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THERMAL INVESTIGATION ON EFFECT OF NUMBER OF FIN IN THE I. C ENGINE BY ANSYS 17.0

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ABSTRACT

Fin is a major important component of engine, which allows heat flux rapidly from engine cylinder bore. When the fuel burns inside; a high temperature and stress is developed. Due to excessive temperature, engine cylinder generally fails. In this paper, the behaviour of heat flux and temperature distribution through rectangular fin is analyzed by ANSYSR having thermal similar boundary condition. In this thermal analysis, aluminium fin is used and different configurations of fin arrangement (5, 6 & 7 fins) are designed with the help of Solid Works design software. On comparison, configuration of six fins provides the greatest heat transfer than that of other configurations having the same thermal conditions. Finally, six fin arrangements were found to be more suitable than 5 and 6 fin configurations. It is hoped that this work will help Designers, Practicing Engineers and Researchers involved in the area, to carry out further research.

***KEYWORDS:** Rectangular Fin, ANSYS R 17.0, Thermal Conductivity, Heat Flux & Aluminium Fin Solid Work*

Original Article

INTRODUCTION

Heat transfer is a discipline of Thermal Engineering that deals with generation, consumption, convection and exchange of thermal energy between physical systems. In every moment of day to day life, it is easy to encounter numerous applications of heat transfer (Cuce and Cuce, 2010). Inside the engine cylinder of an IC engine, combustion of air and fuel take place which results in generation of hot gasses. This combustion leads to development of high temperature of around 2300-2500^{o} c. Such high temperature may result into seizing of engine. So, for efficient working of the system, temperature has to be reduced to about 150-200 ^{o}C (Sorathiyaet al., 2014). An effective cooling measure is required to attain such temperature conditions and thus the concept of extended surface (fins) attached to engine cylinder is introduced. Different types of fin are used for transferring the heat as shown in below figure 1, but generally rectangular fins are used.

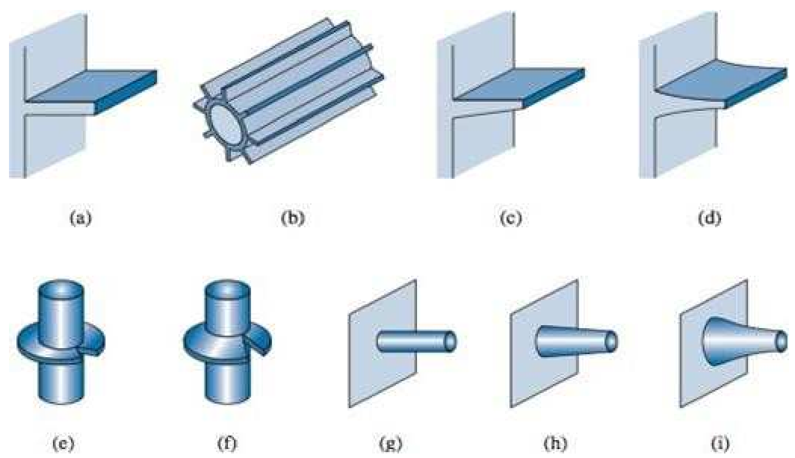

Figure 1(a): Different Types of Fin Configuration (https://mechzoneblog).

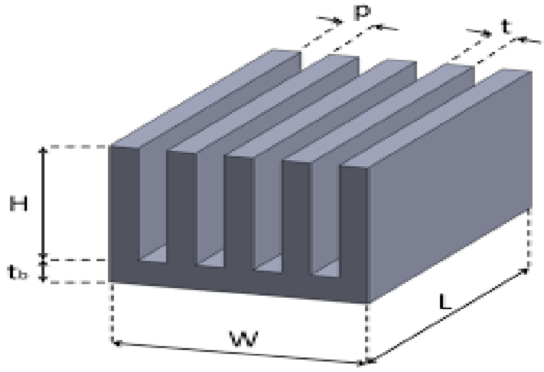

Figure 1(b): Different Types of Rectangular Fin
(https://www.google.com/search?q=rectangular+fin+heat+transfer&sxsrf)

Nomenclature of Rectangular Fin

L = length of rectangular fin from base

B = width of the fin (parallel to the surface from which heat is to be removed)

Y = total thickness of the fin

P = perimeter of fin [=2(b+y)]

