"Comparative Thermal Analysis of Fin of I.C. Engine with Extensions"

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Abstract- **An air cooled I.C. engine releases heat to the atmosphere through the modes of forced convection, to facilitate this, fins are provided on the outer side of cylinder .the heat transfer rate depend on velocity of vehicle, fin geometry and the ambient temperature. Insufficient removal of heat form engine will lead to high thermal stresses and lower engine efficiency. Enhancement in geometry of fin can be improved the heat transfer rate from the engine.**

In this research, the heat transfer performance of fin of an internal combustion engine is analysed by design of fin with various extensions such as rectangular extension, trapezium extension, triangular extensions and circular segmental extensions. The heat transfer performance of fin with same geometry having various extensions and without extensions is compared.

Fin with various extensions design with the help of APDL mechanical ANSYS 15.0 software. Analysis of fin performance done through the same software. In this thermal analysis, temperature variations w.r.t. distance at which heat flow occur through the fin is analysed. Extensions on the finned surfaces is used to increases the surface area of the fin in contact with the fluid flowing around it. So, as the surface area increase the more fluid contact to increase the rate of heat transfers from the base surface as compare to fin without the extensions provided to it. On comparison, trapezoidal extensions provide on fin gives the greatest heat transfer than that of other extensions having the same length and width attached to finned surface.

Key words- I.C.Engine, Thermal Analysis, ANSYS 15.0, heat transfer rate, Thermal Flux, Fin.

Nomenclature:

D	Outer Diameter of Cylinder
d	Inner diameter of cylinder
h	Height of cylinder
t	Thickness of fine
b	Width of fin
Nu	Nusselt number
Re	Reynold's number
Pr	prandtl number
C_ϱ =	Specific heat at constant pressure,
K	Thermal conductivity ,
ϱ	Density
µ	Dynamic viscosity
V	Velocity
h	Coefficient of convective heat transfer,
Q	Quantity of convective heat transferred

I INTRODUCTION

In an I.C. engine, the temperature of the gases inside the engine cylinder may vary from 35^{0}C or less to as high as 2750^{0}C during the cycle. If an engine is allowed to run without external cooling, the cylinder walls, cylinder and pistons will tend to assume the average temperature of the gases to which they are exposed, which may be of the order of 1000 to 1500^{0}C. Obviously at such high temperature; the metals will lose their characteristics and piston will expand considerably and sieve the liner. Of course theoretically thermal efficiency of the engine will improve without cooling but actually the engine is seize to run. If the cylinder wall temperature is allowed to rise above a certain limit, about 65^{0}C, the lubricating oil will begin to evaporate rapidly and both cylinder and piston may be damaged.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 04, April-2017

There are mainly following two methods/system of cooling I.C. engines:

1. Air cooling
2. Water liquid cooling.

In Air-Cooling System heat is carried away by the air flowing over and around the cylinder. Here fins are cast on the cylinder head and cylinder barrel which provide additional conductive and radiating surface. The fins are arranged at right angle to cylinder axis. The number and dimensions should be adequate to take care of the surplus heat dissipation.

In Water/Liquid Cooling System**,** the cylinder and heads are provided with jackets through which the cooling liquid can circulate. The heat is transferred from cylinder wall to the liquid by convection and conduction. The liquid becomes heated in its passage through the jackets and itself cooled by means of an air cooled radiator system. The heat from liquid in turn is transferred to air.

Thermal convection is the process of energy transport affected by the circulation or mixing of a fluid medium (gas, liquid or a powdery substance). Convection is possible only in a fluid medium and is directly linked with the transport of medium itself. Macroscopic particles of a fluid moving in space cause the heat exchange, and thus convection constitutes the macro form of the heat transfer. Fuel or Natural Convection occurs when the fluid circulates virtue of the natural differences in densities of hot and cold fluids. **Forced Convection:** When the work is done to blow or pump the fluid, it is said to be forced convection. The transmission of heat per unit time from a surface by convection is given by:

$$Q = h\,A\,(t_1 - t_2)$$

Q= Quantity of convective heat transferred,

h= Coefficient of convective heat transfer,

A= Area of surface,

(t_1-t_2)= temperature difference between and surface.

