Design Modification and Analysis of Two Wheeler Engine Cooling Fins by CFD

Mohsin A. Ali and Prof. (Dr.) S.M Kherde

***Abstract*— An air-cooled motorcycle engine releases heat to the atmosphere through the mode of forced convection to facilitate this, fins are provided on the outer surface of the cylinder. The heat transfer rate depends upon the velocity of the vehicle, fin geometry and the ambient temperature. Insufficient removal of heat from engine will lead to high thermal stresses and lower engine efficiency. The cooling fins allow the wind to move the heat away from the engine. Low rate of heat transfer through fins is the main problem of air cooling system. An attempt is made to simulate the heat transfer using CFD for different shape and geometry of Fins to analyze effects on rate of heat dissipation from fins surfaces. The heat transfer surfaces of Engine are modelled in CATIA and simulated in FLUENT software. The main of aim of this work is to study different shapes and geometry of fins to improve heat transfer rate by changing fin geometry under different velocities.**

***Index Terms*— cooling fins, Heat transfer, Convection & Thermal Stresses.**

I. INTRODUCTION

In Engine When fuel is burned heat is produced. Additional heat is also generated by friction between the moving parts. Only approximately 30% of the energy released is converted into useful work. The remaining (70%) must be removed from the engine to prevent the parts from melting. For this purpose Engine have cooling mechanism in engine to remove this heat from the engine some heavy vehicles uses water-cooling system and 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. In air-cooled engine, extended surfaces called fins are provided at the periphery of engine cylinder to increase heat transfer rate. That is why the analysis of fin is important to increase the heat transfer rate. Computational Fluid Dynamic (CFD) analysis have shown improvements in fin efficiency by changing fin geometry, fin pitch, number of fins, fin material and climate condition.

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II. METHODOLOGY

A. Modeling and Design

For the analysis purpose existing Model of Bajaj discover is taken and same model is modified with different geometry of fins and comparison is plotted in results.

The Design of different geometrical shape of Fins was in CATIA and Analysis done by the ANSYS FLUENT software and for mashing purpose Hyper Mesh was used. The computational domain consists of a rectangular volume of large dimensions containing the finned body at its Centre. It was focused on the fins and appropriate boundary conditions were applied at the domain ends to maintain continuity. A fine mesh has been created near the fins to resolve the thermal boundary layer which is surrounded by a coarse external mesh for better results and fast solution. A face mesh has been done by Tetrahedron element as shown in Fig.1. The volume was meshed by Hyper Mesh. Figures

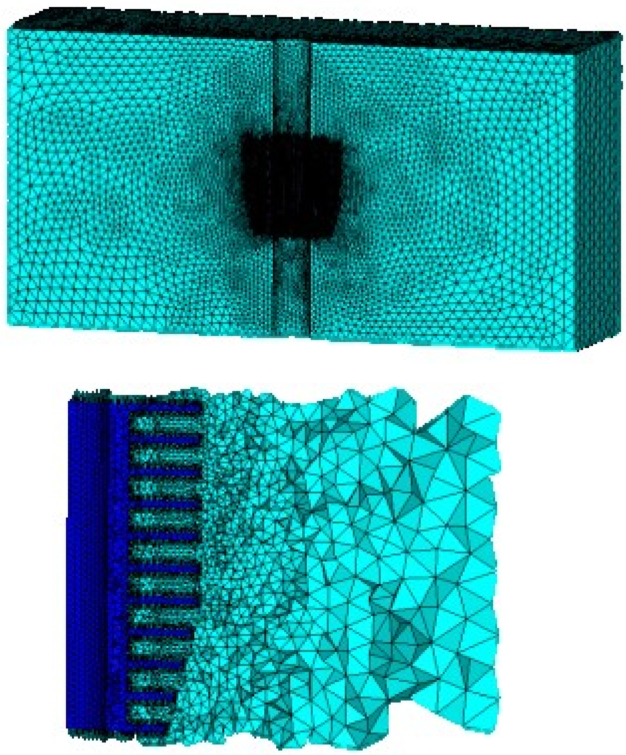

Fig. 1: 3D and sectional view of Meshing with Tetrahedron fluid elements

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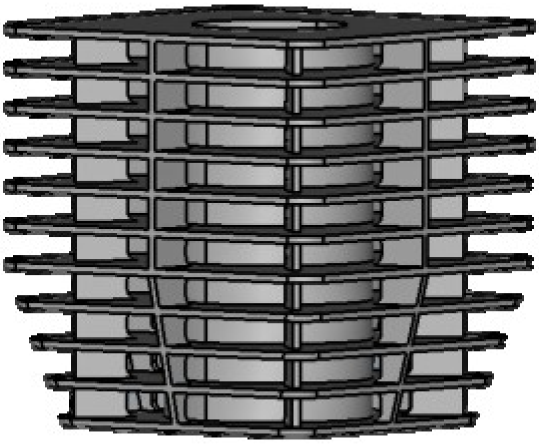

