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MODELING AND THERMAL ANALYSIS OF I.C ENGINE FINS WITH DIFFERENT GEOMETRIES

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Abstract: The Engine cylinder is one of the major automobile components, which is subjected to high temperature variations and thermal stresses. In order to cool the cylinder, fins are provided on the surface of the cylinder to increase the rate of heat transfer. By doing thermal analysis on the engine cylinder fins, it is helpful to know the heat dissipation inside the cylinder. We know that, by increasing the surface area we can increase the heat dissipation rate, so designing such a large complex engine is very difficult. The main aim of this project present is to analyze the thermal properties by varying geometry of cylinder fins using Ansys work bench. The 3D model of the geometries are created using CATIA V5 and its thermal properties are analyzed using Ansys workbench R 2022. The variation of temperature distribution over time is of interest in many applications such as in cooling. The accurate thermal simulation could permit critical design parameters to be identified for improved life. Presently Material used for manufacturing cylinder fin body is Aluminium Alloy AA 6061 which has thermal conductivity of 160 – 170 W/mk. presently analysis is carried out for cylinder fins using this material.

***Keywords*: Dissipation, Thermal conductivity, cylinder, fins, CATIA V5, Aluminium Alloy**

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 wheeler uses Air cooled engines, because Air- cooled engines are only option due to some advantages like lighter weight and lesser space requirement. The expansion of the high-temperature and pressure gases produced by combustion applies a direct force to some component 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 2500°C is reached. To withstand such a high temperature a very high melting point material has to be used for construction of engine. Practically it is less possible because, “Platinum”, which has one of the highest melting point, melts at above 1800°C. 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. Combustion engines at best can transform about 25 to 35 percentage of the chemical energy in the fuel in to mechanical energy. About 35 percentage of the heat generated is lost in to the surroundings of combustion space, remainder being dissipated through exhaust’ and radiation from the engine. The temperature of the burning gases in the engine cylinder is about 2000 to 2500° C. The engine components like cylinder head, cylinder wall piston and the valve absorb this heat. This force moves the component over a distance, generating useful mechanical energy. We know that in case of Internal Combustion engines, combustion of air and fuel takes place inside the engine cylinder and hot gases are generated. The temperature of gases will be around 2300- 2500°C. This is a very high Temperature and may result into burning of oil film between the moving parts.