The unit of coefficient of heat transfer are:

$$h = Q/A(t_1-t_2) = W/m^2K$$

The coefficient of convective heat transfer ‘h’ (also known as film heat transfer coefficient).May be defined as the amount of heat transmitted for a unit temperature difference between the fluid and unit area of surface in unit time. The value of ‘h’ depends on the types of fluids, their velocities and temperatures, dimensions of the pipe and the types of problems. Since ‘h’ depends upon several factors, it is difficult to frame a single equation to satisfy all the variations, however a dimensional analysis gives an equation for the purpose which is given as under:

$$hD/k = C(_{\varrho}VD/\mu)^a\,(C_{\varrho}\mu/k)^b\,(D/L)^c$$

OR

$$Nu = Z(Re)^a\,(Pr)^b\,(D/L)^c$$

Different analysis with ANSYS software were performed for the heat transfer inhancement in I. C. Engine fins. Abdenour Bourabaa, MalikaFekih, Mohamed Saighi[1] , a numerical investigation of the fin efficiency and temperature distribution of an annular fin under dehumidification has been presented in this paper. Babu, M. Lavakumar[2] ,in this paper the thermal properties by varying geometry, material and thickness of cylinder fins, Parametric models of cylinder with fins have been developed to predict the transient thermal behaviour. The models are created by varying the geometry, rectangular, circular and curved shaped fins and also by varying thickness of the fins. The 3D modeling software used is Pro/Engineer. The analysis is done using ANSYS. Presently Material used for manufacturing cylinder fin body is Aluminum Alloy 204 which has thermal conductivity of 110-150W/mk. We are analyzing the cylinder fins using this material and also using Aluminum alloy 6061 and Magnesium alloy which have higher thermal conductivities. Pardeep Singh, Harvinderlal, Baljit Singh Ubhi[3] , in this research, the heat transfer performance of fin is analysed by design of fin with various extensions such as rectangular extension, trapezium extension, triangular extensions and circular segmental extensions. The heat transfer performance of fin with same geometry having various extensions and without extensions is compared. Near about ranging 5% to 13% more heat transfer can be achieved with these various extensions on fin as compare to same geometry of fin without these extensions. Fin with various extensions design with the help of software AutoCAD. Analysis of fin performance done through the software Autodesk Simulation Multiphysics. Mohsin A. Ali1, Prof. (Dr.) S.M Kherde[4], in this paper the study of various researches done in past to improve heat transfer rate of cooling fins by changing cylinder block fin geometry and climate condition. D.Merwin Rajesh,K.Suresh Kumar[5], main aim of the project is to analyze the thermal properties such as Heat flux, Thermal gradient by varying geometry, material and thickness of cylinder fins. Parametric models of cylinder fins have been developed to predict the transient thermal behavior. Masao YOSHIDA, Soichi ISHIHARA, Yoshio MURAKAMI, Kohei NAKASHIMA and Masago YAMAMOTO [6] , in this paper the effects of the number of fins, fin pitch and wind velocity on air-cooling were investigated using experimental cylinders for an air-cooled engine of a motorcycle. Mohsin A. Ali and Prof. (Dr.) S.M Kherde[7] The main of aim of this work was to study different shapes and geometry of fins to improve heat transfer rate by changing fin geometry under different velocities. Deepak Gupta, Wankhade S.R[8] ,The main aim of the project was to study and comparing with 100 cc Hero Honda Motorcycle fins and analyze the thermal properties by varying geometry, material and thickness. Parametric models of cylinder with fins have been developed to predict the transient thermal behavior. The models are created by varying the geometry like rectangular, circular shaped fins and also by varying thickness of the fins 3mm and 2.5mm. The 3D modeling software used is Pro/Engineer. The analysis is done using

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 04, April-2017

ANSYS. Presently Material used for manufacturing the models is grey cast iron which has thermal conductivity of 53.3 W/mK and aluminum alloy 6063 which has thermal conductivity of 200W/mk. We are analyzing the designed models by taking the thermal temperature of 11000C.

II PROBLEM FORMULATION

The transfer of heat takes place due to difference in temperature and from higher temperature to lower temperature. Thus, there is a heat transfer to the gases during intake stoke and the first part of compression stroke, but during the combustion and expansion process the heat transfer take place from the gases to the walls.

The hot combustion gases give part of their heat to the following components:

1. Cylinder liner
2. Piston and piston rings
3. Cylinder head
4. Exhaust valves and exhaust ports

Most of this heat is carried away by the cooling system while some is lost by direct radiation from the engine surface. The heat going to the surrounding air, to the surface of the engine and to the lubricating oil is usually small (less than 10%), whereas most of the heat rejected goes either to the cooling system or as heat is exhaust gases.

2.1 Geometry of Engine

In present engine there is no addition of extensions on fin surface. The figure 1 shows be dimensions of engine with rectangular fins.
Outer diameter of cylinder core D = 78 mm
Inner diameter of cylinder core d = 62 mm
Height of cylinder H = 120 mm
Size of fin =lXbXh = 158mmX 158mm X 3mm
Space between two fins = 24mm

