A NUMERICAL STUDY ON PERFORATED FIN

A Technical project Report
Submitted for fulfilment of
The requirements for the
Degree of Bachelor of Technology
Under Biju Pattnaik University of Technology

BY

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BONAFIDE CERTIFICATE

This is to certify that the project entitled “ **a numerical study of perforated fin** *“ Is a bonafide record by* ***RISHABH DEV SINHA and SIDDHARTH PANDA*** *(Roll No. BTECH 201710434 AND 201710375) under my supervision and guidance, in partial fulfilment of the requirements for the award of Degree of Bachelor of technology from National Institute of Science and Technology under Biju Pattnaik University of Technology for the year 2021.*

Mr. Alok Patra

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ABSTRACT:

In this project we have designed various perforated fin profiles of different shapes and materials by using Ansys Inc. modeling software & have calculated the effectiveness and efficiency of the fin profiles under various boundary & atmospheric conditions.

We have plotted a temperature vs. length curve of the fin profiles that we found and have done a brief comparison between them in both graphical as well as in a tabular form.

ACKNOWLEDGEMENT:

I would like to take this opportunity to thank all those individuals whose invaluable contribution in a direct or indirect manner has gone into the making of this project a tremendous learning experience for me.

It is my proud privilege to epitomize my deepest sense of gratitude and indebtedness to my faculty guide, **Mr. Alok Patra** for his valuable guidance, keen and sustained interest, intuitive ideas and persistent endeavour. His guidance and inspirations enabled me to complete my report work successfully.

I give my sincere thanks to **Dr. Sandipan Mallick, Project Coordinator**, for giving me the opportunity and motivating me to complete the project within stipulated period of time and providing a helping environment.

I acknowledge with immense pleasure the sustained interest, encouraging attitude and constant inspiration rendered by **Dr. Sukant K. Mohapatra** (Chairman) ,**Mr. Priyadarshi Tripathy** (Principal), **Dr. Souren Misra** (HOD , School of Mechanical engineering) N.I.S.T. Their continued drive for better quality in everything that happens at N.I.S.T. and selfless inspiration has always helped us to move ahead.

TABLE OF CONTENTS:

LIST OF FIGURES:

LIST OF TABLES:

1. INTRODUCTION

Introduction of Cooling Fins:

- Fins are the extended surfaces designed to Increase heat transfer rate for a fixed surface temperature, or lower surface temperature for a fixed heat transfer rate.
- Heat transfer by convection between a surface and the fluid surrounding can be increased by attaching to the surface called fins.
- The heat-conducting through solids, walls, or boundaries has to be continuously dissipated to the surroundings or environment to maintain the system in a steady-state condition. In many engineering applications large quantities of heat needed to be dissipated from small areas.
- The fins increase the effective area of a surface thereby increasing the heat transfer by convection. Rectangular fin and triangular fins are straight fins. Triangular fins are attractive, since for an equal heat transfer it requires much less volume than rectangular fins. Hence the fins have practical importance because it gives maximum heat flow per unit mass with ease of manufacture **[1]**

● TYPES OF COOLING FINS:

● Fig 1.1 Rectangular fin

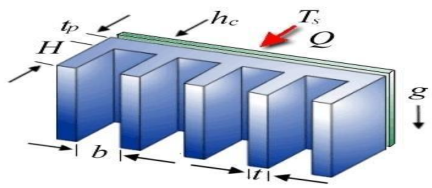


Fig 1.2 Radial fin

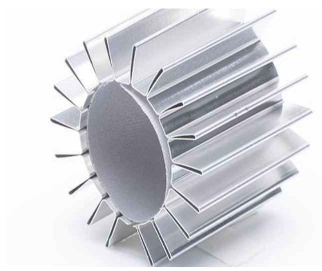
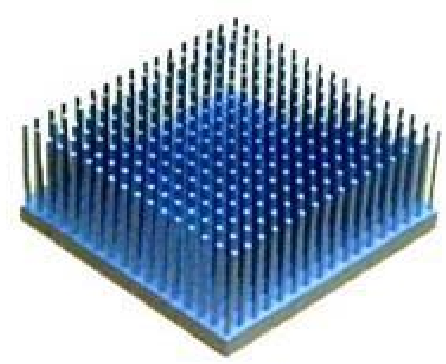


Fig 1.3 Pin fin



Some Other types of Fins are :

- Constant area straight fin
- Variable area straight fin
- Pin Fin
- Annular Fin

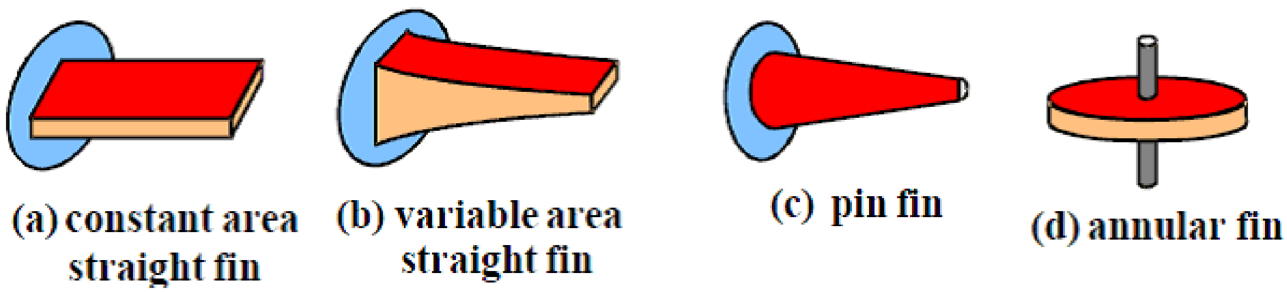


Fig 1.4 Some other types of fins

Material of fins and Numerical analysis

- The most common heat sink materials are aluminum alloy has one of the higher thermal conductivity values at 229 W/mK but is mechanically soft. **[3]**
- Copper has around twice the thermal conductivity of aluminium alloy and faster, more efficient heat absorption. But it is more expensive than aluminium alloy. **[3]**

Heat Transfer From Extended Surface

The rate of heat transfer from a surface at a temperature Ts to the surrounding medium at T infinity is given by Newton's law of cooling as,

$$\dot{Q}_{\text{conv}} = hA_s(T_s - T_\infty)$$

Where,

A_s is the heat transfer surface area and where.

h is the convection heat transfer coefficient

temperatures Ts and T infinity are fixed by design considerations,

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

- **<u>By increase the convection heat transfer coefficient (h)</u>**

  Increasing h may require the installation of a pump or fan, or replacing the existing one with a larger one, but this approach may or may not be practical. Besides, it may not be adequate.

- **<u>By increase the surface area (As)</u>**

  The alternative is to increase the surface area by attaching to the surface extended surfaces called fins made of highly conductive materials such as aluminum. Finned surfaces are manufactured by extruding, welding, or wrapping a thin metal sheet on a surface. Fins enhance heat transfer from a surface by exposing a larger surface area to convection and radiation.

Finned surfaces are commonly used in practice to enhance heat transfer, and they often increase the rate of heat transfer from a surface several-fold. The car radiator is shown in Fig. below is an example of a finned surface. The closely packed thin metal sheets attached to the hot water tubes increase the surface area for convection and thus the rate of convection heat transfer from the tubes to the air many times. There are a variety of innovative fin designs available in the market, and they seem to be limited only by imagination.

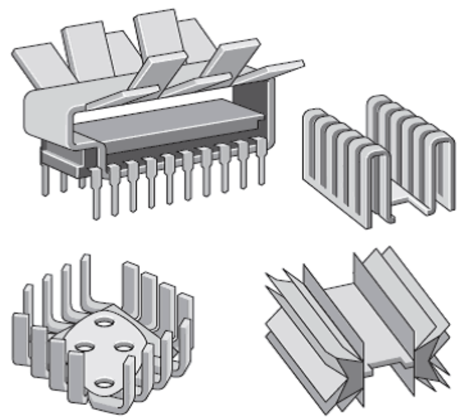


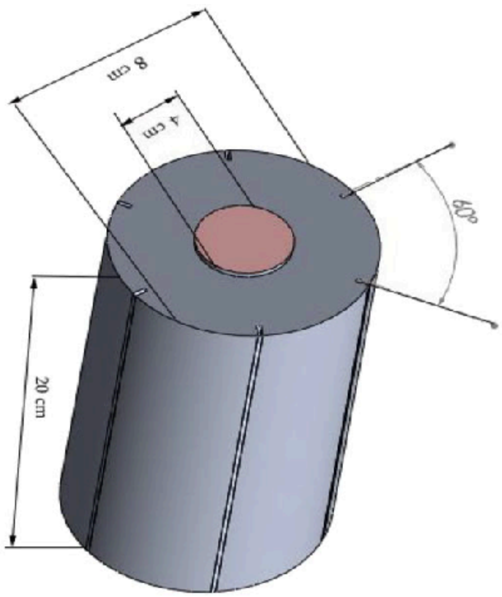
Fig 1.5 Innovations in Fins

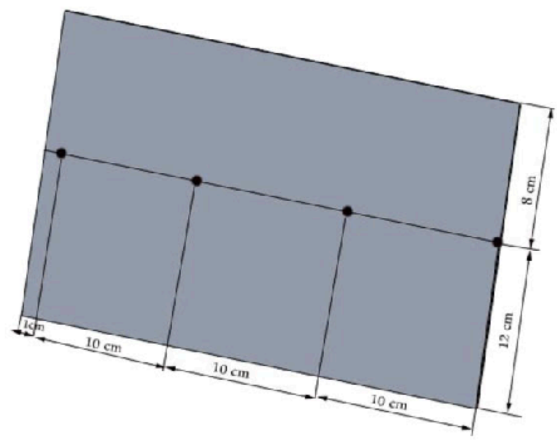
- In the analysis of fins, we consider steady operation with no heat generation in the fin, and we assume the thermal conductivity k of the material to remain constant.
- We also assume the convection heat transfer coefficient h to be constant and uniform over the entire surface of the fin for convenience in the analysis.
- We recognize that the convection heat transfer coefficient h, in general, varies along the fin as well as its circumference, and its value at a point is a strong function of the fluid motion at that point.
- The value of h is usually much lower at the fin base than it is at the fin tip because the fluid is surrounded by solid surfaces near the

base, which seriously disrupt its motion to the point of **“suffocating”** it, while the fluid near the fin tip has little contact with a solid surface and thus encounters little resistance to flow.

- Therefore, adding too many fins on a surface may actually decrease the overall heat transfer when the decrease in h offsets any gain resulting from the increase in the surface area.