II. LITERATURE REVIEW

Vinit Vikas Sawant et,al [1] In this they talk about different problems due to heat dissipation. In order to reduce those heat dissipation, they designed a fin and perform the operation on 250cc engine. The cooling of engine is essential. For this purpose we have two options either we use Liquid cooling system or Air cooling system. The main objective of this project is to design and thermal analysis of 250 cc engine cylinder fins by using different materials to replace liquid cooling system. From above analysis we conclude that Aluminum alloy is the best material for engine fins.Ch. Sushnath et,al [2] Here they take fins which are made up of is made up of Aluminium alloy and Zinc alloy. 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 heat transfer surfaces of Engine are modelled in ANSYS, and the main aim of this work is to study different materials and geometry of fins to improve heat transfer rate by changing fin materials under different conditions.S.M Kherde et,al [3] In this project they take fins with different geometries. And also they test the fins under maximum temperature 1500oc to minimum 1400oc and the material used for fins is Aluminium. By testing all the fins at certain temperature conditions the curve shaped fins shows high result when compared to other shaped fins.Roshan Kumar Nirala et,al [4] In this the geometries circular, rectangular and trapezoidal fins with Aluminum alloy 204, Aluminum alloys 6063 and 7068 of thickness 2.5mm & 3mm are compared on the basis of total rate of heat flux & effectiveness.it is found that aluminum alloy 6063 of circular geometry with 2.5 mm thickness is having more rate of heat flux &effectiveness. By comparing the two alloys of the aluminium alloy 6063 show better result than other allot type.Daya Shanker Singh et,al [5] In this present analysis, the fin materials are different from those recently used in the integrated circuit motor. The main objective of the project is to analyze the thermal properties by varying the geometry, the material of the cylinder fins.Three different aluminum alloys are used and two different fin sections are also used and the result is calculated using ANSYS 14.5.The various parameters (i.e., shape and geometry of the fin) are considered in the study, shape (Circular and Triangular), and thickness (3 mm) by changing the shape of the fin to triangular shaped, the weight of the fin body reduces thereby increasing the heat transfer rate and efficiency of the fins.Suresh et,al [6] In this paper implemented in this project is to increase the heat dissipation rate by using the invisible working fluid, nothing but air. Thermal analysis is done on the fins to determine variation temperature distribution over time. The analysis is done using ANSYS. Analysis is conducted by varying material. Presently Material used for manufacturing fin body is Cast Iron. By observing the thermal analysis results, thermal flux is more for Aluminum alloy than other two materials and also by using Aluminum alloy its weight is less, so using Aluminum alloy is better. And also by reducing the thickness of the fin, the heat transfer rate is increased. S. Mayakannan et,al [7] In this The aim of this project investigates alternative cooling methods for an engine fins Assembly. IC engine fins. ANSYS results from modified fins Assembly designs are compared to baseline geometry ANSYS results. Baseline cooling analyses are performed to validate the FEA models. The baseline results show the average temperature at the inner surface of the heat during normal operating conditions is approximately 23°C above the maximum technical limit of 423K.From the analysis the materials it's best comparing its AL200 compared to AL6061 produces the better thermal behaviour than the existing material. .P.T. Nitnaware et,al [8] These fins are designed to optimize the heat loss and the temperature inside an IC engine. 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. 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 .Mohsin A et,al [9] 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. The heat transfer surfaces are modelled in CATIA and simulated in FLUENT software. 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.N. Srinivasa Rao et,al [10] The main objective of the project is to analyze the thermal behavior of cylinder fins by varying geometries, materials and thickness. In this project 2.5 mm and 3mm thickness of fins are considered for various fin geometries and they are designed using AUTO CAD 2016. In our project we have taken materials aluminum alloy 6063 and aluminum alloy 7068 instead of general material aluminum alloy 204. The geometries circular, rectangular and trapezoidal fins with Aluminum alloy 204, Aluminum alloys 6063 and 7068 of thickness 2.5mm &3mm are compared on the basis of total rate of heat flux & effectiveness. By observing thermal analysis results, we can clearly conclude that fin material aluminum alloy 6063 of circular geometry with 