order of 2100-2200°C of combustion chamber. This results into seizure if IC engine sub parts. So as to maintain the temperature of combustion chamber of IC engines at about 200-230°C, fins are provided to optimize the efficiency and performance of an IC engine. These fins are designed particularly without increasing the weight of engine above optimal level and thermal efficiency is maintained at optimal level. Also the determination of values which gives optimized fin surface from the aspect of thermos structure at given heat flux carried out. Further, using GAMBIT and FLUENT/ANSYS the fin profile and fin array parameters optimized for a given heat flux. This study is carried out to understand the effects of fin pitch, no. of fins, relative wind velocity, ambient temperature on air cooling of two wheeler using CFD.

Keywords: Computational fluid dynamics, FLUENT/ANSYS, GAMBIT, Internal combustion engine, Thermal efficiency, Fin array, Fin profile

I. INTRODUCTION

During combustion of air fuel mixture, the high temperature and pressure gases applies direct force to components of engine, such as piston, nozzle or turbine blades, which further results into movement of component over a distance generating mechanical energy. To withstand a high temperature of 2500OC generated due to combustion of air-fuel mixture in engine cylinder, a very high melting point material has to be used for engine construction [2]. This is practically less possible. It has been observed that out of the total heat generated by IC engine due to combustion only 30% is converted into useful work, 40% carried out by exhaust gases during exhaust stroke and rest 30% must be carried away to atmosphere by some convenient arrangement[3]. The lack of cooling system there will increase in repairing costs and breakdown period due to seizure and frequent replacements of components[1]. Thus engine life reduced, volumetric efficiency will decrease and preignition due to high temperatures will tend the engine to detonate. Air-cooling is one of the very efficient and cheap method of cooling IC engines. These fins are the extended surfaces extended from the combustion chamber to cool the engine. However, Low rate of heat transfer through cooling fins is the main problem in this type of cooling [5]. This paper is the study of effects of fin pitch, fin geometry, material, relative wind velocity, number of fins and ambient temperature on air cooling of a two wheeler IC engine of Bajaj Pulsor/ Hero Honda Passion Plus 150cc using Computational Fluid Dynamics codes (CFD). Also the determination of values which gives optimized fin surface from the aspect of thermos structure at given heat flux for various trends of parameters are carried out. [7]. Further, an effort is made to optimize the fin profile and fin array parameters for different materials and for a given heat flux using GAMBIT and FLUENT/ANSYS.

II. LITERATURE REVIEW

- A. Modelling and Simulation of engine Cylinder Fins using FEA; (IJRASET April 2014); R Arularasan, S Prathap: Effect of different fin shapes on fin efficiency using Ansys
- B. Kumbhar D.G et.al. 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

- C. N. Nagarani et.al.: Analyzed the heat transfer rate and efficiency for circular and elliptical annular fins for different environmental conditions
- D. G.Raju, Dr. Bhramara Panitapu, S. C. V. Ramana Murty Naidu: This study also includes the effect of spacing between fins on various parameters like total surface area, heat transfer coefficient and total heat transfer.
- E. Ashok Tukaram Pise and Umesh Vandeorao Awasarmol conducted the experiment to compare the rate of heat transfer with solid and permeable fins.
- F. Pulkit Agarwal et.al. simulated the heat transfer in motor-cycle engine fins using CFD analysis. It is observed that when the ambient temperature reduces to a very low value, it results in overcooling and poor efficiency of the engine.
- G. Thornhill D. and May A., An Experimental Investigation into the Cooling of Finned Metal Cylinders in a free Air Stream, SAE Paper 1999-01-3307 (1999): Effect of air velocity and environmental condition on fin performance.
- H. P. Agarwal, et al. (2011). Heat Transfer Simulation by CFD from Fins of an Air Cooled Motorcycle Engine under Varying Climatic Conditions. Proceedings of the World Congress on Engineering: Effect of environmental condition, material, wind velocity, ambient temperature etc. on fin performance.