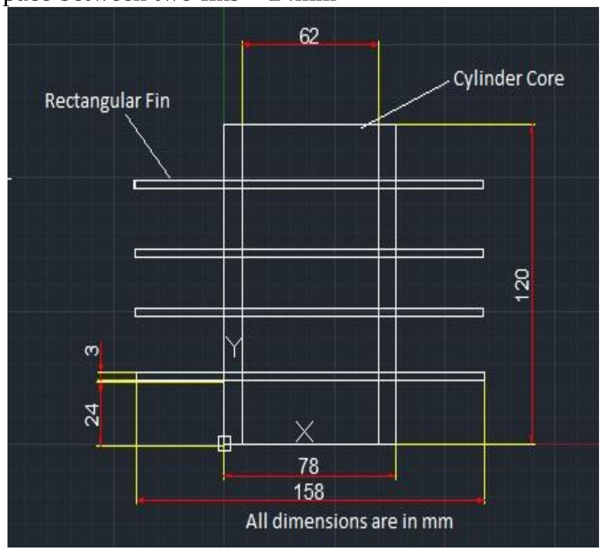


Figure2.1: Geometry of engine cylinder with fin

The heat transfer of engine cylinder can be increased by increasing heat transfer coefficient of fin material, thermal conductivity of fin material and heat transfer surface area. We are going to increase the heat transfer surface of fin of engine by providing various extensions on fin.

2.2 Geometry of various extensions

The fins with various extensions are design with the help of design software. Main Fin specifications: Length, l = 40mm = 0.04 m, width, b = 240 mm = 0.24 m and thickness, y = 15mm = 0.015 m. Specifications of various extensions shown in the Fig. 3 and number of extensions used on main fin is 10 nos.

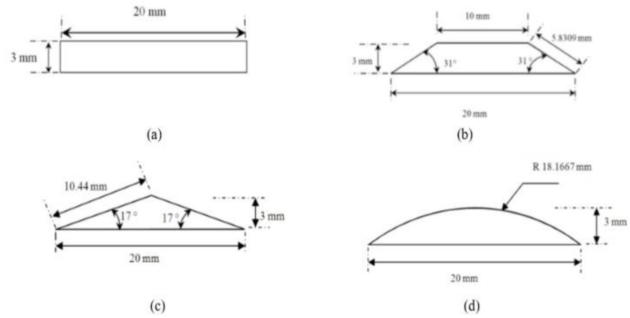


Figure2.2: Shape of various extensions

A fin is a surface that extends from an object to increase the rate of heat transfer to or from the environment by increasing convection. Extensions on the finned surfaces is used to increases the surface area of the fin in contact with the fluid flowing around it. So, as the surface area increase the more fluid contact to increase the rate of heat transfers from the base surface as compare to fin without the extensions provided to it. Types of extension provided on fin such as (a) Rectangular extensions, (b) Trapezium extensions, (c) Triangular extension, and (d) Circular Segmental extension.

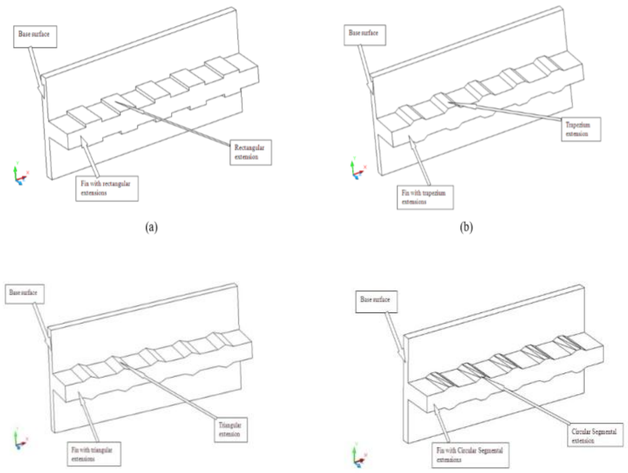


Figure 2.3: Fins with various extensions Rectangular, Triangular, Circular, and Trapezoidal

III METHODOLOGY

In this project work thermal analysis of fin has been perform in the engine cylinder by providing various extensions. A parameters for these analysis has been referred from the papers Pardeep Singh, Harvinderlal, Baljit Singh Ubhi(Vol. 3, Issue 5, May 2014) and Deepak Gupta, Wankhade S.R.

Thermal analysis of fin in the APDL Mechanical ANSYS software starts with the construction of desired geometry and mesh for the modelling. The boundary and initial conditions for the model leads of the modelling of the system. Finally it is followed by analysis of the results, discussion and conclusion.

3.1 Introduction of ANSYS:

ANSYS mechanical is finite element analysis tool for structural analysis, including linear, nonlinear and dynamic studies. This computer simulation product provide finite to model behaviour, and proposed material model and equation solvers for a wide range of mechanical design problems. ANSYS Mechanical also includes thermal analysis and coupled-physics capabilities involving acoustics, piezoelectric, thermal structural and Thermo electric analysis.

ANSYS software uses different numerical methods and a number of computerized algorithm in order to solve and analyse the problem that involve heat transfer and flow of fluids.

3.2 Solid Modelling of System:

A typical modelling process is performing by the ANSYS 15.0; we are using the APDL Mechanical work bench for the modelling of any geometry. There are two different parts in the model one is cylindrical core and other one is rectangular fin with or without extension.