2.5mm thickness is most effective in terms of rate of heat flux & effectiveness. By using circular fins with aluminum alloy 6063, the weight of the fin body is also reduces compared with the existing material of fin body.Akash M Vyas et,al [11] When fuel is burned in an engine, heat is produced. Additional heat is also generated by friction between the moving parts. The analysis of fin is important to increase the heat transfer rate. The main of aim of this work is to study different types of fins to improve heat transfer rate of cooling fins by changing cylinder fin geometry.N. Raja Sekhar et,al [12] The models are generated by varying the geometry such as rectangular and triangular. The models were created by using the software 3D Experience. The analysis was carried out by using ANSYS 18.1. The conventional Material used for manufacturing fin body is generally Aluminium Alloy 204 and Aluminium Alloy 6061.We Analyse Aluminium Alloy 6063 which has a higher thermal conductivity of 201-218 W/m-ºC. After analysis, the performance parameters are compared with all types of geometries of different material compositions in Aluminium 6063.Ashok Tukaram Pise et,al [13] Solid and Permeable fins block are kept in isolated chamber to study the natural convection heat transfer. Base and tip of the each fin showed different temperature profile at the same input conditions. Engine cylinder blocks having solid and permeable fins were tested for different inputs. (i.e. 75W, 60W, 45W, 30W, 15W). It was found that permeable fins block average heat transfer rate improved by about 5.63% and average heat transfer coefficient 42.3% as compared to solid fins with reduction of cost ofthe material 30%.Masao YOSHIDA et,al [14] Experimental cylinders that had a various number of fins and fin pitches were tested in a wind tunnel. We also obtained the expression of average fin surface heat transfer coefficient derived from the fin pitch and the wind velocity.This expression is useful for the fin design of an air-cooled cylinder. Pulkit Agarwal et,al [15] An air-cooled motorcycle engine releases heat to the atmosphere through the mode of forced convection. However, an attempt is made to simulate the heat transfer using CFD analysis. The heat transfer surface of the engine is modeled in GAMBIT and simulated in FLUENT software. An expression of average fin surface heat transfer coefficient in terms of windvelocity is obtained. Janaeela Pradeep Kumar et,al [16] By doing thermal analysis on the engine fins, it is helpful to know the heat dissipation inside the cylinder. Transient thermal analysis determines temperatures and other thermal quantities that vary overtime. The variation of temperature distribution over time is of interest in many applications such as in cooling. The accurate thermal simulation could permit critical design parameters to be identified forimproved life. Prof.Avinash Patil et,al [17] "In recent years there has been significant increase in a chip level heat fluxes, along with increasing demands for miniaturization. The reliability of the electronic system will suffer it high temperature are permitted to develop. The same is attempted in this work, to maintain surface temperature near ambient temperature jet impingement method of convection is used for cooling electronic component. Mahendra Kumar Ahirwar et,al [18] The main of aim of this work is to study various researches done in past to improve heat transfer rate of cooling fins by changing cylinder fin geometry and material. By doing thermal analysis on the engine cylinder fins, it is helpful to know the heat dissipation inside the cylinder. We know that, by increasing the surface area we can increase the heat dissipation rate, so designing such a large complex engine is very difficult. The main aim is to analyze the thermal properties by varying geometry, material and thickness of cylinder fins using CAD software. Kirubadurai. B et,al [19] The fins are of different types which are generally used based on the heat transfer rate requirement. The main aim of this project is to find the best material for cooling fins to increase the heat transfer rate. The modelling of cylinder block with fins is done by using SOLIDWORKS 2016. The design specifications of the IC engine Cylinder block with fins are is taken from Honda CB Shine 125CC. FEA analysis is done through Steady- State Thermal which used to find out the total heat flux distribution and temperature distribution. Four different materials are selected and analysis is done by using them, to select the best material. Ankit Vyas et,al [20] "Heat dissipation is a major aspect in many applications involving thermal energy. Thermal performance can be enhanced considerably using fins. In this paper perforated fins with varying contact ratio with base plate are analyzed for the augmentation of heat transfer from the base plate. Comparison of Nusselt number with Reynold number has been done for various configurations of fins in this study.