III. PROBLEM FORMULATION & MODELLING

A. Scheme of Implementation.

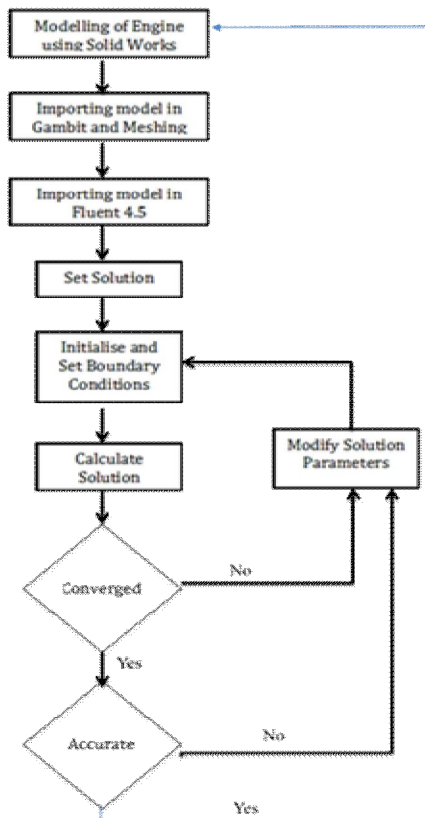


Fig 1. Schematic Flow Chart

B. SI Engine Modelling

The Spark Ignition engine considered here for study is Bajaj Pulsar 150 cc engine. The engine and fin specifications is as follows:

Engine	4 Stroke, Single Cylinder, Air Cooled
Displacement	149.01 cc
Bore and Stroke	57 × 56.4 mm
Compression Ratio	9.5:1
Max. Power	4.09 PS (10.35 KW) @ 8500rpm

Max. Torque	12.76 Nm @ 6500rpm
Transmission	5 Speed
Fin Material	Al. Alloy
No. of fins	12
Fin Pitch	10
Fin Thickness	2mm
Fin Profile	Rectangular (uniform cross section) with curved edges
Max. Fin Height	35mm
Min. Fin Height	10mm

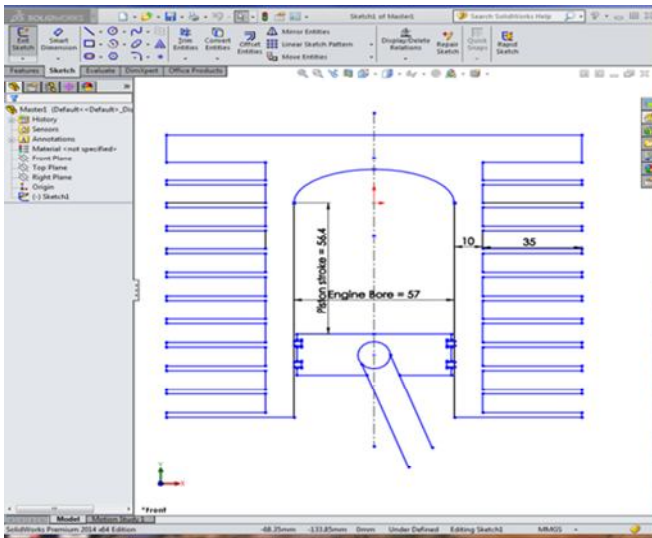


FIG 2: SYMMETRIC MODELLING OF ENGINE IN SOLID WORKS. FOR THE PURPOSE OF STUDY THE ENGINE IS MODELED AS AXIS-SYMMETRIC WITH DIFFERENT FIN CONFIGURATION.