A = area of section

To = maximum temperature of fin at the base

Ta = surroundings temperature

K = thermal conductivity of fin material

H = heat transfer coefficient

The fins are widely used in various applications such as: Economizers for steam power plant for steam and hot water heating system, Radiator of automobiles, Air cooled engine cylinder head, coolings coils and condenser coils in refrigerators, small capacity compressor, electric motor bodies, transformer and electronics equipments etc. Considering an air cooled petrol engine with two strokes, at no load condition engine does not generate power. When load increases on an engine, the upward movement of a piston causes compression of the previously available charge inside the cylinder. Thus, during upward stroke, suction and compression of charge takes place simultaneously, and both transfer port and exhaust port remain closed. At the end of compression stroke, the charge is ignited by a high voltage electric spark. After ignition of charge, hot high pressure gases expand. The piston goes downwards and compresses the charge drawn in the crank case. At the end of expansion stroke, exhaust port which is slightly placed higher than the transfer port, opens releasing the burnt gases from cylinder to the atmosphere. Fins are provided on a periphery of engine. Exhaust heat is exposed to outside of engine cylinder. Air cooled engines have fins to radiate heat to surrounding air. Cylinder is made of cast iron and fins are made of stainless steel. In thermal engineering application, there is extensive use of fins to boost up the rate of heat transfer from a hot surface, especially where cooling is required. Apart from the traditional application, fins also prove to be efficient for rejecting heat in space vehicle. By applying principle of thermal analysis on fins, it is possible to know the heat dissipation and rate of heat transfer in different configuration of a fin (Prabhu et al., 2018). Using theoretically driven numerical methods to validate the results provide a comprehensive view of different heat transfer properties offin. Through decades, researches are applying various concepts and theories of heat distribution for evaluating and enhancing the performance of fin. Investigation of two dimensional performance of fin for different shapes is carried out through finite element approach. Dependence of heat transfer rate on different fin parameters such as fin size, ambient temperature, biot number etc are presented. The relation between rate of heat dissipation and different geometric profiles of fins laid emphasis on the necessity for study in the field of fin geometry. Yujie et al., (2014) proposed the idea of relative entropy generation distribution factor to assort the thermodynamic advantages of fins. Existence of values of related geometrical parameter which enhances the degree of heat transfer of fin is also documented. Arslanturk, (2011) discussed homotopy perturbation method to examine the temperature distribution within the straight radiating fin with a step change in thickness. Abrupt changes in temperature profile and thermal condition parameter describe that thermal condition has a important role in heat transfer rate. The phenomenon of elevation in temperature distribution in the fin and fin efficiency is affected by the temperature as the thermal conductivity increase and vice versa (Darvishi et al., 2016). Thus the need for research in field of fin geometry and related temperature distribution motivates researchers to perform experiments and evaluate current scenario on the basis of different analytical methods. For a finned annulus tube, conservation equations of mass, momentum and energy are numerically solved by K-Ɛ model (Mishra, and Mohapatra, 2014) so that fluid flow and heat transfer characteristics of fin can be determined. The result proclaimed that heat transfer to air increases, if the number of fins between the annulus space increases, thus the size of heat exchanger unit can be reduced by modifying the number of fins in given annulus space. The dependence of fin efficiency and thermal conductivity of fin material on Reynold's number studied by (Nieckele and Mouraosaboya, 2000) is noted. Author performs experimental investigation for turbulent flow through annular ducts to determine that for a fully developed flow, efficiency and thermal conductivity of fin is directly proportional to Reynold's number. The effect of number of fins on a horizontal cylinder having multiple equally spaced and high conductivity permeable fins discussed by Abu-Hijleh, (2003). The problem of crossed flow convection heat transfer has been numerically investigated and parameters such as number of fins and fins height are studied with wide ranges of Reynold's number (50–200). This study gave us insight that larger aerodynamic and thermal wakes are observed in permeable fins which significantly reduces the effectiveness of downstream fins. Yoshida et al., (2006) studied effect of fin pitch, wind velocity and fin number on air cooled engine. Circular shaped experimental had number of fins and pitches which were tested in wind tunnel. Result proclaimed that heat release from cylinder is inversely proportional to number of fins and directly proportional to inter fin spacing 20mm and 8mm fin pitch have been proposed to have maximum cooling effect by author. Thermal specifications of different types of fins are shown in below table no 1.