III. DESIGN AND ANALYSIS

1.MODELING

First, we took the steady state thermal analysis and we give the material selection. We designedthe sketch in the geometry with specific dimensions that are mentioned below. After the sketchis modeled, we did mesh to that sketch with default size. Here we choose Aluminum as the material for fin. After meshing is done, we applied the boundary conditions as Temperature of 80ºC is applied to the base and side parts of that fin. After the heat flux convection is given withan ambient temperature of 27ºC to the fins. After convection is given, radiation is also given toall the fins that are applied with convection.

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 wereapplied 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 all the designs should be shown in below fig 1,2 & 3.

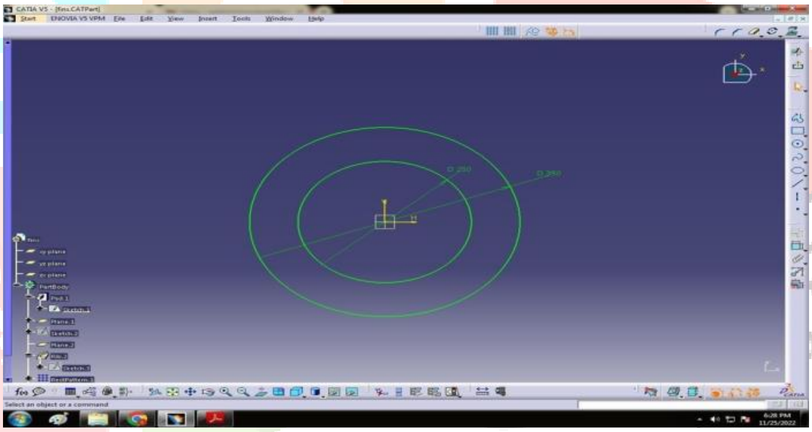

Fig 1: Selecting two circles with having dimensions

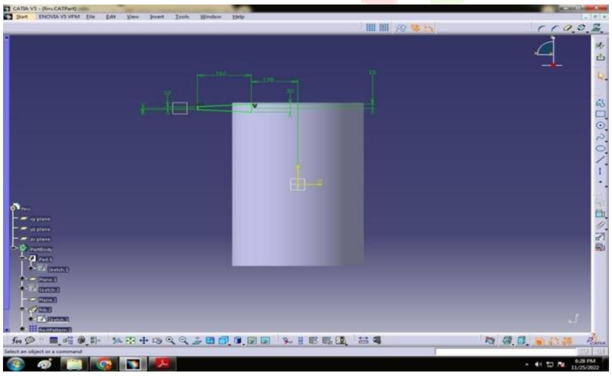

Fig 2: Sketch based features of cylinder.

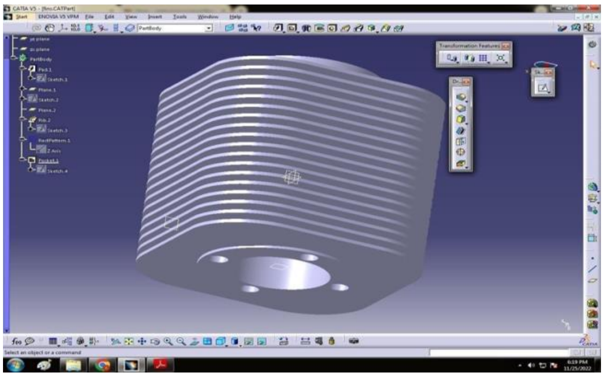

Fig 3: Model of the rectangular fin

2.THERMAL ANALYSIS

First, we can draw the Engine fins in CATIA and then imported into ANSYS workbench software. In the Thermal analysis, we calculate the Temperature, Convention, Total Heat Flux. The Engine fins is imported into ANSYS and generate a mesh in figures . Calculate the Temperature, Convention, Total Heat Flux of Rectangular should be shown in below figures 4, 5, 6, 7 and the Circular should be shown in below figures 8, 9, 10, 11.

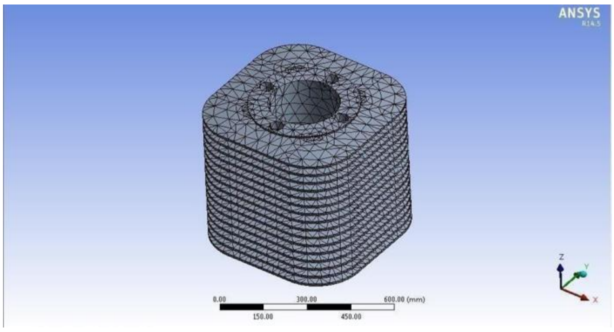

Fig 4: Meshing(Rectangular)

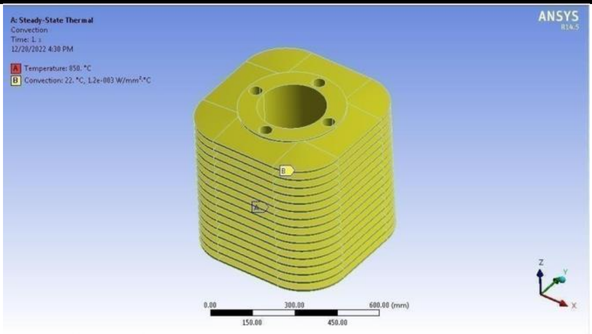

Fig 5: Covention(Rectangular)