Fig. 2(a): 3D Model of Existing Bajaj Discover

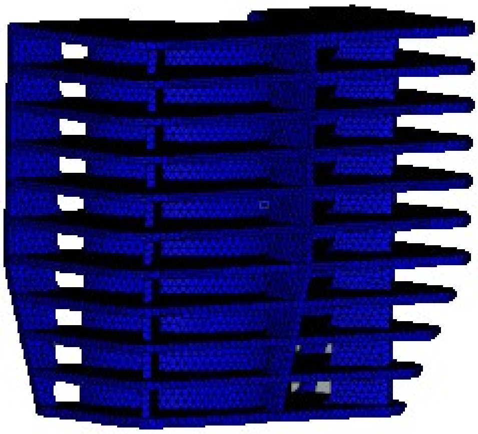

Fig. 2(b): Half Sectional Meshing Model

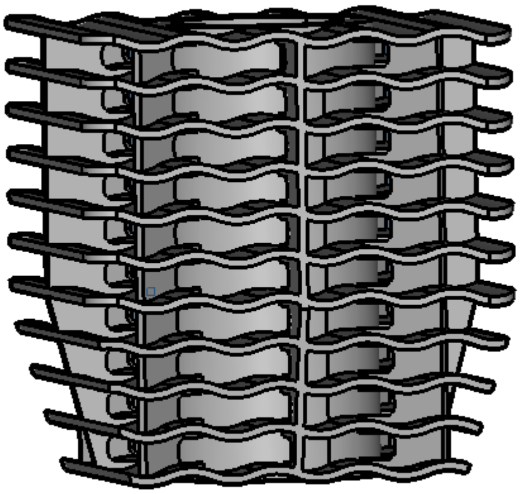

Fig. 3(a): 3D Model With ‘S’ Shape Fin

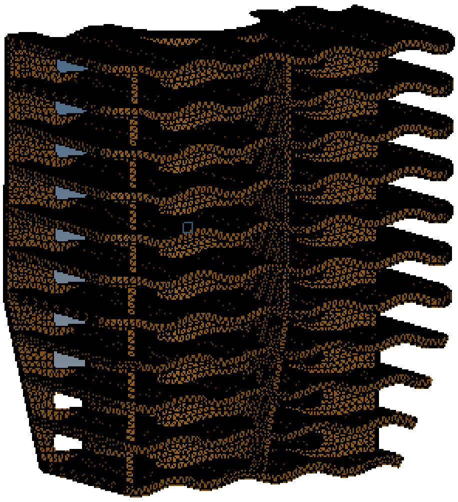

Fig. 3(b): Half Sectional Meshing Model

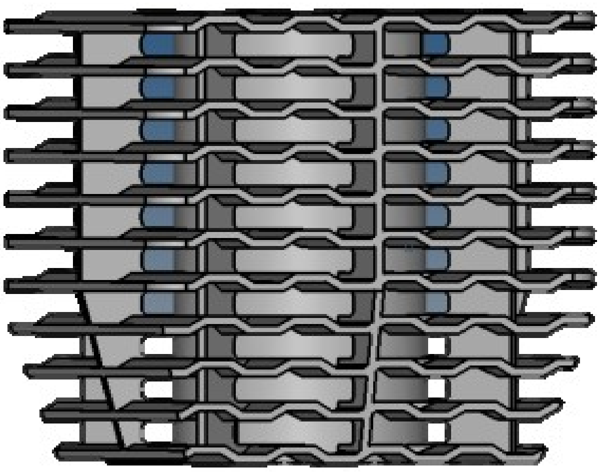

Fig. 4(a): 3D Model with ‘Step’ Shape Fin

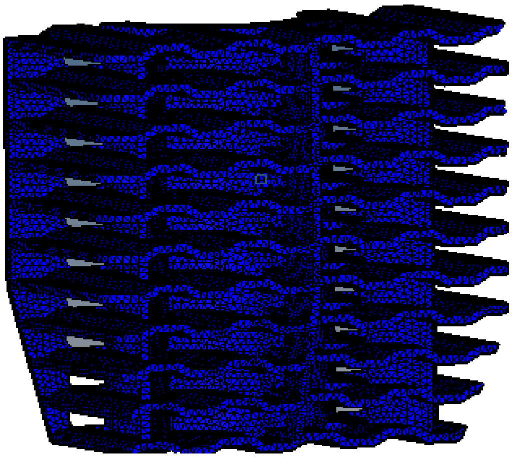

Fig. 4(b): Half Sectional Meshing Model

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TABLE I
Parameter Consider for analyis of Different Models

