International Journal of Research Available at https://edupediapublications.org/journals

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 10
September 2017

Fem Analysis Of Fins With Varying Shapes And Material For Their Behaviour And Applications

[1]Gaurang Sharma, [2]Akshay Panchaity, [3]Avin Chandrakar
Email: [1]sgaurang91@gmail.com,[2]aks_1702@yahoo.com, [3]avinchandrakar@gmail.com

ABSTRACT

The heat transfer performance of fin is analyzed by several cross sectional design of fin i.e. rectangular, trapezium, triangular and circular segmental. The heat transfer performance of fin with unchanged geometry which have various extensions and without extensions is compared. Approximate ranging 4% to 14% greater heat transfer can be reached with different extensions on fin as compare to unchanged geometry of fin without these extensions. Fin with various extensions are designed with the help of software Pro-E. Analysis of fin performance done through the software ANSYS. In this thermal analysis, temperature variations of the fin is analyzed. Extensions on the finned surfaces is set while designing 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, rectangular extensions provide on fin yields the superior heat transfer than that of other extensions having the same length and width attached to finned surface. The effectiveness of fin with rectangular extensions greater as compare to other extensions on fin.

Key works: Heat Dissipation, Fin Geometry, Fin Material, Thermal Analysis, ANSYS.

1. Introduction

In the study of heat transfer, **fins** are surfaces that extend from an object to increase the rate of heat transfer to or from the environment by increasing convection. The amount of conduction, convection, or radiation of an object determines the amount of heat it transfers. Increasing the temperature gradient between the object and the environment, increasing the convection heat transfer coefficient, or increasing the surface area of the object increases the heat transfer. Sometimes it is not feasible or economical to change the first two options. Thus, adding a fin to an object, increases the surface area and can sometimes be an economical solution to heat transfer problems.

There are two ways to increase the rate of heat transfer:

1. To increase the convection heat transfer coefficient h.
2. To increase the surface area As.

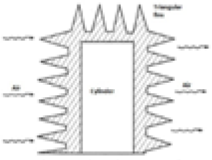
It is noted that: Increasing h may require the installation of a pump or fan, or replacing the existing one with a large one. The alternative is to increase the surface area by attaching to the surface extended surfaces called fins made of highly conductive material such as aluminum.

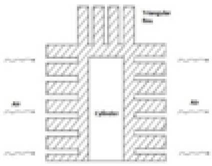
2. Literature Review

Sandhya Mirapalli et.al,2015 says, fins are the most effective instrument for increasing the rate of heat transfer. As we know, they increase the area of heat transfer and cause an increase in the transferred heat amount. Based upon the cross sectional area type, straight fins are of different types such as rectangular fin, triangular fin, trapezoidal fin parabolic fin or cylindrical fin. Fin performance can be measured by using the effectiveness of fin, thermal resistance and efficiency. Triangular fins have applications on cylinders of air cooled cylinders and compressors, outer space radiators and air conditioned systems in space craft.

Sampath SS et.al., 2015 discussed as the heat developed inside a two stroke engine cylinder is more, the heat has to be dissipated to surroundings by fins. These fins fitted are having an appropriate surface area to take away the heat to surroundings.

Seiyed E. et.al, 2014 says for ordinary fins problem, the thermal conductivity assumes to be constant, but when temperature difference between the tip and base of the fin is large, the effect of the temperature on thermal conductivity must be considered. Also, it is very realistic that to consider the heat generation in the fin (due to electric current or etc.) as a function of temperature.