To prepare the model we add the solid element SOLID 87. After defining the element we define properties of the cylinder core and fin which are given in the table:

Table 3.1: Properties of material for cylinder core and fin

S. NO.	PROPERTY	CYLINDER CORE (Grey cast iron)	FIN(Aluminium alloy 6063)
1	Thermal conductivity	53.3 W/mK	200 W/mK
2	Specific heat	490 J/kg K	900 J/kg K
3	Density	7100 kg/ m^3	2700 kg/ m^3

The overall length of the cylindrical core is 120mm and inner and outer diameter of cell is 62mm and 78 mm respectively. Further the rectangular fin are arranged around the cylinder by maintaining the pitch length of 24 mm.The overall length and width is 150mm and thickness of fin is 3mm. In our project we are going to model a fin with extension in various shapes as shown in fig. with dimension. We have taken only four extensions on each fins which are mounted on one side of fin surface.

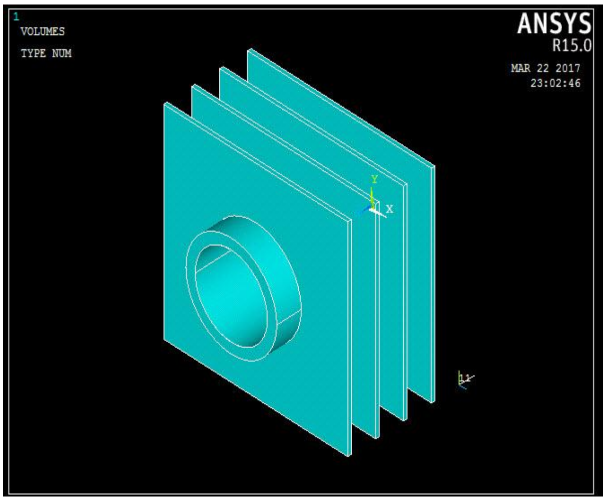


Figure3.1: fin model without extension

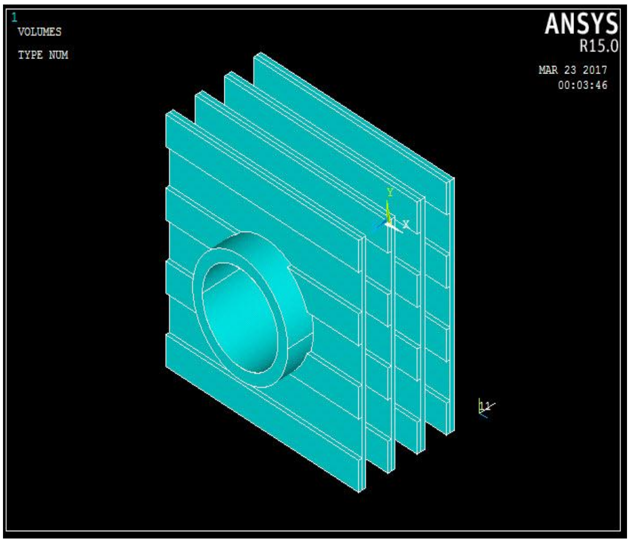


Figure 3.2: fin model with extensions

3.3 Meshing of Model:

Meshing is a discretization of model into nodes and elements. Relatively a fine mesh is generated byusing mesh tool of ANSYS software. Before meshing the model it is required the select or define the mesh attribute where the material for each part is defined. We have meshed the model in small size in the shape of the each element is tetrahedron. The meshing condition of each model is shown in fig.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 04, April-2017

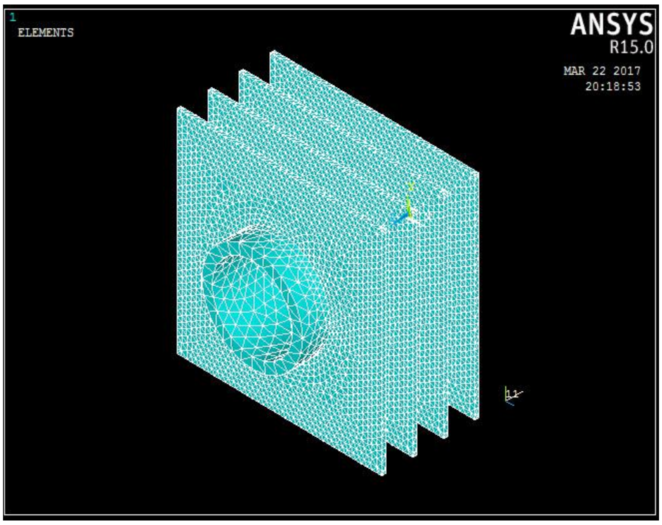


Figure 3.3: Meshing Of Models

3.4 Loading:

In this step we define the boundary conditions for model, the temperature of inner surface of cylindrical core is taken as 1373K and the atmospheric pressure and temperature is maintained at 303K. We have also defined convection heat transfer coefficient of whole body as 30 W/MK taking atmospheric bulk temperature as 303K. We have taken the initial temperature of whole body as 303K.

