DESIGN AND ANALYSYS
OF STRAIGHT AND CURVED FINS

An Internal Project report submitted in partial fulfilment of the requirement for the award of the degree of

BACHELOR OF TECHNOLOGY
IN
MECHANICAL ENGINEERING

Submitted by

S. GOWTHAM	**318126520049**
V. HARISH NAIDU	**318126520056**
V. JAYA KRISHNA	**318126520057**
A. RAVI TEJA	**318126520005**
M.MANISH KUMAR	**318126520027**

Under the Esteemed Guidance of

Prof.T.V.HANUMANTHA RAO, M.Tech, Ph.D., F.I.E

Mr. J. V BHANUTEJ, MTech, (Ph.D.)

Assistant Professor

DEPARTMENT OF MECHANICAL ENGINEERING

ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES(A)

(Affiliated to Andhra University, Approved by AICTE, Accredited by NBA, NAAC)

SANGIVALASA, VISAKHAPATNAM (District) – 531162.

2022

ANIL NEERUKONDA INSTITUTE OF TECHNOGY & SCIENCES &TECHNOLOGY

(UGC Autonomous & Affiliated to Andhra University)
Sangivalasa, Bheemunipatnam (M), Visakhapatnam (Dt)

PRAGNANAM BRAHMA
ANITS

CERTIFICATE

This is to certify that the Project Report entitle **"DESIGN AND ANALYSYS OF STRAIGHT AND CURVED FINS"** has been carried out by **S. GOWTHAM (318126520049), V.HARISH NAIDU (318126520056), V.JAYA KRISHNA (318126520057), A. RAVI TEJA (318126520005), M.MANISH KUMAR (318126520027)** under the esteemed guidance of **Prof T.V.Hanumantha Rao** and **J.V BHANU TEJ**,in partial fulfilment of the requirements for the award of the Degree of Bachelor of Technology in Mechanical Engineering by Andhra University,Visakhapatnam

APPROVED BY

25.5.22

Dr. B. NAGA RAJU
Head of the department,
Dept. of Mechanical Engineering
ANITS, Sangivalasa,
Visakhapatnam.

PROFESSOR & HEAD
Department of Mechanical Engineering
ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCE
Sangivalasa-531 162 VISAKHAPATNAM Dist A.P

PROJECT GUIDE

Dr. T. V. HANUMANTHA RAO
Professor
Dept. of Mechanical Engineering,
ANITS, Sangivalasa,
Visakhapatnam

J.V.Bhanu Tej 25/5/22

Mr. J. V BHANUTEJ
Assistant Professor
Dept. of Mechanical Engineering,
ANITS, Sangivalasa,
Visakhapatnam.

THIS PROJECT IS APPROVED BY THE BOARD OF EXAMINERS

INTERNAL EXAMINER

27.5.22

PROFESSOR & HEAD
Department of Mechanical Engineering
ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES
Sangivalasa-531 162 VISAKHAPATNAM Dist A P

EXTERNAL EXAMINER

27/5/22

ACKNOWLDGEMENT

We express immensely our deep sense of gratitude to Dr. **T.V.Hanumantha Rao,** Professor and **Mr. J. V BHANU TEJ**, Assistant Professor, Department of Mechanical Engineering, Anil Neerukonda Institute of Technology & Sciences, Sangivalasa, Bheemunipatnam Mandal, Visakhapatnam district for his valuable guidance and encouragement at every stage of the work made it a successful fulfilment.

We are very thankful to Professor **T.V.Hanumantha Rao**, Principal. Dr.**B.NagaRaju,** Head of the Department, Mechanical Engineering, Anil Neerukonda Institute of Technology & Sciences for their valuable suggestions.

We express our sincere thanks to the members of non-teaching staff of Mechanical Engineering for their kind co-operation and support to carry on work.

Last but not the least, we like to convey our thanks to all who have contributed either directly or indirectly for the completion of our work.

S.GOWTHAM	(318126520049)
V.HARISH NAIDU	(318126520056)
V.JAYA KRISHNA	(318126520057)
A.RAVITEJA	(318126520005)
M.Manish Kumar	(318126520027)

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF GRAPHS

ABSTRACT

Fins are commonly used for augmentation of heat transfer from thermal systems, various gases are the working fluids. The thermal properties of gases are generally poor and therefore the convective heat transfer coefficients are less. Hence as heat transfer enhancement technique, extended surfaces in the form of fins are used which provide higher heat transfer surface areas. Fins are therefore regarded as a common devices heat has to be dissipated.

A series of fins commonly known as heat sinks are adapted in various thermal appliances the computer and other electronic systems, where large chunks of heat generated have to be dissipated. This project is mainly concerned with developing unconventional fins as a substitute to the conventional rectangular fins.

Heat Transfer analysis of curved fins was carried out in this work which can be a substitute for a normal rectangular fins as heat sinks. A detailed evaluation of temperature distribution and heat flux rates with heat sinks made up of curved fins is accomplished and compared with the rectangular fins. This objective was fulfilled for three different types of materials mainly copper, aluminium , magnesium. The entire project was done using CATIA platform for modelling and ANSYS for finite element analysis.

It was observed from the analysis that curved fins are better option than the regular fins as it has been demonstrated by this work that their heat transfer dissipating characteristics are far more superior. The augmentation heat transfer when compared with regular rectangular fins was found to order of 5:6.

CHAPTER 1

INTRODUCTION

1.1 Fins

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. The amount of conduction, convection, radiation of an object determines the amount of heat it transfers. Increasing the temperature difference 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 economical or it is not feasible to change the first two options. Adding a fin to the object, however, increases the surface area and can sometimes be economical solution to heat transfer problems. Circumferential fins around the cylinder of a motor cycle engine and fins attached to condenser tubes of a refrigerator are a few familiar examples. Automobile Fin the temperature distribution within an SI engine is extremely important for proper engine operation to maximize the thermal efficiency of an engine; it has to be operated at specific thermal condition. This condition is controlled by cooling process of fins that tends to remove the heat that is highly critical in keeping an engine and engine lubricant from thermal failure and thermal effects. Actually, Fins are provided because, they provide a channel for cooling the engine whenever it gets hot. Fins doesn't let the engine to burn out. The fins provided on the engine cylinder depends on the capacity of the engine. Higher the capacity of the engine, a greater number of fins provided on the surface of the engine block.

1.2 Classification of Fins of Various Shapes:

Many of researchers investigated variable outcomes in analysis of fin by performing numerical simulation, mathematically and experimentally, the survey had been done on different types of fin shape to predict behaviour of heat dissipation and temperature distribution , further material of fin is changed to predict behavior of heat Analysis and Comparison of Two Wheeler Bike Engine Fins flux and temperature distribution including different shapes of fin, the effect of convection condition with conduction on fins were analyzed for improvement in higher heat dissipation , natural convection analysis had been performed in fins using software simulation with finite element method for determination of high thermal effect and compared outcome results obtained by variable parameters the potency of different fins by optimizing their form were reviewed for prediction of thermal efficiency, the review is also done for prediction the thermal effects on fins by analysis is performed in ANSYS software by applying parametric evaluation and determined optimum dimensions for effective cooling performance.

1.3 Structure of Fin

The structure of fin supports in effectiveness of heat dissipation, many researchers have proposed different shape of fins and predicted the heat transfer effectiveness in different heat flux as well as parametric evaluation have been performed by varying fin thickness, fin spacing and length of fin, the different type of fin structures are:

1.4 Types of Fin:

1. Longitudinal fin
2. Radial fin
3. Pin fin
4. Curved fin

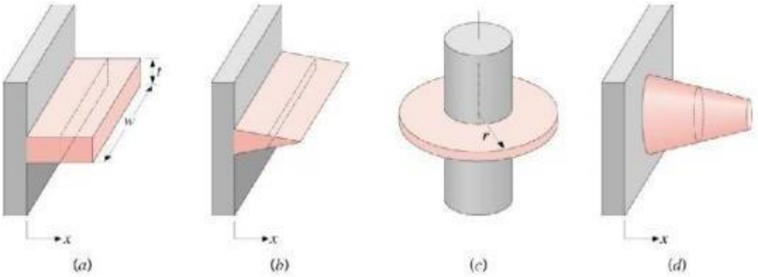


Fig 1.1 a) Rectangular b) Varible c) Radial d) Taper

Fig 1.2 Longitudinal Fins

Fig 1.3 Curved fin

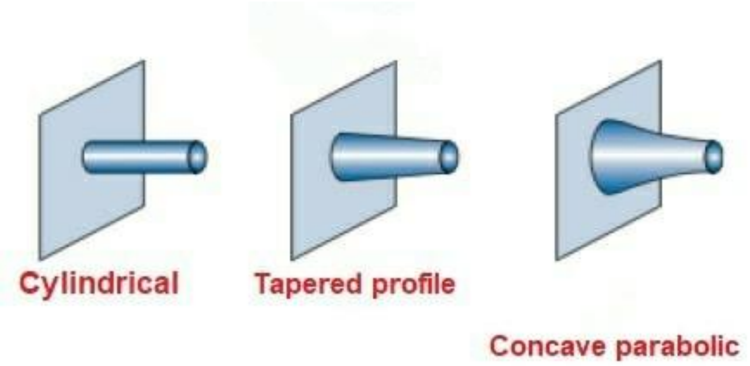


Fig 1.4 Pin Fin

1.5 Steady State Thermal Analysis

Steady-state thermal analysis is evaluating the thermal equilibrium of a system in which the temperature remains constant over time. In other words, steady-state thermal analysis involves assessing the equilibrium state of a system subject to constant heat loads and environmental conditions. The simplest form of steady-state analysis is linear steady- state analysis in which input parameters, such as material properties, are prescribed independent variables.

Real systems exhibit non-linear steady state behaviour. Non-linear steady state analysis is where input parameters are inter-dependent. In such cases, a solver must iterate to find a steady-state solution to the governing equations that satisfies the input parameters. Examples of systems with non-linear characteristics include those with temperature-dependent thermal conductivity, radiation, or natural convection.

For many simulations, steady-state thermal analysis can be used to design and evaluate systems, even throughout the final stages of the design process. For example, steady-state thermal analysis can be used when simulating a server’s thermal state, which typically remains constant over time. Steady state thermal analysis is also beneficial when used to guide early design and prototyping efforts with quick feedback for simple models. It facilitates design decisions for typical operating conditions and acts as a baseline for transient analysis of controls and failure analysis.

1.6 Assumptions of Fins :

The following assumptions are considered for solving the problem,

1. Fin material is assumed as homogeneous.
2. Steady state one dimensional heat conduction.
3. No heat generation within the fin.
4. Uniform heat transfer over the entire surface of the fin.
5. Negligible contact resistance.
6. Thermal conductivity of material is same in all direction and assumed to be constant.
7. Ambient temperature surrounds the fin uniformly.
8. The temperature of the surrounding air do not change significantly.
9. Temperature at the base is uniform.
10. Negligible radiation.

1.7 Applications Of Fins

Natural Convection is caused by temperature variations in the fluid. Natural convection from heat sinks has long been used for thermal management of low-power-density devices. This cooling technique has many advantages such as the absence of moving parts, of power consumption, and of maintenance necessity. In addition, it offers quiet operation, high reliability, and low cost. For these reasons, natural convection heat transfer plays an important role in many types of cooling systems including electronic industry which has attracted constant researches for decades. Some applications can be listed as:

- Economizers for steam power plant
- Electrical transformers and motors
- Convectors for hot water and steam heating system
- Air cooled cylinders of aircraft engines, I.C. engines and air compressors
- Cooling coils and condenser coils in refrigerators and conditioners

1.8 Materials

1.8.1 Copper

Copper is known for having good thermal properties, coming a close third behind diamond,then silver in terms of measured thermal conductivity of naturally occurring materials. The typical thermal conductivity of pure copper is 386.00 W/(m·K) at 20 degrees Celsius.

This means that heat passes quickly through the metal. This is due to the close lattice structure of the copper atoms that vibrate more as the temperature rises, transferring heat internally.

Copper also has a high melting point (1,085°C), making it ideal for high-temperature applications such as bases for cooking implements like saucepans, heat exchangers in boilers and heat sinks in electrical equipment.

1.8.2 Aluminium

Aluminum is lightweight, durable, malleable and corrosion-resistant. This metal is widely used for components in the aerospace, transportation and construction industries

- Non-corrosive
- Easily machined and cast
- Lightweight yet durable
- Non-magnetic and non-sparking
- Good heat and electrical conductor

1.8.3 Magnesium

Magnesium is used in products that benefit from being lightweight, such as car seats, luggage, laptops, cameras and power tools. It is also added to molten iron and steel to remove sulfur. As magnesium ignites easily in air and burns with a bright light, it's used in flares, fireworks and sparklers.

Magnesium alloys are also used in other industries where lightweight, sturdy alloy applications are crucial, such as in chainsaws and machinery parts, and in sporting goods like baseball bats and fishing reels.

MATERIAL	PROPERTY	VALUE
Aluminium	DENSITY	2770 Kg/m^3
	YOUNGS MODULUS	7.1*10^10 Pa
	POISSONS RATIO	0.33
	BULK MODULUS	6.9608*10^10 Pa
	THERMAL CONDUCTIVITY	237 W/m-K
	SPECIFIC HEAT	875 J/kg-k
Copper	DENSITY	8920 kg/m^3
	YOUNGS MODULUS	100 GPa
	POISSONS RATIO	0.33
	BULK MODULUS	129 GPa
	THERMAL CONDUCTIVITY	398 W/m-K
	SPECIFIC HEAT	384 J/kg-K
Magnesium	DENSITY	1800 kg/m^3
	YOUNGS MODULUS	4.5*10^10 Pa
	POISSONS RATIO	0.35
	BULK MODULUS	1.66*10^10 Pa
	THERMAL CONDUCTIVITY	156 W/m-K
	SPECIFIC HEAT	1024 J/kg-k

Table 1.1 Properties of Materials

1.9 Objective of Project:

The crux of the project is to study the enhancement in heat transfer that can be obtained by using curved fins instead of rectangular fins. The augmentation in heat transfer is also studied through using analytical softwares. The purpose of using curved fins is to increasing the rate of

heat transfer comparatively more and analyzed using analytical softwares.

