

Experimental Analysis to Investigate the Thermal Performance of Different Types of Fin Geometry

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Abstract - The main aim of our project is to analyze the steady state thermal performance of various types of fin geometry. Fins geometry plays a vital role in heat dissipation. Different type of fin arrays used are rectangular, circular and trapezoidal fins. Experimental model is created to find out which fin geometry is most efficient. For heat dissipation parameters like density and thermal conductivity is taken into consideration for making fins. Surface area of each type of fin is kept same. This paper presents an experimental analysis of the results obtained by orientation of various fin geometry.

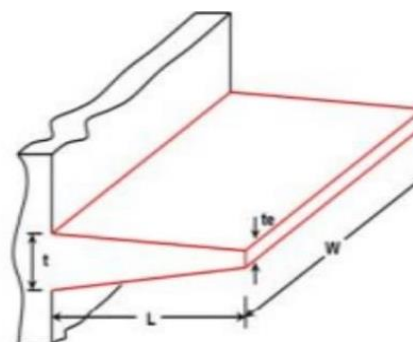
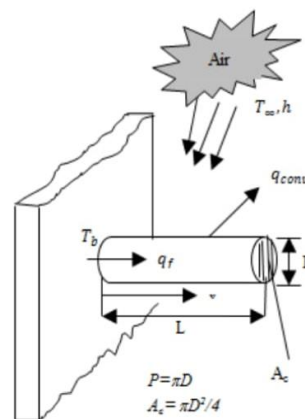
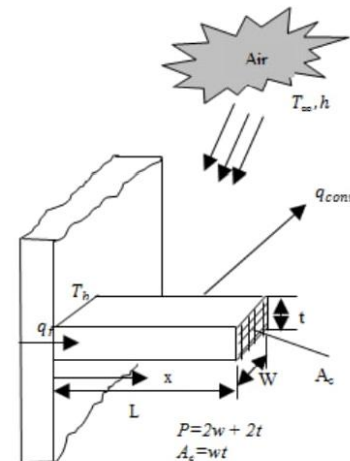
Key Words: Fins, Natural convection, Heat transfer coefficient, Efficiency, Effectiveness, Steady state thermal analysis.

1. INTRODUCTION:

In most of industries many mechanical equipment fails due to overheating. Thereby increasing maintenance cost. Hence a remedy for such failures is by increasing the heat transfer through fins. Fins are the extended surface used in air cooled system for increasing heat transfer rate. Fins are mostly used in cooling of generator, automobile engine, computer processor, aircraft engine and other electronic devices. The heat transfer rate depends upon external surface area, ambient temperature and surface geometry. Excess heat is dissipated with the help of heat sink. Without fins or extended surface modern air cooled automobiles engine could not run efficiently. Fins are mostly used for heat management and in electrical appliances such as computer power supply and other applications like semi-conductor devices, microcontroller and micro-processor. In fins heat transfer occurs by natural convection.

In some cases the fin itself block the base area of the surface and it acts as a resistance to heat conduction. Hence heat transfer from the base decreases. Thus it does not make sure that the heat transfer rate will increase or not by providing the fins on the base surface. This is determined by term called fin effectiveness.

In natural convection, the motion of fluid takes place by means such as buoyancy. Because the velocity of fluid associated with natural convection is relatively low, heat transfer coefficient associated in natural convection is also low. Natural convection on a surface depends on orientation, the geometry of the surface, variation of temperature on the surface and thermodynamic properties of the metal



1.1 Objectives

The objectives of this research can be listed as:

- To analyze and compare efficiency of different types of fins.
- To determine steady state thermal properties of different geometries.
- To calculate the optimum heat transfer rate using different geometrical shape fin.
- To conclude which type of fin is most efficient
- To determine the type of geometry and its dimension for optimum heat transfer rate.

1.2. Problem Definition

In recent years cooling devices have become a crucial component in electronic part and internal combustion engine. Tradition style heat sinks are inadequate for advance devices, which dissipate large amount of heat and power.

Fins can be used for following application compared to traditional style heat sinks.

