International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 04 | Apr-2016 www.irjet.net p-ISSN: 2395-0072

Analysis of Heat transfer through fins of an IC Engine using CFD

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Abstract - - *In this paper, analysis of heat transfer across finned surfaces is done using CFD software. The CFD software was used to simulate the heat transfer across the fins under two different air velocities around the fins. Experiment based research done by different researchers in the past is a time consuming process; hence CFD software was used to simulate the heat transfer across fins of an IC Engine. The simulated results were found to be comparable with experimental results.*

***Key Words*: Cooling fins, CFD, Heat transfer, Convection, Profile.**

1. INTRODUCTION

Fins are the extended surfaces purposely provided at a place from where heat is to be removed. The amount of conduction, convection, or radiation of an object determines the amount of heat it transfers. Increasing the temperature gradient between the object and the environment, increasing the convection heat transfer coefficient, or increasing the surface area of the object increases the heat transfer. Fins are widely used for cooling of IC engines.

The different types of fin geometries that can be used for an IC engine are-

- Rectangular fins: The cross section of fins is rectangular in shape.
- Triangular fins: The cross section of fins is triangular in shape.
- Trapezoidal fins: The cross section is trapezoidal in this case providing greater surface area for heat transfer.
- Pin fins: The area for heat transfer is in the form of small pin shaped fins called as Pin fins.

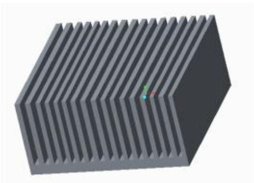

Fig 1: Rectangular fins

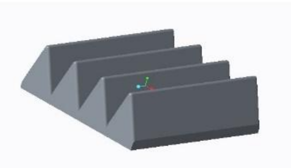

Fig 2: Triangular fins

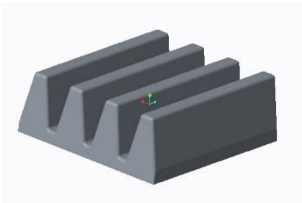

Fig 3: Trapezoidal fins

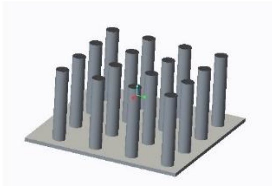

Fig 4: Pin fins

Heat transfer through extended surfaces is mainly focused on convectional heat transfer. The condition of cooling medium that surrounds those surfaces is responsible for conventional heat transfer. The movement of air across the fins and its pattern of movement over the periphery of extended surfaces greatly affect the heat transfer rate.

Optimum length of fins: Since we are purposely increasing the surface area for getting maximum heat transfer, but it does not mean that we can go on increasing the length (and thereby the surface area) beyond a certain limit. If the length of fins is increased too much, the convective thermal resistance would increase thus reducing the heat transfer rate, fin efficiency and also; it adds unnecessary material and costs also. Conversely, if the length of fins is too short, the heat transfer rate and fin efficiency would decrease again. Hence the length of fin needs to be optimum in value.

2. METHODOLOGY

The methodology followed was computational fluid dynamics (CFD). The brief is as follows:-

A four stroke cycle cylinder was procured from the market (Casted and press fit; *Diamond* four stroke cycle engine cylinder). The dimensions of this block were measured and CAD model was generated using PTC Creo 3.0 Student edition. The model was saved in IGES file which is a standard CAD export file. This file contains model information like its geometrical features and dimensions and is ready to be imported in the any analysis software.

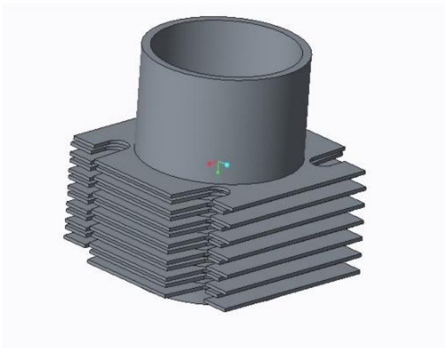

Fig 5: CAD Model of cylinder and fin block

Then heat transfer analysis was carried out in student version of commercially available analysis software ANSYS. This software basically uses numerical methods for finding out solutions to the problems fed with some initial conditions. For this, the model needs to be converted into many small sized cell like network which is called as a mesh and the process is called as meshing.