Parameter	Straight Fin Model	Step Fin Model	'S' shape Fin Model
Length=width=height	150mm	150mm	150mm
Thickness of each plate	3mm	3mm	3mm
Gap between the plates	11.7mm	11.7mm	11.7mm
Dia.of cylinder(inner dia)	60mm	60mm	60mm
Material	Aluminium alloy	Aluminium alloy	Aluminium alloy
Air Velocity	10 to 40 Km/Hr	10 to 40 Km/Hr	10 to 40 Km/Hr
Half Surface area	0.213 m^2	0.221 m^2	0.219 m^2
No. of Mesh Elements	15,71,066	16,01,127	16,34,775

B. Problem setup in Fluent

The flow around the fin has been solved at different airflow velocities from 10 km/hr to 40 km/hr, and at air temperatures at 30^0C.

A three dimensional steady state heat transfer analysis has been done by assuming a constant temperature on the inner surface of the wall. The temperature at the inner surface is assumed constant at 250^0C to account for heat generated due to combustion inside the engine.

For obtaining the relation between heat transfer coefficient and velocity, the temperature was maintained constant and the simulations were carried out varying the velocity from 10km/hr to 40 km/hr. Values of HTC and Kinetic turbulence Energy were obtained for different velocities.

C. Mathematical Equations

Ansys FLUENT solve problem with Finite Volume Method (FVM) and in this case solved the standard Navier - Stokes equations of fluid flow in three dimensions for finding the pressure and velocity at domain points. The following momentum conservation was used along with the continuity equation [9]

$$\frac{\partial(\rho)}{\partial t} + v\nabla.(\rho v) = -\nabla P + \nabla.\tau + F + \rho g$$

For heat transfer, the energy equation is solved in the following form:

$$\frac{\partial(\rho E)}{\partial t} + \nabla.\big(v(\rho E + p)\big) = \nabla.\left(k_{eff}\nabla T - \textstyle\sum_j h_j J_j + (\tau.v)\right) + Sh$$

III. RESULTS AND DISCUSSION

A. HTC Values across the Fins

HTC values for the different air velocity are found out for the three shapes fins. Result figure (5) showing significantly increase in HTC for Step shape and 'S' Shape Fin. Analysis conducted for the four different velocity from 10Km/Hrs. to 40Km/Hrs.

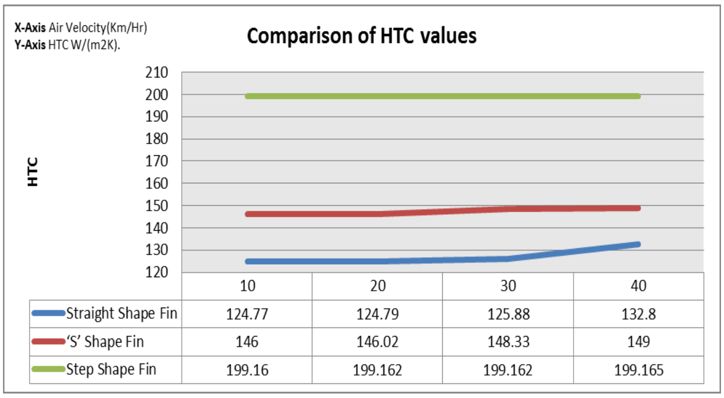

Fig. 5: HTC Values across the Fins

B. Kinetic Turbulence Energy Values across the Fins

A figure (5&6) shows variation in HTC and Turbulence energy w.r.t the air velocity. Significant change increase Kinetic Turbulence Energy can observe on changing the shape of the fin from Straight to Step and Sine 'S' Shape.
To increase the rate of heat transfers from any surface need to increase its surface area and turbulence of flowing air around the surface. Results of simulation are showing increase in both the factor .i.e. HTC and turbulence.