Photographic View of Model			
Model Name	Bajaj Pulser	Bajaj 2s RE	Bajaj Pulser
CC	149	145.45	135
Stroke (mm)	56	57	54
Bore (mm)	57	57	59
No. of Fins	6	10	6
Fin Pitch (mm)	11	8	10
Fin Thickness (mm)	2	2.5	2
Fin Material	Al Alloy	Cast Iron	Al Alloy
Position of fins w.r.t. cylinder axis	Perpendicular	Perpendicular	Perpendicular

Figure 2: Technical Specification of Different Types of Fins used in I. C. Engine (Sorathiya et al., 2014).

Maximization of cooling effect can also be achieved by moderating dimensions of engine which is treated as specimen by [Fernando Illánet al, 2010]. On behalf of maximum temperature admissible at the hottest point of the engine, which has been adopting as limiting condition percentage reduction in sizes of engine diameter and height has been proposed to achieve greater heat transfer and engine efficiency. Sandhya Mirapal and Kishore (2015) discussed the effect of heat transfer over the length and temperature of fin as shown in below figure.

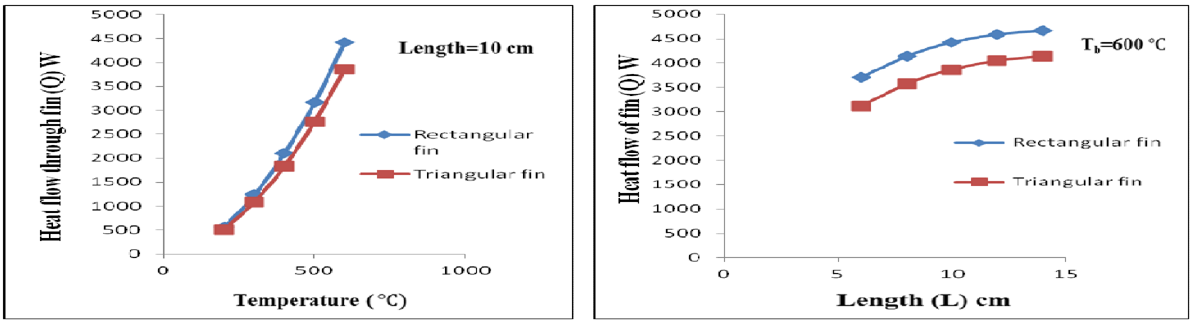

Figure 3: Effect of Heat Transfer over the Length and Temperature of Fin (Sandhya Mirapal and Kishore, 2015).

Thus, the scope for innovation and research are inevitable in the field of heat transfer through extended surfaces. Numerical as well as analytical analysis has been done for different number of fins and inter-fin spacing and optimum result as well as explanation has been proposed in the article. ANSYS WORKBENCH has been used for analytical observation and investigation while name of principle used for calculation has been used as base for verification of analytical result. There are several types of methods by which we can find out the rate of heat of transfer. We hope to provide optimum analysis and result in field of research in fin geometry and also new corridor of investigation and discussion in the respective field of study. Through this research paper, we get to know that if we change the number of fin, then it will have an direct impact on heat transfer performance. We have designed different fin configuration in solid works design software. In this research, the following steps are used for analyzing the heat transfer through the rectangular fin as disused below.

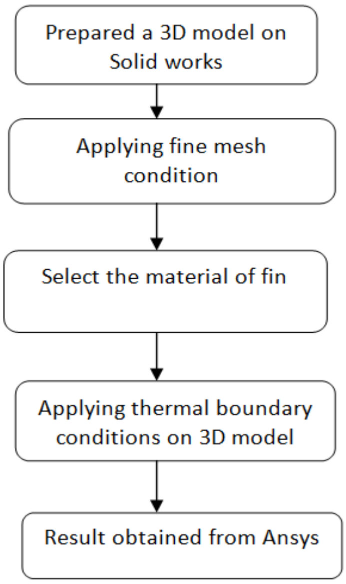

Figure 4: Flow Chart for Calculating the Heat Transfer through the Fin.

In the present research paper, temperature and heat flux analysis has been carried out on different rectangular fin arrangements under applied due thermal boundary condition (t 0=10000C, ta=400C,

The following assumption is made for the analysis of heat flow through the fin:

- Steady state heat transfer is assumed
- No heat generation take place inside the fin
- Uniform value of heat transfer coefficient over the length of fin
- Homogeneous and isotropic fin material assumed
- Only one dimensional heat transfer take place
- No radiation take place inside the fin material

K = 285 W/m0 C) to using ANSYS 17.0 software with fine mesh size (351217 nodes & 175929 node).

