



Thermal Performance of Engine Cylinder with Dissimilar Materials

M. Udaya Kumar

Associate Professor, Department of Mechanical Engineering
Indur Institute of Engineering and Technology, Siddipet, Telangana
iiet.uday@gmail.com

Abstract: *The engine cylinder is subjected to rapid changes in temperature due to combustion of air and fuel mixture inside the cylinder; so fins are provided on the cylinder which increases the heat dissipation rate. The medium used for heat dissipation is air. Though the dissipation rate of heat can be improved by enlarging the surface area of engine but designing such complex engine is difficult and it requires more space. Hence fins are used which provide additional surface area to cool down the engine. Fins used for engine cylinder might be of different materials depending upon the heat transfer rate. The commonly used material for fins is Aluminum but other materials can also be used in place of it depending upon the heat transfer rate required. In the present work, three different types of materials for fins and carry a thermal analysis on three of them by using varying geometries, altering thickness of the fins and the distance between them. The materials used are Aluminum Alloy with Aluminum percentage 92, 94 and 96. The rest composition includes the percentages of copper, magnesium and tin.*

Keywords: Fins, Heat dissipation, Thermal Analysis, Engine Cylinder, Materials

I. INTRODUCTION

Engines are of two types, they are External and Internal Combustion Engine. If the air-fuel ratio is combusted within the engine cylinder then it is termed as Internal Combustion Engine. In an external combustible engine mixture is heated inside from an external source. As a result, hot gases are produced which could result in temperature about 2300-2500°C which is very high and could damage the engine if not dissipated. So, this temperature should be brought to about 140-200°C to make the engine work efficiently. Cooling more than required is not desirable because it tends to decrease the thermal efficiency of the engine. So a system of cooling is incorporated to reduce the temperature and allow the engine to function effectively. Engines produce mechanical energy by extracting energy from flows, same as that of a water wheel extracting energy from mass of stream which falls from a distance. The heat that is wasted will be removed by cool air; while hot gases are exhausted the result is cooling of the engine. Engines which perform high have greater energy as mechanical movement and have fewer heat wastes. A little waste heat is required: it guides heat thru the engine, tons as a water wheel works only if there may be some go out speed (energy) in the waste water to hold it away and make room for more water. For that reason, all warmth engines need cooling to perform. Cooling is likewise wanted because excessive temperatures harm engine materials and lubricants. Engine cooling gets rid of power rapid enough to preserve temperatures low so the engine can continue to exist. The cooling of engine takes place in two ways in an Internal Combustible Engine. They are air-cooled and liquid cooled. Marine engines and a few stationary engines have prepared to get admission to a immense volume of water at a suitable temperature. If water is used as a coolant to chill the engine, it could clog coolant passages due to sediments or can damage the engine due to salt reaction with water.

II. LITERATURE REVIEW

Charan et. al. [1] analyzed extended surfaces, which are commonly used to enhance convection heat transfer in a wide range of engineering applications. The conception of introducing perforations on the lateral surface of fin is to enhance heat transfer rate effectively. From the research, it is evident that tip temperature is minimum for aluminum triangularly perforated with three perforations in it and heat transfer is maximum for triangularly perforated with three perforations of aluminum material.



Sangaj et. al. [2] experimentally found out the temperature distribution within the pin fin made of different material and geometries and performed steady state heat transfer analysis using a finite element software ANSYS to test and validate results.. Beldar et. al. [3] performed steady thermal analysis by using CFD software. Air Flow analysis, pressure drop analysis had performed. The notch size is varying from 10%, 20% and 30% the heat input is varying from 25 watt, 45 watt and 65 watt. Rajesh et. al. [4] analyzed the thermal properties by varying geometry, material (Cu and Al alloy 6082), distance between the fins and thickness of cylinder fins. The Fins models are created by varying the geometry circular and also by varying thickness of the fins for both geometries. The 3D modeling software Pro/Engineer & UniGraphics were used. Thermal analysis was done on the cylinder fins to determine variation temperature distribution over time.. Jain et. al. [5] analyzed the thermal heat dissipation of fins by varying its geometry. Parametric models of fins have been developed to predict the transient thermal behavior. There after models were created by varying the geometry such as rectangular, circular, triangular and fins with extension. The modeling software CREO Parametric 2.0 has been used. The analysis has been done using ANSYS 14.5. Kummitha et. al. [6] studied thermal analysis of cylinder block. The thermal analyses were performed with various alloys to find out the best material which gave the best heat transfer rate through it and kept the engine in safe working condition and also had high strength with light weight. For this study, passion pro bike cylinder block was considered and modeled by using GAMBIT software and also thermal analyses were performed by using ANSYS software. Hence in this study, some of aluminium alloys are also considered for thermal analysis and compared all the results for best one. it is to be concluded that A380 had the better heat transfer rate along with more strength as compared with other considered alloys.