Nodes and Mesh: Nodes can be defined as the points which are joined by lines thus forming a network (mesh). This network is also called as grid. A grid is a discrete representation of the geometry and state of the model (object). The mesh plays an important role in obtaining the convergence of the solution of a problem in analysis software. Mesh are of many types like triangular, quadrilateral, tetrahedral, pyramidal, hexahedral etc.

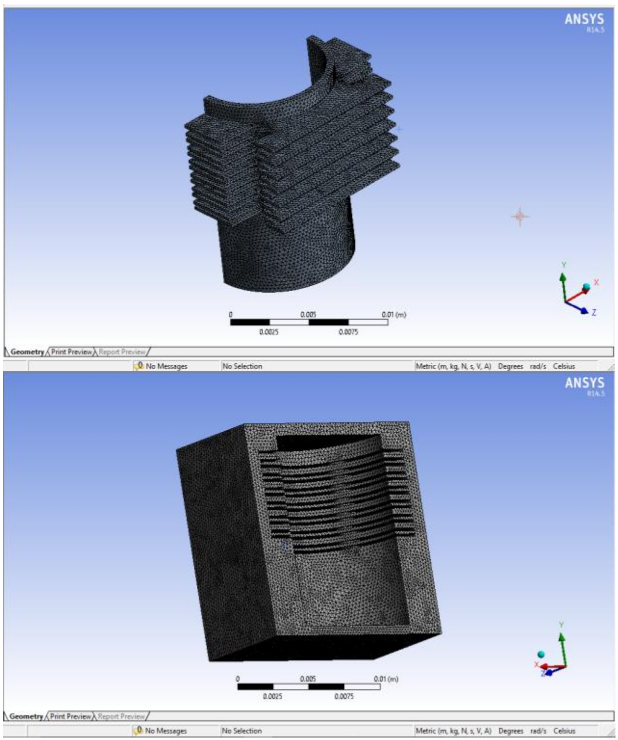

Fig 6: Sectioned and meshed CAD models

Before solving and simulating, materials and initial boundary conditions were inputted as shown in the Table1. Results from CFD software were obtained and compared.

Table 1: Parameter Values

CASES	AIR VELOCITY (m/s)	TEMPERATURE (BLOCK) (K)	TEMPERATURE (AIR) (K)
I	11.11	373	300
II	16.66	373	300

First, the analysis was done, considering the normal conditions that exist in a vehicle i.e. the air velocity, maximum engine (cylinder) temperature, flow direction of air etc.

Now analysis was done again considering and arbitrary value for air velocity (which essentially has to be greater than the previous value used in first case). The graph and contours have been shown below.

3. RESULTS & DISCUSSIONS

The results produced by the analysis software are in the form of color contours of the required parameter. The contours are such that they give us the idea about at what place, the value of that parameter ranges, which is indicated by the color legend in the results. We can estimate the value of a particular parameter by matching the respective color from the contours.

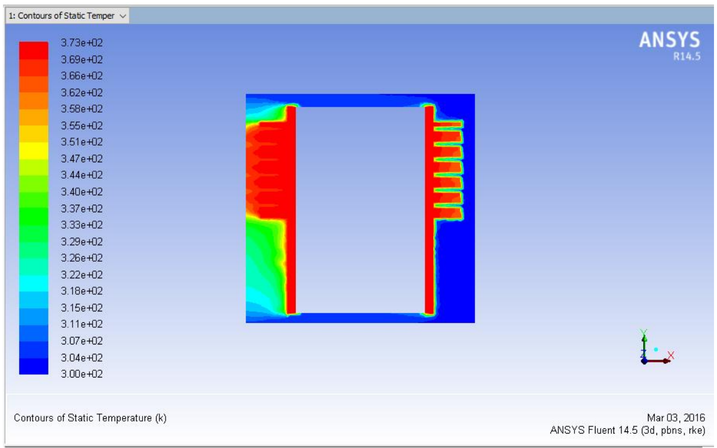

Fig 7: Temperature contours around the fins (Case 1)