LITERATURE REVIEW

Table 1: Research Works Carried Out for Calculating the Heat Transfer through Fin

Reference	Summary of Research Work
Sukumar et al., 2013	Discussed the modeling and design of heat sink also find out the heat transfer through heat sink.
Deepak Gupta et al., 2014	Discussed the various heat applications in CPU. He also the discussed the various principal of heat transfer in heat source.
Phani Raja Raoet al., 2013	Discussed the effect of fin on the performance on engine. In his research, he also analyzed the heat transfer through fin in engine by developing a fin model.
Sane et al., 2008	Discussed the Computational Analysis of Horizontal Rectangular Notched Fin Arrays Dissipating Heat by Natural Convection.
Pudiri Madhu, and Sateesh, 2015	Discussed the Modeling and Simulation of Fins for 150cc Engine. He also discussed the heat transfer through fin on engine.
Qusay et al., 2015	Discussed the optimum design of rectangular heat sink palte for maximizing the rate of heat transfer.
Hussam Jouhara,	Discussed the Modelling and Simulation Techniques for forced convection Heat Transfer

	in Heat Sinks with Rectangular Fins. He also classified the various types of modes of convection i.e forced convection and free convection.
Salila Ranjan Dixit, Dr. Tarinicharana Panda 2013	Discussed commercial Analysis of Inverted Notched Fin Array Using Natural Convection.
Y. Chung and K. Luo, 2008	Discussed the Unsteady heat transfer analysis of an impinging jet.

TEMPERATURES ANALYSIS FOR DIFFERENT CONFIGURATIONS OF FINS (5 FIN)

ANSYS R 17.0 is simulator design workbench that deals with variety of engineering application, including duckling stress, direct stress, static structural thermal analysis, weight optimization vibrations, temperature, heat flux analysis, thermo-electric, and magneto static simulations etc. and also provides tools to conceptualize design and validate ideas on the desktop. An Ansys simulation consists of setting up the basic design model and the different boundary condition (i.e. thermal, design) applied to it, solving for the model's responses to the condition, then examining the details of the response with a variety of tools. Dynamics software provides incredibly short solution times for even the most complex multi-part assemblies undergoing dramatic translations and rotations. It is an ANSYS Workbench add-on module that works directly with ANSYS Structural, ANSYS Mechanical, and ANSYS Metaphysics. All the 3D models of the different fin configurations are imported to ANSYSWORKBENCH 17.0 for meshing and steady state thermal analysis at same thermal boundary condition as mentioned above.

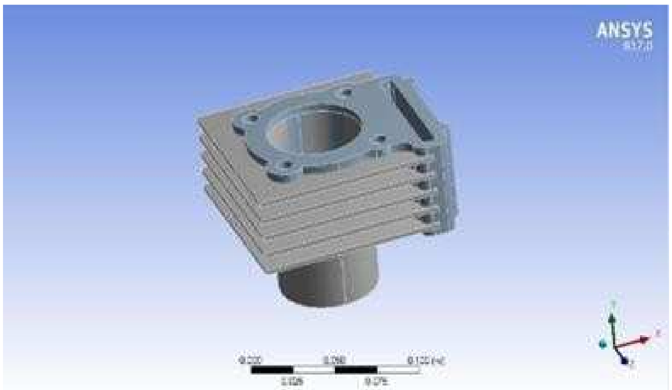

Figure 5: Fin Configuration in ANSYS.

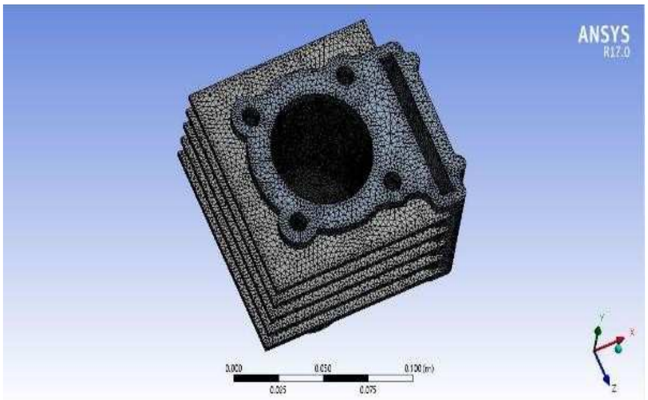

Figure 6: Fine Meshed Model in ANSYS.