Ravikumar et. al. [7] discussed about the geometric variables and design of heat sink for enhancing the thermal performance is experimented. This project makes use of thermal evaluation to perceive a cooling answer for a computer pc, which uses a 5 W CPU. The design was able to cool the chassis with heat sink joined to the CPU which was adequate to cool the whole machine. This work considered the round cylindrical pin fins and square plate heat sink fins layout with aluminium base plate and the control of CPU heat sink procedures. An opportunity model of heat fins has been designed to increase heat dissipation. In ANSYS, the proposed substance has been analyzed and the consequences of regular state and transient thermal evaluation are taken for comparison.

Senthilkumar et al. [8] in this study design of circular fin has been done by finite element method, the investigation is performed by comparing the different profiles of fin with determination of thermal stress also the parameters were compared in form of temperature distribution, heat flux as well as structure of fin. Yang Xu et al. [9] investigated thermal performance by parametric evaluation with different configuration of pin fin including impingent flow, the final observation is the optimum ratio of distance between fin and spacing ratio develops maximum heat transfer characteristic in inclusion if impingent flow. Su Min Hoi et al. [10] – the study represents a fractal shaped inserts in plate fin heat sink to enhance convective heat transfer, increase in heat transfer is analyzed by varying thickness of fractal, the results were compared by evaluating Reynolds number with each optimized design of plate fin heat sink, this study also propose that fractal inserts with unity enhances overall thermal performance of plate fin heat sink. Ngoctan Tran et al. [11,12] presented the configuration of louvered fins and improved 19.54% of thermal performance using forced convection the velocity ranges that were considered is between 1m/s to 6 m/s with louvered angle between 27 degree to 40.5 degree the results are compared together and heat dissipation is improved.

Lei Li et al. [13] – The pin fins including the inner cavity increases the circular flow and make it move beneath, in order that the Nusselt number within the area below the pin fins is enhanced; meanwhile, local convective heat transfer coefficient and therefore the area of thermal exchange have both increased to enhance the convective heat transfer effect. Adeel Tariq et al. [14] – The experimental data validates the conjugate model of heat sink using finite volume method. The results from the FVM model show that the heat transfer coefficient is higher in the plane fins without slots and perforations. Also need of pumping power is compared to be less in comparison of base model.

III. THERMAL ANALYSIS

- To know the types of Thermal analysis, we must be familiar with The Mechanical interface used to perform Thermal analysis.
- The terms used in performing Thermal analysis.
- The procedure to carry out Steady-State type of Thermal analysis.



- The procedure to run Transient type of Thermal analysis.
- Temperature distribution on different sides of the model.
- The way to run the problem
- Before a model is set for production, it passes through several stages. Thermal analysis has an essential role in product improvement. Various designs of parts such as engines, refrigerators, heat exchangers are accepted based on the outcomes of the analysis.

The output from a thermal analysis can be the following:

Temperature distribution, Amount of heat loss or gain, Thermal gradients. Thermal fluxes.

3.1 Creating of Fins in CATIA

In CATIA, to create fins for analysis, open CATIA software and select part design module in mechanical design under the start button. In part design - go to sketch based feature and select pad tool. In part tool click on sketch tool and specify as shown in figure