Fig. 1 a: A cylindrical aluminum
bar with a heat source and fins
groove
b: Fin 1, flate plate
c: New proposed fin shape; (fin 2)
d: Fin 3 new shape with inner side
perforation
e: Fin 4 with fifty circular perforations on the top side of the fin
f: Fin 5 fifty circular perforations in square distribution
g: Fin 6 fifty circular perforations in a triangular distribution
h: Fin 7; fifty corners circular
perforations distribution 1: Main
experimental rig parts (a, b, c, d, e,f, g, and h)


8 cm
4 cm
60°
20 cm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10 cm
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10 cm
8 cm
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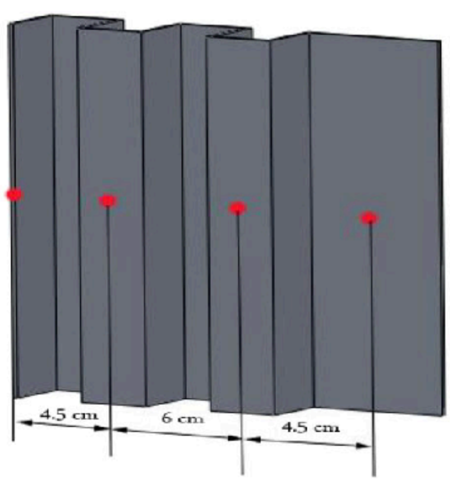
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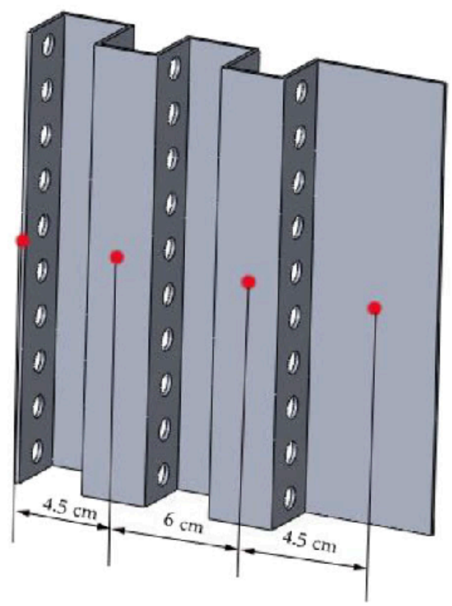
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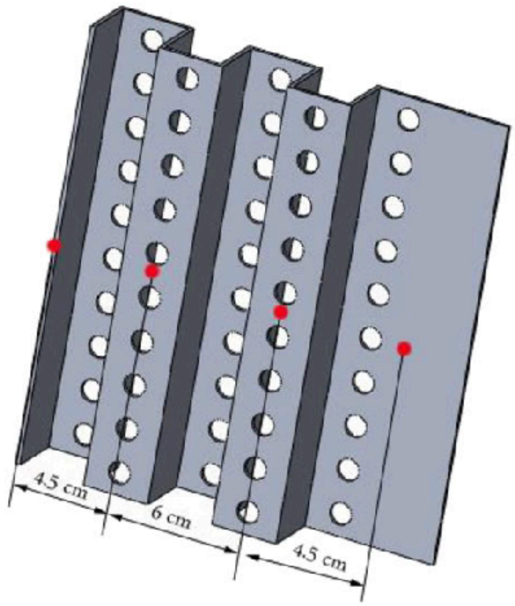
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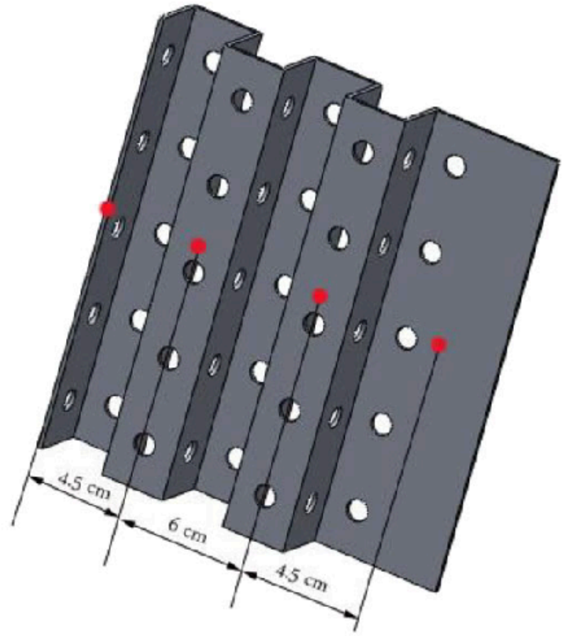
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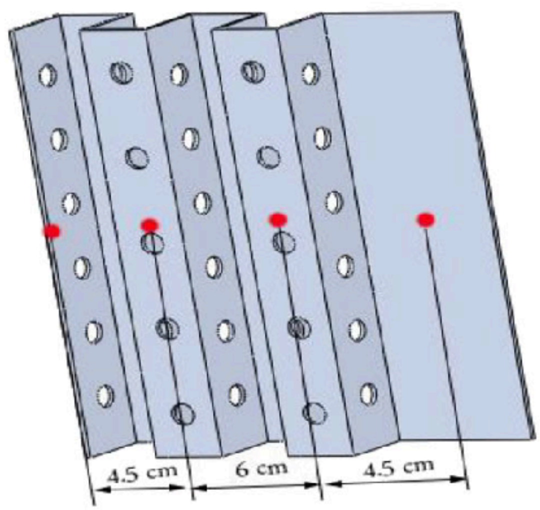
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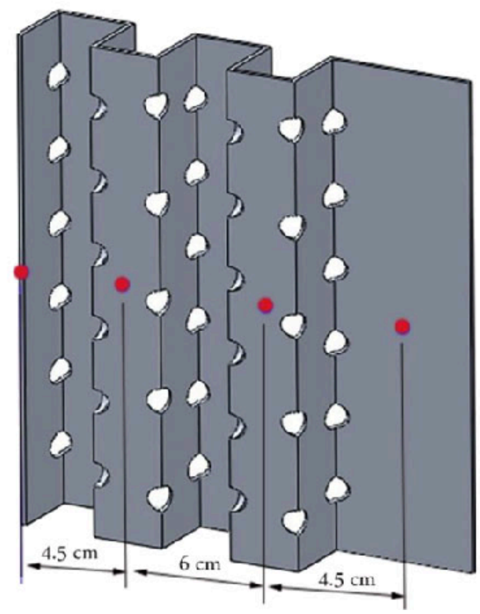
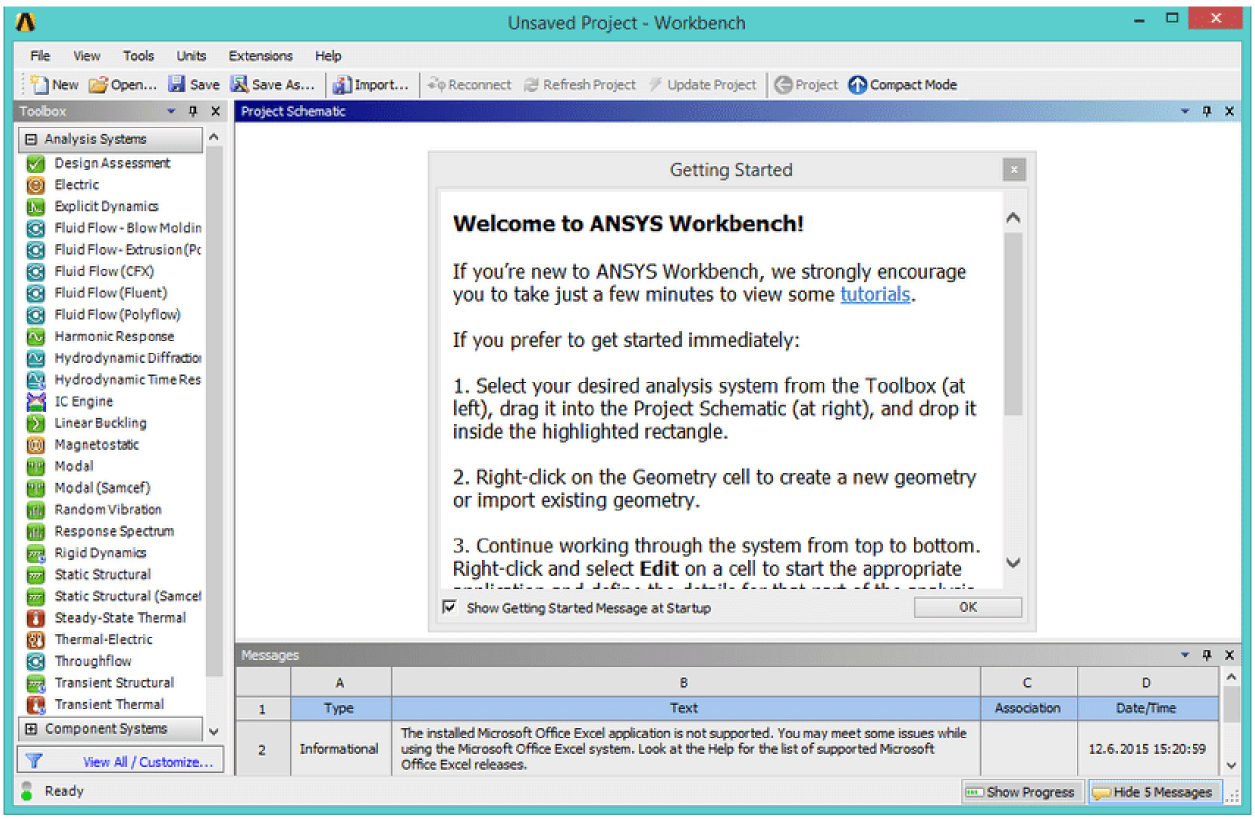

4.5 cm
6 cm
4.5 cm

We have made our project using **Steady State Thermal analysis** in ANSYS Inc. Software.

<u>What is ANSYS:</u>

Ansys, Inc. is an American company based in Canonsburg, Pennsylvania. It develops and markets multiphysics engineering simulation software for product design, testing and operation and offers its products and services to customers worldwide. Ansys was founded in 1970 by John Swanson.



<u>Figure 1.6: ANSYS WORKBENCH</u>

WHAT IS 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.

Figure 1.7: Steady State Thermal

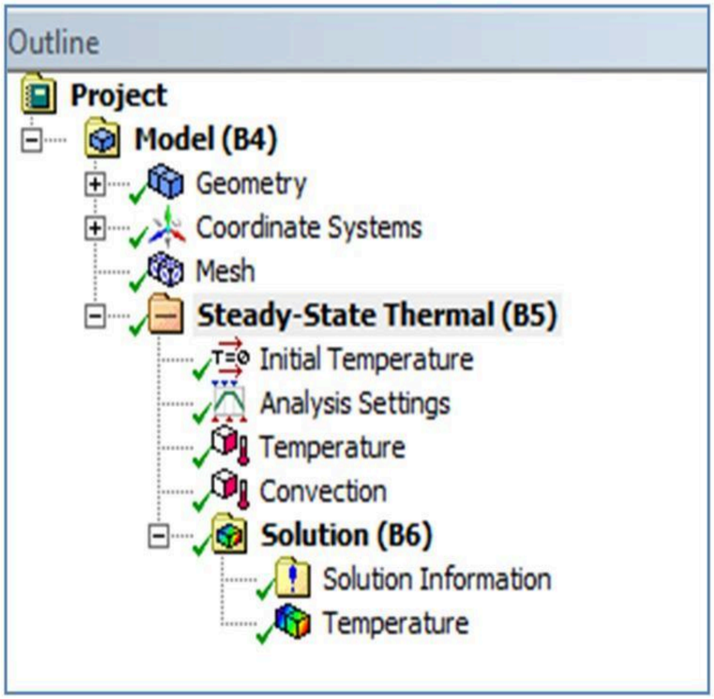
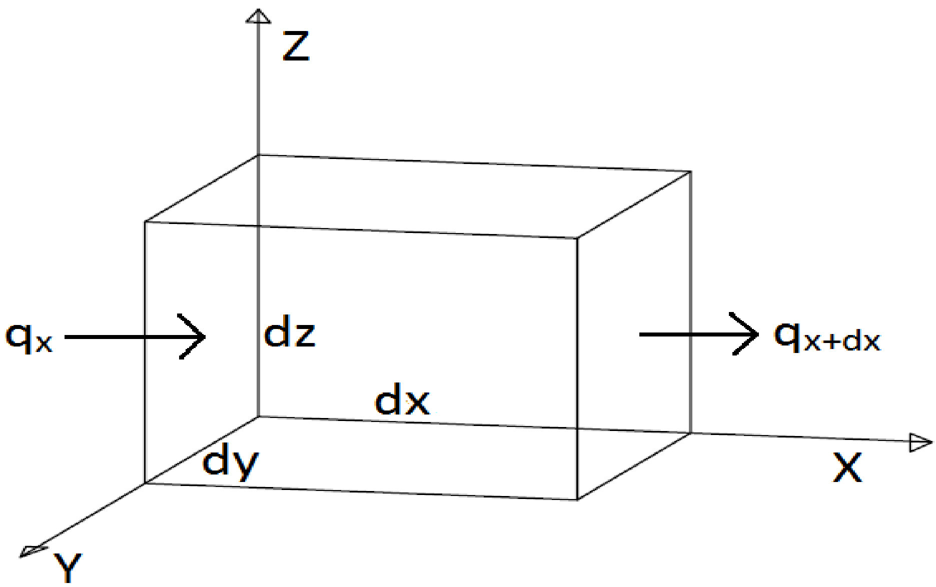


