

Design and Analysis of Extended Surfaces with Different Thermal Conductivity Using ANSYS 12

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ABSTRACT: The engine is the heart of any vehicle and heat is mainly generated in the engine. The cooling mechanism of any engine is mainly dependent on the design of the fin and fin material. Fins are used to increase the heat transfer rate of any surface. Generally aluminum alloy with thermal conductivity 235W/m-K is used as fin material in the bikes and our aim of the analysis is to study the different materials which can be used in fins and analyze the cooling rate by varying the heat flux accordingly. The model of rectangular fin is created and thermally analyzed with the help of ANSYS software which is FEA based. FEA divides (descretize) the structure (which is continuous otherwise) into small but finite, well defined, elastic substructure (element).

Element type SOLID87 which has tetrahedral 10 node structure is well suited to model irregular meshes (such as produced from various CAD/CAM systems). The element has one degree of freedom, temperature, at each node.

KEYWORDS: SOLID87, FEA, Descretize etc.

I. INTRODUCTION

Many engineering devices generate heat during their operation. If this generated heat is not dissipated rapidly to its surrounding atmosphere, this may cause rise in temperature of the system components. This cause overheating problems in device and may lead to the failure of component [1]. Fins or extended surfaces are known for enhancing the heat transfer in a system. Liquid cooling system enhances better heat transfer than air-cooling system, the construction of air cooling system is very simpler. Therefore it is imperative for an air-cooled engine to make use of the fins effectively to obtain uniform temperature in the cylinder periphery [2]. The generated heat from an electronic device is causes damage to the surface and make the system incompatible in terms of operation, unreliable. Therefore, this generated heat necessary to dissipate as soon as immediately when the temperature of device is high. One of the techniques to solve this kind of problem is to use extended surfaces. The fins have the capability to transfer heat and it protects the device as a result suitable operation will occur. Natural convection is played as vital solution to the above issue with the help of natural circulation of air. This cooling procedure plays a key role in the electronics cooling system, such as cooling engine, transformer etc. Experimental studies on vertical rectangular fin arrays was carried by Guvenc A. and Leung C. [3, 4]. the natural convection heat transfer enhancement from a horizontal rectangular fin embedded with equilateral triangular perforations. The heat dissipation rate from the perforated fin is compared to that of the equivalent solid one. The effect of geometrical dimensions of the perforated fin and thermal properties of the fin was studied in detail. They concluded that, For certain values of triangular dimensions, the perforated fin can result in heat transfer enhancement. The magnitude of enhancement is proportional to the fin thickness and its thermal conductivity. The perforation of fins enhances heat dissipation rates and at the same time decreases the expenditure of the fin material. Abdullah, H. Alessa et. al. [5]. The need to increase the thermal performance of the systems, thereby affecting energy, material and cost savings

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has led to development and use of many techniques termed as “Heat transfer Augmentation”. This technique is also termed as “Heat transfer Enhancement” or “Intensification”. Augmentation techniques increase convective heat transfer by reducing the thermal resistance in a heat exchanger. Many heat augmentation techniques has been reviewed, these are (a) surface roughness, (b) plate baffle and wave baffle, (c) perforated baffle, (d) inclined baffle, (e) porous baffle, (f) corrugated channel, (g) twisted tape inserts, (h) discontinuous Crossed Ribs and Grooves. Most of these enhancement techniques are based on the baffle arrangement. Use of Heat transfer enhancement techniques lead to increase in heat transfer coefficient but at the cost of increase in pressure drop. B. Ramdas Pradip et. al. [6]. Extended Fins in the Optimization of Internal Combustion Engine they found for high speed vehicles thicker fins provide better efficiency. When fin thickness was increased, the reduced gap between the fins resulted in swirls being created which helped in increasing the heat transfer. Large number of fins with less thickness can be preferred in high speed vehicles than thick fins with less numbers as it helps inducing greater turbulence J .Ajay Paul, Sagar Chavan Vijay [7].

II. RELATED WORK

Kumbhar D.G, Dr. N.K. Sane, Chavan S. T., et al (2009) [8]. In this paper, the effect of triangular perforations on rectangular fin is investigates the comparison of perforated fin with solid fin for temperature distribution along the fin and heat transfer rate. The analysis is done using software ANSYS and also by experimentation. The investigation observed that heat transfer rate increases as well as the same time reduce the cost of fin with perforations as compared to fins of similar dimensions without perforations. It concluded that heat transfer rate is different for different materials or heat transfer rate changes with change in thermal conductivity of the material.