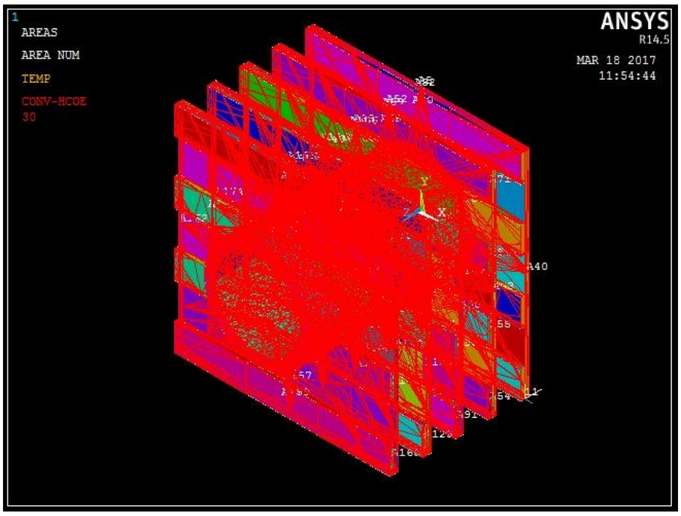


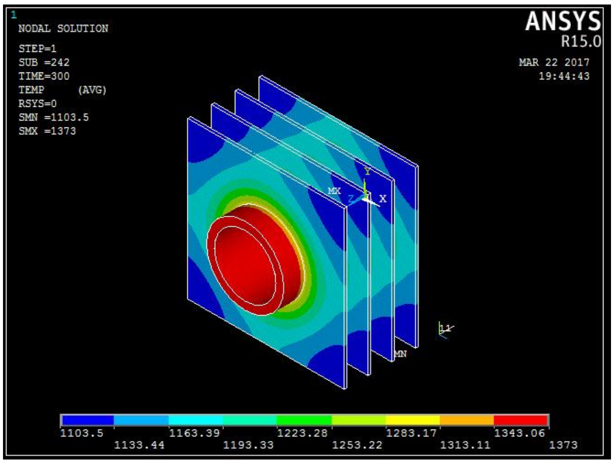
Figure 3.4: Loading condition of model

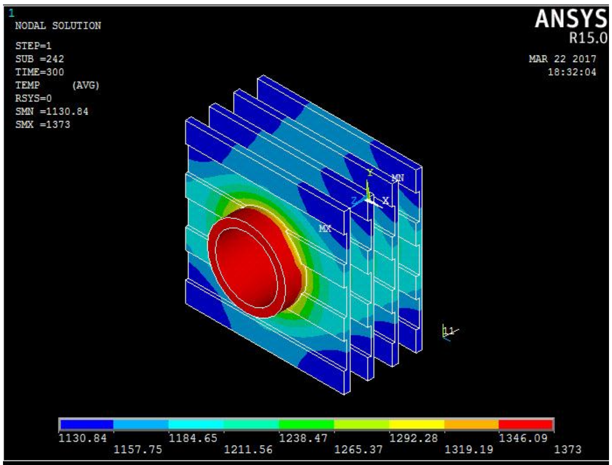
3.5 Solution:

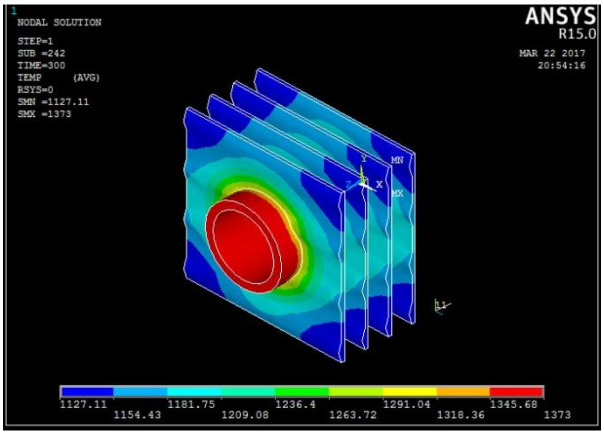
The ANSYS software gives the solution of different heat transfer problem on the basis of given boundary condition and assumptions. This work is based on following assumptions:

1. Heat transfer is transient.
2. The temperature of cylinder core maintained at constant temperature.
3. Initial temperature of whole body is 303K.
4. Heat transfer is taken for 300 seconds.
5. Free convection heat transfer.

We perform the transient solution of each model with or without extensions. We critically analysis the result obtained by providing the extensions on fin in various shapes. We solve the problem after defining the initial conditions for 50 iterations. After 50 iterations we will got the result for thermal flux and temperature changes over the models. After the transient thermal analysis of model the analysis results are given below in the form of coloured figures.