Figure 1.8: Project Outline

2. GOVERNING EQUATIONS & FORMULAS USED:

- ✔ The basic form of heat conduction equation is obtained by applying the first law of thermodynamics (principle of conservation of energy). [4]
- ✔ Steady state refers to a stable condition that does not change over time. Time variation of temperature is zero. Hence,



$$\frac{\partial}{\partial x}\left(k\,\frac{\partial T}{\partial x}\right)+\frac{\partial}{\partial y}\left(k\,\frac{\partial T}{\partial y}\right)+\frac{\partial}{\partial z}\left(k\,\frac{\partial T}{\partial z}\right)+\dot{e}_{gen}=0$$

✔ Fin efficiency with insulated tip:

$$\eta=\frac{\theta_0\sqrt{hPkA_c}\,\tan h\;ml}{hPl\theta_0}$$

✔ Fin efficiency without insulated tip:

$$\eta=\frac{\theta_0\sqrt{hPkA_c}\left[\dfrac{\tan h\;ml+\dfrac{h}{mk}}{1+\dfrac{h}{mk}\tan h\;ml}\right]}{h(Pl+b\delta)\theta_0}$$

✔ Fin effectiveness:

$$\varepsilon_{fin} = \frac{q_{fin}}{q_{no\,fin}} = \frac{q_{fin}}{h A_b \left(T_b - T_\infty\right)} = \frac{\eta_{fin}\, h A_{fin} \left(T_b - T_\infty\right)}{h A_b \left(T_b - T_\infty\right)} = \frac{\eta_{fin} A_{fin}}{A_b}$$

3. LITERATURE SURVEY:

Heat transfer performance of fin is analyzed by ANSYS workbench for the design of fin with design configuration such as rectangular configuration and by giving different boundary conditions (with insulated tip & without insulated tip). The heat transfer performance of fin with same base temperature is compared. In this thermal analysis,

Aluminum alloy was used as the base metal for the fin material. Fins are design with the help of ANSYS 17.0. Analysis of fin performance done through the software ANSYS 17.0.

Here it has been analyzed in the project," Thermal Analysis Of Rectangular fins by taking 2 cases" that there is scope of improvement in the fin geometry & material used for fin manufacturing for enhancing the temperature distribution along the fin length **[2]**

Theoretical analysis

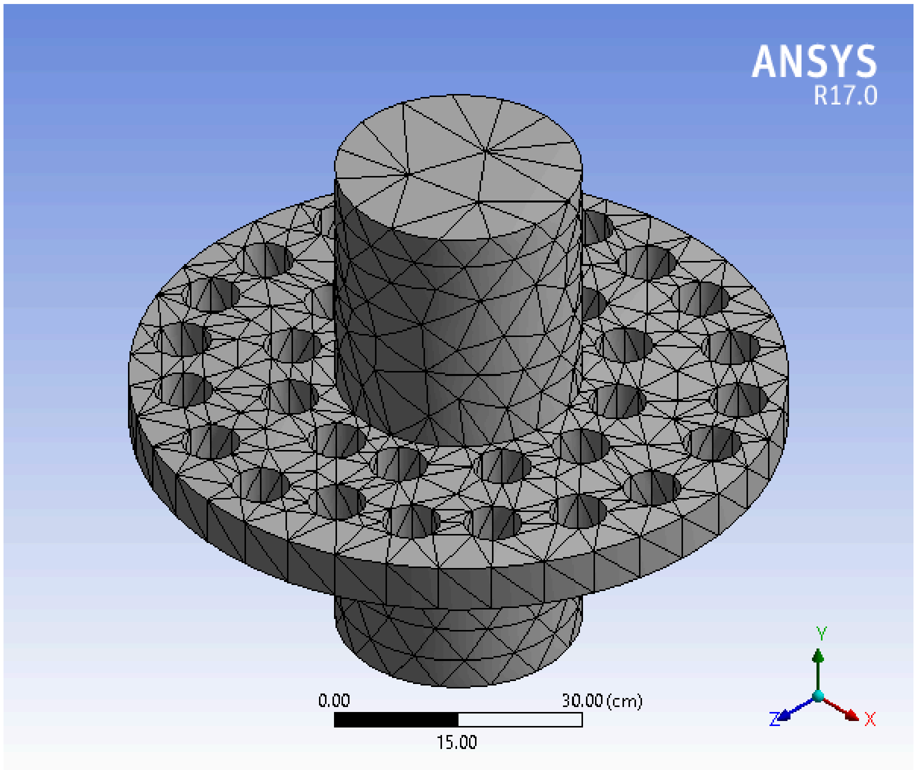
The analysis of heat transfer from solid and perforated fins
Was done by analytical solution with the following

Assumptions.
1. There is no heat generation across the fin.
2. The thermal conductivity of the fin is constant.
3. Uniform and constant base and ambient temperature.
4. Uniform and constant heat transfer coefficient along the fin.
5. Constant heat flux.
6. Steady state one dimensional heat flux.
7. No forced convection.

SYSTEM SPECIFICATIONS

- WINDOWS VERSION: 10
- RAM: 8GB
- GRAPHICS CARD: NVIDIA GRAPHICS CARD 2GB
- PROCESSOR: INTEL CORE i3-8130U CPU@ 2.20GHz
- GENERATION: 8^{th}
- SYSTEM TYPE: 64 bit Operating System, x64 based processor
- ANSYS VERSION: 17.0

4. ANALYSIS OF PERFORATED ANNULAR FINS:



In thermal engineering, an annular fin is a specific type of fin used in heat transfer that varies, radially, in cross-sectional area. Adding an annular fin to an object increases the amount of surface area in contact with the surrounding fluid, which increases the convective heat transfer between the object and surrounding fluid. Because surface area increases as length from the object increases, an annular fin transfers more heat than a similar pin fin at any given length. Annular fins are often used to increase the heat exchange in liquid–gas heat exchanger systems.

ANALYSIS OF COPPER ANNULAR FINS WITH INSULATED TIP:

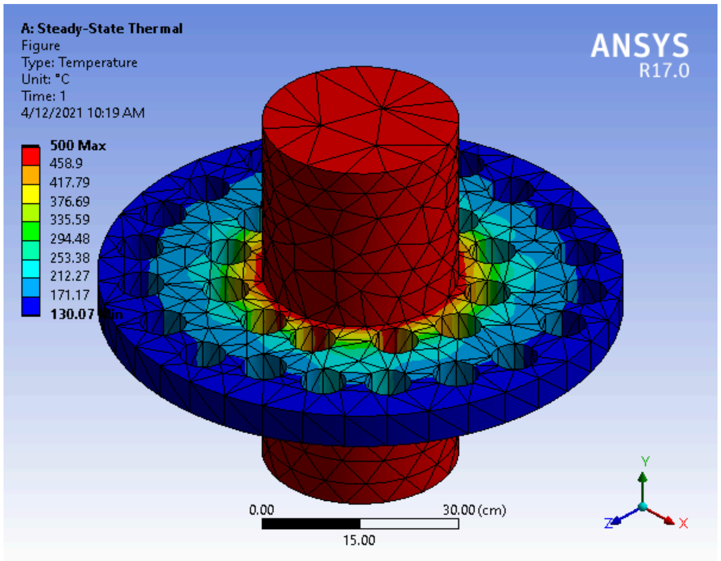


Fig 1: Annular fins without insulated tip in summer

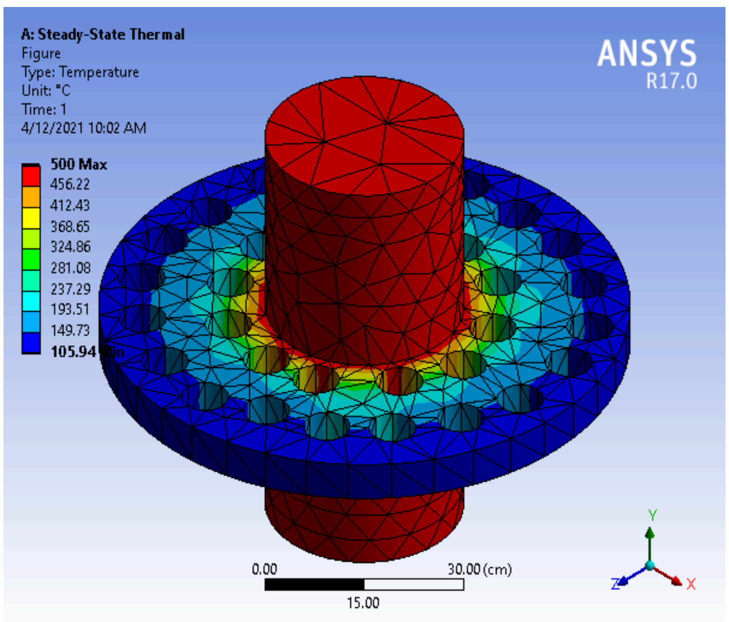


Fig 2: Annular fins without insulated tip in winter

ANALYSIS OF COPPER ANNULAR FINS WITHOUT INSULATED TIP:

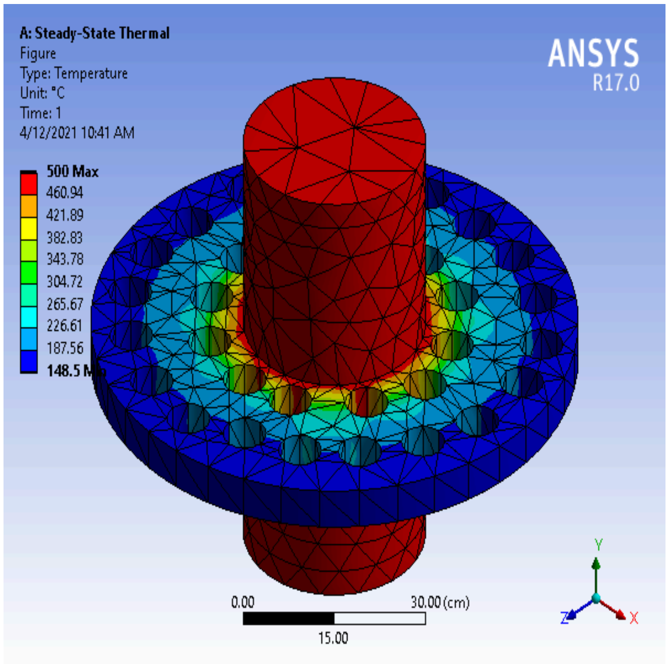


Fig 3: Annular fins with insulated tip in summer

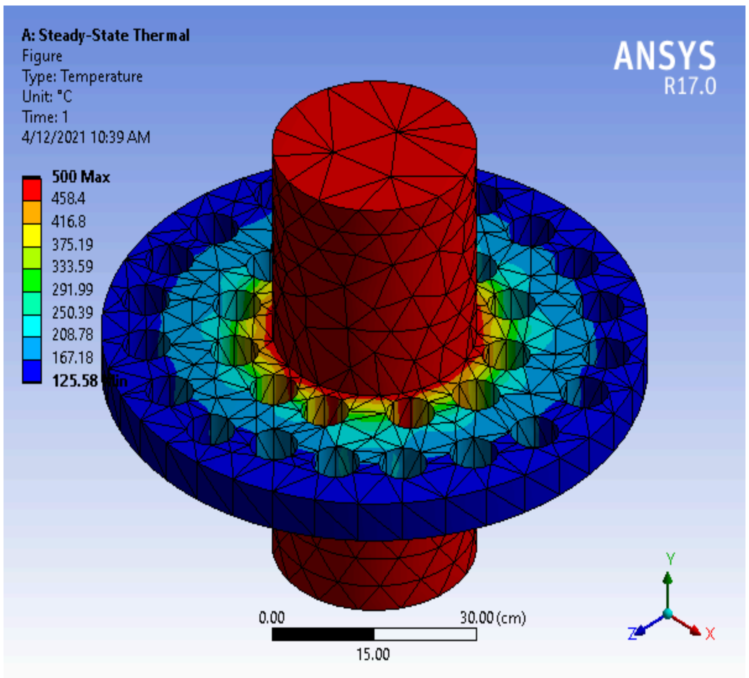


Fig 4: Annular fins with insulated tip in winter

TEMPERATURE vs. LENGTH CURVE OF COPPER ANNULAR FINS :

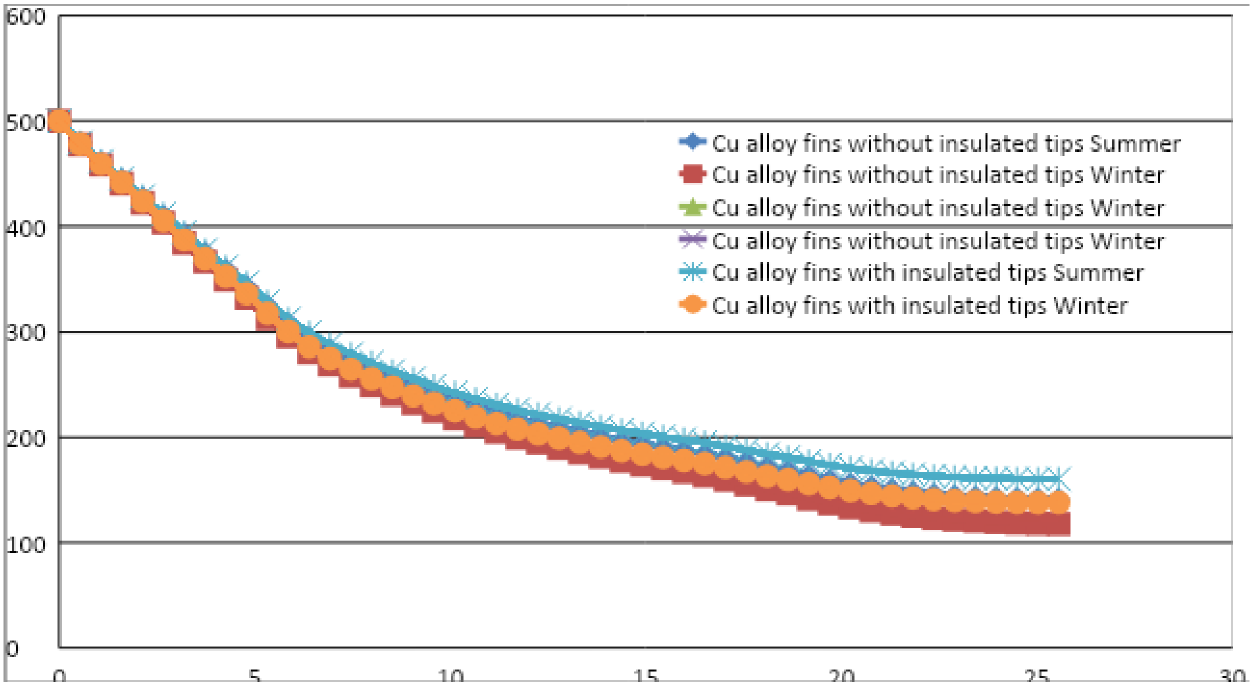


Fig 5: Temp. vs. Length graph of Cu annular fins

In the above graph is a temp. vs. length curve of copper annular fins, here the base temperature of annular fins is 500℃ & the min temp in summer for insulated tip & non-insulated tip is 130.07℃ & 148.5℃ respectively whereas in winter it is 105.94℃ & 125.98℃ respectively. The graph plotting depends mostly on Fourier's law of conduction equation which is given by: $Q =- KA\frac{dt}{dx}$

Where, 'Q' is the heat transfer rate

'K' is the thermal conductivity of the fin material

'A' is the area of cross section of the fin profile

$\frac{dt}{dx}$ is the rate of change of temperature w.r.t change in length

ANALYSIS OF COPPER ANNULAR FIN BASE WITHOUT FINS:

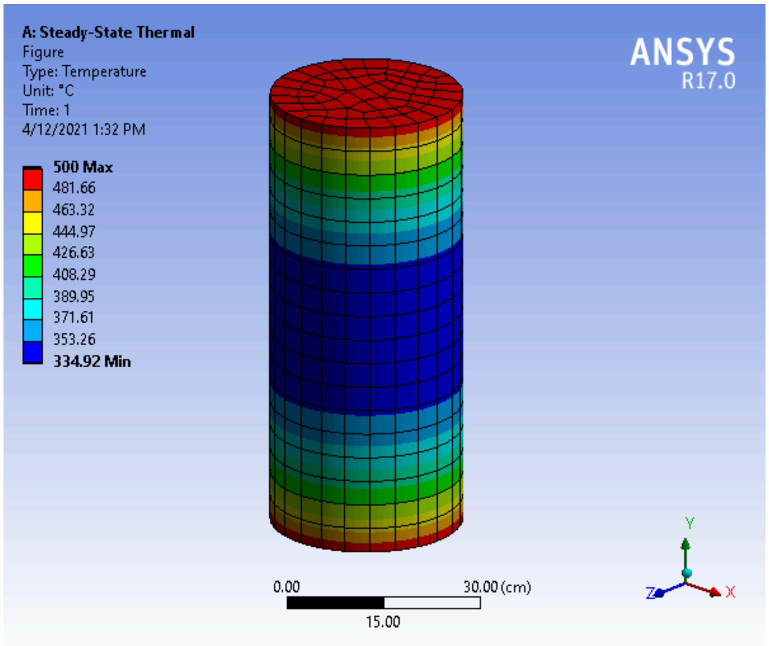


Fig 6: Copper Annular fin base in summer

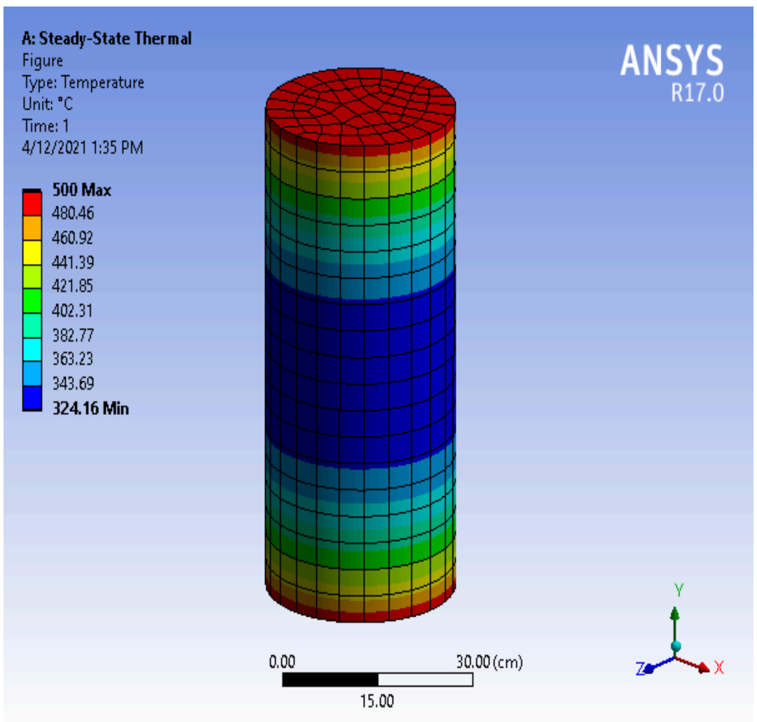


Fig 7: Copper Annular fin base in winter

ANALYSIS OF ALUMINIUM ANNULAR FIN BASE WITHOUT FINS:

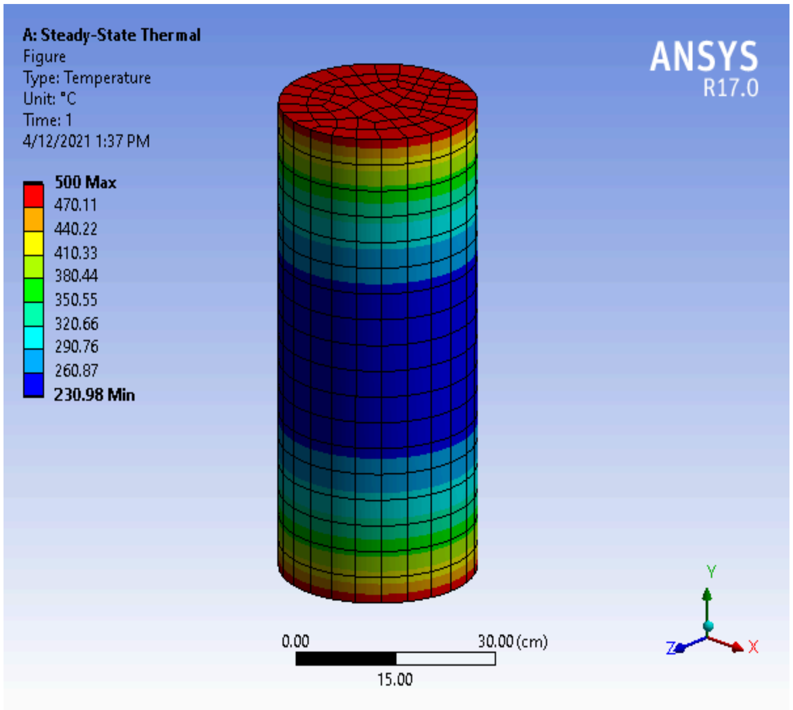


Fig 8: Aluminum Annular fin base in summer

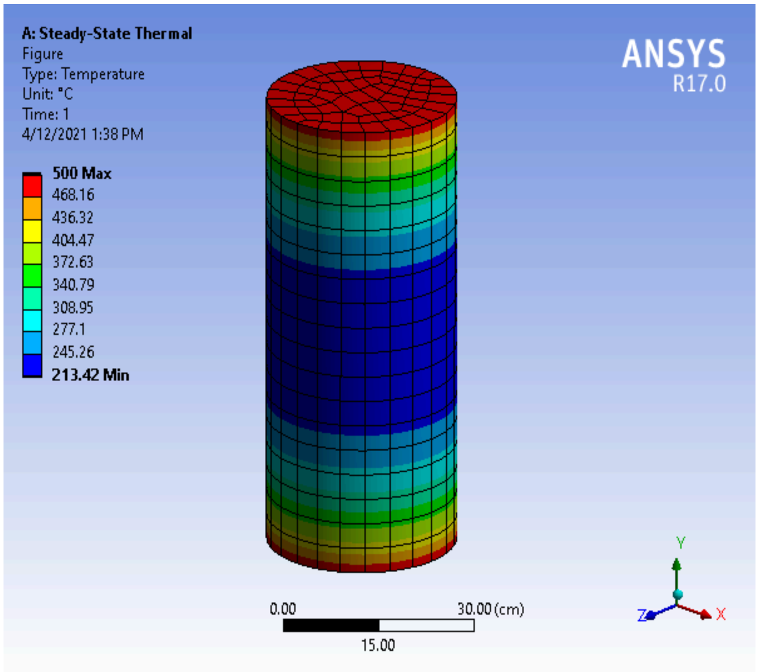


Fig 9: Aluminum Annular fin base in winter

TEMP vs. LENGTH CURVE OF ANNULAR FIN BASE WITHOUT FINS :

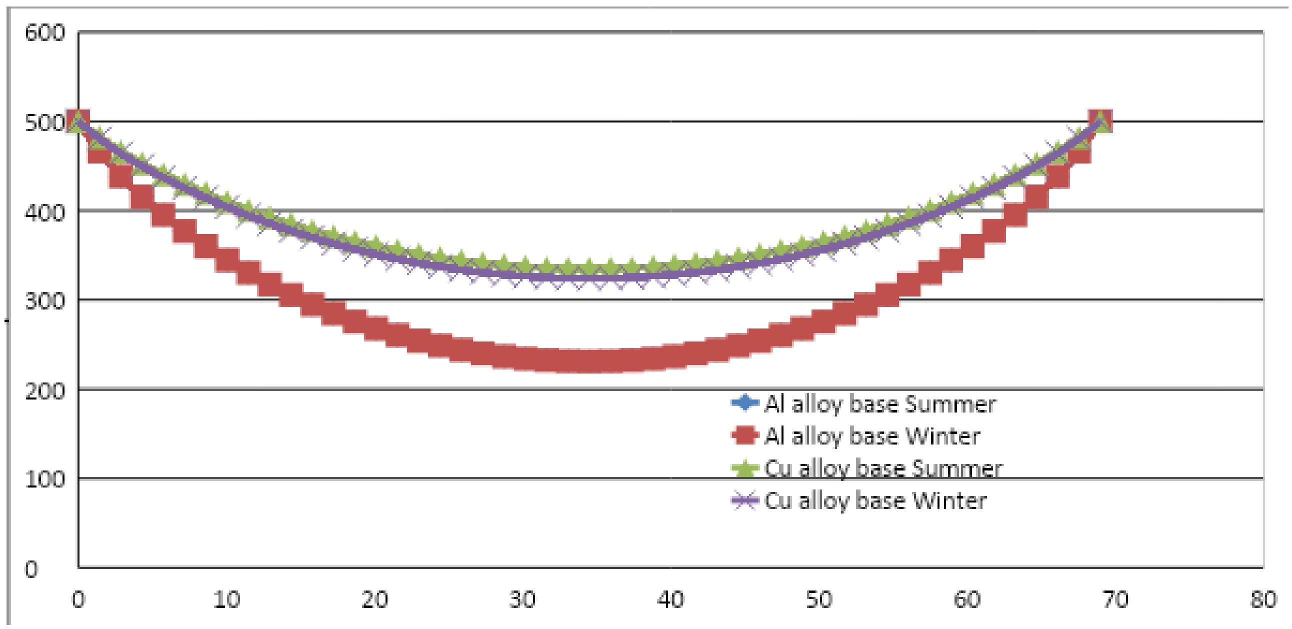


Fig 10: Temp. vs. Length graph of Cu annular fin base

In the above graph is a temp. vs. length curve of annular fin base without fins, Here the temp. First increases then slowly decreases when it comes to centre & then again increases. The graph plotting depends mostly on Fourier's law of conduction equation which is given by: $Q = -KA\frac{dt}{dx}$

Where, 'Q' is the heat transfer rate

'K' is the thermal conductivity of the fin material

'A' is the area of cross section of the fin profile

$\frac{dt}{dx}$ is the rate of change of temperature w.r.t change in length

ANALYSIS OF ALUMINIUM ANNULAR FINS WITHOUT INSULATED TIP:

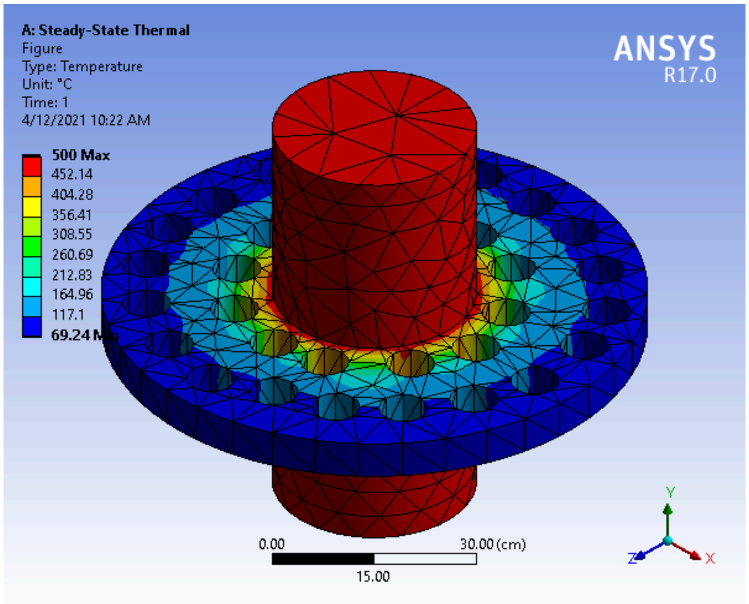


Fig 11: Aluminum annular fins in summer

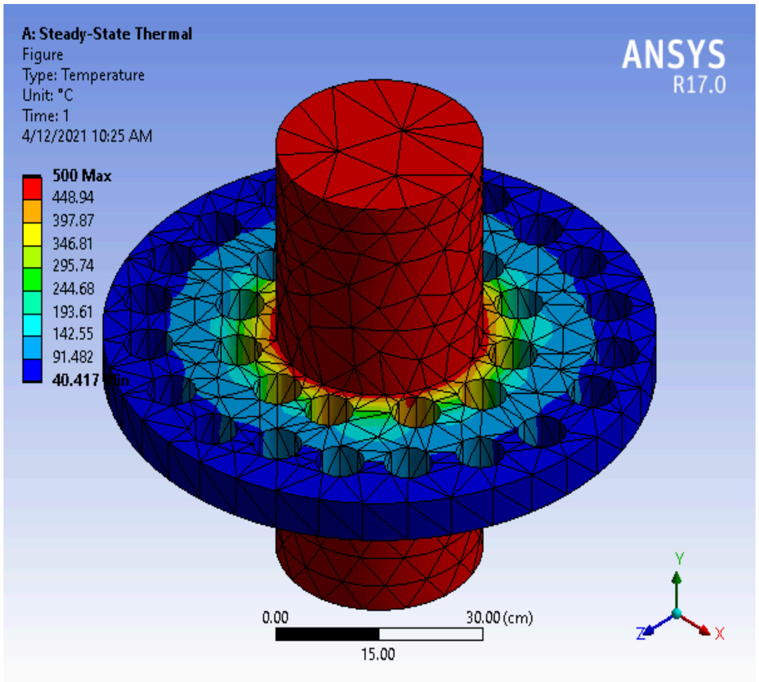


Fig 12: Aluminum annular fins in winter

ANALYSIS OF ALUMINIUM ANNULAR FINS WITH INSULATED TIP:

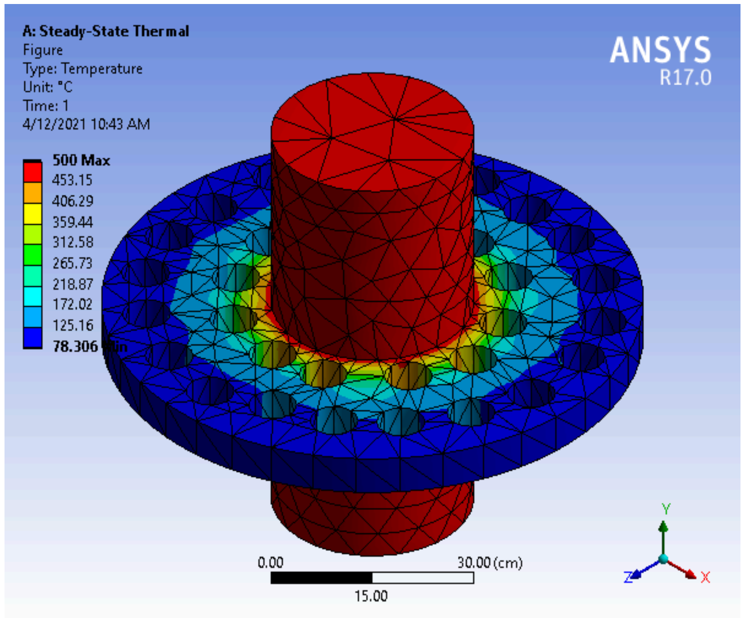


Fig 13: Aluminum annular fins in summer

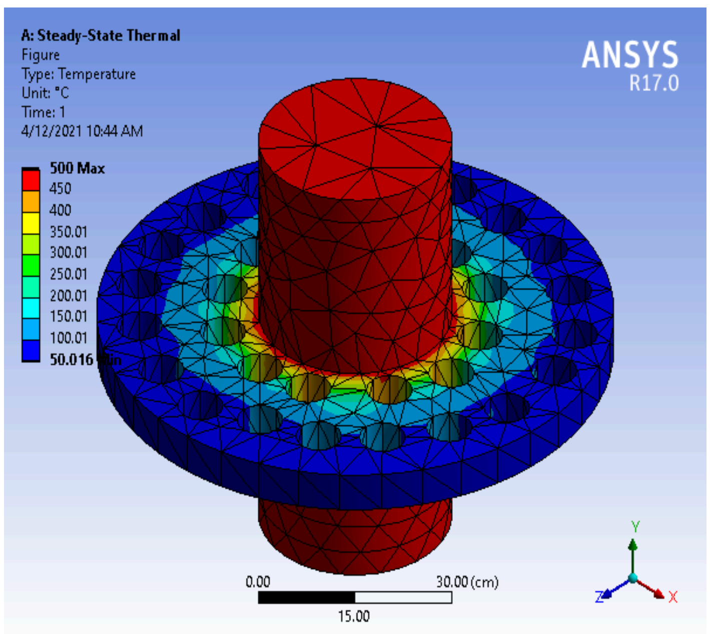


Fig 14: Aluminum annular fins in winter

TEMPERATURE vs. LENGTH CURVE OF ALUMINUM ANNULAR FINS :