Abdullah, H. Alessa et. al. [5] had studied the natural convection heat transfer enhancement from a horizontal rectangular fin embedded with equilateral triangular perforations. The heat dissipation rate from the perforated fin is compared to that of the equivalent solid one. They concluded that, For certain values of triangular dimensions, the perforated fin can result in higher heat transfer enhancement. The magnitude of enhancement is proportional to the fin thickness and its thermal conductivity.

[9] Shivdas S kharche et.al theoretically and experimentally cost analyzed the natural convection heat transfer from vertical rectangular fin arrays with and without notches at the center. They analyzed the notches of different geometrical shapes. After the experimental study they have concluded that the heat transfer rate in notch fins is more as compare to the un notched fins.

[10]. Mr. N.Phani Raja Rao, Mr. T. Vishnu Vardhan. “Thermal Analysis of Engine Cylinder Fins by varying its geometry And Material.”[12]. The principle implemented in the project to increase the heat dissipation rate by using the air. In present study, Aluminum alloy 6061 and magnesium alloy are used and compared with Aluminium Alloy A204. The various parameters (i.e., shape and geometry of the fin) are considered in the study, shape (Rectangular and Circular), thickness (3 mm and 2.5 mm). By reducing the thickness and also by changing the shape of the fin to circular shaped, the weight of the fin body reduces thereby increasing the heat transfer rate and efficiency of the fin. The weight of the fin body is also reduced when Magnesium alloy is used. The results shows, by using circular fin with material Aluminum Alloy 6061 is better since heat transfer rate, Efficiency and Effectiveness of the fin is more. By using circular fins the weight of the fin body reduces compare to existing engine cylinder.

III. EXPERIMENTAL SETUP AND FIN DESIGN

Extended surfaces or developed surfaces, also called fins, are frequently used to dissipate heat. There are many examples of their uses in practical engineering applications such as computers, electronic systems, radiators, just to mention a few of them. Fin is made by different material namely aluminum with thermal conductivity coefficient $k=170$ W/m K, aluminum with thermal conductivity coefficient $k=235$ W/m K, copper with the current study have been

developed using ANSYS 12 .The dimensions for the fin shown in fin.1 In the present study surrounding temperature at 293 K.. Bottom surface of the fin is exposed to a variable heat flux of 600,800, 1000, 1200, 1400 W/m².

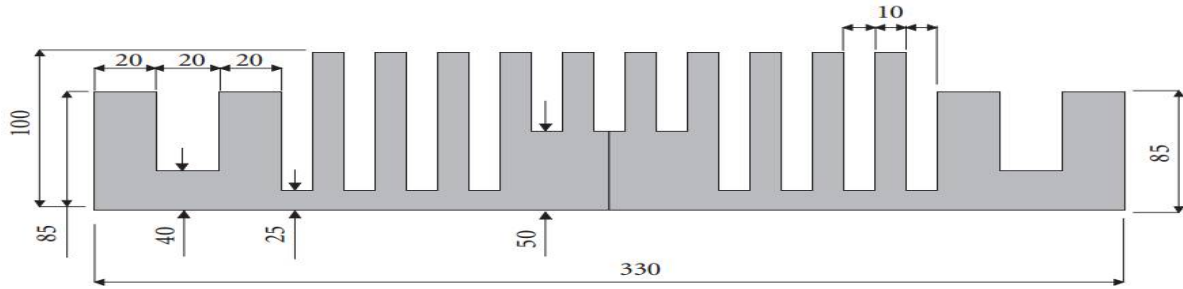


Fig. 1 Dimensions of fin

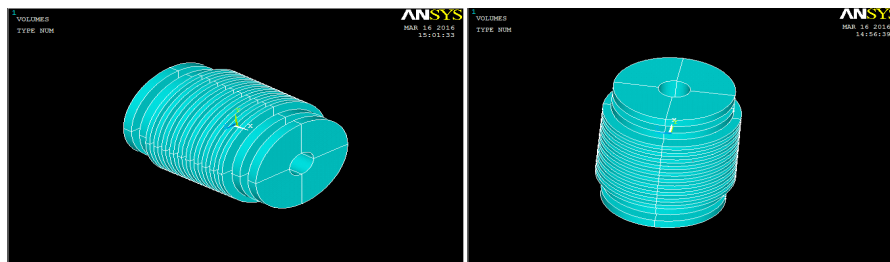


Fig.2 Models of fin

It is, however a 2D model. The width of the fin is 100 mm and this dimension can be used to create 3D model. After that meshing of the fin can be carried out. The 3-D model is shown in fig.3 and fig-4 in different views.

