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

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Abstract - *Internal combustion engines, produces energy by the combustion of fuel and air, i.e. by converting the chemical energy of the fuel into mechanical energy of the reciprocating piston. During the combustion of fuel in an IC engine very high temperature of the order of 2100-2200°C is produced inside the combustion chamber. As a result the lubricant oil film between the different parts starts burning. It may also result into seizure of IC engine sub-parts or welding. So, as to prevent this and to maintain the working health of an IC engine the temperature of the combustion chamber should be reduced to about 200-230°C. Too much cooling also will lead to lower thermal efficiency of the engine. Fins are provided to optimize the performance, and the efficiency of an IC engine, by providing exterior extended cooling surfaces. These fins are particularly designed to optimize the loss of heat and temperature inside of IC engine so that thermal efficiency is optimal without increasing the weight of engine above optimal level. This study is an attempt to understand the effects of the number of fins, fin pitch, relative wind velocity and ambient temperature on air-cooling of a two- wheeler IC engine using commercially available CFD codes. Also the determination of values which gives optimized fin surface from the aspect of thermos structure at given heat flux carried out.*

Further, the fin profile and fin array parameters optimized for a given heat flux using GAMBIT and FLUENT/ANSYS.

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

1. INTRODUCTION

While combustion in internal combustion engine, the high-temperature and pressure gases applies a direct force to few components of the engine, such as pistons, turbine blades, or a nozzle. This force moves the component over a distance, generating useful mechanical energy. When the combustion of air-fuel mixture takes place in the engine cylinder, a temperature as high as 2500OC is reached. To withstand such a high temperature a very high melting point material has to be used for construction of engine [2]. Practically it is less possible because, "Platinum", which has one of the highest melting point, melts at above 1800oC.

It has been practically found that out of total heat generated by internal combustion engine due to combustion of fuel, only 30% of heat is converted in useful work, out of remaining 70% about 40% is carried by exhaust gases into the atmosphere during exhaust stroke. The rest of 30% must be passed to atmosphere by some suitable arrangement [3]. In lack of cooling system, a complete seizure of the piston, bearing and other important parts will occur. Due to this, there will be more frequent replacements of the components are required. It will also increase the repairing cost and breakdown period [1]. The engine life will be reduced considerably. Also, higher temperatures lower the volumetric efficiency of the engine; promote pre-ignition and tendency of the engine to detonate. Air-cooling is one of the very efficient and cheap method of cooling IC engines which uses the extended surfaces called 'Fins' 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 documents the effects of the number of fins, fin pitch, geometry, material, relative wind velocity and ambient temperature on air-cooling of a two- wheeler IC engine (Hero Honda Passion Plus/ Bajaj Pulsar 150cc) using analytical calculations and commercially available Computational Fluid Dynamics (CFD) codes. 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.

2. LITERATURE REVIEW

1] 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. 2] 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. 3] 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. 4] 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.

5] N. Nagarani et.al.: Analyzed the heat transfer rate and efficiency for circular and elliptical annular fins for different environmental conditions. 6] Ashok Tukaram Pise and Umesh Vandeorao Awasarmol conducted the experiment to compare the rate of heat transfer with solid and permeable fins. 7] 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. 8] 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.