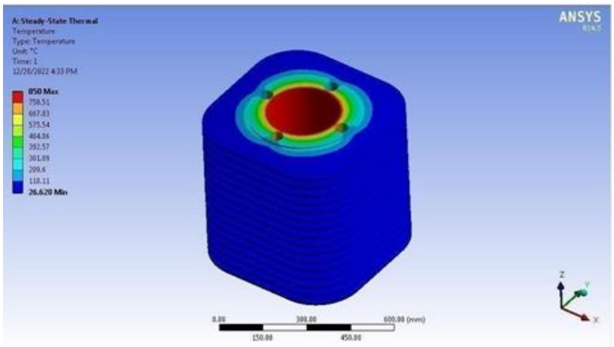

Fig 6: Temperature(Rectangular)

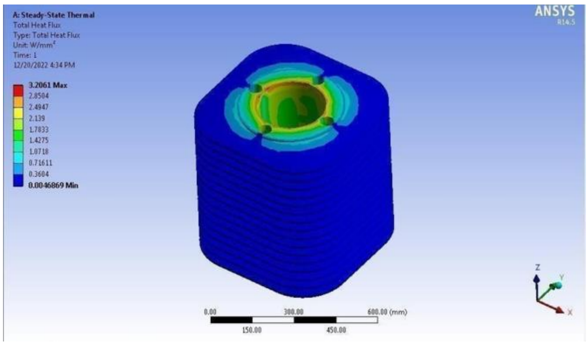

Fig 7: Total Heat flux(Rectangular)

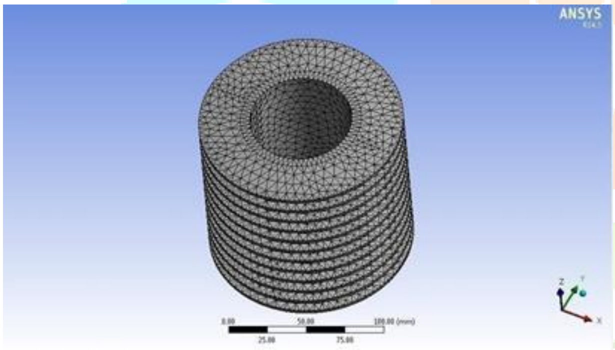

Fig 8: Meshing(Circular)

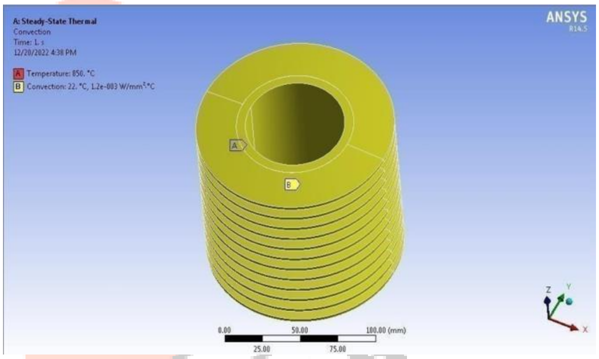

Fig 9: Convention(Circular)

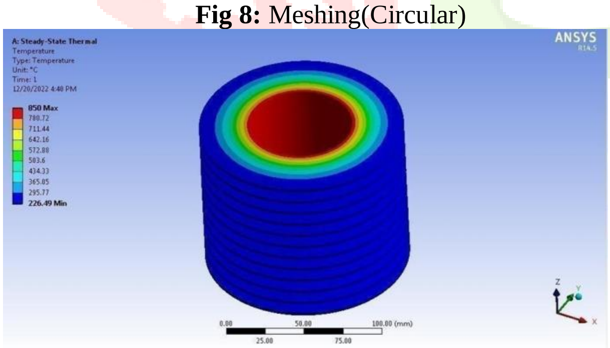

Fig 10: Temperature(Circular)

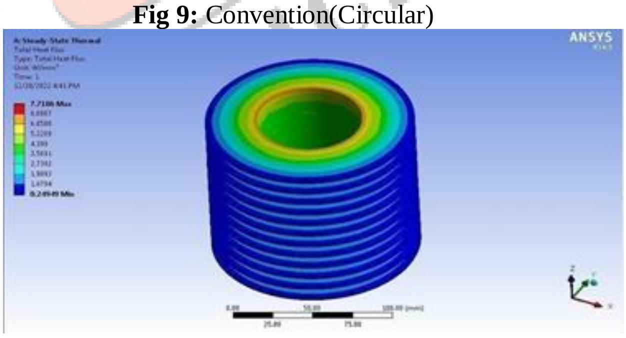

Fig 11: Total Heat Flux(Circular)