IV. RESULT ANALYSIS

For thermal analysis of designed fin, different materials like aluminium (thermal conductivity 170 and 235 W/mK), stainless steel (thermal conductivity 14 W/mK and copper (thermal conductivity 398 W/mK) have been used in ANSYS 12. The result obtained for nodal temperature after varying the heat flux from 800 to 1200 at the interval of 200 was observed and shown below in the detail.

Case 1 Aluminum with thermal conductivity $k= 170$ W/mK.

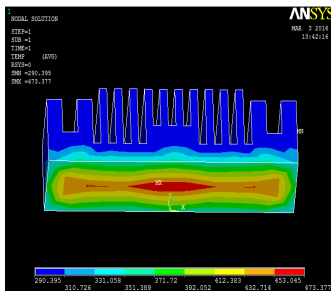


Fig.3 Nodal temp at flux 800

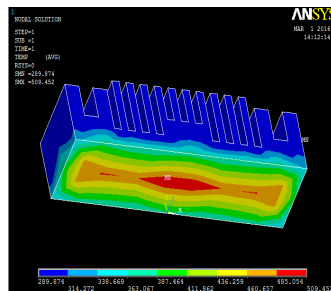


Fig.4 Nodal temp at flux 1000

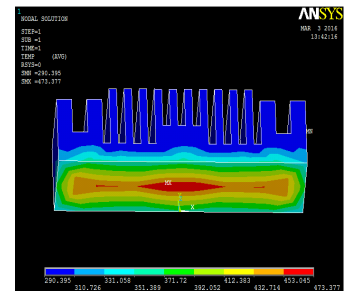


Fig.5 Nodal temp at heat flux 1200

Nodal temperature values at heat flux 800, 1000, 1200 for aluminium are 437.301, 473.377 and 509.452 respectively.

Case 2 Copper with thermal conductivity $k=398$ W/mK.

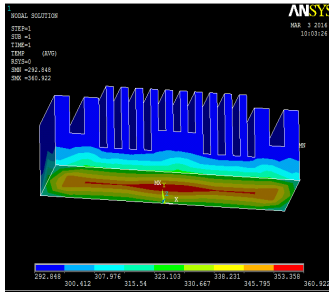


Fig.6 Nodal temp.at flux 800

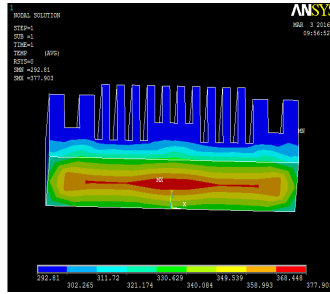


Fig.7 Nodal temp.at flux 1000

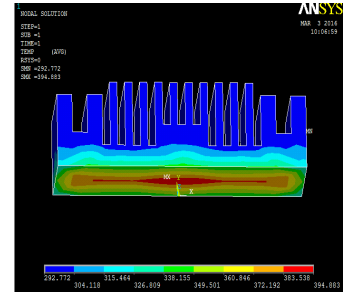


Fig.8 Nodal temp.at flux 1200

Nodal temperature values at heat flux 800, 1000, 1200 for copper are 360.922, 377.902 and 394.883 respectively.

Case 3 Stainless steel with thermal conductivity $k=14$ W/mK.