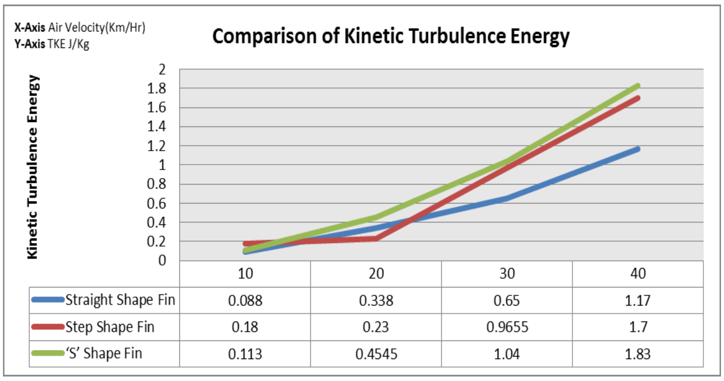

Fig. 6: Comparison of Kinetic Turbulence Energy

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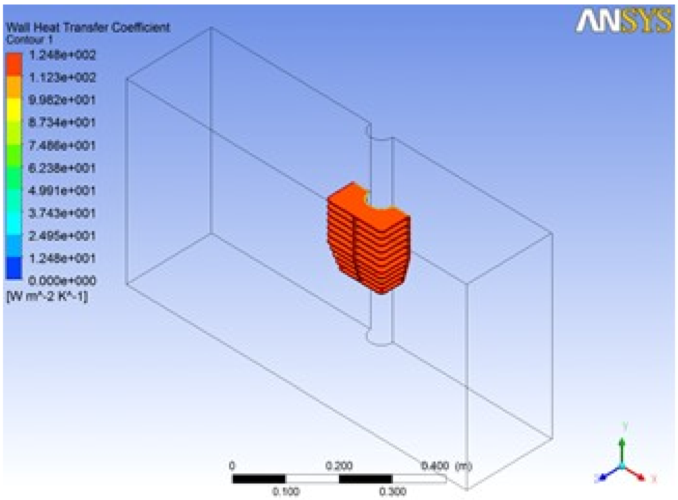