IV. RESULTS AND DISCUSSIONS

Effect of Fin geometry on Heat Transfer on actual 150cc engine:

For all fin configuration the effectiveness is noted in the range 2.4-7

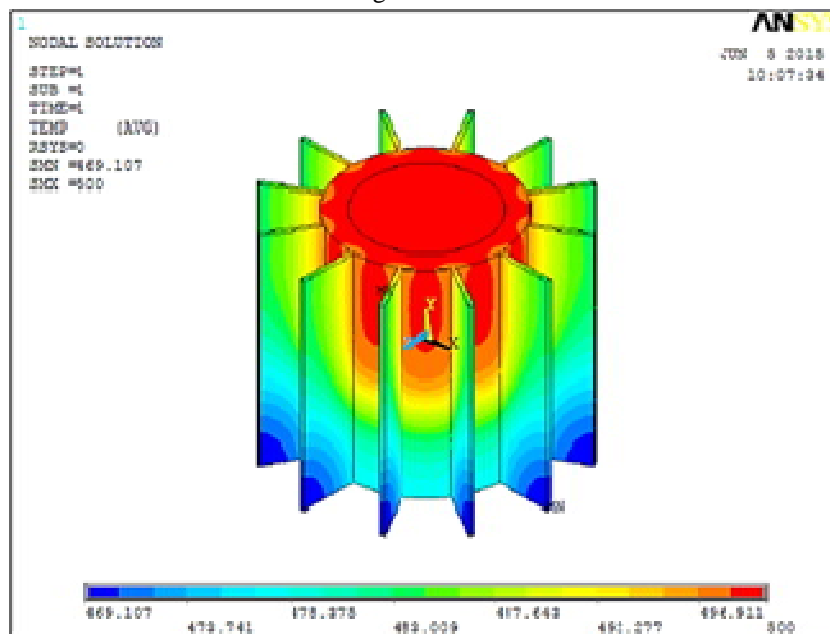


Fig 3: Temperature Profile across Parallel Fin

Parallel fins effectiveness is far lesser than other configuration fins. Thus parallel fins should not be chosen for designing the air cooling systems of IC engines., due to configuration constraints. The conical fins weight is 55.4% lesser than rectangular fins. However, the effectiveness is only 5.6% lower than rectangular fins. Thus conical fins are better than rectangular fins.

Hence extra design measures should be taken in fin design to increase the turbulence and hence the convective heat transfer coefficient.

The heat transfer rate is directly proportional to convective heat transfer coefficient. The heat transfer rate increases as increase in convective heat transfer coefficient. For small values of h , the rise is linear, for greater values of h , the increase is nonlinear. The heat transfer rate increases with the increase in convective heat transfer coefficient, h .

The rise is linear for small values of h , however for larger values of h , the increase is non-linear. As the h increases the heat transfer increases.

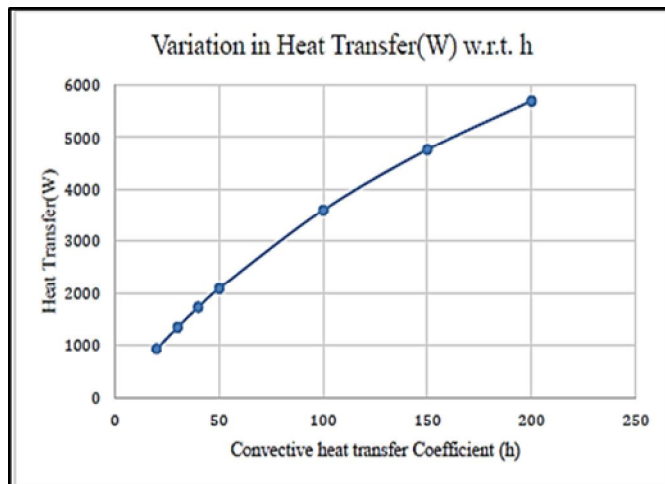


Fig 4: Effect of h on Rate of Heat Transfer

The increase in h is one of the foremost way of increasing the heat transfer. Hence extra design measures should be taken in fin design to increase the turbulence and hence the convective heat transfer coefficient.

V. CONCLUSION

The effect of fin geometries, coefficient of heat transfer coefficient (h) and material (K) is studied for the heat loss for air cooling of an IC engine. Also heat transfer per unit weight of fin is larger for conical fin than rectangular fins, hence conical fins are preferred over rectangular cross section fins. The rate of heat transfer increases with increase in h , linearly, for small values of h . Aluminum is the better material for designing fins for air-cooled IC engines due to low weight, high rate of heat transfer and lower cost.

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