CHAPTER 2

LITERATURE SURVEY

Fins find a wide range of applications in mechanical, electrical and electronic devices ranging from computers to heat transfer devices that are used in process palnts, power plants, aeronautics etc. There has been an intensive and extensive study or on the usage of fins in a wide spectrum of applications. The studies included were related to the geometry of fins, heat transfer, boundary condition etc. A few of the papers from the literature are reviewed as given below:

2.1 Literature Review

Pulkit Sagar [1] has analyzed the heat transfer rate by varying the shape and surface roughness of fins. The model are created by varying the shape and roughness of the fin in AUTODESK INVENTER (2015) and simulated in AUTODESK NASTRAN (2015). The main aim of this paper is to study following effects on the heat transfer through fins in motorcycle and other motor power vehicles by changing the geometry. Fins may be consider as a form of heat exchanger that represents the flow of heat transfer from a medium to the atmosphere here several research have been done and the main motive of this paper is to attain the goal of particular study and then to examine in which field of operations is to be carried out. The object of this study is to analyze various studies and establish the best approaches of them so initially Jain and Aurangabadkar analyzed heat transfer and optimization of fins by variation in geometry they examined heat transfer coefffient through fins through various geometries which were rectangular, circular and triangular with rectangular and trapezoidal extensions.

Pardeep Singh [2] had done this research, the heat transfer performance of fin is analyzed by design of fin with various extensions such as rectangular, trapezium, curved 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.

Viveksheel Yadav [3] has noticed that fins with curved or notches gives the best results reducing in cost of the material so here in this paper we have discussed various designs of fins with detailed research papers to study the optimized heat transfer rate with different materials. Material also plays an important role so for dissipation of heat process

M.J. ALshukri [4] This study is a numerical study. It investigates the steady state flow of fluid by natural convection in three dimensions as well as the transfer of heat for a set of innovative shapes of fin array. This study utilized four different shapes of fin array as well as the absence of fins. The different forms are as follows: straight, vertical (sine wave along y-axis), horizontal (sine wave along z-axis) and sweep (sine wave along both y and z axis). We examined the following parameters of the fin: geometrical dimension and thermal properties. In the steady state thermal analysis, an analysis of the differences in temperature regarding the distance at which heat flow takes place through the fin is carried out using CFX Ansys 15. The result shows that the sine wave along z-axis increases the transfer of heat more than the fin array of other shapes. Nusselt number increased as a result of the increasing heat flux which is exerted on the base as a boundary condition.

Pradeep Kr. Kurmi [5] The Engine cylinder is one of the primary engine elements, that is subjected to excessive temperature variations and thermal stresses. Fins are placed on the surface of the cylinder to enhance the amount of heat transfer by convection. For thermal analysis of the engine cylinder fins, it is more beneficial to know the heat dissipation inside the cylinder. Present study has been done to enhance knowledge about the various researches done in recent years which show that heat transfer by fins depend upon on variety of fins, fin pitch, fin layout, wind velocity, fabric and climate situations. Literature survey shows that heat transfer is enhanced through extended surfaces and the heat transfer coefficient is affected by changing cross section of the fins. This study is useful to recognize the better geometry and material for the fins for higher heat dissipation rate and engine cooling.

Charan et. al. [6] 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. From research study, it shows that Nusselt number increases for perforated fin when compared with non- perforated fin. Therefore it is concluded that a three triangle laterally perforated aluminum is most suitable for the fin applications.

Sangaj et. al. [7] 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. The main aim of the work is to optimize the thermal properties by varying geometry, material and thickness of fins. The present work is successfully carried out by comparing various parameters (shape, geometry, material) of pin-fin. The different types of shape and material have been chosen for the comparison. Analysis has been carried out in ANSYS. From above two cases it is found that copper circular hollow pin-fin and copper rectangular pin-fin are the most optimum pin-fins.

Beldar et. al. [8] 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. In area not compensated fin array though area of fin will decrease still heat transfer increase. with compensation fin array the central material of fin is exposed to fresh cold air again it is found that heat transfer is increasing. After provision of notch at the central portion of fin leads to change of flow pattern of natural air, increase in the air velocity across channel, Variation of air pressure across channel and increase of air temperature in cylindrical heat sink.

Rajesh et. al. [9] 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. The analysis was done using ANSYS. By doing thermal analysis on the engine cylinder fins, it has been concluded that it is helpful to know the heat dissipation inside the cylinder.

Jain et. al.[10] 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. It is discussed that presently material which is used for manufacturing fin body is generally Aluminum Alloy 204 which has thermal conductivity of 110-150W/m-^{0}C. After determining the material, the third step is to increase the heat transfer rate of the system by varying geometrical parameters such ascross sectional area, parameter, length, thickness, etc. which ultimately leads us to fins of varying shape and geometries.

Kummitha et. al. [11] studied thermal analysis of cylinder block. The thermal analyses were performed with variousalloys 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. [12] 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 computerpc, which uses a 5 W CPU. The design was able to cool the chassis with heat sink joined to the CPU whichwas 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.

Sandeep Kumar et. al. [13] Studied heat transfer rate from the heating zone in IC engine, for that transient thermal analysis have been performed on actual design of Bajaj discover 125 CC single cylinder engine. Transient thermal analyses were performed for actual and proposed design of engine cylinder in order to optimize geometrical parameters and enhanced heat transfer from the IC engine. Result revel that the proposed designof IC engine has better performance and heat transfer rate from the heating zone in the IC engine that is why the result of present work are found to be more concentrated on it and also proposed replacement of new design. Transient thermal analysis has been performed on actual design and also on two different geometrical designs at ambient temperature of 25 ^{0}C.

Mogaji et. al. [14] performednumerical analysis of heat flow through fin of a rectangular profile surface with and without considering radiation heat loss. The effects of physical parameters which include: length, L, thickness, t, fin metal type and emissivity, å, on the fin thermal performance have been comparatively studied. It was observed that heat dissipation rate for the fin with thermal radiation was higher than those without thermal radiation independently of the fin type metal considered in the study. For studying the effect of increasing the fin material emissivity subjected to the cases of considering radiation, heat loss, appreciable enhancement of the fin thermal performance was observed for aluminium and copper materials compared to stainless steel material.

Arefin [15] introduced modified pin design for pin fin heat sink where the pins have been expanded outward. After that, thermal analysis of the conventional pin fin heat sink and the modified pin fin heat sink has been conducted numerically for natural convection for circular shape in inline arrangement assuming steady state condition. The modified pin fin heat sink has been observed to perform better than the conventional ones. For this numerical thermal analysis has been used with the help of Solidwork. The proposed model of the modified pin fin heat sink has been created in a virtual environment. The conventional model of pin fin heat sink was also created in the same environment for comparison. Thermal analysis of the conventional model and the modified model was conducted and compared successfully.

Balendra et. al. [16] performed experimental analysis and simulation for rectangular unnotched fin and validated it for different thermal loads. After that the authorsworked for different forms of constant area as an inverted notched fin. All above result of the distribution of temperature, velocity vector plot, Nusselt no. and the heat transfer coefficient, it was concluded that the heat transfer coefficient increased continuously in all cases but inverted triangular notched fin gave maximum heat transfer rate. Inverted trapezoidal notched fin gave 6.08 W/m2°k heat transfer coefficient which was better than inverted rectangular notched fin which give 5.67 W/m2°k heat transfer. As per the result, it is concluded that heat transfer rate of inverted triangular notched fin has been increased by almost 50.51% as compared to rectangular unnotched fin.

Kongre et. al. [17] analyzed the temperature distribution by varying geometry and thickness of cylinder fins using ANSYS workbench. By doing experimental work on array of perforated fins of solid Vs square & circular perforation it is observed that; Nusselt number of solid as well as perforated fins increase with increase in Reynolds number. Also for same size of perforations square perforations give slight higher percentage of effectiveness improvement in square holes than circular. Thus the authors concluded that even though the attempts have been made to modify several parameters related to fin for HT augmentation, but still there is a vast scope for fin designmodification.

From the literature survey,it was concluded that a study on curved fins could be defined as this particular topic has received little attention

CHAPTER 3

THEORETICAL DESIGN AND CALCULATIONS

3.1 Theoretical Design

Design theory has been approached and interpreted in many ways from personal statements of design principles, through constructs of the philosophy of design to a search for a design science. In this design we have calculated the heat flux for fins of different geometries .The required heat flux calculations are also done for different shapes of fins .

In this theoretical design we will know all the required parameters to calculate the heat flux for the rectangular fin. In order to analyze the heat flux for fins of various shapes we have decided to do the project.

3.2 Boundary Conditions:

Variables	Units	Value
Heat Transfer Coefficient	W/m^2-K	**16**
Ambient Temperature	K	**295**
Power Input	W	**50, 100, 150**

Table 3.1 Boundary conditions

$T_b =$ base temperature of the body

$h_l =$heat transfer coefficient

$Q =$ heat dissipated

$p =$perimeter of the fin

T_∞ =ambient temperature

$k =$ thermal conductivity of aluminium

$A =$Cross section area of the fin

$L =$Length of the fin

3.3 Heat Flux Calculation :

RECTANGULAR FIN (At 50 Watts)

$$T_b = 117^o c,\ T_\infty = 22^o c$$

$$h_l = 16\ w/m^2,\ k = 237\ w/(mK)$$

$$L = 62.8mm$$

$$p = 2(w+h) = 2(60+5) = 130mm$$

$$A = (w*h) = (60*5) = 300mm^2$$

$$m = \sqrt{\left(\frac{hp}{kA}\right)} = \sqrt{\left(\frac{16*0.130}{237*0.3*10^{-3}}\right)} = \sqrt{29.25457} = 5.40874$$

$$Q = (T_b - T_\infty)\left\{\frac{\tanh(ml) + (h_l/mk)}{1+\left(h_l/mk\right)\tanh(ml)}\right\}(hpkA)^{0.5}$$

$$Q = (117-22)\left\{\frac{\tanh(5.40874*0.0628) + \{\frac{16}{(5.40874*237)}\}}{1+\left(\frac{16}{(5.40874*237)}\right)\tanh(5.40874*0.0628)}\right\}\sqrt{(16*0.130*237*0.3*10^{-3})}$$

$$= 95*\left\{\frac{0.339663}{1.0040838}\right\}*0.3845620\ W$$

$$= 12.35857092\ W$$

$$Heat\ flux = \left\{\frac{Q}{A}\right\}$$

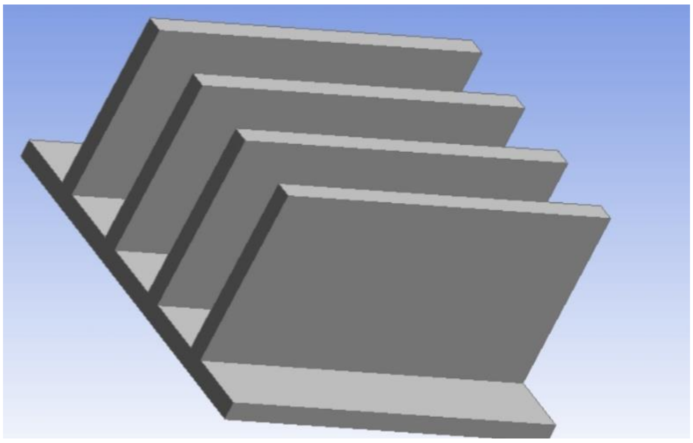
$$= \left\{\frac{12.35857092\ W}{80*10^{-3}*60*10^{-3}\ m^2}\right\}$$

$$= 2574.702274\ W/m^2$$

For 4 no.of Fins,

$$Heat\ flux\left\{\frac{Q}{A}\right\} = 4*2574.702274\ W/m^2$$

$$= 10,298.8091\ \ W/m^2$$



For Aluminium

Heat flux=10,298.8091 W/m^2

For Copper

Heat flux=10401.382 W/m^2

For Magnesium

Heat flux=10150.765 W/m^2

Hence the heat flux of rectangular fin for different materials are calculated. The dimensions are in S.I unit. Hence the theoretical design is done by the above calculations. The design is to formulate a plan for the satisfaction of a special need or to solve a problem.

CHAPTER 4

3D MODELLING OF FINS

4.1 Introduction

CATIA is 3D CAD modelling software used to design, visualize, and test product ideas. It allows you to create product prototypes that accurately simulate the weight, stress, friction, driving loads, and much more of products and their components in a simulated 3D environment. It enables the Creation of 3D parts, 3D sketches, sheet metal, composites and moulded for or tooling Parts up to the definition of mechanical assemblies

It provides took to complete product definition, ink hiding functional tolerances, as well as kinematics definition CATIA provides a wide range of applications for tooling design, for both generic tooling and mold & die. In the case of Aerospace engineering an additional module named the aerospace Sheet metal design offers the user combine the capabilities of generative Sheet metal design and generative surface design.