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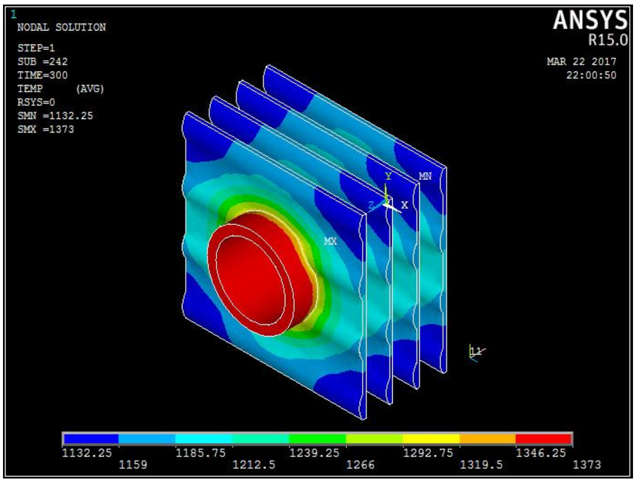
ISSN: 2278-0181
Vol. 6 Issue 04, April-2017



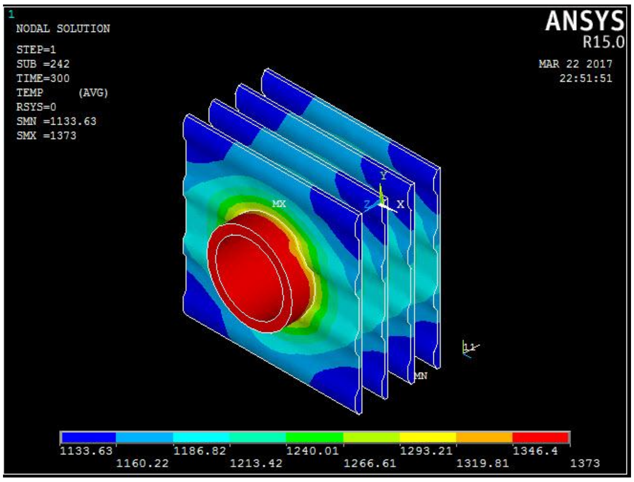
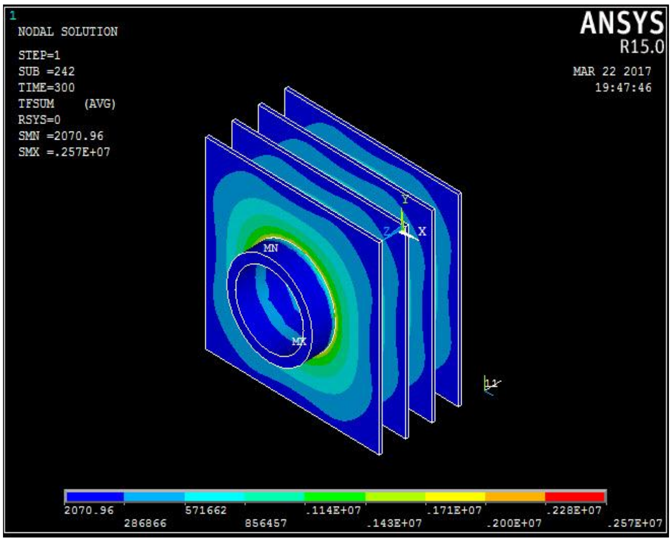
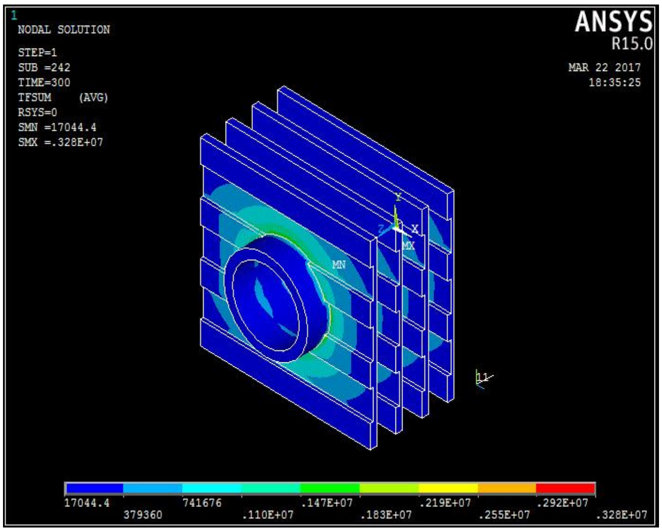
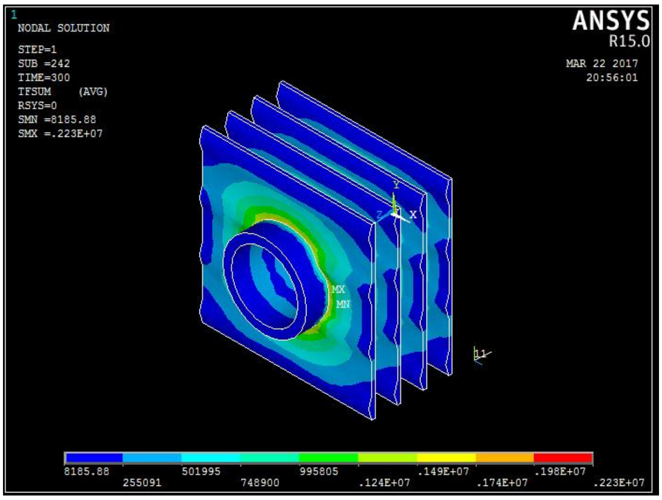