Air cooled cylinder with rectangular fins


Air cooled cylinder with triangular fins

VS Daund et.al, 2014 describes 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.
H.N. Gandate 2014 says so it is very important to predict the magnitude of heat transfer in designing engine, hence it is the objective in this analysis to study the dissipation of heat as well as temp distribution on the cylinder for the engine model.
R Jassem, 2013 told that large number of studies has been conducted on optimizing fin shapes. Other studies have introduced shape modifications by cutting some material from fins to make cavities, holes, slots, grooves, or channels through the fin body to increase the heat transfer area and/or the heat transfer coefficient.
Magarajan U et.al, 2012 defines 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.
SH Barhatte et.al ,2012 says the major heat transfer takes by two modes that is by conduction or by convection. Heat transfer through fin to the surface of the fin takes place through conduction whereas from surface of the fin to the surroundings, it takes place by convection. Further heat transfer may be by natural convection or by forced convection.
Aziz and Bouaziz, 2011 used the least squares method for predicting the performance of a longitudinal fin with temperature-dependent internal heat generation and thermal conductivity and they compared their results by Homotopy Perturbation Method (HPM), Variational Iteration Method (VIM) and double series regular perturbation method and found that the least squares method is simpler than other applied methods. A complete review on this topic is presented by **Krause et al, 2002**. Fins are widely used in many industrial applications such as air conditioning, refrigeration, automobile, chemical processing equipment and electrical chips. Although there are various types of the fins, but the rectangular fin is widely used among them, probably, due to simplicity of its design and its easy manufacturing process. **Razani and Ahmadi 1977**, considered circular fins with an arbitrary heat source distribution and a nonlinear temperature-dependent thermal conductivity and obtained the results for the optimum fin design. **Unal 1987**, conducted an analytical study of a rectangular and longitudinal fin with temperature dependent internal heat generation and temperature-dependent heat transfer coefficient.

3. Problem Formulation

The performance of fins with varying cross section and extension is designed and analyzed using Pro-E and ANSYS respectively.
The results for fin shapes (No extension, Circular, rectangular and triangular) and materials (Aluminium alloy, Aluminium 1050 and Magnesium alloy) under variety of temperature along the fin length are to be observed.
Fin shapes are required to analyze against varying ambient temperature. Finally the result and conclusion are to be discussed to nominate best and optimized type of fin shape and material with respect to performance.
This work is selected as there is scope of continuous improvement in the field of fin design. Performance of find in the terms of heat transfer directly effects life and performance of engine. The problem of engine heating and its abnormal effects are feeling since the time of invention of engine. Fins thermal conductivity depends on material selected for fins manufacturing and the shape of fin selected. The materials used regularly for fin manufacturing should be tested with new options such as improved property alloy materials. The present work is selected for same reasons as discussed above.

4. Methodology

The complete methodology followed to perform this research is predefined, This methodology is followed strictly step by step to find problem from literature, Model Fins and further to analyze fin model which is then followed by result, conclusion and future scope.
Preprocessing is followed by Analysis and Element selection. Material properties were defined and meshing is performed. Further boundary conditions were defined and analysis were run to obtain temperature and heat flux.

5. Modeling and Analysis

Pro E Modeling:

e-ISSN: 2348-6848
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Volume 04 Issue 10
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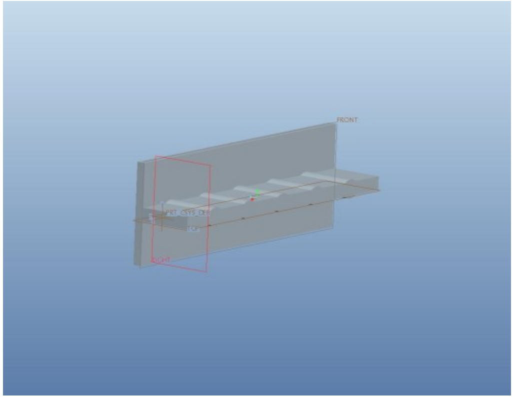
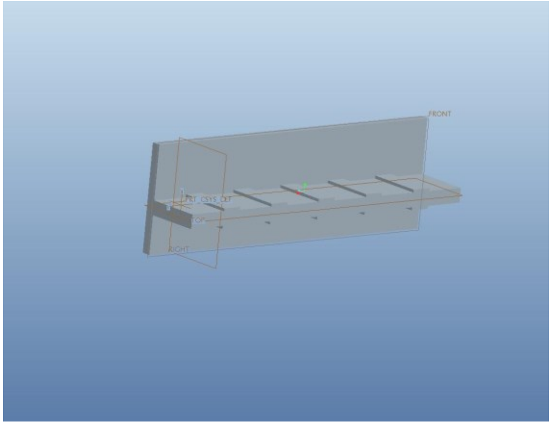
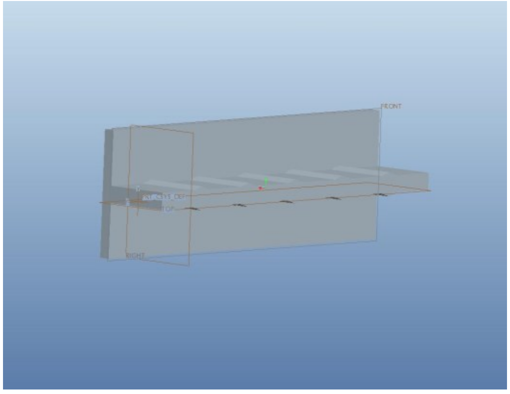


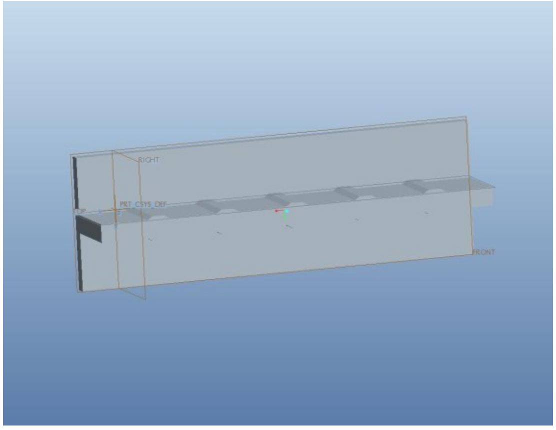
Circular fin Model



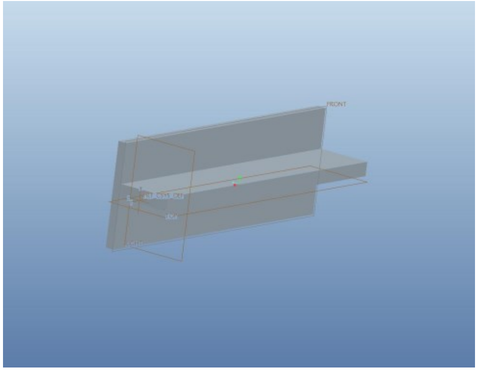
Rectangular Fin Model



Triangular Fin Model



Trapezium Fin Model



No Extension Fin Model

6. Thermal Analysis in ANSYS

Assigning Load and Constraints to the Meshed Model In this assign the material having thermal conductivity, convection coefficient of heat transfer for fluid, temperature of surface and ambient temperature as: Thermal conductivity, k = Variable for all material Convection coefficient of heat transfer, h = 25 W/m2 **Temperature** of wall surface at which fin attached, to = 773 K Ambient temperature, ta = 303 K The model is created in Pro-E and then is imported to ANSYS for analysis purpose. The model is created uniquely for each type of fin extension. Meshing is than done for ANSYS model. Boundary conditions and material properties are than defined. Thermal analysis is performed for various fin extension types. Analysis for Aluminum Alloy, Aluminum 1050 and Magnesium Alloy were analyzed for All Fin Extensions Shape.