The main features of CATIA are

- It allows 2D and 3D data integration in a single environment, creating a virtual representation of the final product that enables users to validate the form, fit, and function of the product before it is ever built.
- It includes powerful parametric, direct edit and freeform modelling tools as well as multi translation capabilities and in their standard drawings.
- It uses Shape geometric modelling . Catia competes directly with Solid Works, Solid Edge, and Creo.
- The automatic updating feature allows easy changes in models.
- With Catia prototyping can be accomplished easily by integrating 2D AutoCAD drawings and 3D data into a digital model which will serve as a virtual representation of the final product.
- By doing so, engineers are able to better design and simulate products without the need to create physical prototype.

4.2 Procedure

Step 1: Sketcher Module

The Sketcher workbench is a set of tools that helps you create and constrain 2D geometries. Features (pads, pockets, shafts, etc...) may then be created solids or modifications to solids using these 2D profiles. You can access the Sketcher workbench in many ways. Two simple ways are by using the top pull down menu (Start – Mechanical Design – Sketcher), or by selecting the Sketcher icon. When you enter the sketcher, CATIA requires that you choose a plane to sketch on. You can choose this plane either before or after you select the Sketcher icon. To exit the sketcher, select the Exit Workbench icon
The Sketcher workbench contains the following standard workbench specific toolbars:

- **Profile toolba**r: The commands located in this toolbar allow you to create simple geometries (rectangle, circle, line, etc...) and more complex geometries (profile, spline, etc...).
- **Operation toolbar:** Once a profile has been created, it can be modified using commands such as trim, mirror, chamfer, and other commands located in the Operation toolbar.
- **Constraint toolbar:** Profiles may be constrained with dimensional (distances, angles, etc...) or geometrical (tangent, parallel, etc...) constraints using the commands located in the Constraint toolbar.
- **Sketch tools toolbar:** The commands in this toolbar allow you to work in different modes which make sketching easier.

Step 2: Part Design Module

Part design environment is used to create 3D models from the basic 2D sketches created in sketcher environment.

- creating the base part 2D sketch
- converting 2D sketch to required 3D model by using features like extrude, extrude cut, revolve, sweep, chamfers, fillets, holes, spiral etc.
- Saving the file with desired part name.

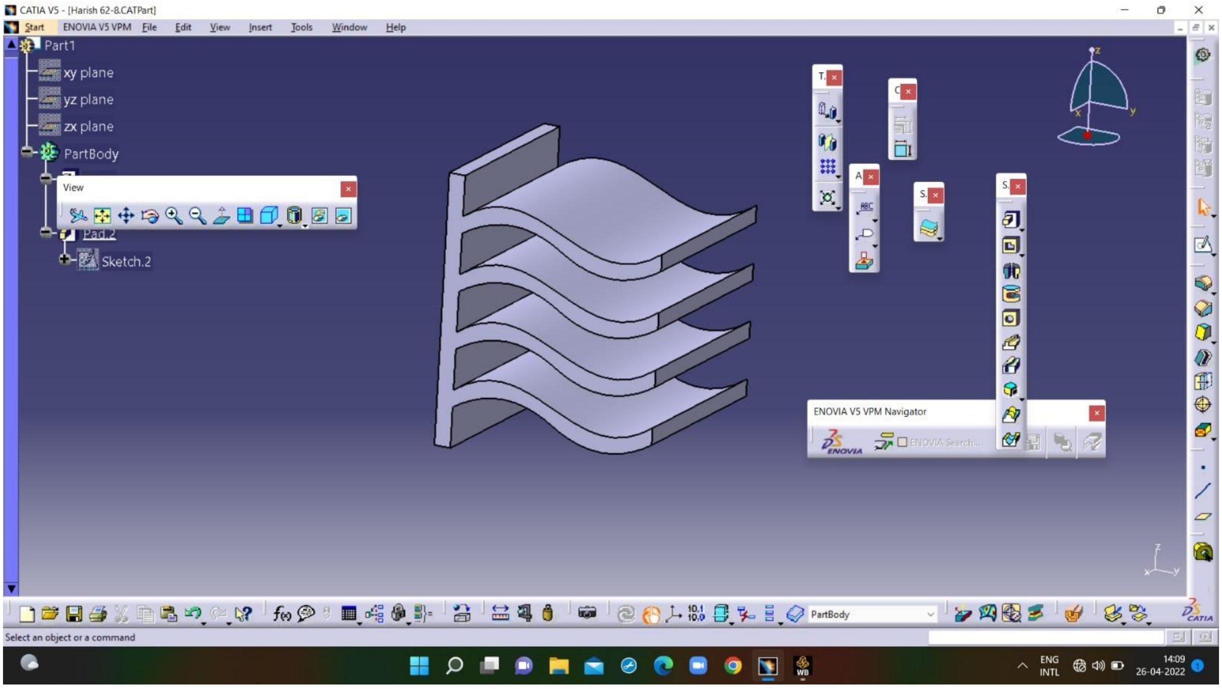


Fig 4.1 Curved Fins Design in CATIA

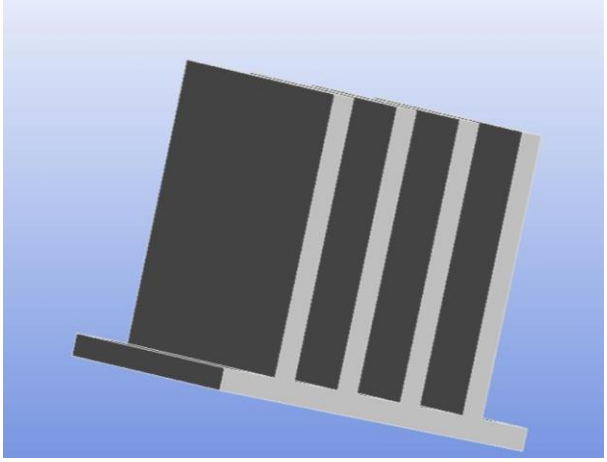


Fig 4.2 Straight Fins Design in CATIA

CHAPTER 5

FINITE ELEMENT ANALYSIS USING ANSYS

5.1 Introduction

Ansys provides a common platform for product development, from design concept to final-stage testing and validation. The company's product portfolio consists of simulation platform offerings that are used in diverse multi-physics fields like heat transfer, fluid mechanics, statics, solid mechanics, etc. However, Ansys is best known for finite element analysis (FEA), which has gained popularity as a modelling and simulation tool over the years (and especially since the introduction of powerful computers) in solving a gamut of complex engineering problems

5.2 ANSYS Software

- Treatment of engineering problems basically contains three main parts: create a model, solve the problem and analyze the results. Ansys, like many other FEA programs, is also divided into three main parts namely the processors which are called pre-processor, solution processor and post-processor.
- The Ansys pre-processor allows users to build geometry, define materials and generate element mesh. The Ansys processor allows users to solve problems by applying loads and obtaining solutions. The Ansys post-processor allows visualization and listing of results in a tabular form or as printouts.
- Ansys offers a comprehensive software suite that spans the entire range of physics, providing access to virtually any field of engineering simulation that a design process requires. Organizations around the world trust Ansys to deliver the best value for their engineering simulation software investment

5.3 Finite Element Analysis

Finite-element method (FEM) is a good choice for the analysis of sheet metal processes since it helps in eliminating the need for time-consuming experiments to optimize the process parameters such as sheet metal thickness, the material of the sheet, punch fillet and percentage clearance. The FEM simulations are increasingly used for investigating and optimizing the punching process. Computer simulations reduce the number of experiments and can obtain accurate results. The results depend on the element type and type of mesh considered for analysis.

5.4 Procedure in Ansys:

- Step 1: Start an ANSYS Workbench Project
- Step 2: Create a Steady-State Thermal Analysis System
- Step 3: Add a New Material
- Step 4: Insert Geometry
- Step 4: Create a Profile Sketch To customize units
- Step 6: Create an Extruded Body
- Step 7: Launch the Steady-State Thermal Program
- Step 8: Generate Mesh
- Step 9: Apply Boundary Conditions
- Step 10: Solve and Retrieve Results

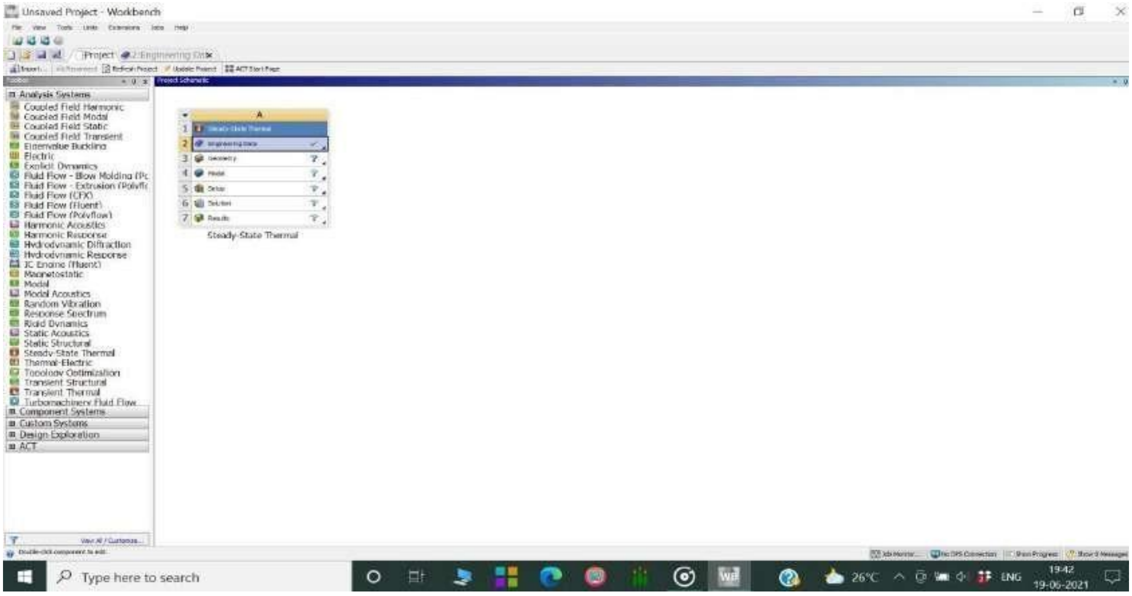
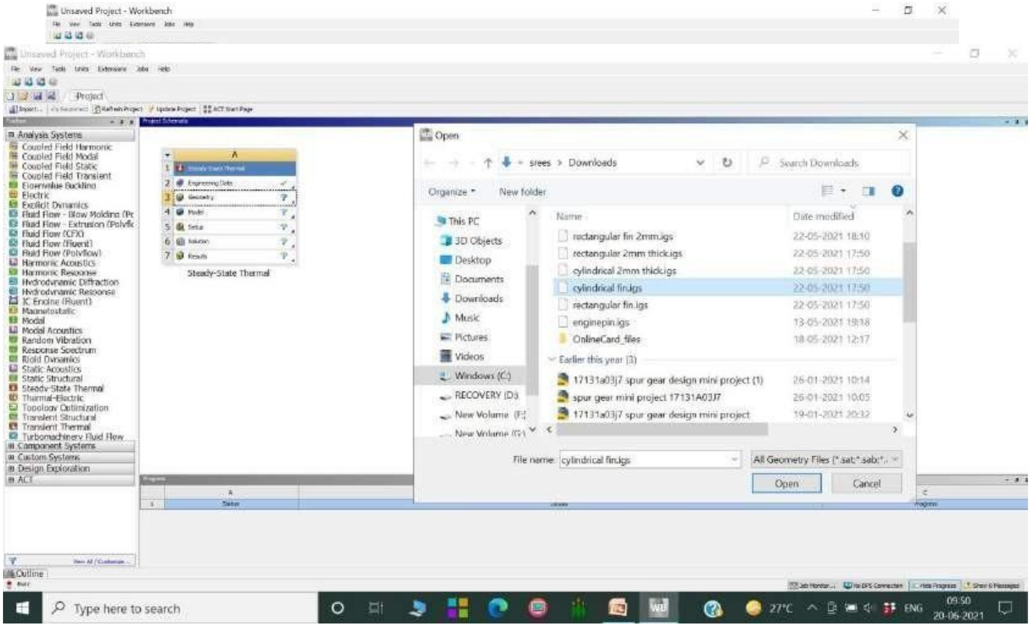


Fig 5.1 Project Setup ANSYS Work Bench

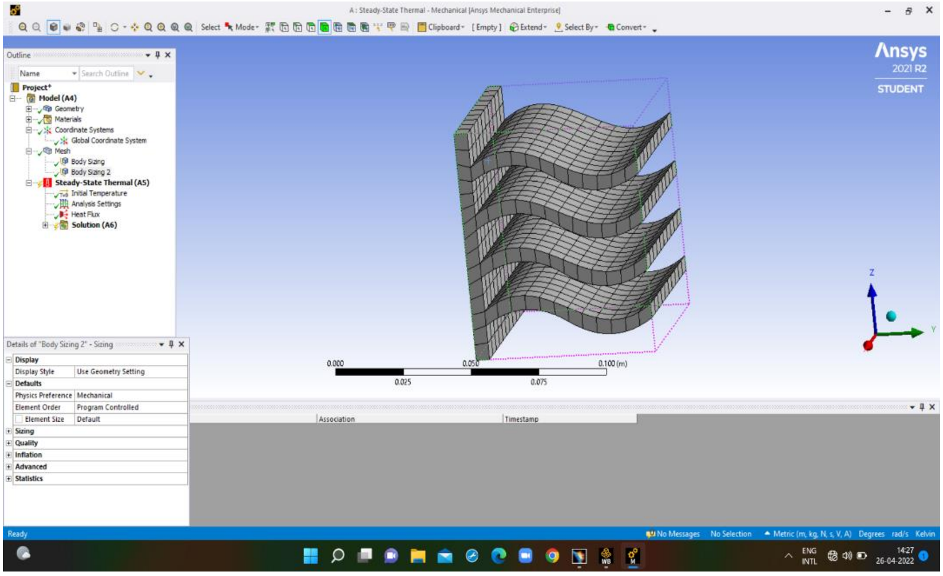


Name	Date modified
rectangular fin 2mm.igs	22-05-2021 18:10
rectangular 2mm thick.igs	22-05-2021 17:50
cylindrical 2mm thick.igs	22-05-2021 17:50
cylindrical fin.igs	22-05-2021 17:50
rectangular fin.igs	22-05-2021 17:50
enginepin.igs	13-05-2021 19:18
OnlineCard_files	18-05-2021 12:17
Earlier this year (3)	
17131a03j7 spur gear design mini project (1)	26-01-2021 10:14
spur gear mini project 17131A03J7	26-01-2021 10:05
17131a03j7 spur gear design mini project	19-01-2021 20:32

File name: cylindrical fin.igs

All Geometry Files (*.sat;*.sab;*.