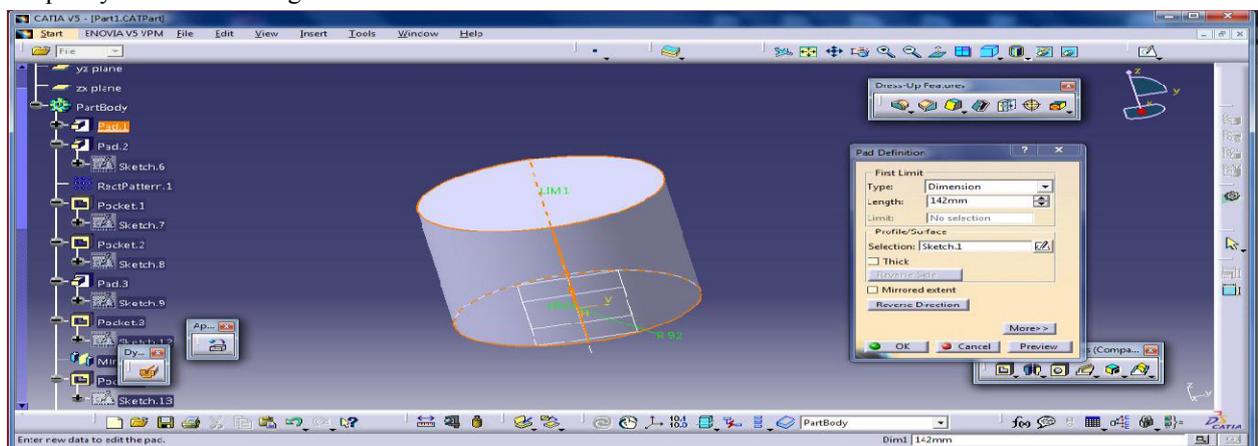


Figure 1: Part tool for bore

Now in part design - go to sketch based feature and select pad tool. In part tool click on sketch tool and specify as shown in below figure

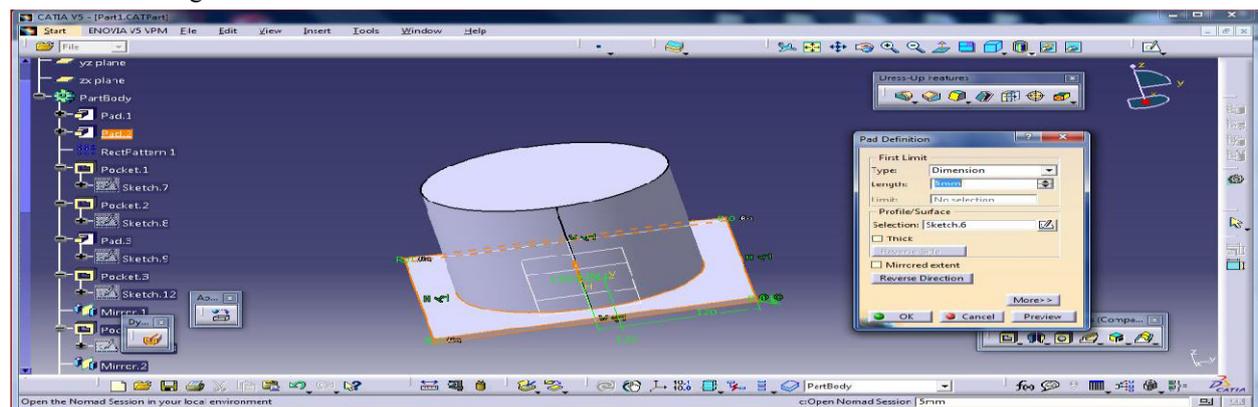


Figure 2: Pad tool for fins

Now in part design - go transformation based feature and select rectangular pattern tool. In pattern select above pad tools as an element to pattern and select required plane as reference plane. then specify instances and length