1.1 Problem Formulation & Modelling

A. Scheme of Implementation.

The scheme of Implementation to be followed is as shown in the following figure,

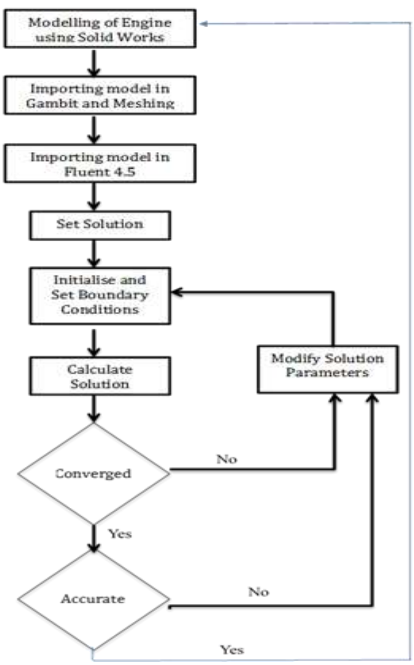

Fig 1. Schematic Flow Chart

B. Modelling of an SI Engine.

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

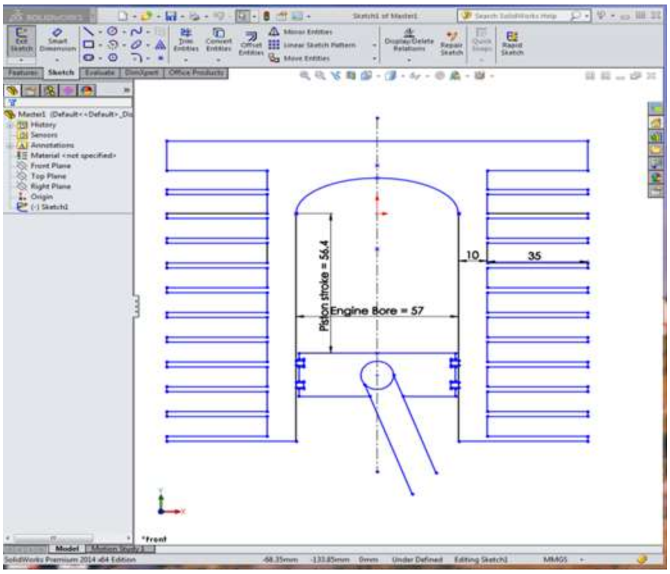

Fig 2: Symmetric Modelling of Engine in Solid Works. For the Purpose of Study the engine is Modeled as Axis-Symmetric with Different Fin Configuration.

3. RESULTS AND DISCUSSIONS

The Effectiveness of all fin configuration varies from 2.4-7.

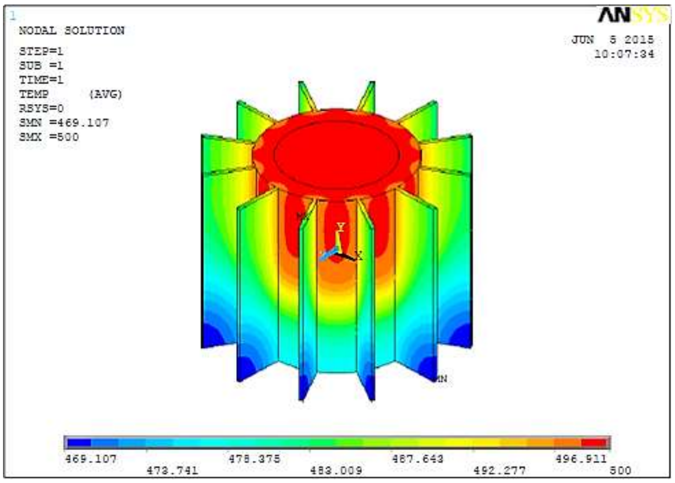

Fig 3: Temperature Profile across Parallel Fin-24

The effectiveness of parallel fins is far lesser than other configuration fins. Hence, Parallel fins should not be chosen for designing the air-cooling systems of IC engines, until due to a configuration constraint. The weight of conical fins is 55.3% lesser than rectangular fins. However, the effectiveness is only 5.6% lower than that of rectangular fins. Hence overall, conical fins are better than rectangular fins.

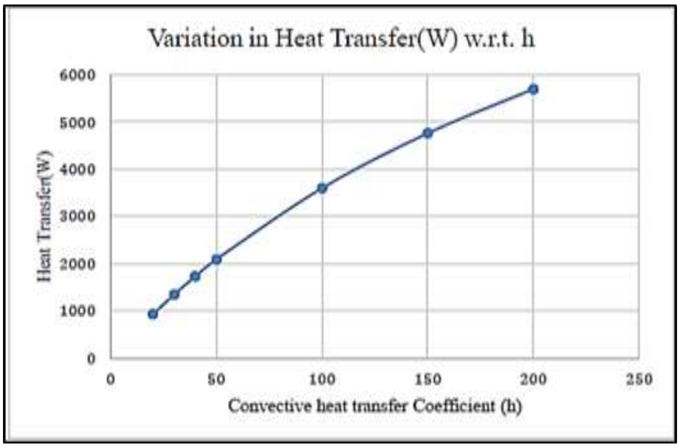

Fig 4: Effect of h on Rate of Heat Transfer

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. 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.

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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