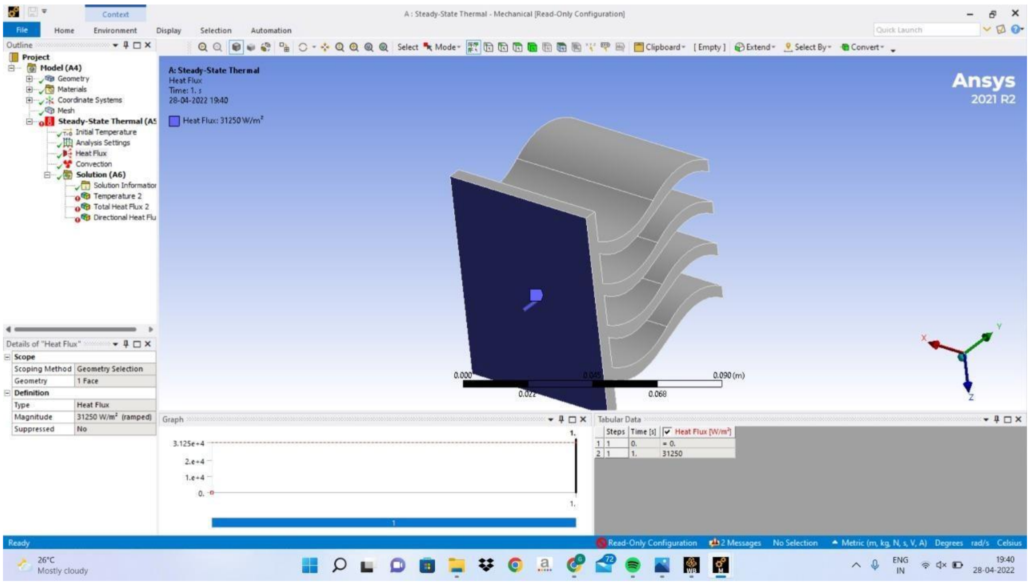
Fig 5.2 geometry selection



Details of "Body Sizing 2" - Sizing

Display	
Display Style	Use Geometry Setting
Defaults	
Physics Preference	Mechanical
Element Order	Program Controlled
☐ Element Size	Default
Sizing	
Quality	
Inflation	
Advanced	
Statistics	

Fig5.3 Mesh Analysis



A: Steady-State Thermal
Heat Flux
Time: 1. s
28-04-2022 19:40

Heat Flux: 31250 W/m²

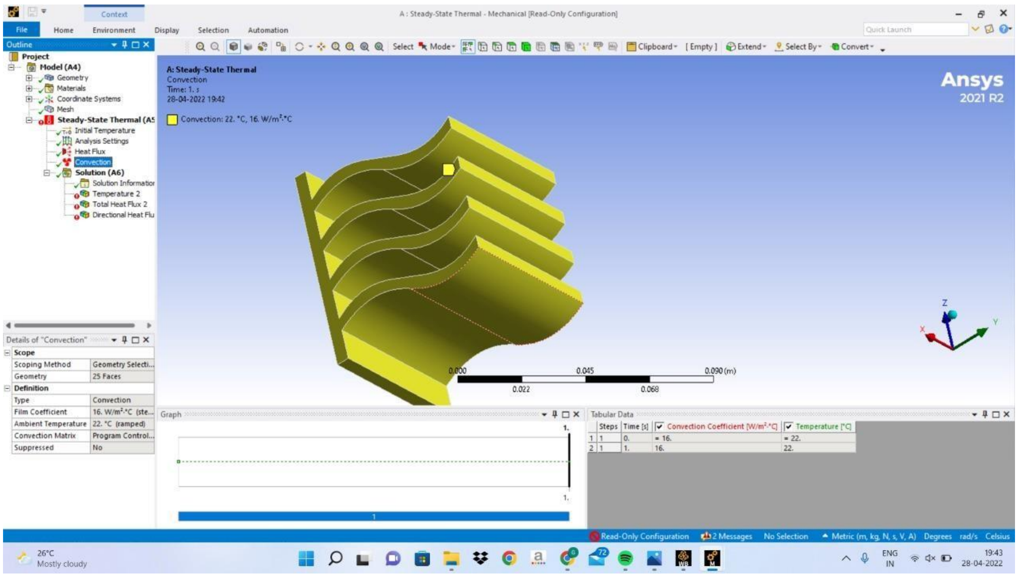
Details of "Heat Flux"

Scope	
Scoping Method	Geometry Selection
Geometry	1 Face
Definition	
Type	Heat Flux
Magnitude	31250 W/m² (ramped)
Suppressed	No

Tabular Data

	Steps	Time [s]	☑ Heat Flux [W/m²]
1	1	0.	= 0.
2	1	1.	31250

Fig 5.4 Applying boundary conditions



A: Steady-State Thermal
Convection
Time: 1. s
28-04-2022 19:42

Convection: 22. °C, 16. W/m².°C

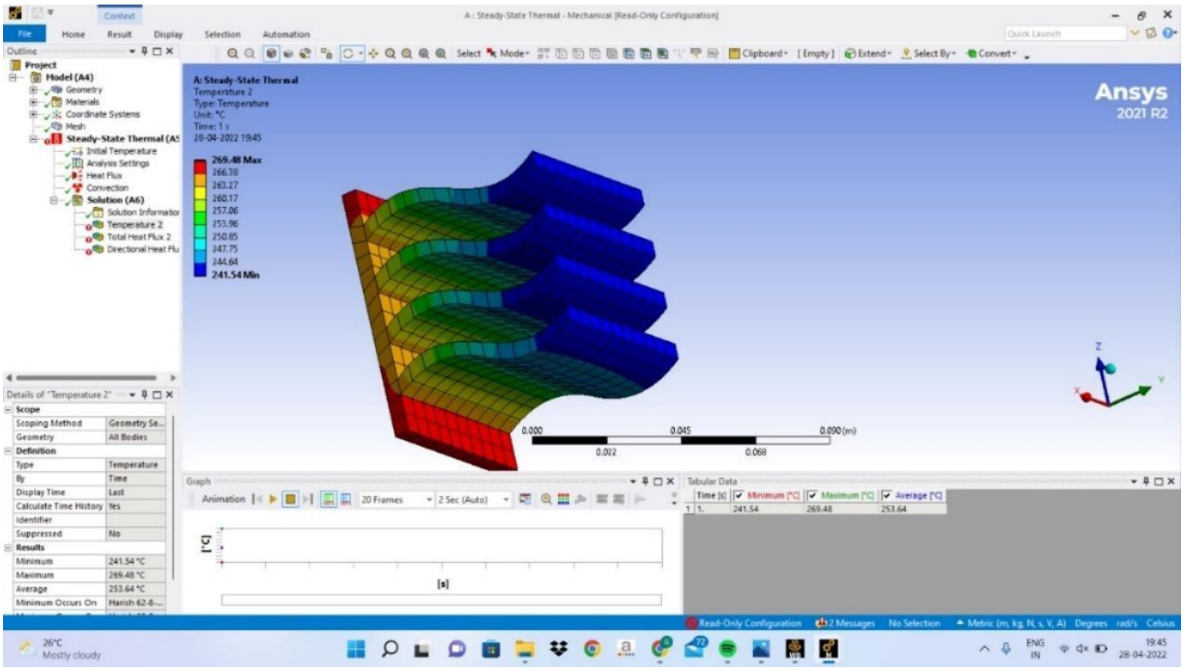
Details of "Convection"

Scope	
Scoping Method	Geometry Selecti...
Geometry	25 Faces
Definition	
Type	Convection
Film Coefficient	16. W/m².°C (ste...
Ambient Temperature	22. °C (ramped)
Convection Matrix	Program Control...
Suppressed	No

Tabular Data

	Steps	Time [s]	☑ Convection Coefficient [W/m².°C]	☑ Temperature [°C]
1	1	0.	= 16.	= 22.
2	1	1.	16.	22.

Fig 5.5 Selection of Convection Geometry



A : Steady-State Thermal - Mechanical [Read-Only Configuration]

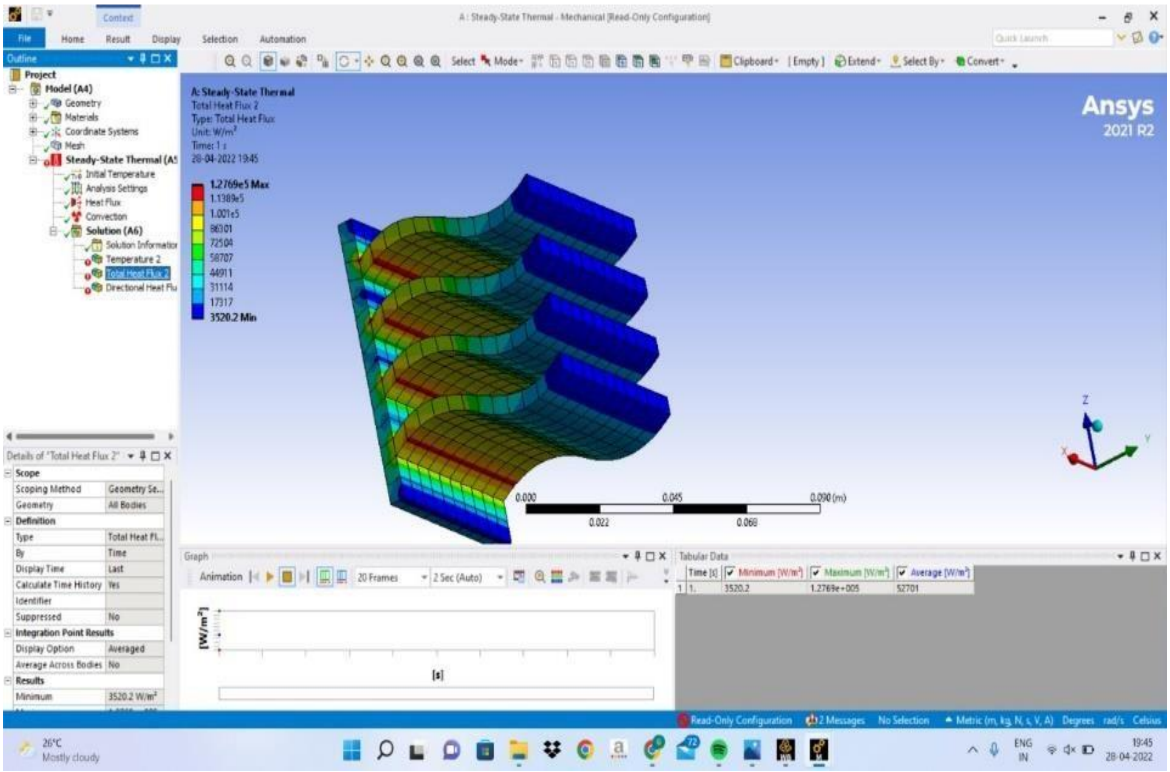
A: Steady-State Thermal
Temperature 2
Type: Temperature
Unit: °C
Time: 1 s
28-04-2022 19:45

Details of "Temperature 2"

Scope	
Scoping Method	Geometry Se...
Geometry	All Bodies
Definition	
Type	Temperature
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Results	
Minimum	241.54 °C
Maximum	269.48 °C
Average	253.64 °C
Minimum Occurs On	Harish 62-8-...