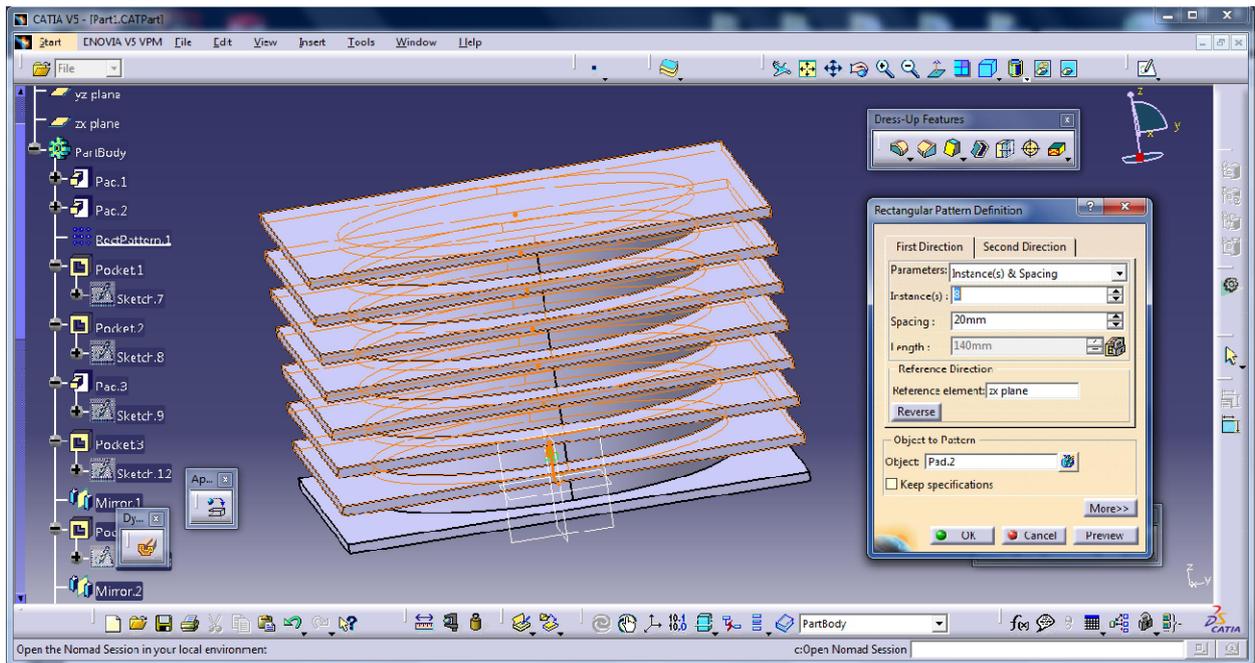


Figure 3: Rectangular patterns for fins

Now in part design - go to sketch based feature and select pocket tool. In pocket tool click on sketch tool and specify as a shown in below figure

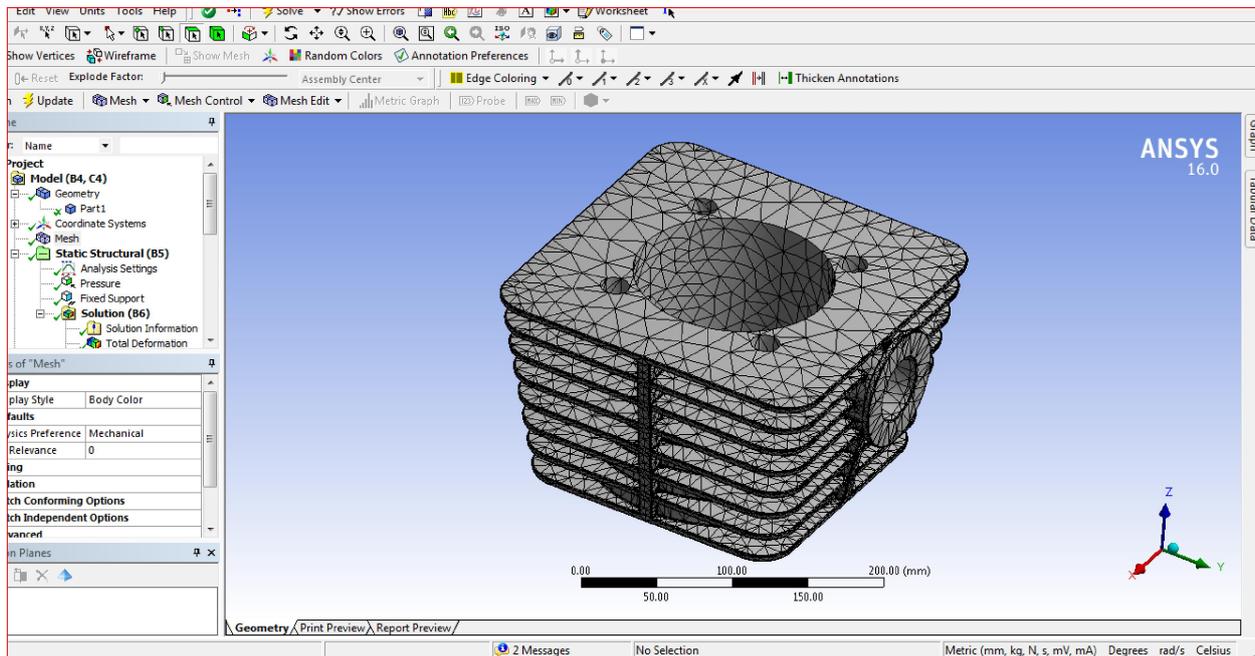


Figure 4: Mesh generated with default Mesh Controls

Open the Statistics node in the Details of "Mesh" window to display the total number of elements generated. This gives the total number of elements

IV. RESULTS AND DISCUSSIONS

Once the model is meshed, it is required to specify the boundary and loading conditions. After that it is applied to various materials as show in below figures



4.1 Cast Iron

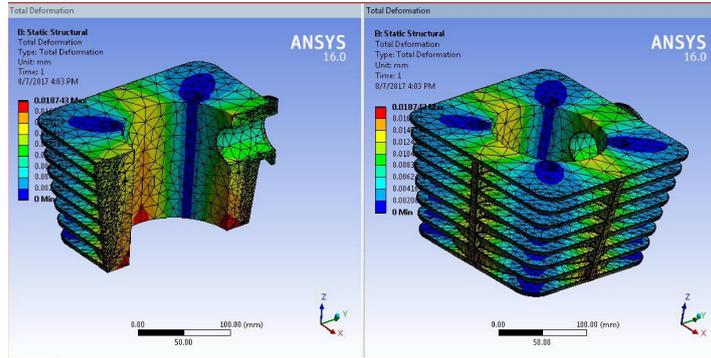


Figure 5: The Values of Total Deformation in Color Bands.