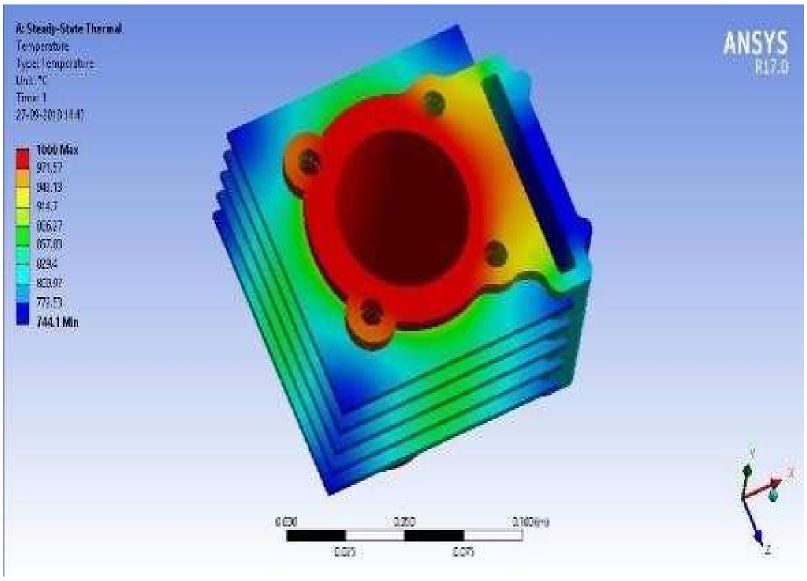

Figure 7: Steady State Thermal Analysis (5 fins) in ANSYS.

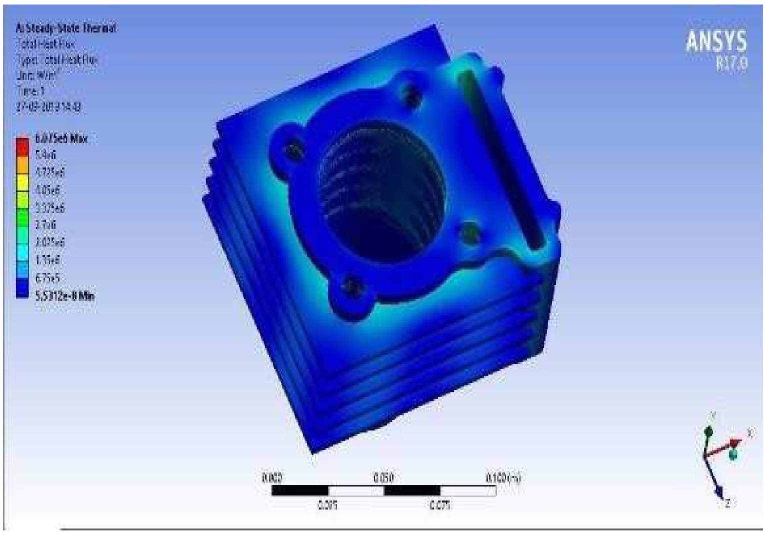

Figure 8: Steady State Heat Flux Analysis (5 fins) in ANSYS.

TEMPERATURES AND HEAT FLUX ANALYSIS FOR 6 FINS

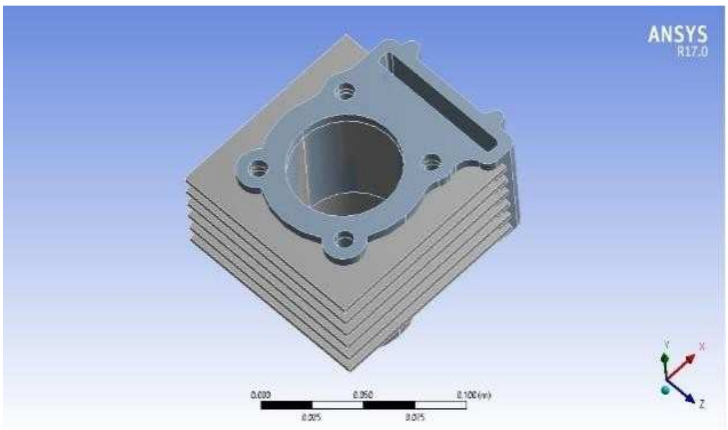

Figure 9: Fin Configuration in ANSYS.