	Time [s]	☑ Minimum [°C]	☑ Maximum [°C]	☑ Average [°C]
1	1.	241.54	269.48	253.64

Fig 5.6 Temperature Distribution of horizontal curved Fins



A : Steady-State Thermal - Mechanical [Read-Only Configuration]

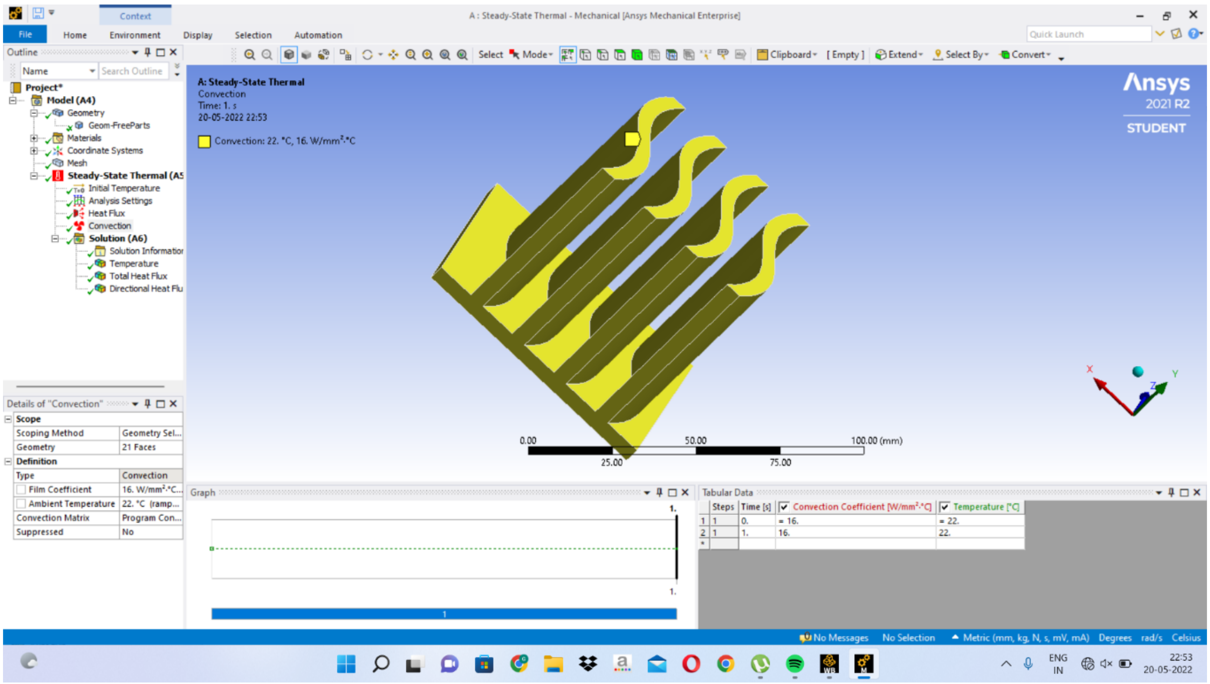
A: Steady-State Thermal
Total Heat Flux 2
Type: Total Heat Flux
Unit: W/m²
Time: 1 s
28-04-2022 19:45

Details of "Total Heat Flux 2"

Scope	
Scoping Method	Geometry Se...
Geometry	All Bodies
Definition	
Type	Total Heat Fl...
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Integration Point Results	
Display Option	Averaged
Average Across Bodies	No
Results	
Minimum	3520.2 W/m²

	Time [s]	☑ Minimum [W/m²]	☑ Maximum [W/m²]	☑ Average [W/m²]
1	1.	3520.2	1.2769e+005	52701

Fig 5.7 Heat Flux Distribution of horizontal curved Fins



A: Steady-State Thermal
Convection
Time: 1. s
20-05-2022 22:53

🟨 Convection: 22. °C, 16. W/mm²·°C

Details of "Convection"

Scope	
Scoping Method	Geometry Sel...
Geometry	21 Faces
Definition	
Type	Convection
☐ Film Coefficient	16. W/mm²·°C...
☐ Ambient Temperature	22. °C (ramp...
Convection Matrix	Program Con...
Suppressed	No

Tabular Data

	Steps	Time [s]	☑ Convection Coefficient [W/mm²·°C]	☑ Temperature [°C]
1	1	0.	= 16.	= 22.
2	1	1.	16.	22.
*				

Fig 5.8 FEA Analysis on Vertical curved Fins

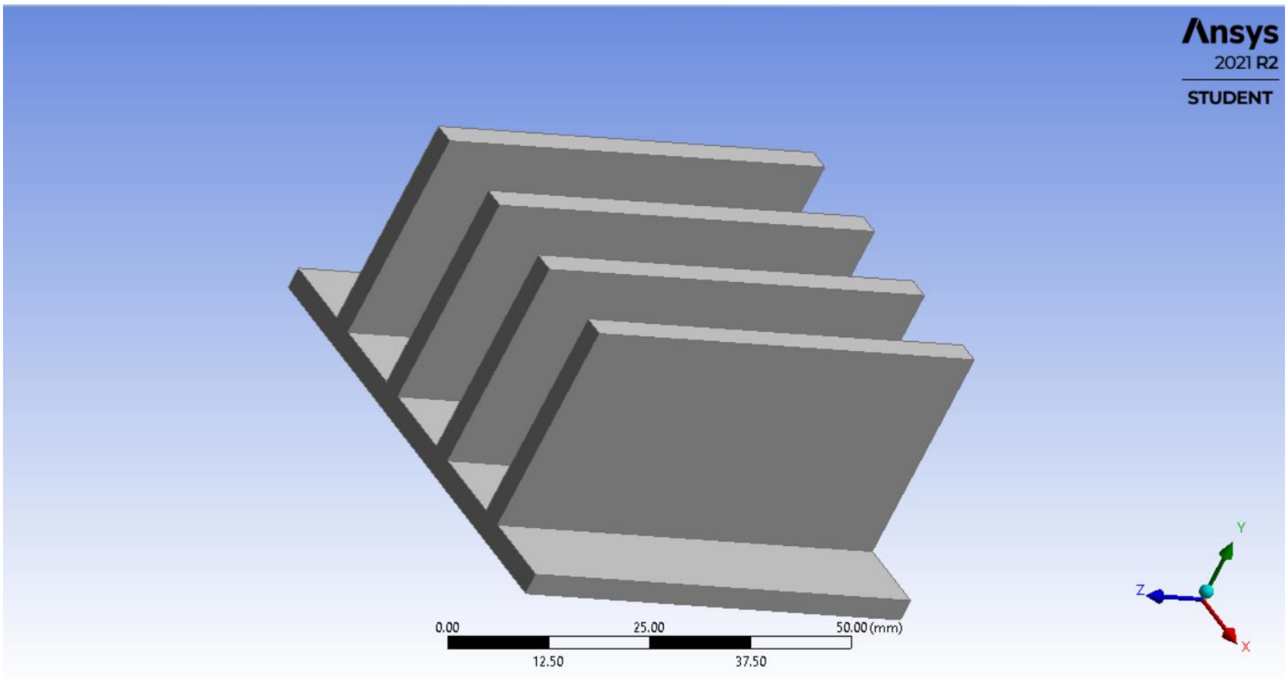
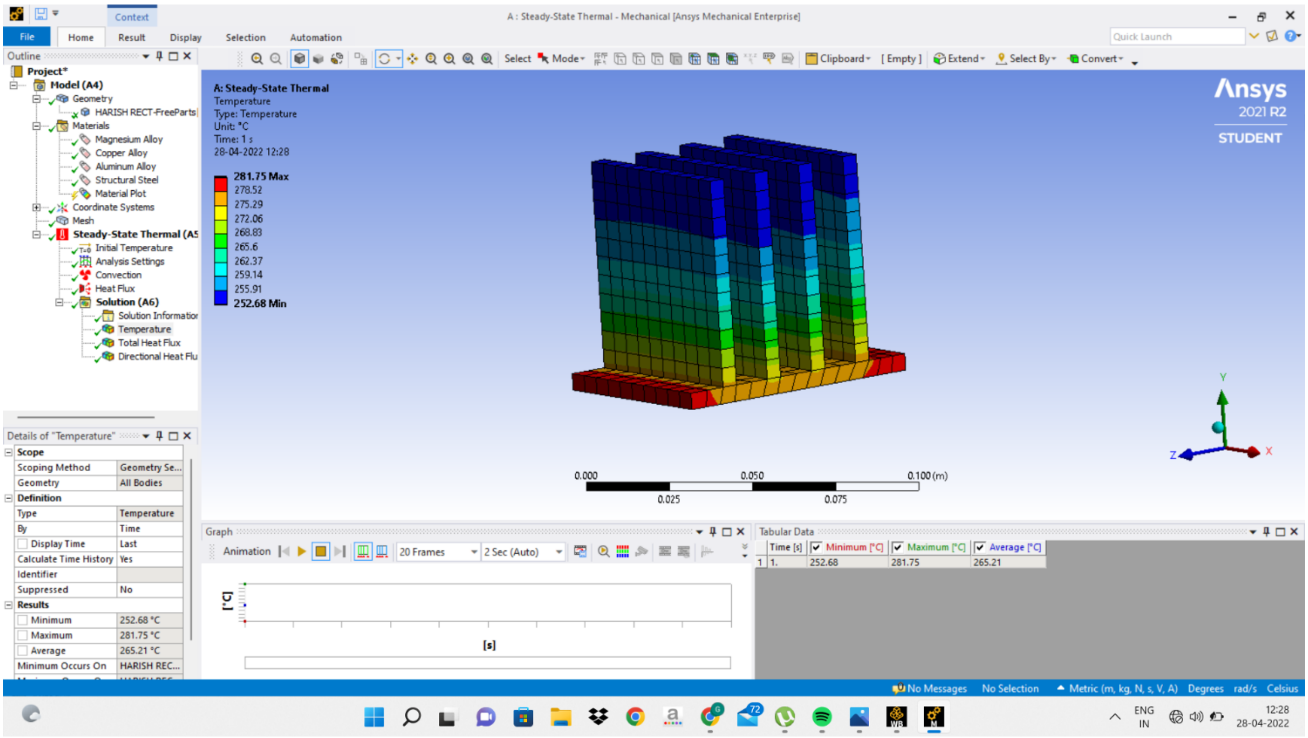


Fig 5.9 FEA analysis on Rectangular Fins



A: Steady-State Thermal
Temperature
Type: Temperature
Unit: °C
Time: 1 s
28-04-2022 12:28

Details of "Temperature"

Scope	
Scoping Method	Geometry Se...
Geometry	All Bodies
Definition	
Type	Temperature
By	Time
☐ Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Results	
☐ Minimum	252.68 °C
☐ Maximum	281.75 °C
☐ Average	265.21 °C
Minimum Occurs On	HARISH REC...

Animation 20 Frames 2 Sec (Auto)

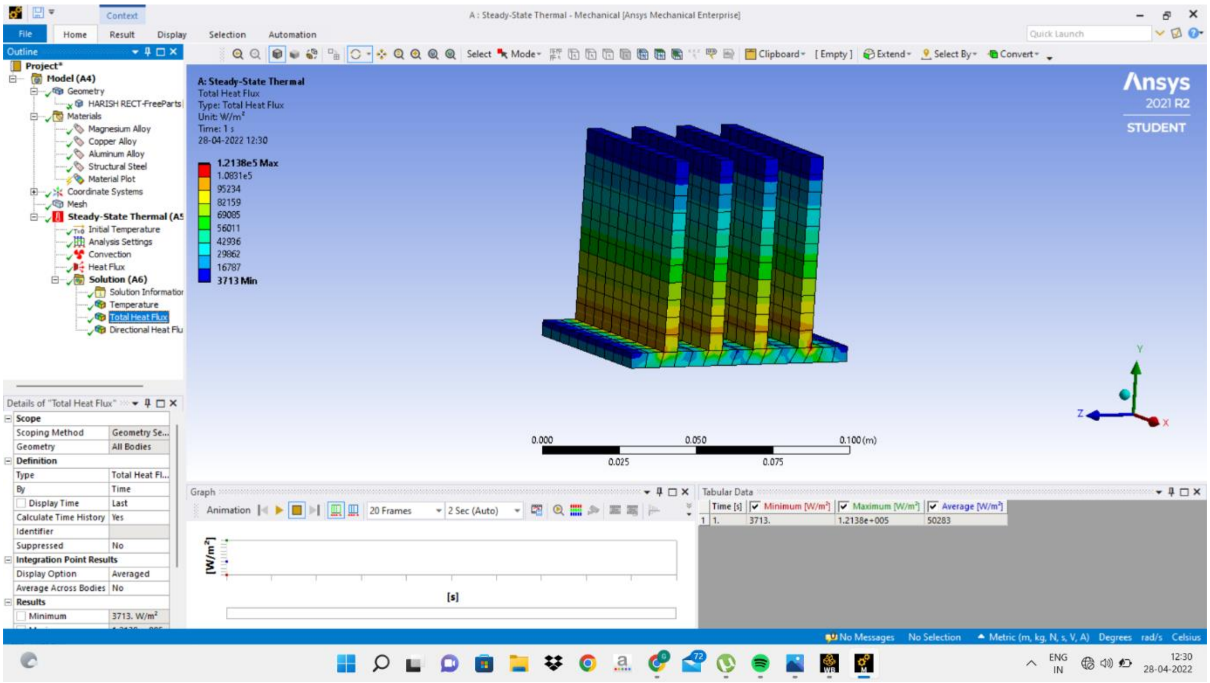
Tabular Data

	Time [s]	☑ Minimum [°C]	☑ Maximum [°C]	☑ Average [°C]
1	1.	252.68	281.75	265.21

No Messages No Selection Metric (m, kg, N, s, V, A) Degrees rad/s Celsius

12:28
28-04-2022

Fig 5.10 Temperature Distribution of Rectangular Fins



A: Steady-State Thermal
Total Heat Flux
Type: Total Heat Flux
Unit: W/m²
Time: 1 s
28-04-2022 12:30

Details of "Total Heat Flux"

Scope	
Scoping Method	Geometry Se...
Geometry	All Bodies
Definition	
Type	Total Heat Fl...
By	Time
☐ Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Integration Point Results	
Display Option	Averaged
Average Across Bodies	No
Results	
☐ Minimum	3713. W/m²

Animation 20 Frames 2 Sec (Auto)

Tabular Data

	Time [s]	☑ Minimum [W/m²]	☑ Maximum [W/m²]	☑ Average [W/m²]
1	1.	3713.	1.2138e+005	50283

No Messages No Selection Metric (m, kg, N, s, V, A) Degrees rad/s Celsius

12:30
28-04-2022

Fig 5.11 Heat Flux Distribution of Rectangular Fins

5.5 Description of the Tabular Data

5.5.1 Temperature distribution

The temperature distribution for curved and rectangle fins obtained through FEA analysis for different energy inputs is specified in tables below.