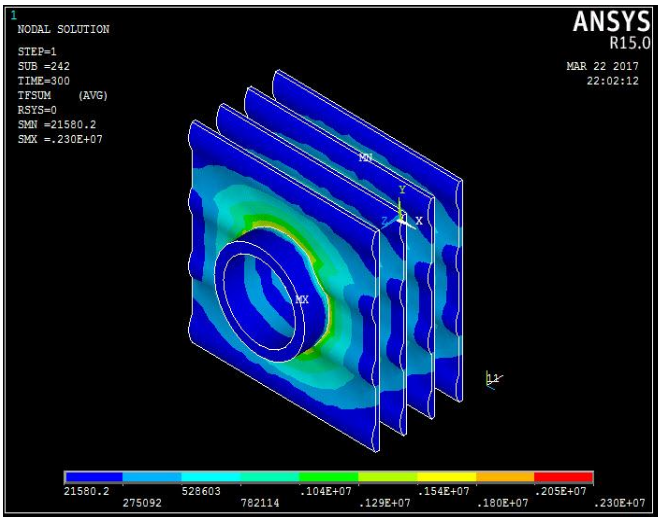
Figure 3.5: Temperature profile over body after 300 seconds

The thermal flux profile over the body after 300 second is shown in figure:









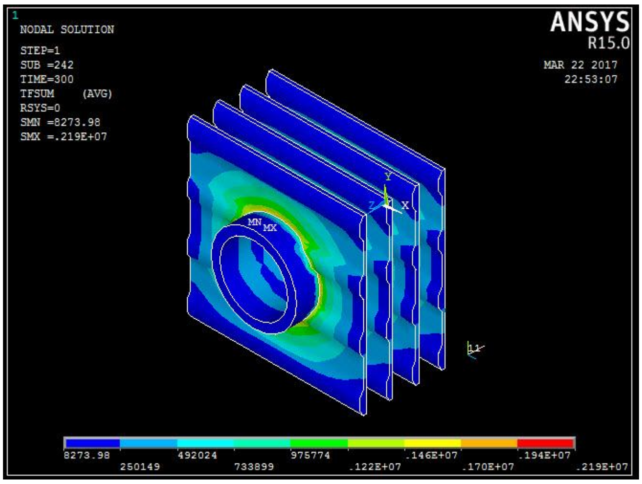


Figure 3.6 : Thermal flux profile over body after 300 seconds

IV RESULT

After using ANSYS Software for thermal analysis of fins the results for inner surface temperature of cylinder core and fin edge is obtained, also maximum and minimum thermal flux is obtained for each model with extension or without extension. Temperature of cylinder core and fin after 300 second is given in the table below

Table 4.1: Comparison of Fin Temperature with Extension

S. N.	Types of Fin	Temperature Cylinder Core In Kelvin	Temperature In Fin In Kelvin	%increase in tem. Of fin with extension
1	Fin without extension	1373	1103.74	------
2	Fin with rectangular extension	1373	1130.86	2.457%
3	Fin with triangular extension	1373	1127.09	2.115%
4	Fin with circular extension	1373	1132.28	2.585%
5	Fin with trapezoidal extension	1373	1133.63	2.708%

Table 4.2: Value of Maximum and Minimum Thermal Flux

S. N.	Types of Fin	Max.Thermal flux(W/m^2)	Min. Thermal flux (W/m^2)
1	Fin without extension	0.257 $*10^7$	20281.9
2	Fin with rectangular extension	0.328 $*10^7$	17044.1
3	Fin with triangular extension	0.223 $*10^7$	8192.72
4	Fin with circular extension	0.230 $*10^7$	21574.2
5	Fin with trapezoidal extension	0.219 $*10^7$	8273.98