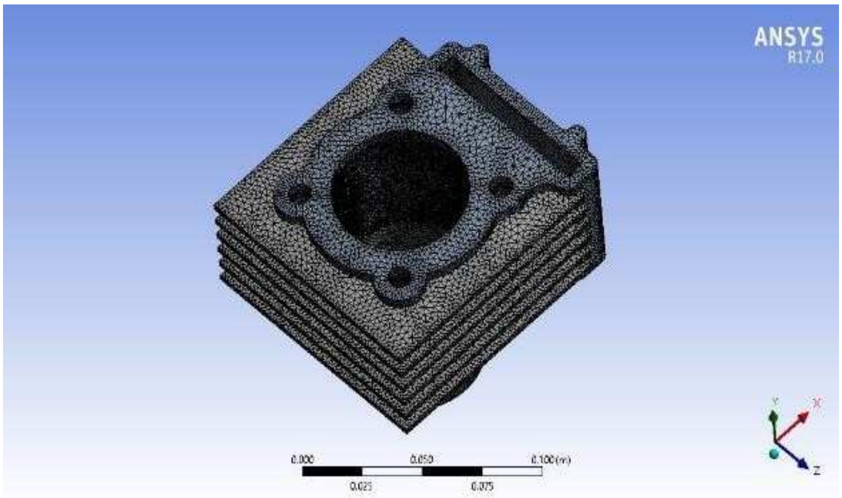

Figure 10: Fine Meshed Model in ANSYS.

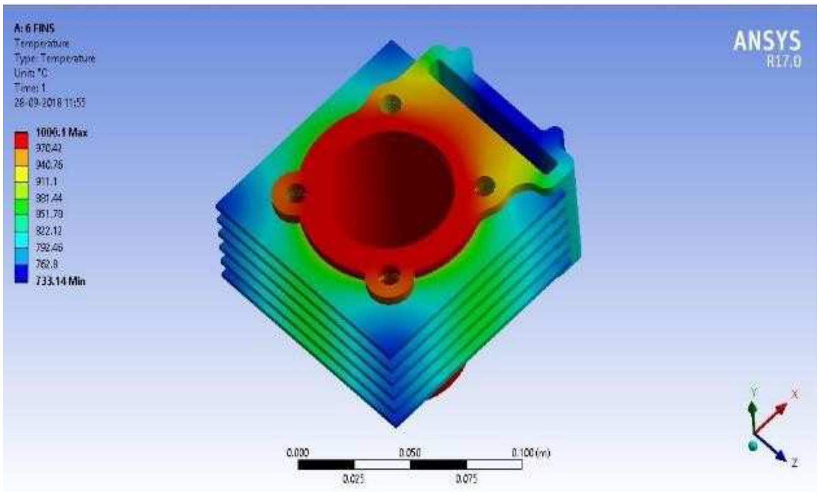

Figure 11: Steady State Thermal Analysis (6 Fins) in ANSYS.

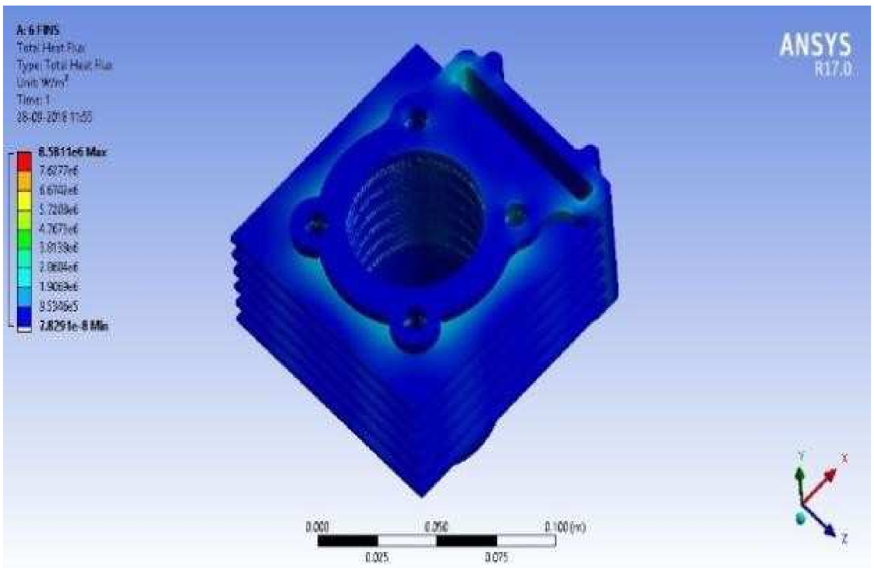

Figure 12: Steady State Heat Flux Analysis (6 fins) in ANSYS.