It can be observed that the temperarure has increase with the increase in input energy.It can also be observed that for any given energy input,the temperature is more uniform in copper as compared to other materails since it possess higher thermal conductivity.It can also be observed that the maximum temperature of the fin is least for copper among the materials choosen

Comparison between rectangular and curved fins it can be inferred that the temperature in rectangular is moderatively higher than the curved fin for any material at a given energy input.This can be attributed to the higher heat transfer surface area for cuved fin.

5.5.2 Heat Flux Distribution

The heat flux distribution for curved and rectangle fins obtained through FEA analysis for different energy inputs is specified in tables below

It can be observed that the heat flux has increase with the increase in input energy. It can also be observed that for any given energy input, the heat flux is more uniform in copper as compared to other materials since it possess higher thermal conductivity. It can also be observed that the maximum heat flux of the fin is high for copper among the materials choosen.

Comparison between rectangular and curved fins it can be inferred that the heat flux in rectangular is moderately higher than the curved fin for any material at a given energy input. This can be attributed to the higher heat transfer surface area for curved fin. The results of FEA are tabulated in tables 5.1 to 5.9

➢ FEA Analysis of Rectangular Fin at 50 Watts

Material`	TEMPERATURE (MIN) °C	TEMPERATURE (MAX) °C	TEMPERATURE (AVG) °C	TOTAL HEAT FLUX (MIN) W/m^2	TOTAL HEAT FLUX (MAX) W/m^2	TOTAL HEATFLUX (AVG) W/m^2
Copper	101.01	104.85	102.67	1264.9	40656	16945
Aluminium	99.077	108.23	103.03	1235.3	40426	16740
Magnesium	98.888	108.58	103.07	1231.8	40416	16721

Table 5.1

➢ FEA Analysis of Rectangular Fin at 100Watts

MATERIAL	TEMPERATURE (MIN) °C	TEMPERATURE (MAX) °C	TEMPERATURE (AVG) °C	TOTAL HEAT FLUX (MIN) W/m^2	TOTAL HEAT FLUX (MAX) W/m^2	TOTAL HEATFLUX (AVG) W/m^2
Copper	180.03	187.71	183.36	2529.8	81316	33891
Aluminium	176.46	193.93	184.01	2475.7	80849	33508
Magnesium	175.78	195.17	184.14	2463.8	80836	33443

Table 5.2

➢ FEA Analysis of Rectangular Fin at 150 Watts

MATERIAL	TEMPERATURE (MIN) °C	TEMPERATURE (MAX) °C	TEMPERATURE (AVG) °C	TOTAL HEAT FLUX (MIN) W/m^2	TOTAL HEAT FLUX (MAX) W/m^2	TOTAL HEATFLUX (AVG) W/m^2
Copper	259.05	270.56	264.04	3794.8	$1.2198*10^5$	50837
Aluminium	253.79	279.79	265	3713	$1.2138*10^5$	50283
Magnesium	252.68	281.75	265.21	3695.7	$1.2126*10^5$	50165

Table 5.3

➢ FEA Analysis of Horizontal Curved FIN AT 50 WATTS

MATERIAL	TEMPERATURE (MIN) °	TEMPERATURE (MAX) °	TEMPERATURE (AVG) °	TOTAL HEAT FLUX (MIN) W/m^2	TOTAL HEAT FLUX (MAX) W/m^2	TOTAL HEATFLUX (AVG) W/m^2
Copper	97.094	101.23	98.891	1177.1	42856	17792
Aluminium	94.963	104.83	99.244	1172.9	42520	17541
Magnesium	94.771	105.18	99.278	1172.9	42500	17518

Table 5.4

➢ FEA Analysis of Horizontal Curved FIN AT 100 WATTS

MATERIAL	TEMPERATURE (MIN) °	TEMPERATURE (MAX) °	TEMPERATURE (AVG) °	TOTAL HEAT FLUX (MIN) W/m^2	TOTAL HEAT FLUX (MAX) W/m^2	TOTAL HEATFLUX (AVG) W/m^2
Copper	132.4	144.64	137.71	3521.9	$1.2788*10^5$	52850
Aluminium	126.59	154.67	138.7	3525.9	$1.2613*10^5$	51467
Magnesium	125.82	156.12	138.84	3528	$1.2588*10^5$	51277

Table 5.5

➢ FEA Analysis of Horizontal Curved FIN AT 150 WATTS

MATERIAL	TEMPERATURE (MIN) °	TEMPERATURE (MAX) °	TEMPERATURE (AVG) °	TOTAL HEAT FLUX (MIN) W/m^2	TOTAL HEAT FLUX (MAX) W/m^2	TOTAL HEATFLUX (AVG) W/m^2
Copper	247.3	259.69	252.69	3531.6	$1.2858*10^5$	53378
Aluminium	241.54	269.48	253.64	3520.2	$1.2769*10^5$	52701
Magnesium	240.33	271.57	253.85	3519	$1.2751*10^5$	52558

Table 5.6

- **FEA Analysis of Vertical Curved FIN AT 50 WATTS**

MATERIAL	TEMPERATURE (MIN) °C	TEMPERATURE (MAX) °C	TEMPERATURE (AVG) °C	TOTAL HEAT FLUX (MIN) W/m^2	TOTAL HEAT FLUX (MAX) W/m^2	TOTAL HEATFLUX (AVG) W/m^2
Copper	96.245	100.18	97.81	1077.8	41789	17245
Aluminium	92.564	102.68	98.23	1072.6	41520	17155
Magnesium	91.498	103.91	98.65	1072.9	41415	17059

Table 5.7

- **FEA Analysis of Vertical Curved FIN AT 100 WATTS**

MATERIAL	TEMPERATURE (MIN) °C	TEMPERATURE (MAX) °C	TEMPERATURE (AVG) °C	TOTAL HEAT FLUX (MIN) W/m^2	TOTAL HEAT FLUX (MAX) W/m^2	TOTAL HEATFLUX (AVG) W/m^2
Copper	121.26	125.68	123.80	3112.76	$1.4643*10^5$	74532
Aluminium	113.71	134.52	126.19.7	3083.18	$1.3858*10^5$	71624
Magnesium	107.53	138.75	128.56	2998.41	$1.3145*10^5$	69432

Table 5.8

- **FEA Analysis of Vertical Curved FIN AT 150 WATTS**

MATERIAL	TEMPERATURE (MIN) °C	TEMPERATURE (MAX) °C	TEMPERATURE (AVG) °C	TOTAL HEAT FLUX (MIN) W/m^2	TOTAL HEAT FLUX (MAX) W/m^2	TOTAL HEATFLUX (AVG) W/m^2
Copper	117.76	131.84	124.11	34237	$1.2954*10^5$	63589
Aluminium	108.96	132.54	120.56	3472.6	$1.2876*10^5$	62431
Magnesium	105.92	136.61	121.52	33212	$1.2732*10^5$	61986

Table 5.9

- **Temperature Distribution in $^\circ C$ Compression at 50W Input**

Material	**Rectangular Fin**	**Horizontal Curved Fin**	**Vertical Curved Fin**
Copper	102.67	98.891	97.81
Aluminium	103.03	99.244	98.23
Magnesium	103.07	99.278	98.65

Table 5.10

- **Total Heat Flux Distribution in W/m^2 Compression at 50W Input**

Material	**Rectangular Fin**	**Horizontal Curved Fin**	**Vertical Curved Fin**
Copper	16945	17792	17245
Aluminium	16740	17541	17155
Magnesium	16721	17518	17059

Table 5.11

CHAPTER 6

RESULTS AND DISCUSSION

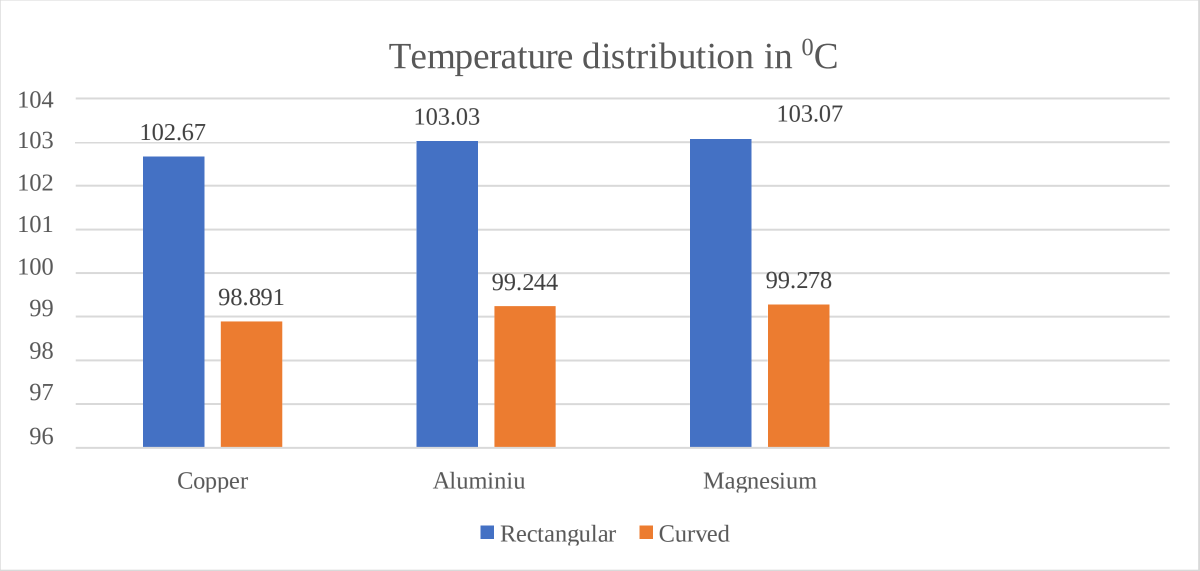
6.1 Results and Discussions

The present work has dealt with the study of heat transfer from curved fins by analytically using software. In comparison between curved fins and rectangular fins was also accomplished to obtain an idea on the effectiveness of curved fins.

This study was carried out assuming similar boundary conditions for rectangular and curved fins. The curved fins and rectangular fins are assumed to be of same length and thickness.

The study was done for three different types of materials i.e copper, aluminum. magnesium. This materials were chosen as fins are generally fabricated of high thermal conductivity materials.Further the analysis was done for three different heat fluxes.

A detailed study of temperature and heat flux distribution was achieved for both the configurations chosen under the considered heat fluxes for three different materials.



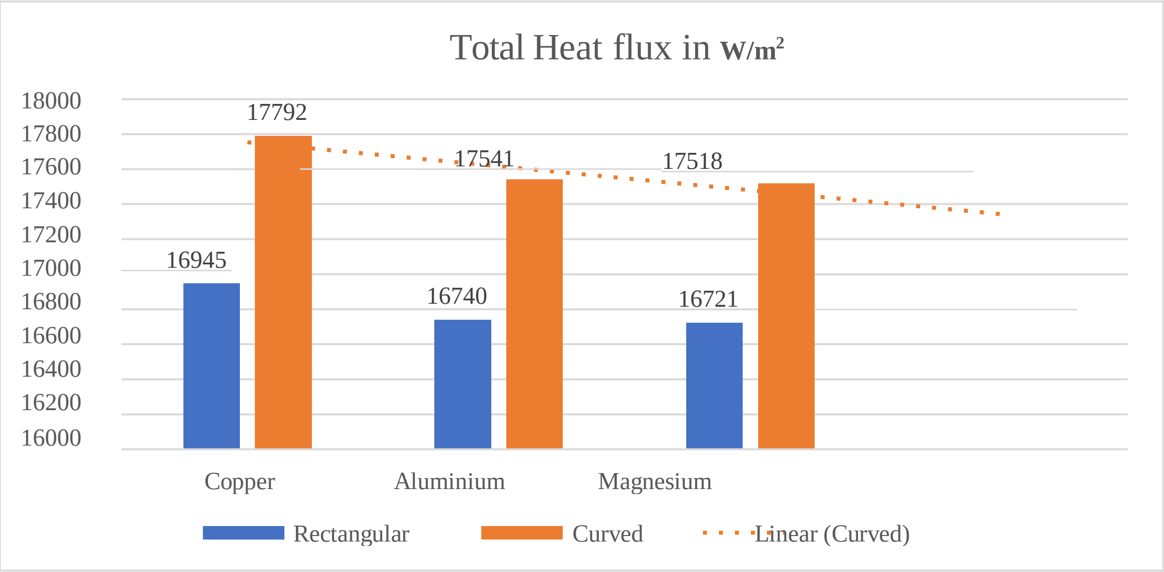
Graph 6.1 Temperature distribution Rectangular VS Curved

6.2 Temperature distribution Rectangular VS Curved

The temperature distribution for curved and rectangle fins obtained through FEA analysis for different energy inputs

It can be observed that the temperarure has increase with the increase in input energy.It can also be observed that for any given energy input,the temperature is more uniform in copper as compared to other materails since it possess higher thermal conductivity.It can also be observed that the maximum temperature of the fin is least for copper among the materials choosen

Comparison between rectangular and curved fins it can be inferred that the temperature in rectangular is moderatively higher than the curved fin for any material at a given energy input.This can be attributed to the higher heat transfer surface area for cuved fin.