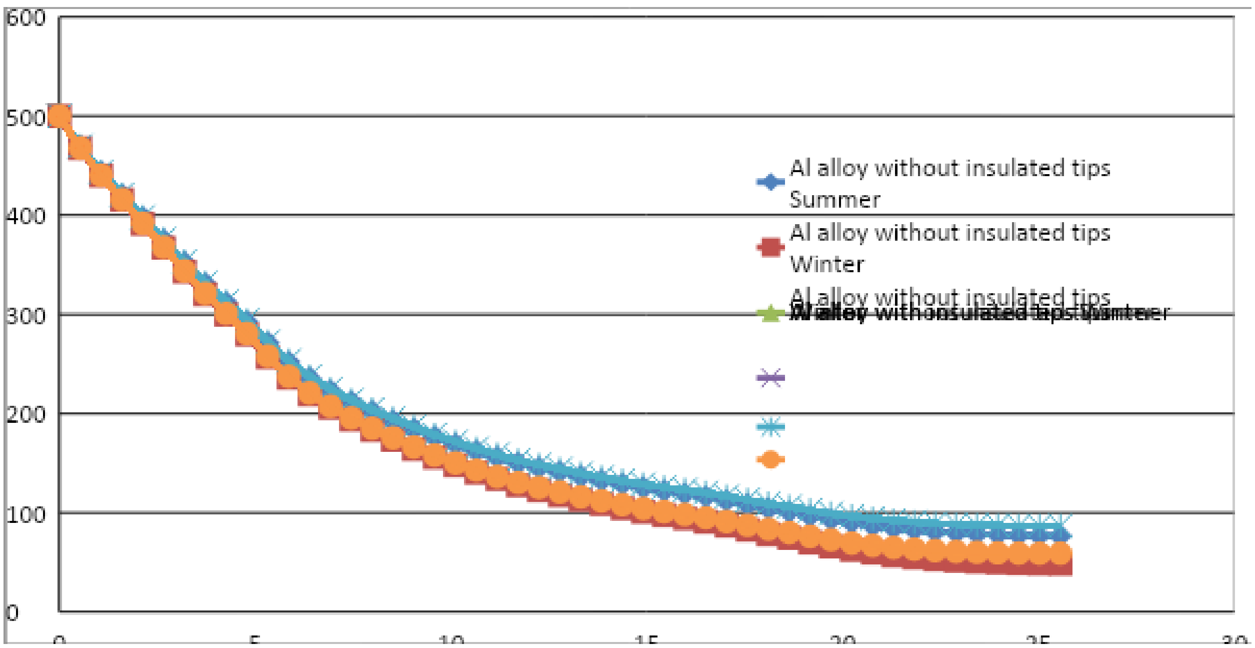


Fig 15: Temp. vs. Length graph of Al annular fins

In the above graph is a temp. vs. length curve of Al annular fins, here the base temperature of annular fins is 500℃ & the min temp in summer for insulated tip & non-insulated tip is 78.30℃ & 69.24℃ respectively whereas in winter it is 54.06℃ & 48.77℃ respectively. The graph plotting depends mostly on Fourier's law of conduction equation which is given by: $Q =- KA\frac{dt}{dx}$

Where, 'Q' is the heat transfer rate

'K' is the thermal conductivity of the fin material

'A' is the area of cross section of the fin profile

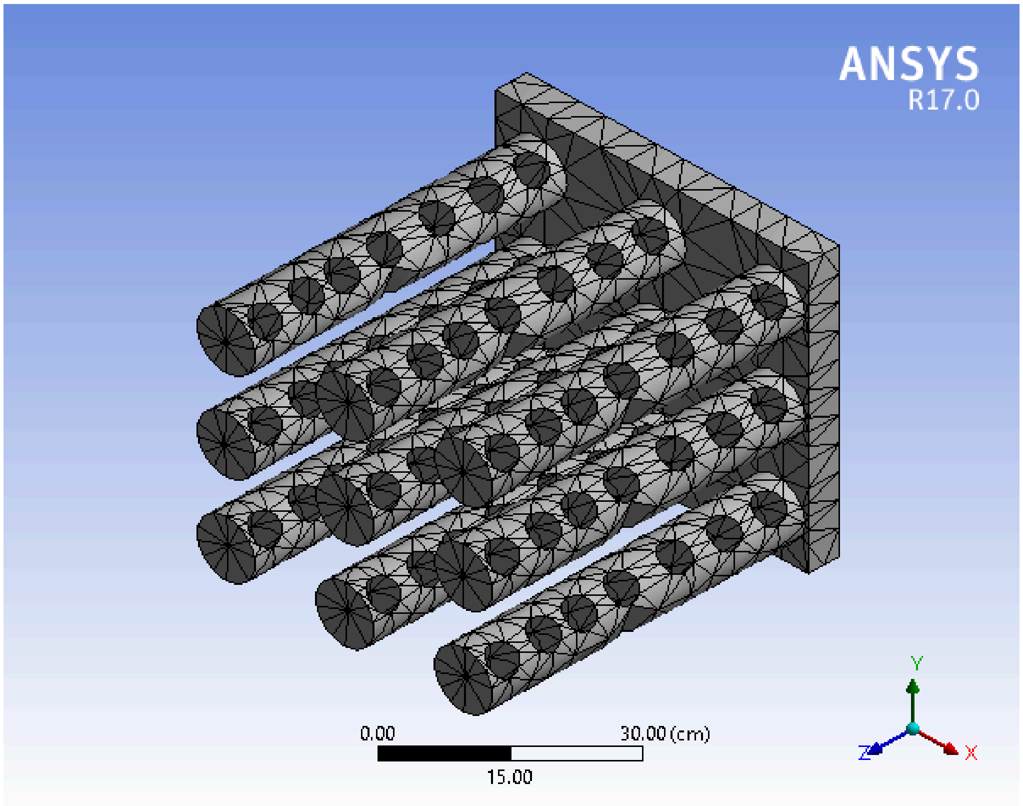
$\frac{dt}{dx}$ is the rate of change of temperature w.r.t change in length

RESULTS FOR ANNULAR FINS:

Fin profile	**Material used**	**Boundary condition**	**Atmospheric temp**	**Max base temp**	**Fin tip temp**	**Effectiveness**	**Efficiency**
Annular fins	Copper alloy	Insulated tip	40℃ (Summer)	500℃	148.5℃	0.84	26.3%
		Non-insulated tip			130.7℃	1.10	35.01%
	Aluminium alloy	Insulated tip			78.36℃	0.91	28.58%
		Non-insulated tip			69.24℃	1.07	33.61%
	Copper alloy	Insulated tip	10℃ (Winter)		125.98 ℃	0.87	27.33%
		Non-insulated tip			105.94 ℃	1.62	50.89%
	Aluminium alloy	Insulated tip			50.061 ℃	0.45	41.37%
		Non-insulated tip			40.412 ℃	1.77	55.60%

Table 1: Results for annular fins

5. ANALYSIS OF PERFORATED CYLINDRICAL FINS:



In thermal engineering, a Cylindrical fins is a specific type of fin used in heat transfer that varies, Perpendicular in cross-sectional area. Adding an cylindrical fin to an object increases the amount of surface area in contact with the surrounding fluid, which increases the convective heat transfer between the object and surrounding fluid. Because surface area increases as length from the object increases, an annular fin transfers more heat than a similar pin fin at any given length. Cylindrical fins are often used to increase the heat exchange in liquid–gas heat exchanger systems.

ANALYSIS OF COPPER CYLINDRICAL FINS WITH INSULATED TIP:

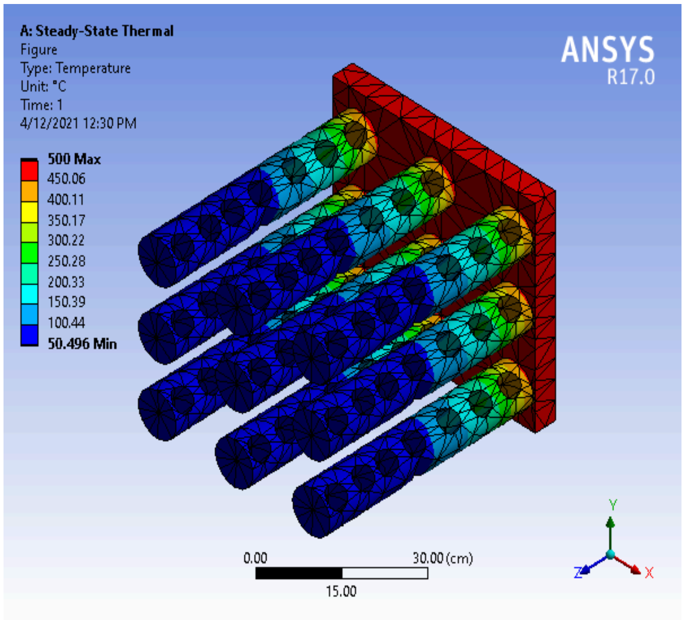


Fig 16: Cylindrical fins with insulated tip in summer

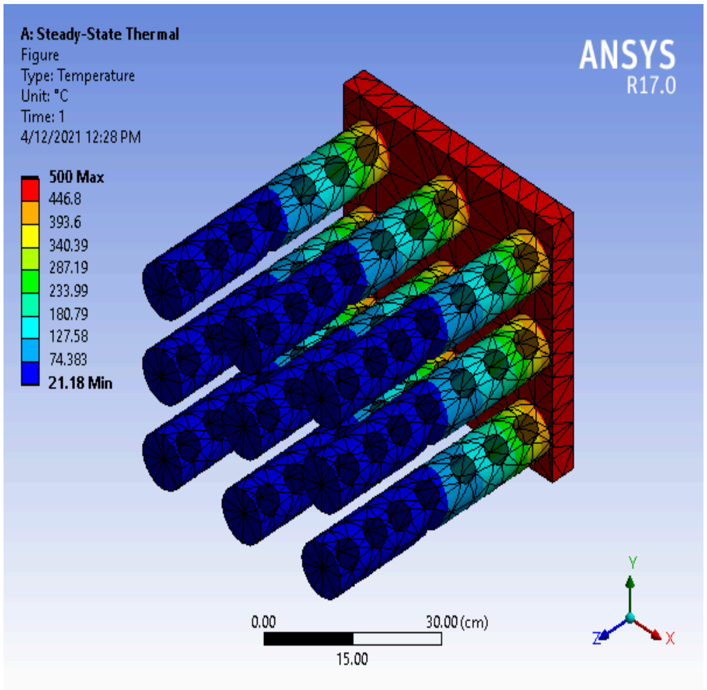


Fig 17: Cylindrical fins with insulated tip in winter

ANALYSIS OF COPPER CYLINDRICAL FINS WITHOUT INSULATED TIP:

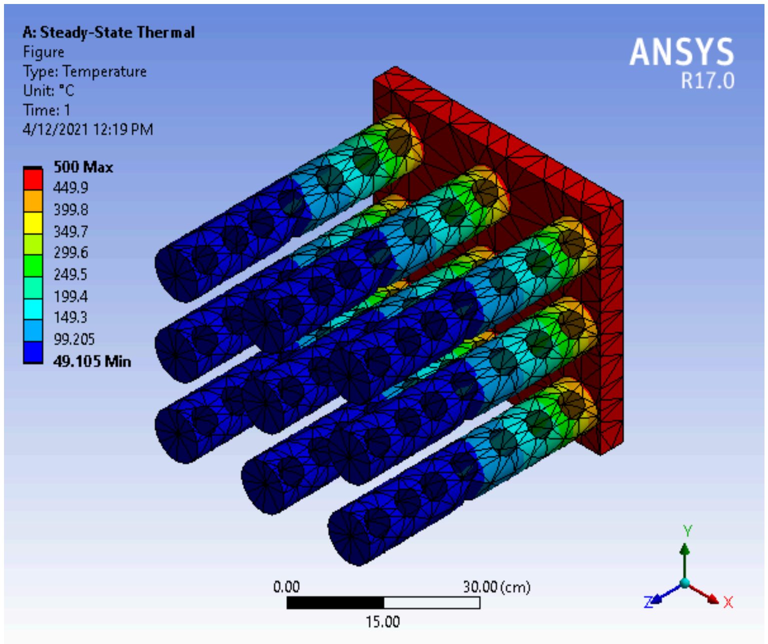


Fig 18: Cylindrical fin without insulated tip in summer

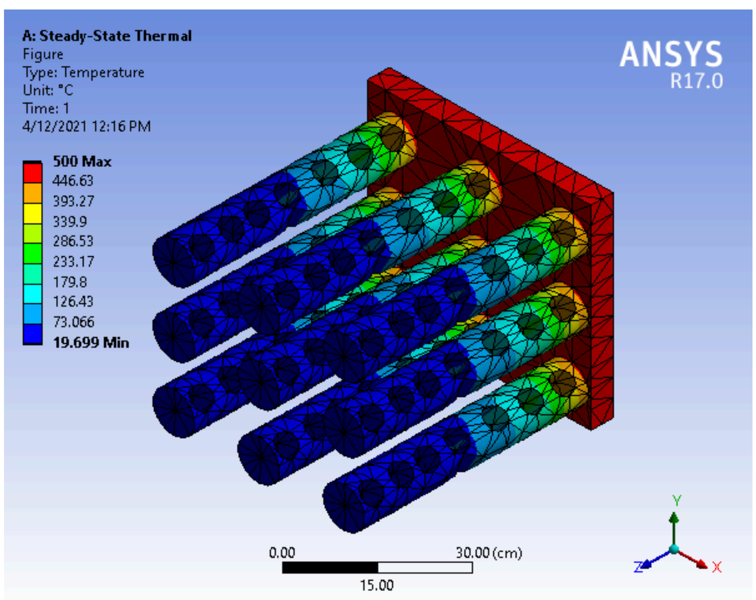


Fig 19: Cylindrical fin without insulated tip in winter

TEMPERATURE vs. LENGTH CURVE OF COPPER CYLINDRICAL FINS:

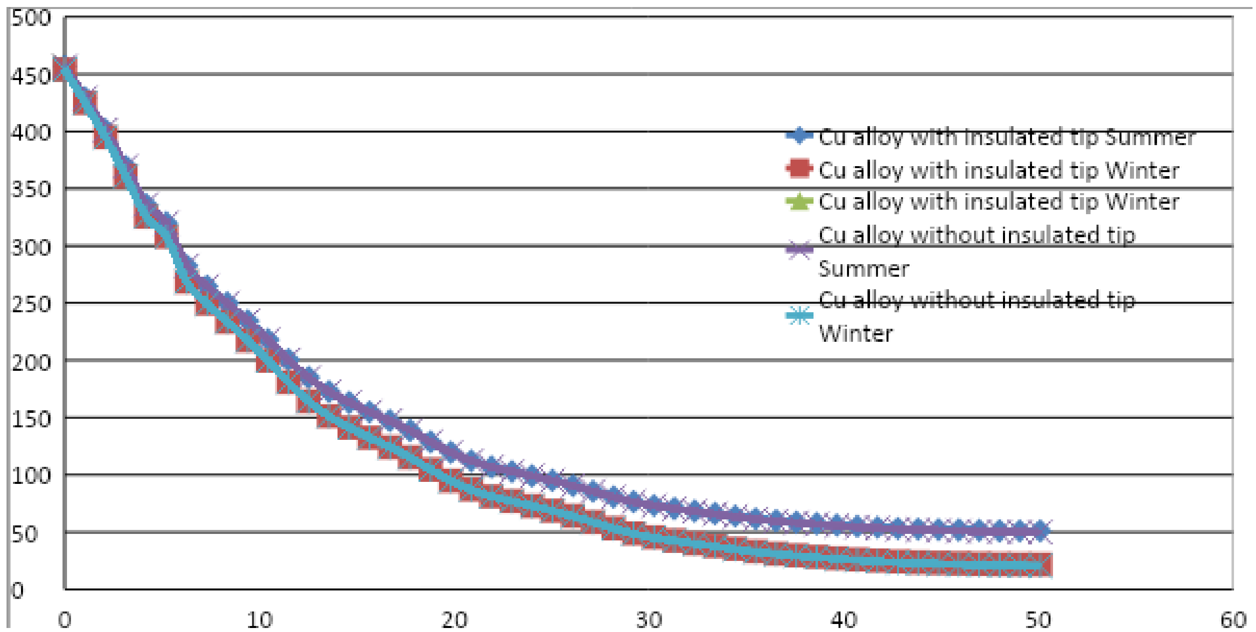


Fig 20: Temp vs. Length graph of Cu cylindrical fins

In the above graph is a temp. vs. length curve of Cu cylindrical, here the base temperature of Cylindrical fins is 500℃ & the min temp in summer for insulated tip & non-insulated tip is 50.496℃ & 49.105℃ respectively whereas in winter it is 21.18℃ & 19.99℃ respectively. The graph plotting depends mostly on Fourier's law of conduction equation which is given by: $Q =- KA\frac{dt}{dx}$

Where, 'Q' is the heat transfer rate

'K' is the thermal conductivity of the fin material

'A' is the area of cross section of the fin profile

$\frac{dt}{dx}$ is the rate of change of temperature w.r.t change in length

ANALYSIS OF COPPER CYLINDRICAL FIN BASE WITHOUT FINS:

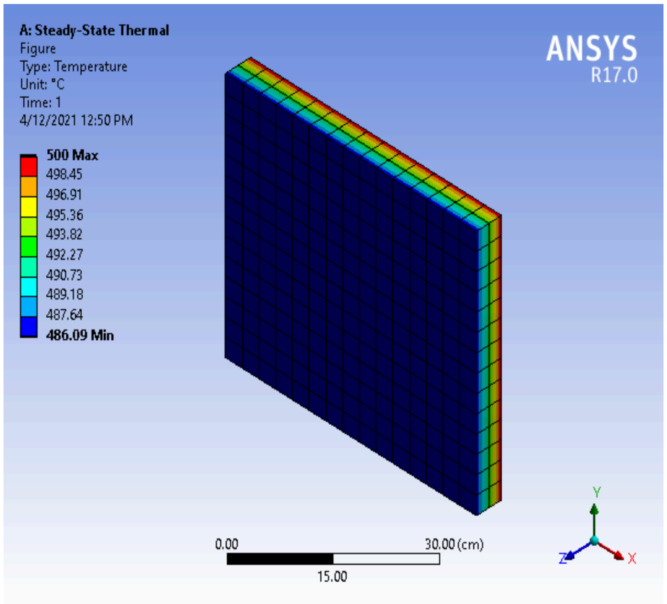


Fig 21: Copper cylinder fin base in summer

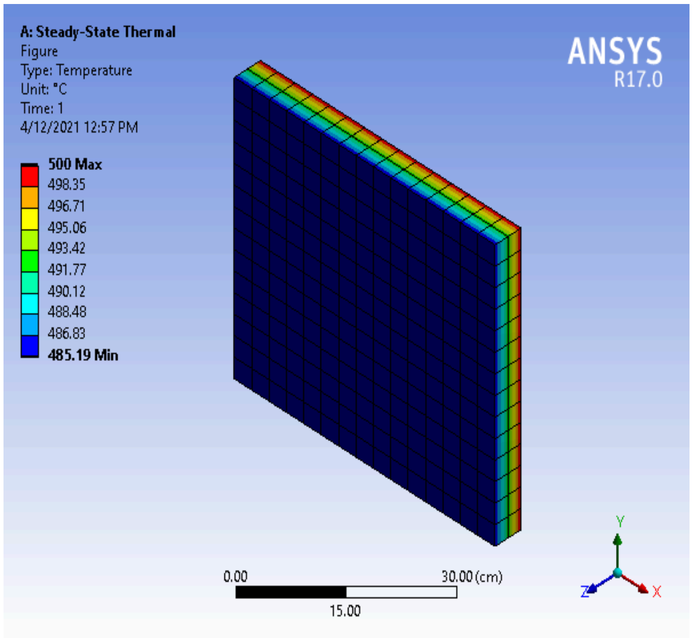


Fig 22: Copper cylinder fin base in winter

ANALYSIS OF ALUMINUM CYLINDRICAL FIN BASE WITHOUT FINS:

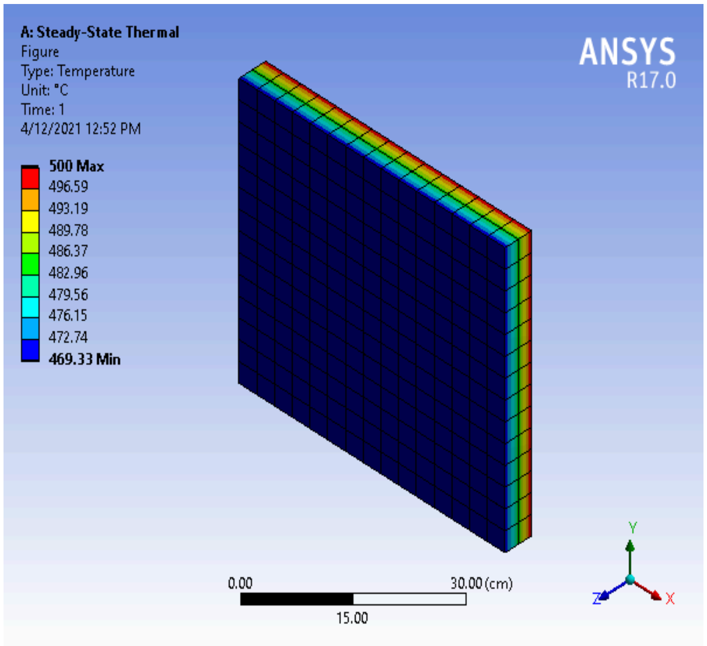


Fig 23: Aluminum cylindrical fin base in summer

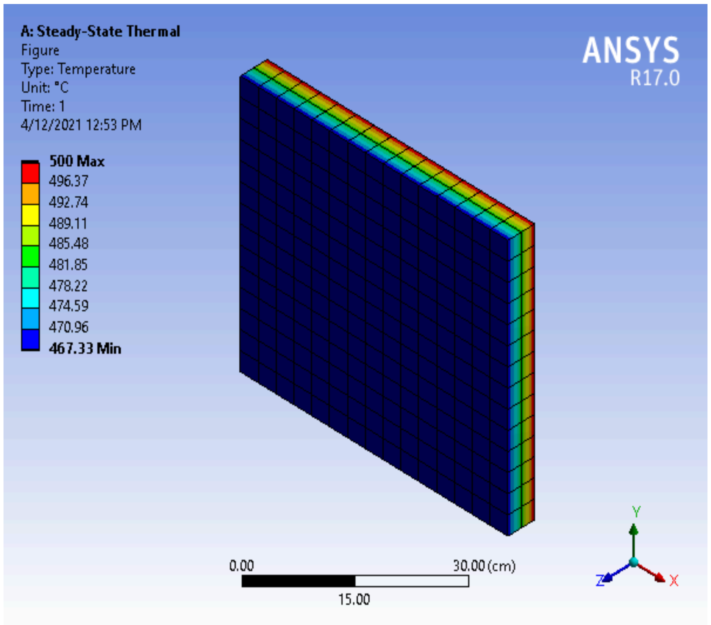


Fig 24: Aluminum cylindrical fin base in winter

TEMP vs. LENGTH CURVE OF CYLINDRICAL FIN BASE WITHOUT FINS :