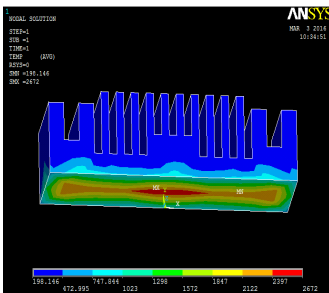


Fig.9 Nodal temp.at flux 800

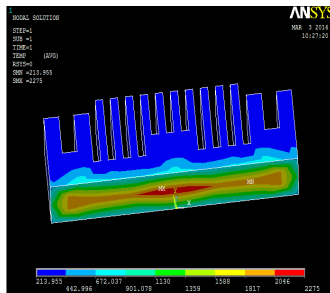


Fig.10 Nodal temp at flux 1000

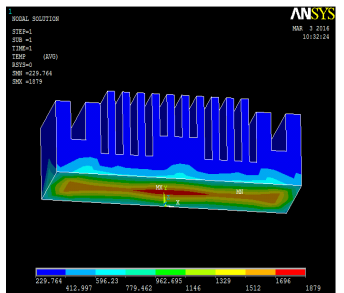


Fig.11 Nodal temp at flux 1200

Nodal temperature values at heat flux 800, 1000, 1200 for stainless steel are 1879, 2275 and 2672 respectively.

Case 4 Aluminum with thermal conductivity $k=235$ W/mK.

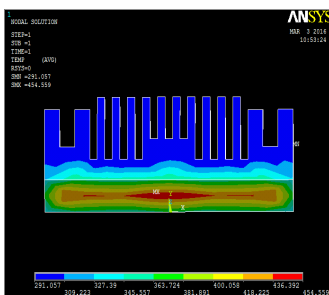


Fig.12 Nodal temp at flux 800

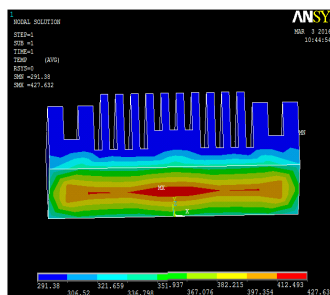


Fig.13 Nodal temp at flux 1000

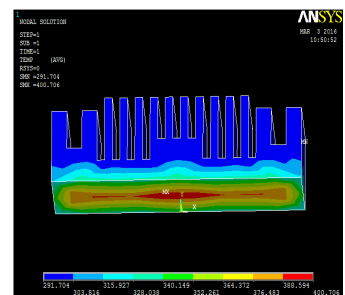


Fig.14 Nodal temp at flux 1200

Nodal temperature values at heat flux 800, 1000, 1200 for aluminium 2024 are 400.706, 427.632 and 454.559 respectively.

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V. ANALYTICAL RESULT TABLE

Table 1 & 2 show the values of thermal gradient vector sum, nodal temperature and thermal flux vector sum for different materials that has been considered in the present analysis.

TABLE 1: Variation of result at different values of heat flux for Aluminium and Aluminium 2024.

Material	Aluminium					aluminium 2024				
Thermal conductivity	170					235				
Convection coefficient	40					40				
Temperature	293					293				
Heat flux	600	800	1000	1200	1400	600	800	1000	1200	1400
Nodal temp.	401.226	437.301	473.377	509.452	545.527	373.779	400.706	427.632	454.559	481.485
Thermal gradient vector sum	5.096	6.795	8.494	10.193	11.891	3.618	4.824	6.03	7.236	8.442
Thermal flux vector sum	866.37	1155	1444	1733	2022	850.25	1134	1417	1700	1984

TABLE 2: Variation of result at different values of heat flux for Copper and Stainless steel.

Material	Copper					stainless steel				
Thermal conductivity	398					14				
Thermal coefficient	40					40				
Temperature	293					293				
Heat flux	600	800	1000	1200	1400	600	800	1000	1200	1400
Nodal temp.	343.942	360.922	377.902	394.883	411.864	1484	1879	2275	2672	3068
Thermal gradient vector sum	2.064	2.752	3.44	4.128	4.816	70.865	94.487	118.108	141.73	165.351
Thermal flux vector sum	821.451	1095	1369	1643	1947	992.109	1323	1654	1984	2315

VI. CONCLUSION

Following conclusions are made on the basis of our analytical results:

1. It is concluded that when we change the material and heat flux, then heat transfer rate is increased.
2. If we increase the thermal conductivity of material then cooling rate of fin will be increased, which can be seen in nodal temp.
3. As thermal conductivity increases the nodal temperature reduces.
4. Fourier's law states as the conductivity increases, heat transfer rate also increases which can be seen with our analysis (Copper with highest conductivity gives better heat transfer).

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