4.2 Aluminum Alloy 92%

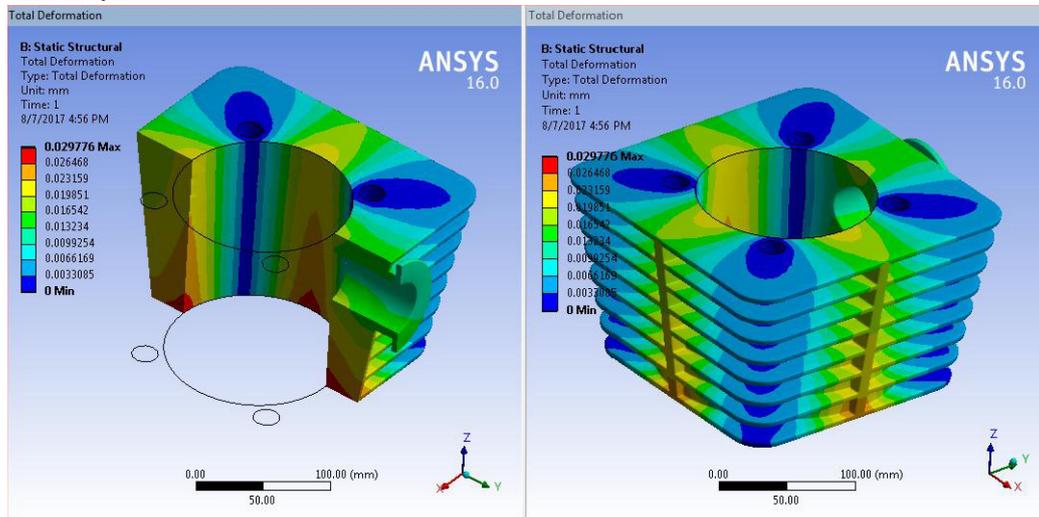


Figure 6: The Values of Total Deformation in Color Bands

4.3 Aluminum Alloy 94%

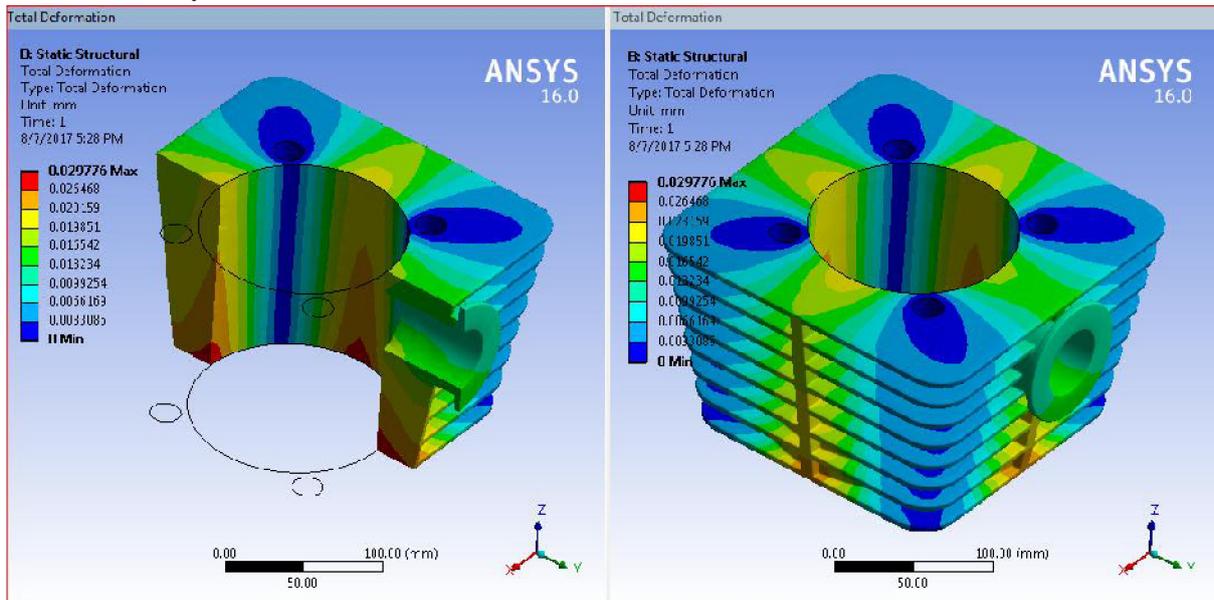
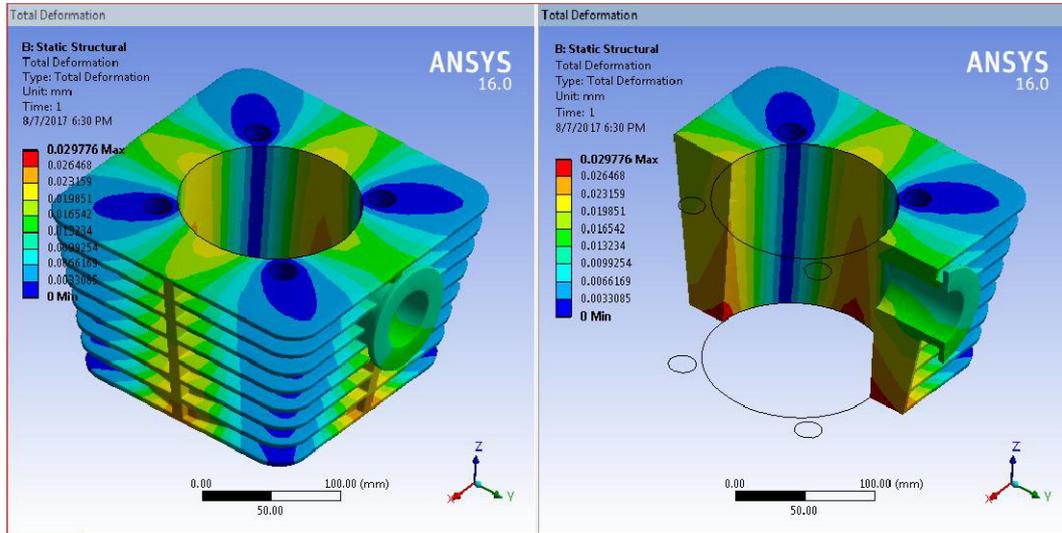