- 1) Cylinder heads of IC engines by air cooling.
- 2) Automobile radiator.
- 3) Economizer of steam power plant.
- 4) Cooling of transformers, electrical equipment.

The determination of optimum fin geometry and material is necessary for cooling above components according to this study. In simulation pin-fin geometries like rectangular, circular taper, etc. and different material such as copper, aluminium and stainless steel may be analyzed.

LITERATURE REVIEW:

1. V Naga Raju, P. Sibakumar investigated a steady state thermal analysis of heat sink with fins of different geometry by using solid works and ANSYS. Analyzed the effect of pin-fins shapes on performance of heat sink for professor (CPU AND GPU) .Designed different geometrical fins and determine the total heat flux, Temperature, Distribution and direction of heat flux.
2. N.A Nawale, A.S Pawar has studied heat transfer through fins having notches. Experimentally to investigate the performance of fins .Heat transfer coefficient of fin with notches and without notches is obtained. It is proved that the set of fins with triangular notches has highest heat transfer coefficient ($6.9541 \text{ W/m}^2\text{K}$). Their concept can be implemented to the application where the fins are used as D.C. motors, I.C. engines heat exchangers, microprocessors, etc.

3. N. Sethurman, Dr.P. Mathiazagan, M. Jayamoorthy S. Vinod Raj (2015) investigated heat transfer rate and temperature distribution of different Fin geometry using simulation method and experiments parabolic fin, Triangular fin ,Rectangular, Trapezoidal and Cylindrical fin are analyzed by measuring temperature distribution for three different power inputs and for different fin material in fluents.
4. Athuman Samila Joel ,Usman Aliyu El-nafaty has studied the effect of fin geometry and cooling process of computer microchips through modeling and simulation for fins of uniform cross-section area, effect of MCM power on heat dissipation per unit volume of fin, MCM Power (Watt) Vs optimum number of fins are plotted graphically using Matlab programming language.
5. Ramkrushna S.More ,Rajan I.Mehta ,Vaibhav A.Kakade had review study of natural convection heat transfer on heated plate by different types of fin array .This paper provides the background of fins to carry out further research work in future.
6. Mayank Jain, Mahendra Sankhala (2017), had analyzed and optimized heat transfer rate of fins by variation in geometry, Rectangular fin with rectangular and trapezoidal extension and without extension and triangular fin are analyzed in ANSYS and theoretical calculation, triangular fins are more efficient is proved.

MATERIAL SELECTION:

Aluminum is silver colored, low density metal that finds use in variety of commercial applications. Aluminum is mostly used in both wrought and cast forms. Because of low density of aluminum it is extensively used in aerospace industry, automobile industry and other transportation field.

Due to its resistance to corrosion it is widely used for making of fins. And hence due to which its maintenance cost is reduced. Due to high thermal conductivity of aluminum material compare to other material it can be used for effective heat transfer.

Thermal conductivity of copper is slightly higher than that of aluminum but due to its high density it cannot be used in automobile industries whereas aluminum can be used. Also copper is more expensive than aluminum and hence to reduce the capital cost aluminum is preferred.

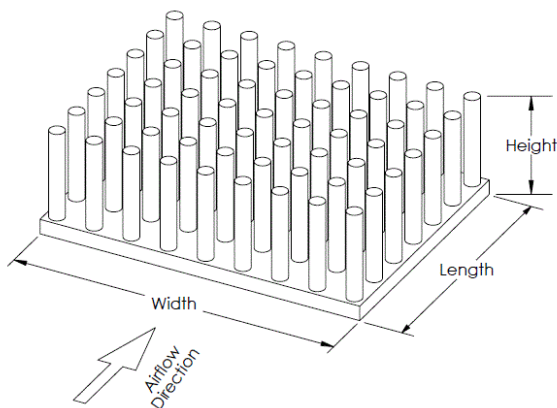
And hence in our project we are using aluminum metal as fin material.