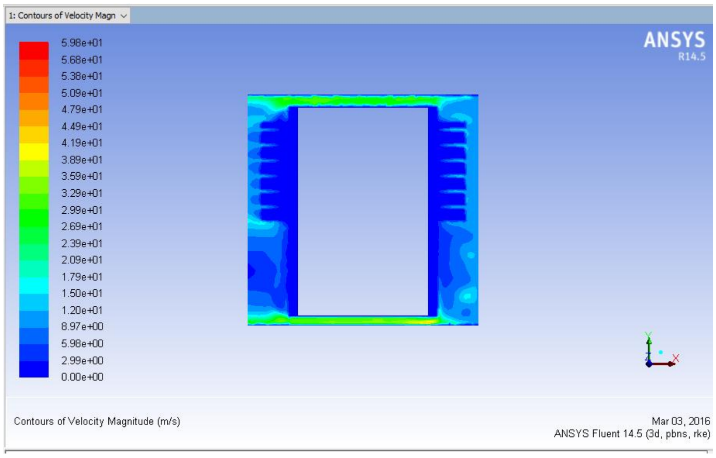

Fig 8: Air velocity contours around the fins (Case 1)

The results obtained in the form of contours indicate the temperature values around the fin set at a particular set of conditions as given in Table 1. Further, the air velocity contours indicate the pattern of velocities of air around the fins. This is important because the convection currents that are responsible for convectional heat transfer depend upon the air velocity around the fins.

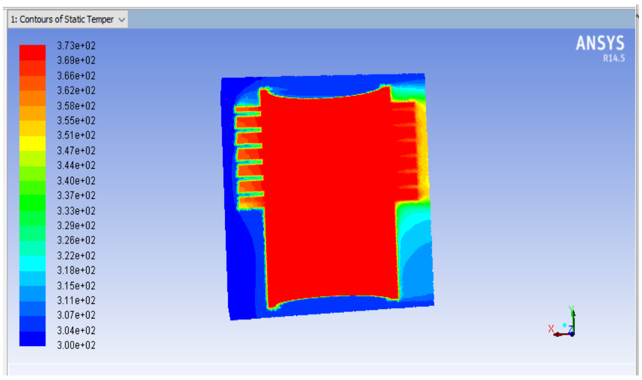

Fig 9: Temperature contours around the fins (Case 2)

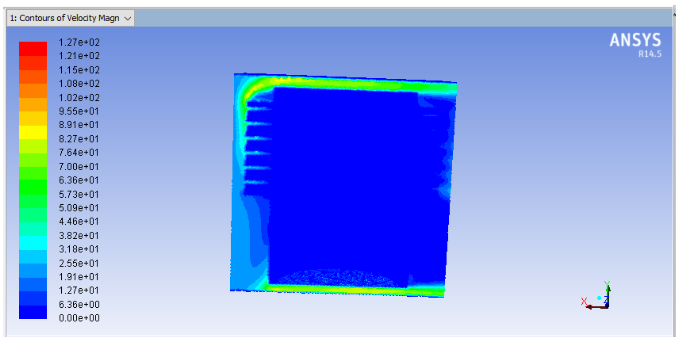

Fig 10: Air velocity contours (Case 2)

The second case with changed parameters clearly indicates the change in pattern of air velocities around the fins and the temperature distribution also.

Clearly, the air velocity contour indicate that if we increase the air velocity around the periphery of the cylinder block having fins, the conventional heat transfer rate will speed up as shown by the difference in the temperature values in both figures.

4. CONCLUSION

It was found that higher air velocities around the extended surfaces increase the heat transfer. The variation in vehicle speed significantly changes heat transfer rate. As a consequence fin efficiency also vary with vehicle speed. The physical dimensions of fin also impact the fin efficiency. It was found that the fin efficiency/heat transfer rate increases when air velocity was increased from 11.11m/s to 16.667 m/s.

The flow pattern of air is governed by physical geometry of fins. CFD technique was found to be very useful and fast. It eliminates the need of fabrication prior to experimental work. Both fabrication and experimental procedures are time consuming, expensive and sensitive to human errors. Using CFD technique produces quick and very accurate results for a wide range of operating conditions.

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