Figure 7: The Values of Total Deformation in Color Bands



4.4 Aluminum Alloy 96%



4.5 Aluminum Alloy 92%

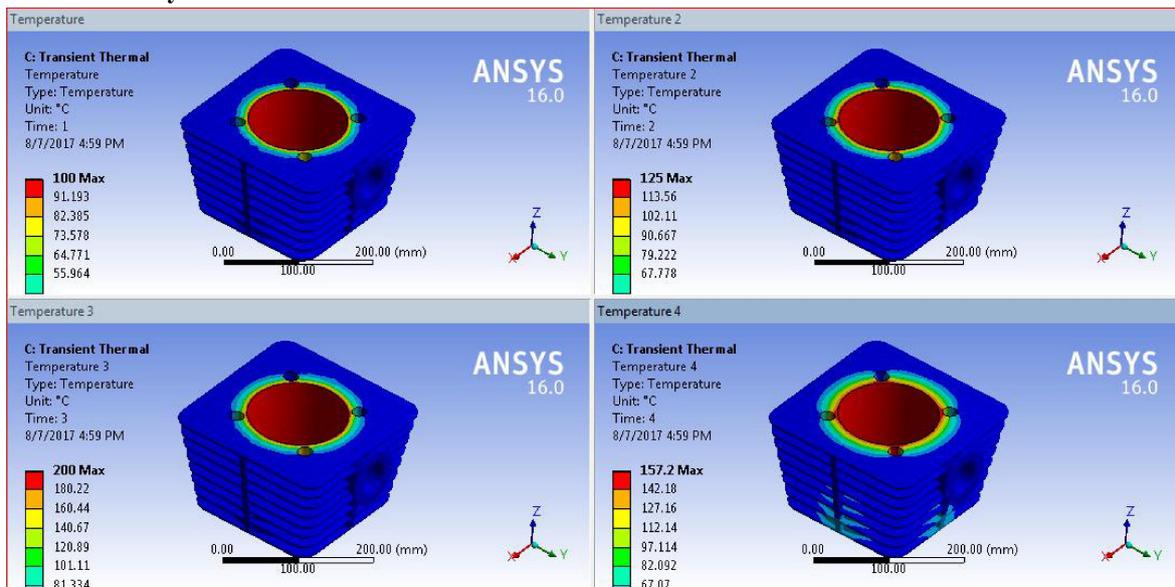


Figure 8: The Values of Temperature at Suction, Compression, Expansion and Exhaust