TEMPERATURES AND HEAT FLUX ANALYSIS FOR 7 FINS

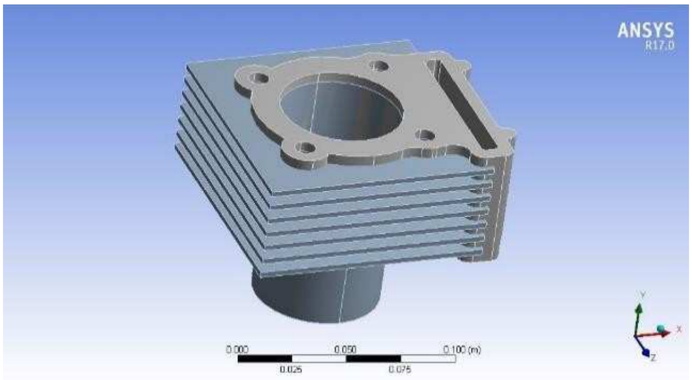

Figure 13: Fin Configuration in ANSYS.

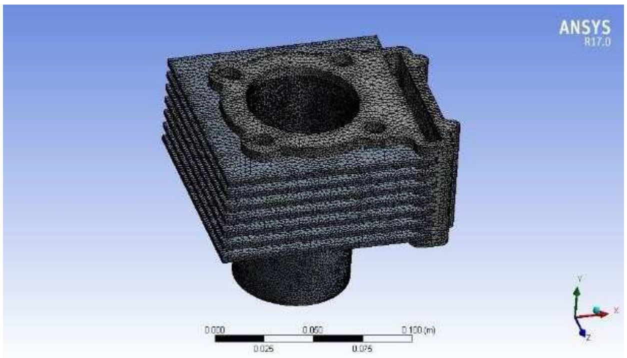

Figure 14: Fine Meshed Model in ANSYS 17.0.

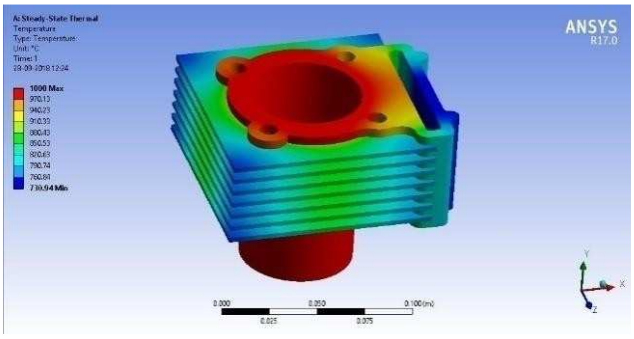

Figure 15: Steady State Thermal Analysis (7 fins) in ANSYS.

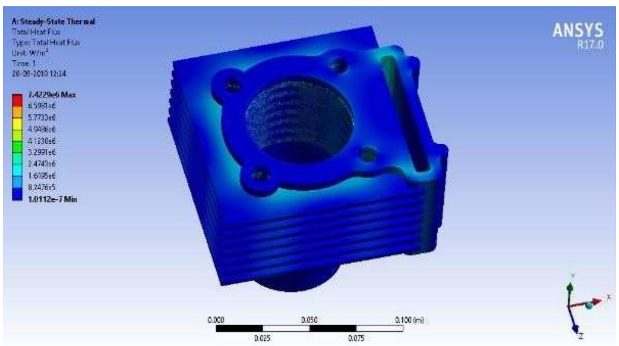

Figure 16: Steady State Heat Flux Analysis (7 Fins) in ANSYS.

CONCLUSIONS

In this paper, we have designed a rectangular fin body used in 100cc Hero Honda Motorcycle and modelled in 3D modelling design software Pro/Engineer. The material of the presently used fin is aluminum alloy. All the temperatures and heat transfer through different configuration of fins are shown in Figure 17 and Figure 18 respectively.