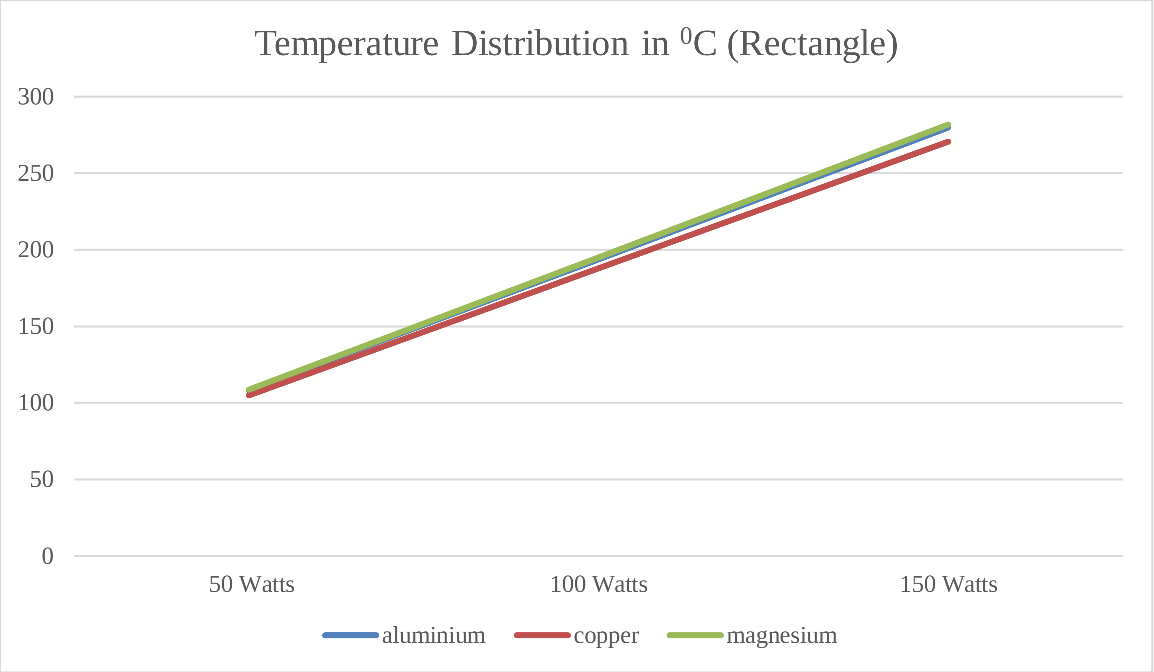
Graph 6.2 Total Heat Flux Distribution (Rectangular vs Curved)

6.3 Total Heat Flux Distribution (Rectangular vs Curved)

The heat flux distribution for curved and rectangle fins obtained through FEA analysis for different energy inputs.

It can be observed that the heat flux has increase with the increase in input energy.It can also be observed that for any given energy input,the heat flux is more uniform in copper as compared to other materails since it possess higher thermal conductivity.It can also be observed that the maximum heat flux of the fin is high for copper among the materials choosen.

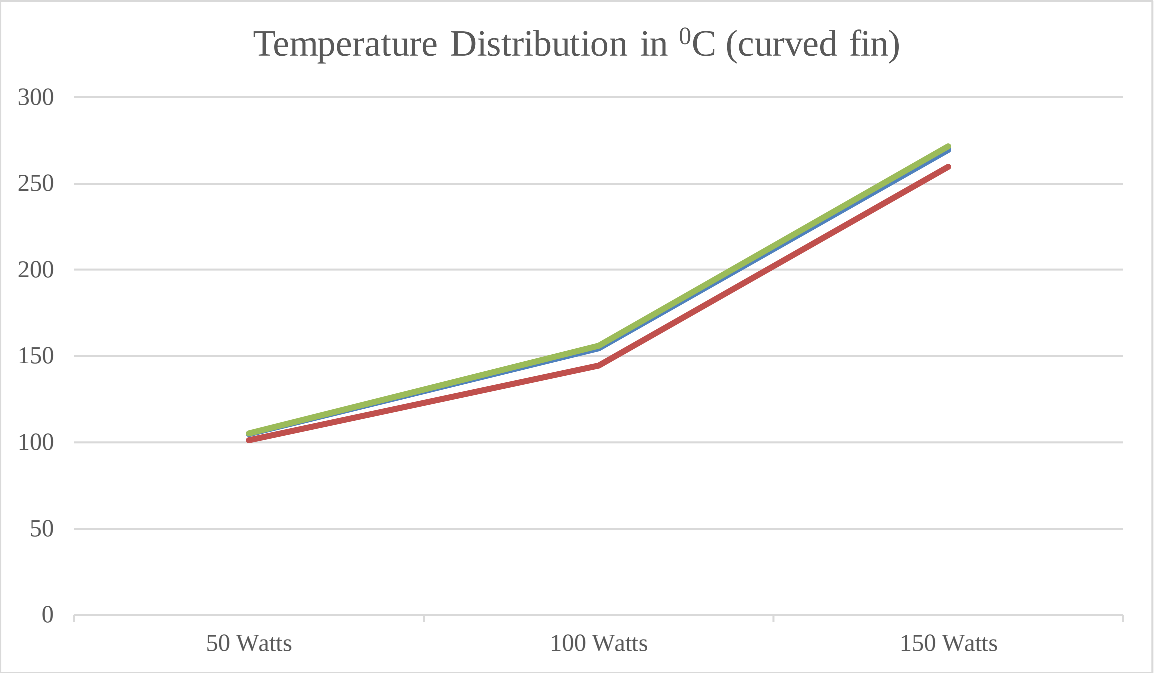
Comparison between rectangular and curved fins it can be inferred that the heat flux in rectangular is moderatively higher than the curved fin for any material at a given energy input.This can be attributed to the higher heat transfer surface area for cuved fin



Graph 6.3 Temperature distribution of Rectangular Fin for three different materials

6.4 Temperature distribution of Rectangular Fin for three different materials

From the graph ,It can also be observed that for any given energy input,the temperature is more uniform in copper as compared to other materails since it possess higher thermal conductivity.It can also be observed that the maximum temperature of the fin is least for copper among the materials choosen

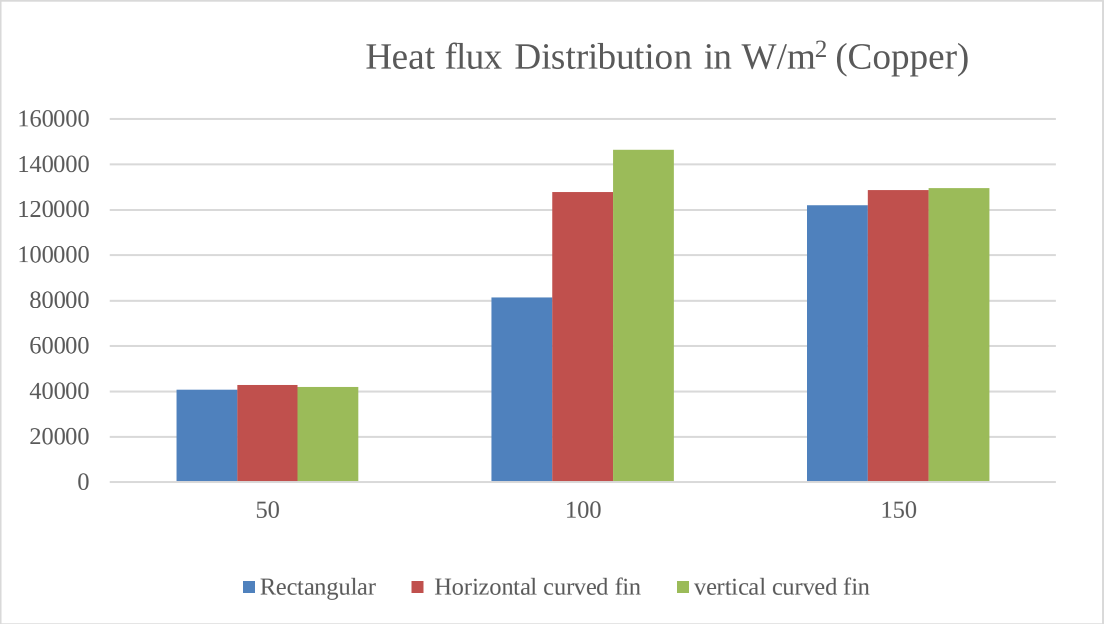


Graph 6.4 Temperature distribution of Curved Fin for three different materials

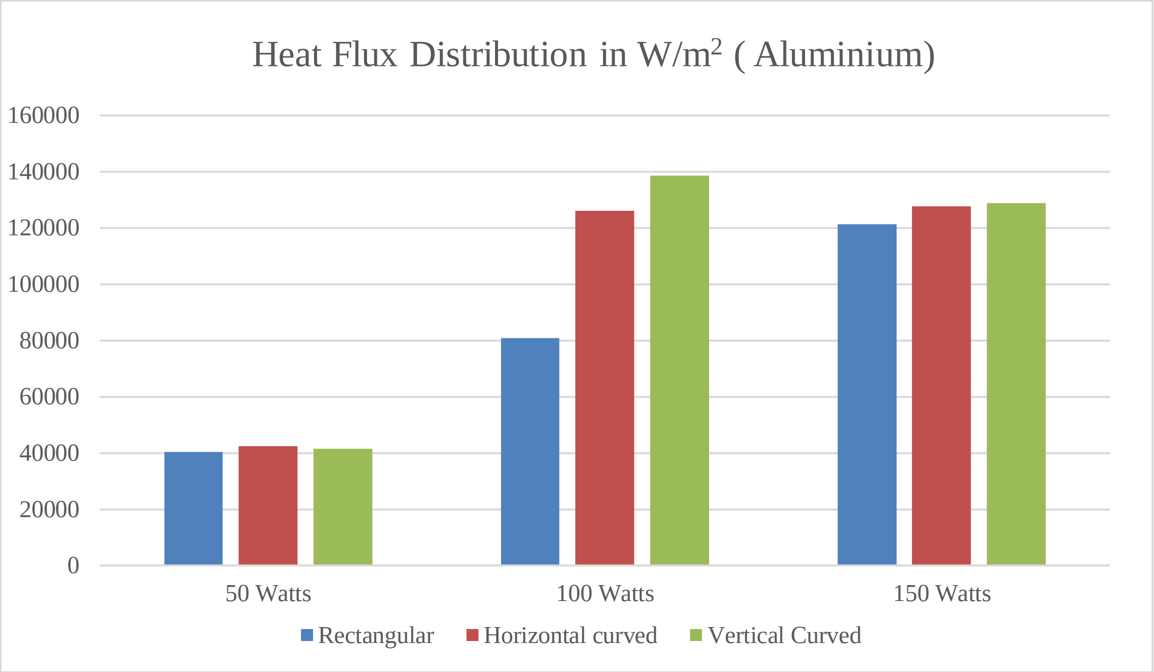
6.5 Temperature distribution of Curved Fin for three different materials

From the graph ,It can also be observed that for any given energy input,the temperature is more uniform in copper as compared to other materails since it possess higher thermal conductivity.It can also be observed that the maximum temperature of the fin is least for copper among the materials choosen

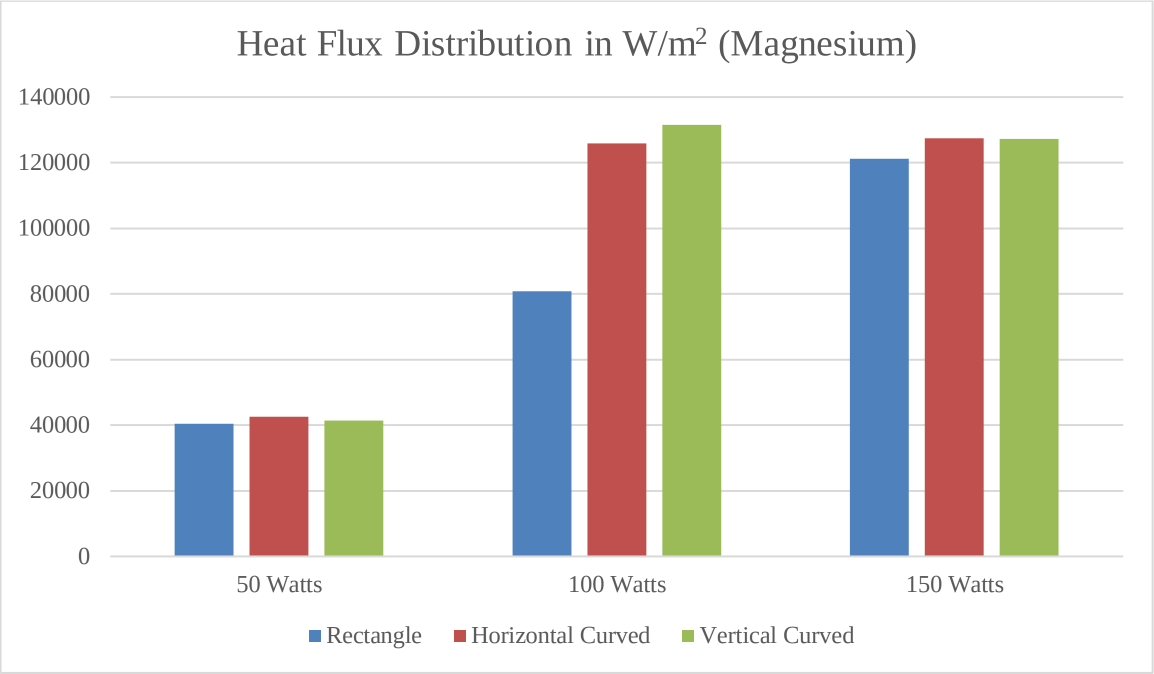
From the graph it can be inferred that the temperature in rectangular is moderatively higher than the curved fin for any material at a given energy input.This can be attributed to the higher heat transfer surface area for cuved fin.