PROPERTIES	UNITS
DENSITY	2704 Kg/m ³
THERMAL CONDUCTIVITY	205 W/mK
HEAT TRANSFER COEFFICIENT	64W/ m ² K
MELTING POINT	643-660°C
HARDNESS BRINELL	12-55
SPECIFIC HEAT CAPACITY	0.900-0.904J/g°C

METHODOLOGY

DESIGN AND DEVELOPMENT OF EXPERIMENTAL SETUP

- The experimental setup consist of aluminum alloy 6063 as the chamber & fin material.
- Designing of different geometry of pin-fin.
- The rectangular fin was machined to thickness of 10 mm and 20 mm from the root of fin.
- The circular fin was machined to a diameter 5.64 mm & length of 22.57 mm from root of fin.
- Chamber is manufactured with thickness of 5 mm.
- 200 watt bulb is used as heat source to the setup.
- Temperature at different parts of the fin are measured with the help of digital thermocouples.
- Cotton wool, wooden lid are provided for insulation.
- To check thermal analysis of different pin-fin geometry experimentally
- Finding most efficient among different shape fins using thermocouples



EXPERIMENTAL PROCEDURE

- The experimental procedure is very simple , quick and straight forward to carry out.

- First turn on the energy source and adjust the bulb at the center of the chamber till it obtains desired heating level
- When system reaches required steady state conditions and temperature the source is turned off and wooden lip (insulation) is placed immediately above the chamber.
- Using thermocouple the axial temperature at fin root & fin tip are measured at every 30 second interval.
- The readings are tabulated.
- Also the temperature inside the chamber at regular intervals are measured using thermocouple & are noted.
- Experiment are carried out at ambient temperature.
- Surrounding air temperature is also measured using digital temperature indicator.

ASSUMPTIONS

1. Thermal conductivity of material is constant that is material is isotropic.
2. No internal heat generation occurs within the fins.
3. Heat transfer coefficient is uniform over the entire surface of the fin.
4. Experiment is carried out at room temperature.
5. Under steady state, heat conduction is along x-axis.
6. Surface area of each type of fin is equal.

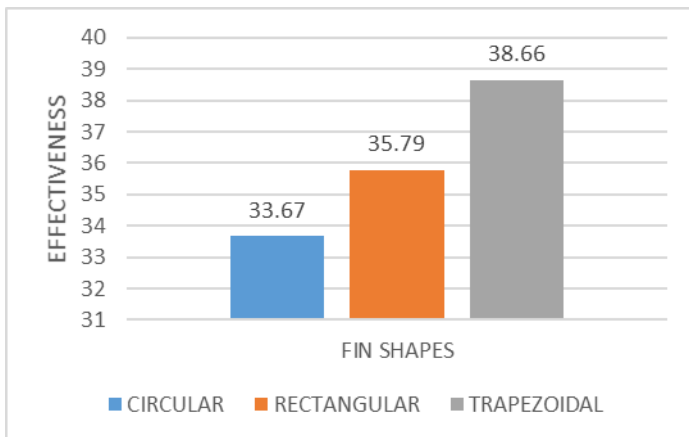
CONCLUSION:

The steady state thermal analysis of fins by modifying its certain parameters such as geometry has been completed.

The theoretical calculation done to determine the heat loss, effectiveness and efficiency of the fins are well supported by the practical results.

By observing the analysis results, we can easily say using triangular fin with material aluminum alloy is better, since the temperature drop and the heat transfer rate in trapezoidal fin is much more compared to the others.

The second geometry that gave the good result is a pin fin geometry while the rectangular fin geometry is least effective among the considered other geometries. From the experimental analysis it has been observed that the temperature distribution for the triangular fins is more uniform then the fins of different geometry having the same base temperature.



FUTURE SCOPE:

- The modification of the fin shape along with perforation i.e. holes or interruption may be provided to improve the heat transfer and can be analyzed.
- As we know that the technologies is improving day by day, there is need for the development in the pin-fin for increasing the heat transfer rate and various parameters.
- The different types of fins and their array, plays an important role in that transfer , Gap between the fins , Thickness of fin and their orientation may be varied for future scope.
- The result obtained after the completion of this project, can be applied for various large scale applications such as fins for air cooled automobile engines which can help in considerable increase in its efficiency and life.
- This concept is followed by number of researches for their application .But still lot many work remains to be carried out in the future. The background of fin is provided in their paper to carry out future research work in future.

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