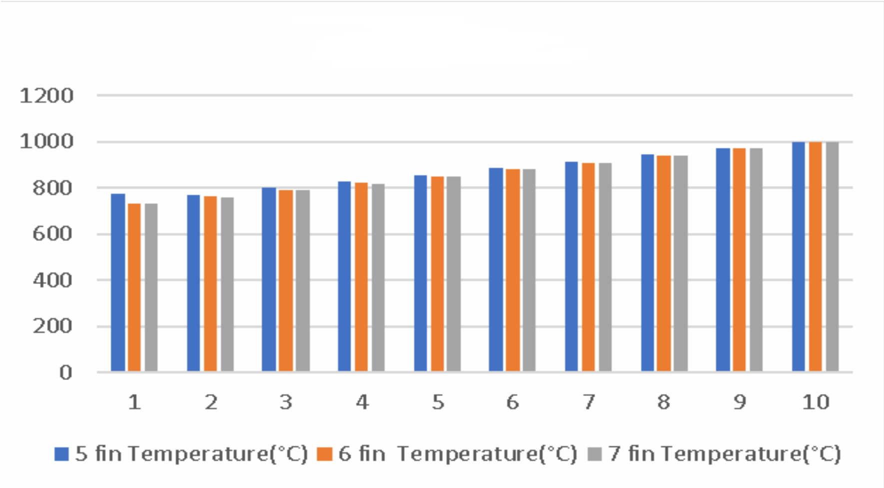

Figure 17: Comparison of Temperature Variation through Different Types of Fin by (ANSYS R17.0).

We have performed thermal analysis on the fin body by varying the fin geometry and thickness. By observing the analysis results, using rectangular fin (6 fin configuration), material Aluminum alloy is better since heat transfer rate is more. Choosing the optimum size fin of rectangular configuration will reduce the cost for heat transfer process and also increase the rate of heat transfer. In future, this research work can be extended by incorporating the various types of fin material on the performance of engine circular fin, triangular fin can be used for calculating the rate of heat transfer through engine. In future, we can also incorporate the various type of material for modeling the fin on design platform.

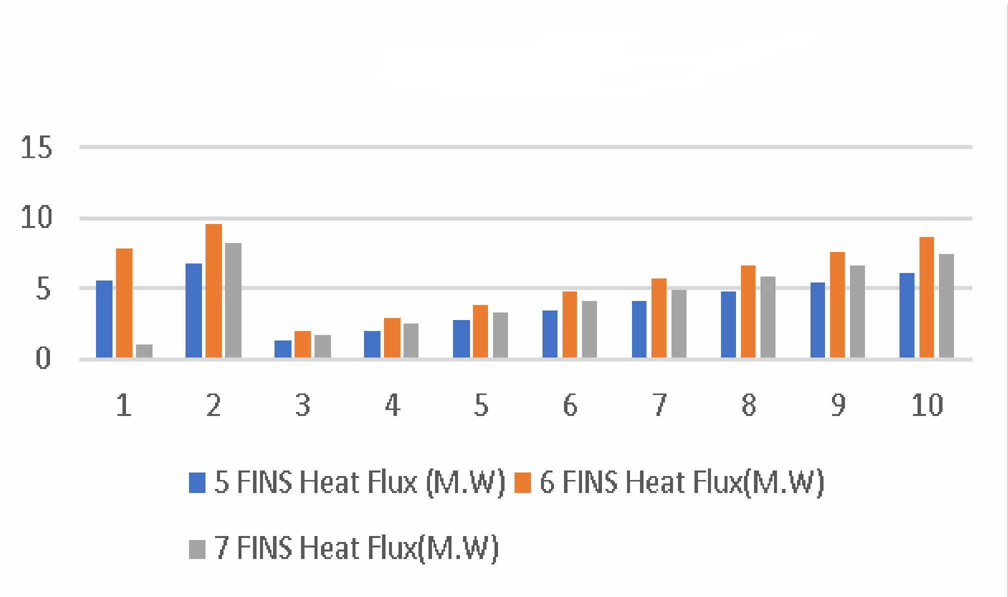

Figure 18: Comparison of Heat Flux Variation Through different Types of Fin by (ANSYS R17.0).

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