Fig. 7(a): HTC Results for Straight Fins

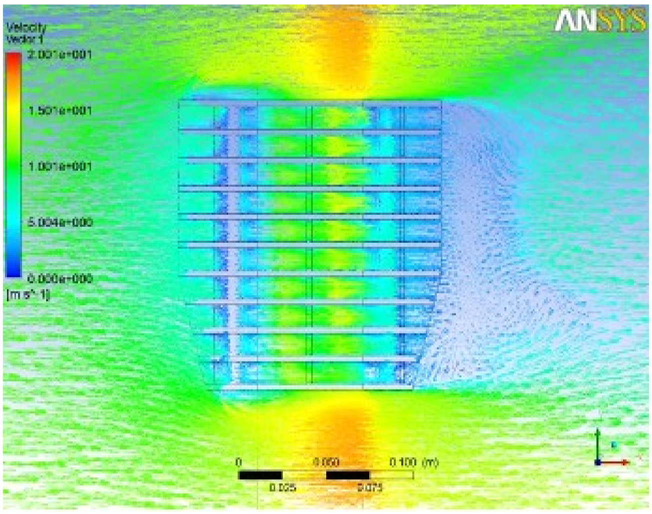

Fig 7(b): Velocity Results for Straight Fins

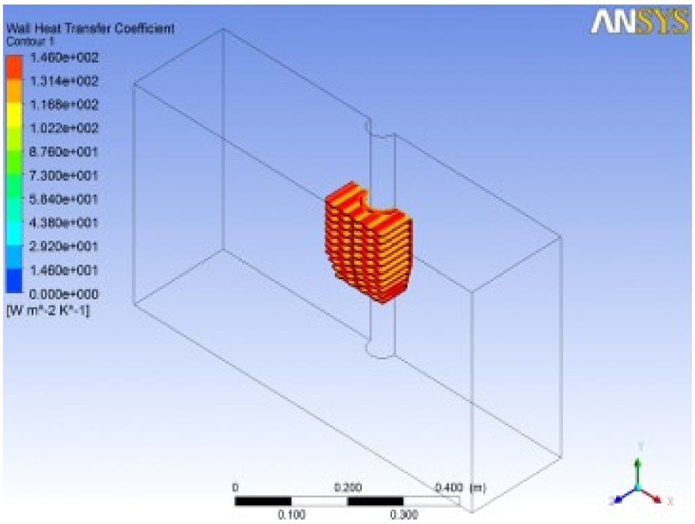

Fig. 8(a): HTC Results for 'S' Shape Fins

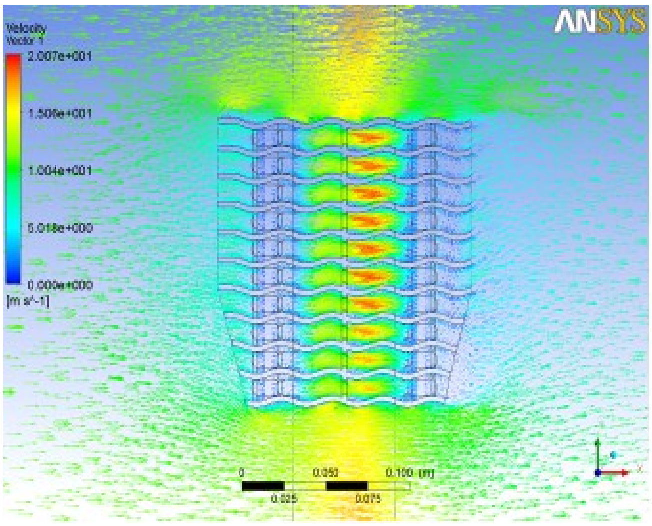

Fig 8(b): Velocity Results for 'S' Shape Fins

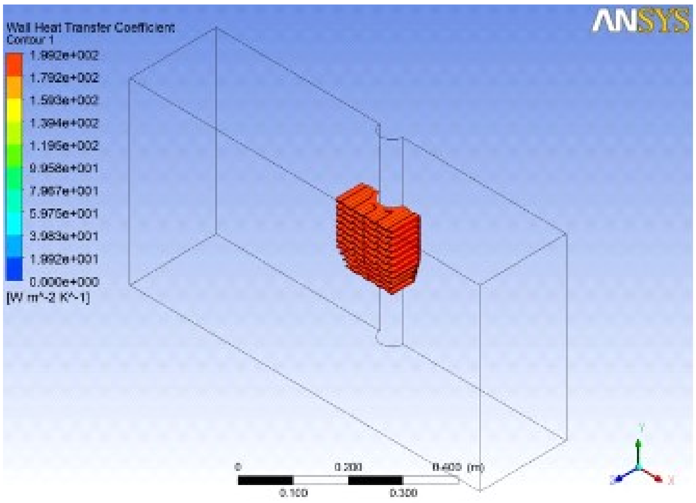

Fig. 9(a): HTC Results for Step Shape Fins

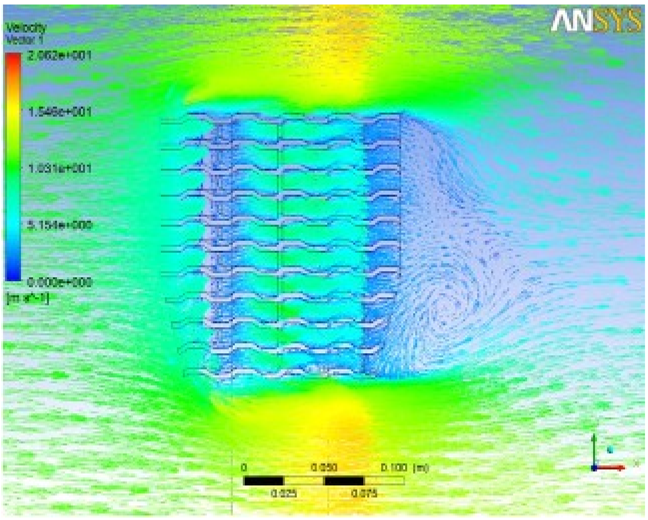

Fig 9(b): Velocity Results for Step Shape Fins

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IV. CONCLUSION

In present work, a Motor Cycle Engine is modelled and CFD analysis is done by using ANSYS Fluent. A brief summary of the work completed and significant conclusions derived from this work are highlighted below.

- Models for three different shapes of Fins were developed and effects of wind velocity and heat transfer coefficient values were investigated. An Analysis is carried out in Ansys Fluent to find the effect of change in geometry of Fins in terns of HTC and air turbulence.

- Heat transfer rate increases after changing fin geometry and it is observed that HTC and turbulence are more in case of Step shape Fin model as compare to 'S' shape Fin model.

- Due to non-uniformness in the geometry of Fins turbulence of flowing air increases which results in more heat transfer rate.

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