IV. RESULTS AND DISCUSSION

In this Project, Modeling and Thermal Analysis of IC Engine Fins with Different Geometries. The original model was changed by changing thickness of the fins. By using thinner fins overall efficiency increases also weight is reduced. Old engines have fin body made up of cast iron. Thermal analysis is performed for aluminium materials and different shapes selected for project. The material for our model is changed by taking consideration of their densities and all other factors. The Emissivity for Natural Convention and Forced Convention should be shown in Table 1&2.

Table 1 : Emissivity for Natural Convention

NODE NUMBER	SL. NO	E = 0.05	E = 0.25	E = 0.45	E = 0.85
20873	1	79.833	79.782	79.731	79.631
20872	2	79.549	79.41	79.273	79.003
20871	3	79.324	79.116	78.911	78.506
20870	4	79.153	78.893	78.637	78.132
20869	5	79.038	78.743	78.451	77.878
20748	6	78.977	78.663	78.353	77.744

Table 2: Emissivity for Forced Convention

NODE NUMBER	SL. NO	E = 0.05	E = 0.25	E = 0.45	E = 0.85
20873	1	77.475	77.439	77.406	77.339
20872	2	73.285	73.193	73.105	72.932
20871	3	70.061	69.927	69.8	69.549
20870	4	67.675	67.511	67.356	67.049
20869	5	66.085	65.901	65.727	65.385
20748	6	65.253	65.059	64.876	64.515

The Fig: 12&13 shows the graphs of radiation with and without in Natural convention and Forced convention.

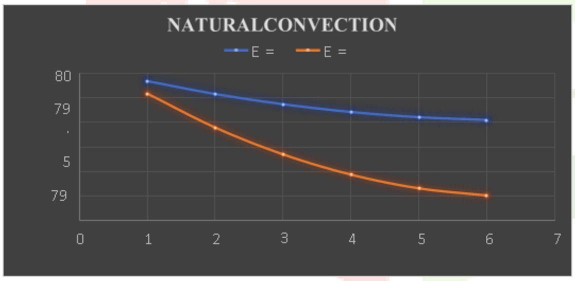

Fig 12: With and without radiation in Natural convention

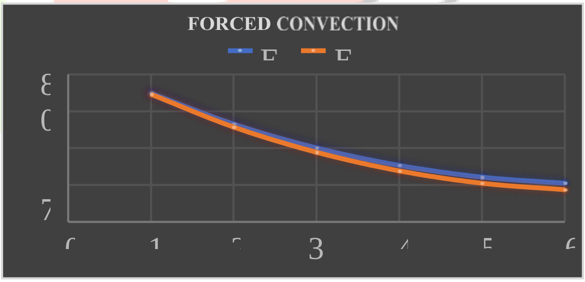

Fig 13: With and without radiation in Forced convention

V. CONCLUSION

In this study, IC engine fin is modeled and steady state thermal analysis is done by using ANSYS workbench. It is investigated under different geometries,convection and temperature, total heat flux such as free and forced convection. Heat release from the cylinder did not improve when the cylinder had more fins and too narrow a fin pitch at lower wind velocities, because it is difficult for the air flow into the narrower space between fins, so temperature between them increased. Optimized fin pitches with the greatest effective cooling are at 20mm for non-moving and 8mm for moving Heat transfer rate increase in permeable fins of same dimension solid fins. Material cost of fins are lesser 10-30% in permeable fins as compared to solid fins for same heat transfer rate. Large number of fins with less thickness can be preferred in high speed vehicles than thick fins with less number as it helps inducing greater turbulence and hence higher heat transfer possible. Wider spacing shorter fins are prefer than the longer fins. Heat transfer rate and heat transfer coefficient can be increased with the wind velocity. Based on study cylinder heat transfer rate also increase by changing the various types of geometry.

VI. ACKNOWLEDGEMENT

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