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7. Results and Comparison

Table1: Result table for Aluminum Alloy Results

	Aluminum Alloy		
Fin Extension Type	Max Temp. Degree C	Total Heat Flux (W/mm²)	Directional Heat (Flux W/mm²)
No Extension	779.44	0.54052	0.5401
Circular	774.37	0.69237	0.69035
Rectangular	781.06	0.61714	0.47076
Triangular	804.89	0.7275	0.48743

Table2: Result table for Aluminum 1050 Results

	Aluminum 1050		
Fin Extension Type	Max Temp. Degree C	Total Heat Flux (W/mm²)	Directional Heat (Flux W/mm²)
No Extension	506.29	1.0314	1.0306
Circular	501.22	1.3212	1.3173
Rectangular	507.91	1.1776	0.89835
Triangular	531.73	1.3882	0.93013

Table3: Result table for Magnesium Alloy Results

	Magnesium Alloy		
Fin Extension Type	Max Temp. Degree C	Total Heat Flux (W/mm²)	Directional Heat (Flux W/mm²)
No Extension	506.29	0.70267	0.70212
Circular	501.22	0.90006	0.89742
Rectangular	507.91	0.80225	0.61198
Triangular	501.83	0.36421	0.24399

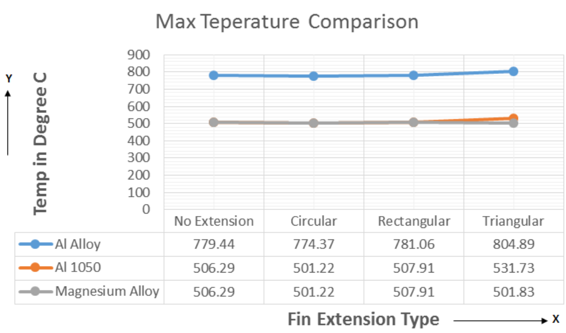

Fig 1: Comparison Graph for Maximum Temperature All Cases

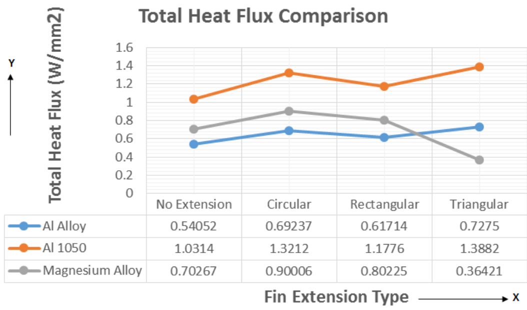

Fig2 : Comparison Graph for Total Heat Flux All Cases

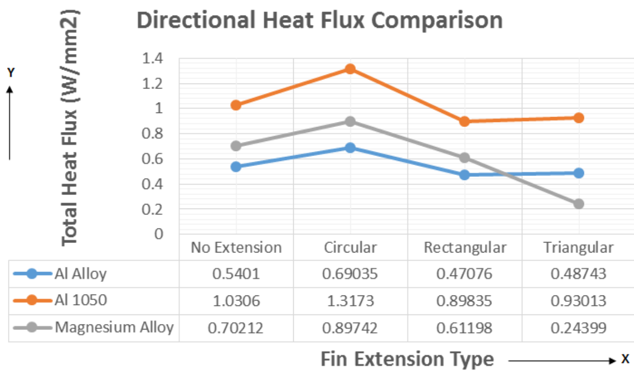

Fig3 : Comparison Graph for Directional Heat Flux All Cases

8. Conclusion and Future Scope

Conclusion

1. Heat transfer through fin with triangular extensions is higher than that of fin with other types of extensions, it is highest with Aluminum Alloy material.
2. Temperature at the end of fin with circular extensions is minimum as compare to fin with other types of extensions. It is same for AL 1050 and magnesium alloys.
3. The effectiveness of fin with triangular extensions is greater than other extensions.
4. Choosing the minimum value of ambient fluid temperature provide the greater heat transfer rate enhancement.

Future Scope

Fins with triangular and parabolic profiles contain less material and are more efficient requiring minimum weight.
An important consideration is the selection of the proper *fin length L.* Increasing the length of the fin beyond a certain value cannot be justified unless the added benefits outweigh the added cost.
The efficiency of most fins used in practice is above 90 percent.

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