Graph 6.5 Heat Flux Distribution Of Copper Fins



Graph 6.6 Heat Flux Distribution Of Aluminium Fins

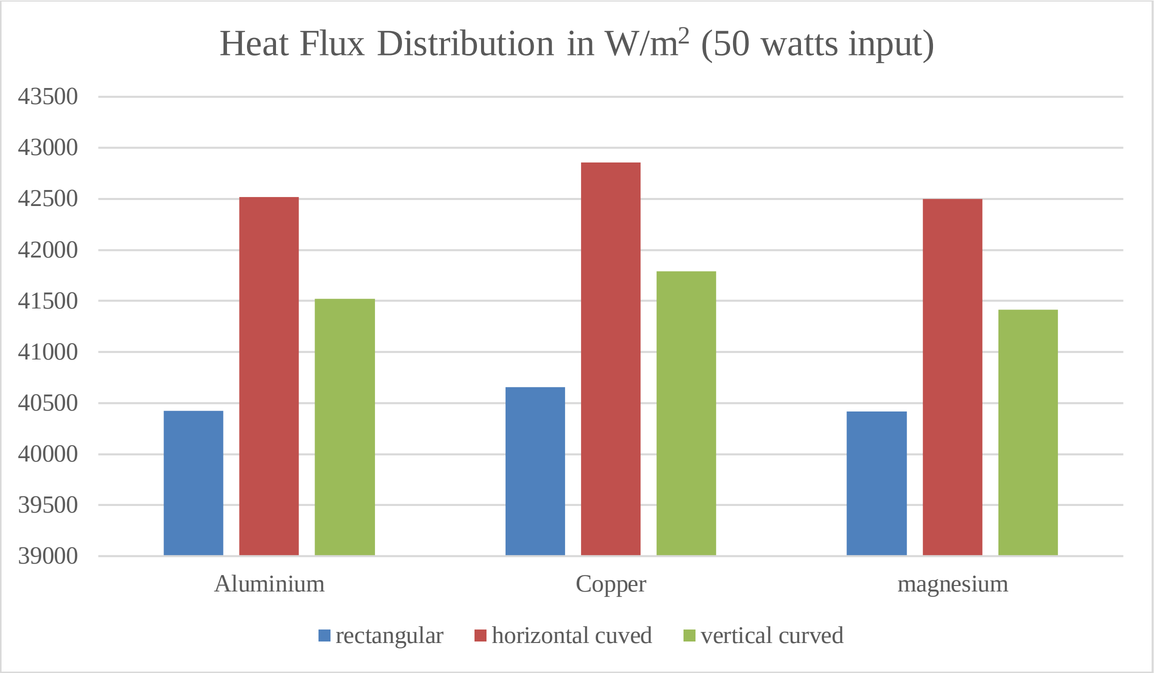


Graph 6.7 Heat Flux Distribution Of Magnesium Fins

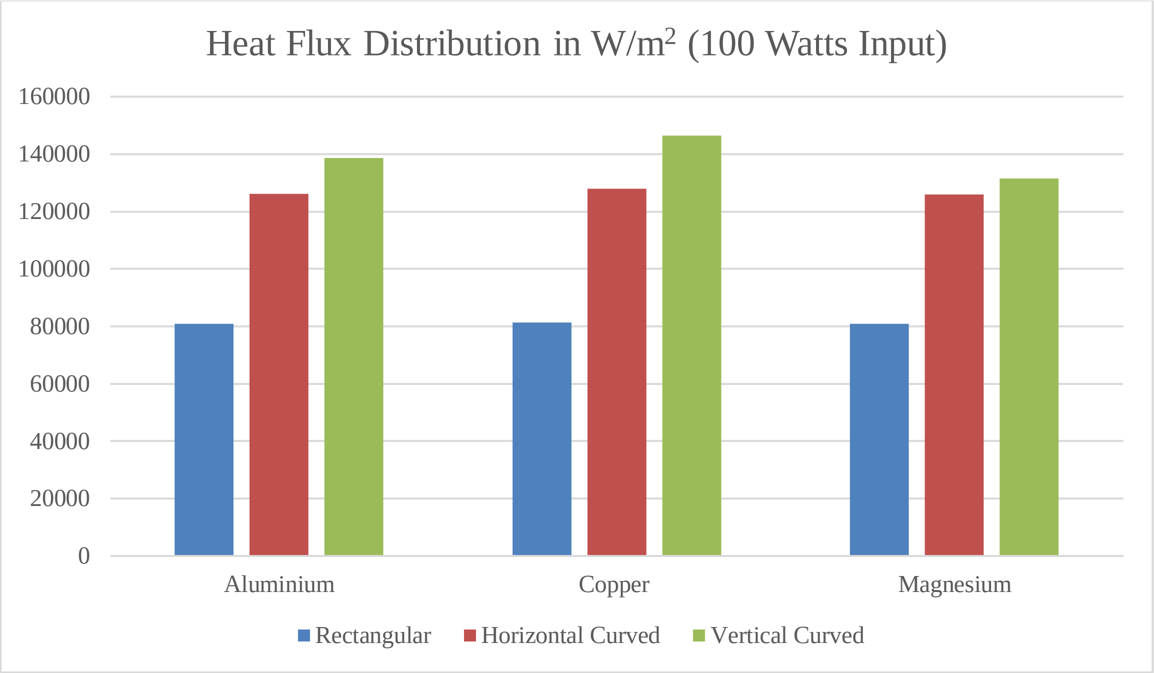
6.6 Heat Flux Distribution Of Fins(3 Materials)

From the above three graphs 6.5, 6.6, 6.7, It can be observed that the heat flux has increase with the increase in input energy.It can also be observed that for any given energy input,the heat flux is more uniform in copper as compared to other materails since it possess higher thermal conductivity.It can also be observed that the maximum heat flux of the fin is high for copper among the materials choosen.

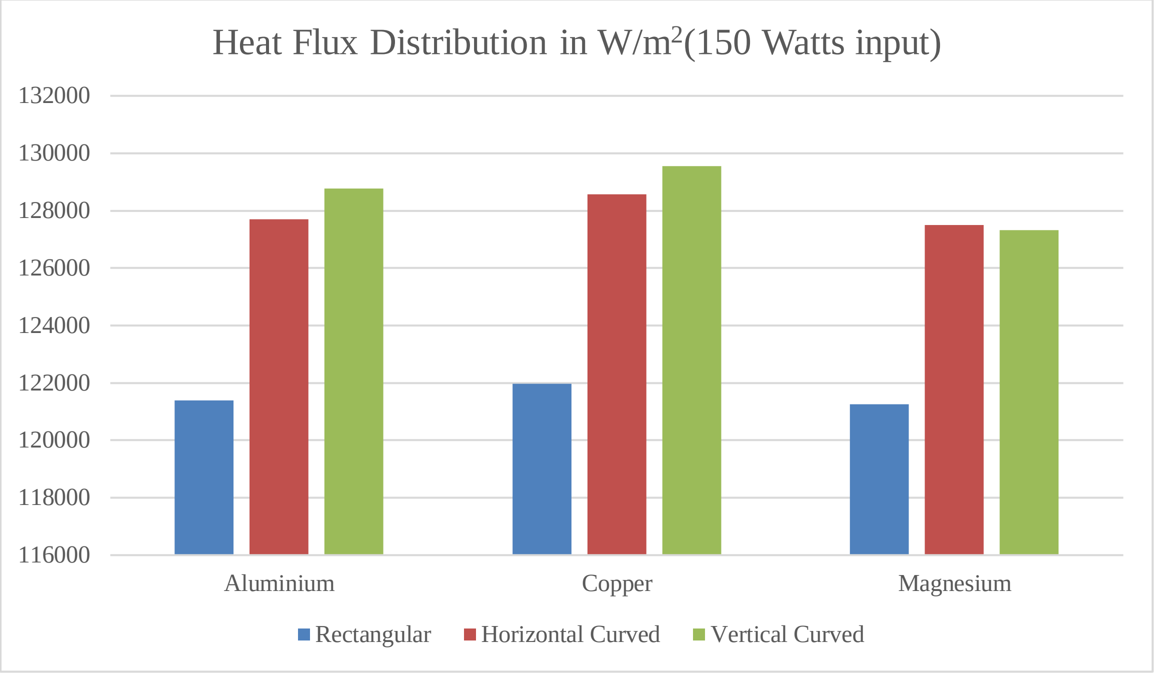
Comparison between rectangular and curved fins it can be inferred that the heat flux in rectangular is moderatively higher than the curved fin for any material at a given energy input.This can be attributed to the higher heat transfer surface area for cuved fin.



Graph 6.8 Heat Flux Distribution Of Materials At 50 Watts Input



Graph 6.9 Heat Flux Distribution Of Materials At 100 Watts Input



Graph 6.10 Heat Flux Distribution Of Materials At 150 Watts Input

6.7 Heat Flux Distribution Of Materials At different power input

From the above three graphs 6.8, 6.9, 6.10, It can be observed that the heat flux has increase with the increase in input energy. It can also be observed that for any given energy input, the heat flux is more uniform in copper as compared to other materials since it possess higher thermal conductivity. It can also be observed that the maximum heat flux of the fin is high for copper among the materials choosen.

Comparison between rectangular and curved fins it can be inferred that the heat flux in rectangular is moderately higher than the curved fin for any material at a given energy input. This can be attributed to the higher heat transfer surface area for curved fin.

CHAPTER 7

CONCLUSIONS

7.1 Conclusions

- Fins are widely accepted for dissipating large chunks of heat from different devices where heat is generated . A no of conventional fins are arranged in parallel on a common base plate which is fixed to the device from which heat has to be dissipated.
- The present work proposes to use curved fins instead of regular rectangular fins and study their heat transfer performance. This objective has been fulfilled by adopting analytical methods. The curved fins are compared with rectangular fins with reference to the temperature distribution and heat flux. The modelling and analysis was carried out by using CATIA and ANSYS workbench respectively. The following conclusions were drawn from the steady state thermal analysis of both the fins.
    - The analysis was done for three materials i.e copper, aluminium and magnesium.
    - Copper exhibited the best results in terms of temperature distribution and heat flux due to its high thermal conductivity.
    - The curved fins were better off when compared with rectangular fins as they have high heat transfer area
    - When comparison of horizontal and vertical configurations gave best results as the heat dissipation rate was higher.
    - The enhancement and heat transfer rate with curved fins when compared with rectangular fins is in the ratio 5:6

7.2 Future Scope:

From the present study, it can be inferred that though curved fins are difficult to manufacture, they passes better heat transfer characteristics.

- To optimize the curvature and material requirements,further analysis is required.
- CFD analysis can be performed to get optimized results of fins heat transfer related to enclosed geometry
- Forced convection analysis can also be performed using FEA

REFERENCES

1. Mayank Jain, Mahendra Sankhala, Kanhaiya Patidar, Lokesh Aurangabadkar Heat Transfer Analysis And ptimization Of Fins By Variation In Geometry International Journal Of Mechanical And Production Engineering, Issn: 2320-2092,Vol 5,Issue-7,July2017.

2. 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

3. Devendra J. Waghulde, Prof. V H Patil, Prof. T. A. Koli , Effect Of Geometry, Material And Thickness Of Fin On Engine Cylinder Fins, International Research Journal Of Engineering And Technology (Irjet), Volume: 04 Issue: 07 | July-2017

4. Mr. Omkarnakadi, Mr. Nitish I Hukkeri, Mr. Jotibabelgaonkar, Effect Of Different Fin Geometries On Heat Transfer Coefficient, International Journal Of Scientific & Engineering Research, Volume 7, Issue 7, July- 2016 1078 Issn2229-5518

5. K. Sathishkumar, K. Vignesh, N. Ugesh, P. B. Sanjeevaprasath, S. Balamurugan Computational analysis of heat transfer through fins with different types of notches International Journal Of Advanced Engineering Research And Science (Ijaers) Vol4,Issue-2,Feb-2017

6. Charan, Srivastav, Bharadwaj, "Thermal Analysis On Rectangular Plate Fin with Perforations Using Ansys", International Journal of Creative Research Thoughts, 2018.

7. 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.

8. Kiran Beldar,AvinashPatil,"Design and Analysis of cylinder having longitudinal fins with rectangular notches", International Journal of Scientific Development and

Research (IJSDR), 2017.

9. 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.

10. Mayankjain, MahendraSankhala, KanhaiyaPatidar,"heat transfer analysis and optimization of fins by Variationin geometry", International Journal of Mechanical and Production Engineering, Volume- 5, Issue-7, Jul.-2017.

11. Kummitha, Reddy, "Thermal Analysis of cylinder block with fins for different materials using ANSYS", ICAAMM, Elsevier, 2016.

12. 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.

13. Sandeep Kumar, Nitin Dubey, "Investigation and Thermal Analysis of Heat Dissipation Rate of SingleCylinder SI Engine", IJEDR, Volume 5, Issue 2, 2017.

14. Mogaji, Owoseni, "Numerical Analysis of Radiation Effect on Heat Flow through Fin of Rectangular Profile", American Journal of Engineering Research (AJER), Volume-6, Issue-10, pp-36-46, 2017.

15. Arefin, "Thermal Analysis of Modified Pin Fin Heat Sink for Natural Convection", 5th International Conference on Informatics, Electronics and Vision, 2016.

16. Balendra Singh, Satish Singh, "A Research Paper on Heat Transfer in Notch Fin and UN Notch Fin",International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 4 IssueIX, September 2016.

17. Kongre, Barde, "A Review Paper on Thermal Analysis and Heat Transfer of Single Cylinder S. I. Engine Fins", International Journal of Engineering Research & Technology (IJERT), Volume 4, Issue 30, 2016.

18. Heat Transfer DATA BOOK, by C. P. Kothandaraman