4.6 Aluminum Alloy 96%

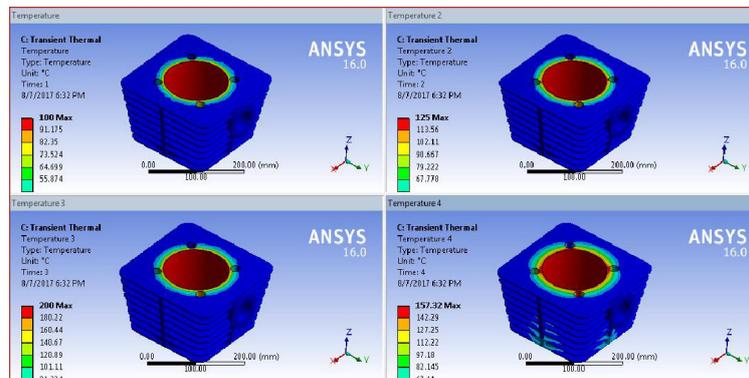
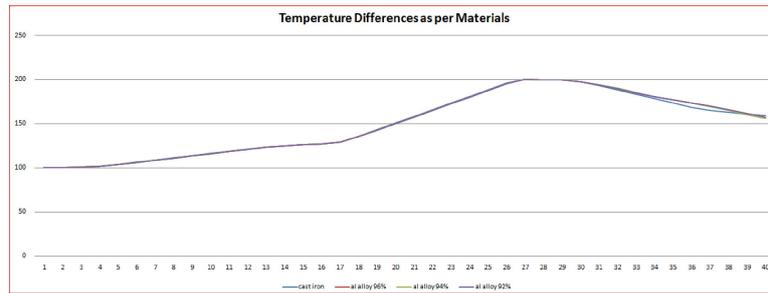
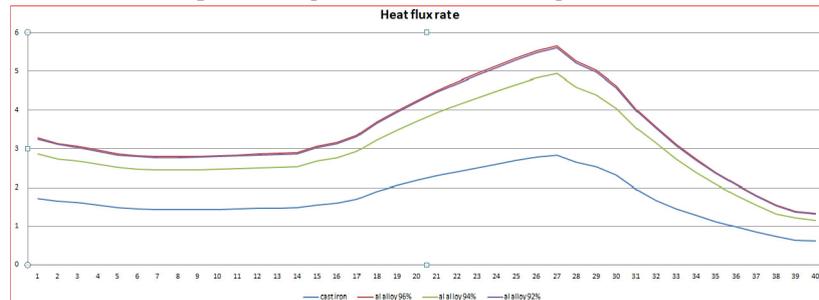


Figure 9: The Values of Temperature at Suction, Compression, Expansion and Exhaust

**Graph 1: Temperature Difference as per Material****Graph 2: Heat Flux as per Materials**

V. ANALYZING THE RESULTS

After the thermal boundary conditions are applied, it is now important to analyze the behavior of the model after the boundary conditions have been set out. The steps for analyzing are as follows:

1. First in the Tree Outline, right-click on the Solution node which opens a shortcut menu.
2. From this shortcut menu, choose Insert > Thermal > Temperature; Temperature is added under the Solution node in the Tree Outline. Also, the Details of "Temperature" window is displayed.
3. In this window, select the Geometry selection box to display the Apply and Cancel buttons.
4. Pick the Body tool from the Select toolbar and then choose the model,
5. Choose the Apply button from the Geometry selection box in the Details of "Temperature" window; 1 Body is displayed in the Geometry selection box.
6. Select Thermal > Temperature from the Solution contextual toolbar; Temperature 2 is added in the Solution node of the Outline. Also, the Details of "Temperature 2" Window are displayed.
7. In the Details of "Temperature 2" window, select the Geometry selection box to display the Apply and Cancel buttons.
8. Pick the Face tool from the Select toolbar and then pick the cylindrical face of the model
9. Choose the Apply button from the details of temperature 2 window, 1 face is displayed in the Geometry selection box in the Details of Temperature 2 window.
10. Pick the Solve tool from the toolbar; it then displays ANSYS Workbench Solution Status message box and the temperature distribution for the Temperature 2 boundary condition on the Graphics screen.
11. Select Temperature under the Solution node in the Tree Outline; temperature distribution in the model is displayed in the Graphics screen.
12. Similarly, select Temperature 2 under the Solution node in the „Tree Outline; the temperature distribution in the model is displayed in the Graphics screen,
13. Select Solution node in the Outline to depict the Solution contextual toolbar.
14. Choose Total temperature from the Thermal drop-down in the Solution contextual toolbar;
15. In the Details of "Total Heat Flux" window, select the Geometry selection box
16. to depict the Apply and Cancel keys.
17. Choose the Body tool from the Select toolbar and then select the model,
18. Choose the Apply button from the Geometry selection box in the Details of "Total Heat Flux" window 1; model is shown in the Geometry selection box.