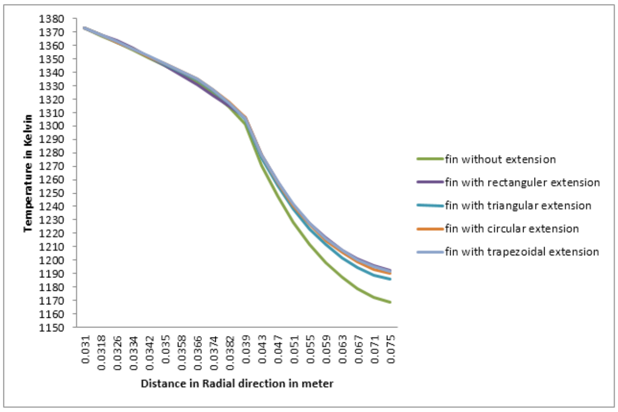


Figure 4.1: Comparative graph between Temperature and Distance

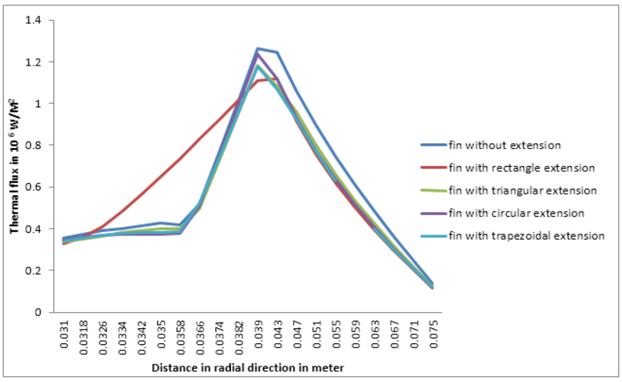


Figure 4.2: Comparative graph between Thermal flux and Distance

V CONCLUSIONS

The use of fin (extended surface) with extensions, provide efficient heat transfer:

- Temperature of Fin with extensions increases about 2 % to 3% as compare to fin without extensions.
- Fin with extensions provide near about 4 % to 13% more enhancement of heat transfer as compare to fin without extensions.
- Heat transfer through fin with trapezoidal extensions higher than that of fin with other types of extensions.
- By providing extensions in fin there is no improvement in thermal flux. From analysis we have got that the thermal flux decreases with extensions.

In this thesis, we concluded that using extension in fins surface is having better heat transfer rate as compared to normal fin.

VI FUTURE SCOPE

The current research work is concentrated on the maximization of amount of heat transfer rate from cylinder to atmosphere through fins. Present work can also extend in terms of changing the number of extensions, pitch length of extensions, velocity of air and also by changing the geometry of the extensions.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 04, April-2017

ANSYS software development will turn automatic design and optimization in realities and the development of web based ANSYS will allow more people to access the technology. All these developments will contribute ANSYS to becoming a mature discipline and a powerful engineering tool. As a result, more widespread and rapid adoption of the use of CFD in the thermal engineering will take place in future.

The present work using the genetic algorithm for Design of Experiment, it may also do by using some other algorithms such as SAA, Fuzzy Inference Systems Artificial Neural Network and Multi Objective Genetic Algorithms. A comparison can be made in terms of heat transfer amongst different optimization techniques.

VII REFERENCES

[1] Abdenour Bourabaa, MalikaFekih, Mohamed Saighi, Study on the heat transfer of the rectangular fin with dehumidification: Temperature distribution and fin efficiency, International Review of Mechanical Engineering 7(5):857-863 · January 2013

[2] Babu, M. Lavakumar, Heat Transfer Analysis and Optimization of Engine Cylinder Fins of Varying Geometry and Material, IOSR Journal of Mechanical and Civil Engineering, ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 7, Issue 4(Jul. -Aug. 2013), PP 24-29

[3] Pardeep Singh, Harvinderlal, Baljit Singh Ubhi, Design and Analysis for Heat Transfer through Fin with Extensions, International Journal of Innovative Research in Science, Engineering and Technology, ISSN:2319-8753, (Vol. 3 Issue 5, May 2014

[4] Mohsin A. Ali1, Prof. (Dr.) S.M Kherde, Fin Analysis For Heat Transfer Rate Augmentation Of Air Cooled Ic Engine, Vol-3 Issue-2 2017, IJARIIE-ISSN(O)-2395-4396

[5] Merwin Rajesh,K.Suresh Kumar, Effect Of Heat Transfer In A Cylindrical Fin Body By Varying Its Geometry & Material, International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163 Volume 1 Issue 8 (September 2014)

[6] Masao YOSHIDA, Soichi ISHIHARA, Yoshio MURAKAMI, Kohei NAKASHIMA and Masago YAMAMOTO, Air-Cooling Effects of Fins on a Motorcycle Engine, JSME International Journal Series B · January 2006

[7] Mohsin A. Ali and Prof. (Dr.) S.M Kherde, Design Modification and Analysis of Two Wheeler Engine Cooling Fins by CFD, International Journal of Science, Engineering and Technology Research (IJSETR), Volume 4, Issue 2, February 2015

[8] Deepak Gupta, Wankhade S.R, Design and Analysis of Cooling Fins, International Journal on Mechanical Engineering and Robotics (IJMER), ISSN: 2321-5747, Volume-3, Issue-2, 2015