19. Similarly, choose Heat Flux from the Thermal fly out in the Solution contextual toolbar;
20. Choose the Solve tool from the Standard toolbar; the ANSYS Workbench Solution Status window is opened. Notice that a tick mark is placed before Total Heat Flux and Directional Heat Flux in the Tree Outline,
21. Select Total Heat Flux from the Solution node in the Tree Outline; the corresponding contours displaying the distribution of heat flux are displayed in the Graphics screen.
22. Similarly, select Directional Heat Flux from the Solution node in the Tree Outline; the corresponding contours displaying the distribution of heat flux along the X axis are displayed in the Graphics screen,
23. Exit the Mechanical window to display the Workbench window.

VI. CONCLUSION

The fins of an engine cylinder of a motorcycle are modeled using CATIA software. The created model is altered by varying the thickness of the fins. The model used here has a thickness of a 3mm.

The generally used material for fins is Aluminum. In this project, we have considered three other materials which are aluminum alloys 92, 94 and 96. Here the material is changed by taking in account the densities and thermal conductivity.

Thermal analysis is carried out for all the three materials. It can be concluded that the heat dissipation rate is more for Aluminum Alloy 96 which is followed by Aluminum 94, 92.

So the heat dissipation is more by using Aluminum 96 for the Fins. Hence using Aluminum 96 for fins results in cooling down the Engine quite fast which results an increase in Engine and fuel efficiency.

It can also be concluded that by changing the thickness of the fins of Engine Cylinder the heat transfer rate can also be altered. Hence depending upon the condition the heat transfer rate can be altered.

REFERENCES

- [1]. Charan, Srivastav, Bharadwaj, "Thermal Analysis On Rectangular Plate Fin with Perforations Using Ansys", International Journal of Creative Research Thoughts, 2018.
- [2]. Sangaj, Shinde, Shanediwan, Potdar, Suryawanshi, "Thermal and Parametric Analysis of Pin-Fin", International Research Journal of Engineering and Technology (IRJET), Volume 05, Issue 02, Feb-2018.
- [3]. Kiran Beldar, Avinash Patil, "Design and Analysis of cylinder having longitudinal fins with rectangular notches", International Journal of Scientific Development and Research (IJS DR), 2017.
- [4]. Rajesh, Rahamathullah, Malleswara Rao, "design and optimization of engine cylinder fins by varying Geometry and material with thermal analysis", International Journal of Core Engineering & Management, 2017.
- [5]. Mayankjain, MahendraSankhala, KanhaiyaPatidar, "heat transfer analysis and optimization of fins by Variation in geometry", International Journal of Mechanical and Production Engineering, Volume- 5, Issue-7, Jul.-2017.
- [6]. Kummitha, Reddy, "Thermal Analysis of cylinder block with fins for different materials using ANSYS", ICAAMM, Elsevier, 2016.
- [7]. S.Ravikumar, Chandra, Harish, "Experimental and Transient Thermal Analysis of Heat Sink Fin for CPU processor for better performance", Materials Science and Engineering, 197, 2017.
- [8]. P.Senthilkumar et al, Design and thermal analysis on circular fin, <https://doi.org/10.1016/j.matpr.2020.02.784>.
- [9]. YangXu et al, Review Effect of pin fin arrangement on the heat transfer characteristics in a convergent channel with impingement, International Journal of Heat and Mass Transfer
- [10]. Su MinHoi et al, Plate-fin heat sink forced convective heat transfer augmentation with a fractal insert, International Journal of Thermal Sciences Volume 142, August 2019, Pages 392-406
- [11]. NgoctanTran et al, Optimization of the airside thermal performance of mini-channel-flat-tube radiators by using composite straight-and-
- [12]. louvered fins, International Journal of Heat and Mass Transfer Volume 160, October 2020, 120163
- [13]. LeiLi et al, Convective heat transfer characteristics of twin-web turbine disk with pin fins in the inner cavity, International Journal of Thermal Sciences Volume 152, June 2020, 106303.
- [14]. AdeelTariq et al, Comparative Numerical and Experimental Analysis of Thermal and Hydraulic Performance of Improved Plate Fin Heat Sinks, Applied Thermal Engineering Available online 26 August 2020, 115949.