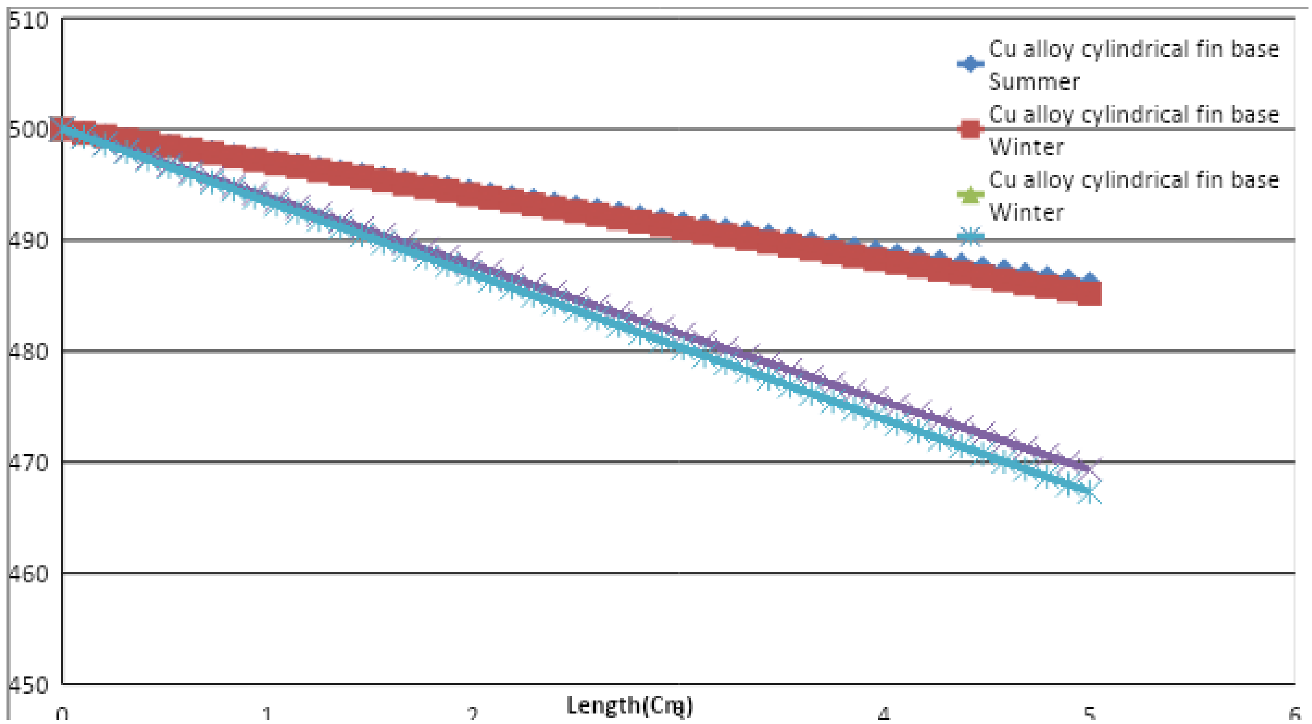


Fig 25: Temp. vs. Length curve of cylindrical fin base without fins

In the above graph is a temp. vs. length curve of annular fin base without fins, Here the temp. Here the max temp is 500℃ in both the cases but the slope of base made of Cu is less as compared to that of Al material which is more. The graph plotting depends mostly on Fourier's law of conduction equation which is given by: $Q =- KA\frac{dt}{dx}$

Where, 'Q' is the heat transfer rate

'K' is the thermal conductivity of the fin material

'A' is the area of cross section of the fin profile

$\frac{dt}{dx}$ is the rate of change of temperature w.r.t change in length

ANALYSIS OF ALUMINUM CYLINDRICAL FINS WITH INSULATED TIP:

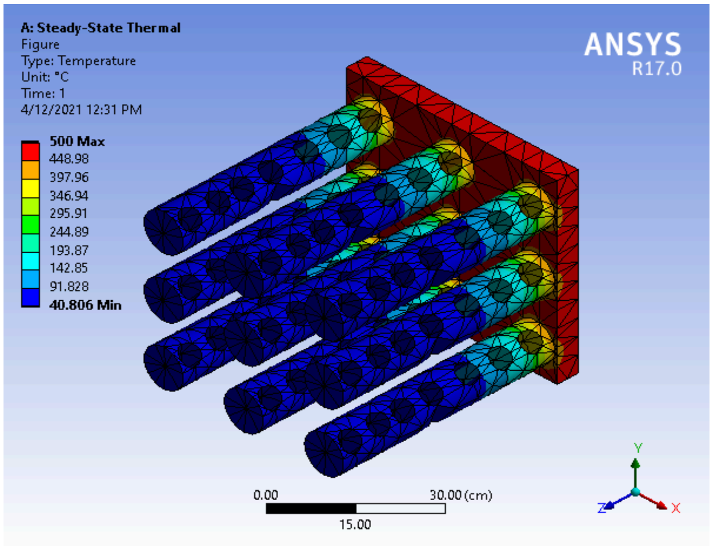


Fig 26: Cylindrical fin with insulated tip in summer

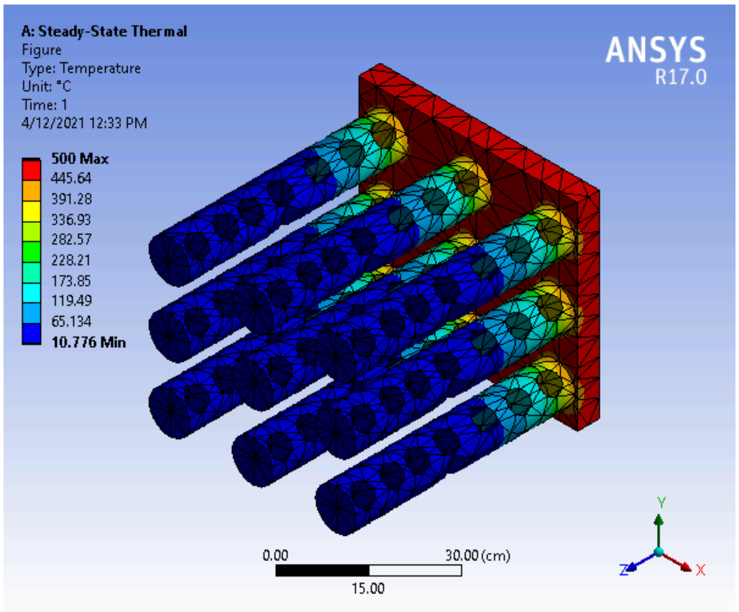


Fig 27: Cylindrical fin with insulated tip in winter

ANALYSIS OF ALUMINUM CYLINDRICAL FINS WITHOUT INSULATED TIP:

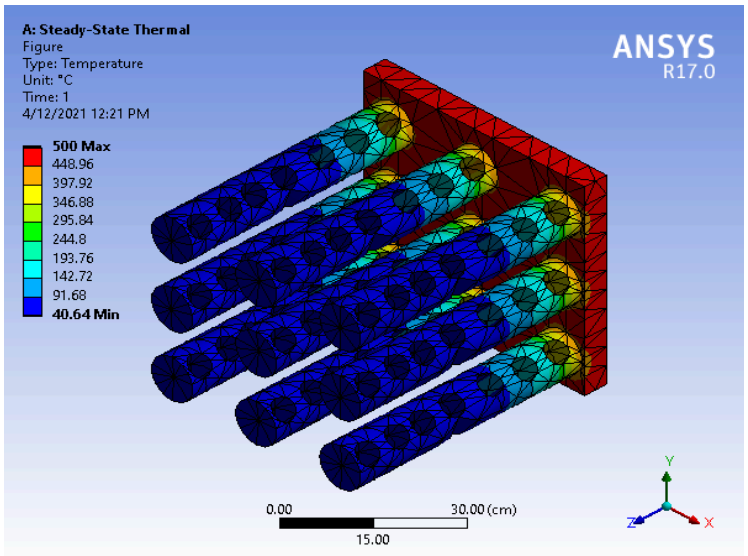


Fig 28: Cylindrical fin without insulated tip in summer

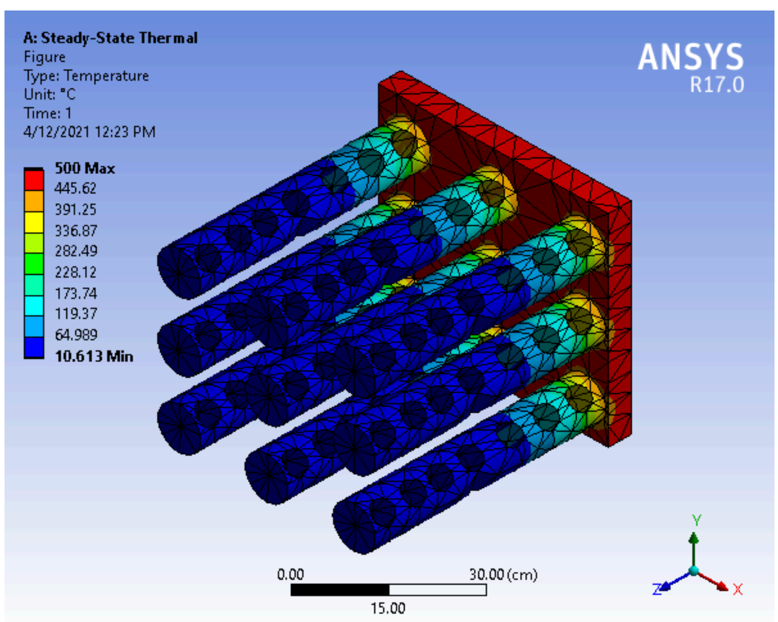


Fig 29: Cylindrical fin without insulated tip in winter

TEMPERATURE vs. LENGTH CURVE OF ALUMINUM CYLINDRICAL FINS:

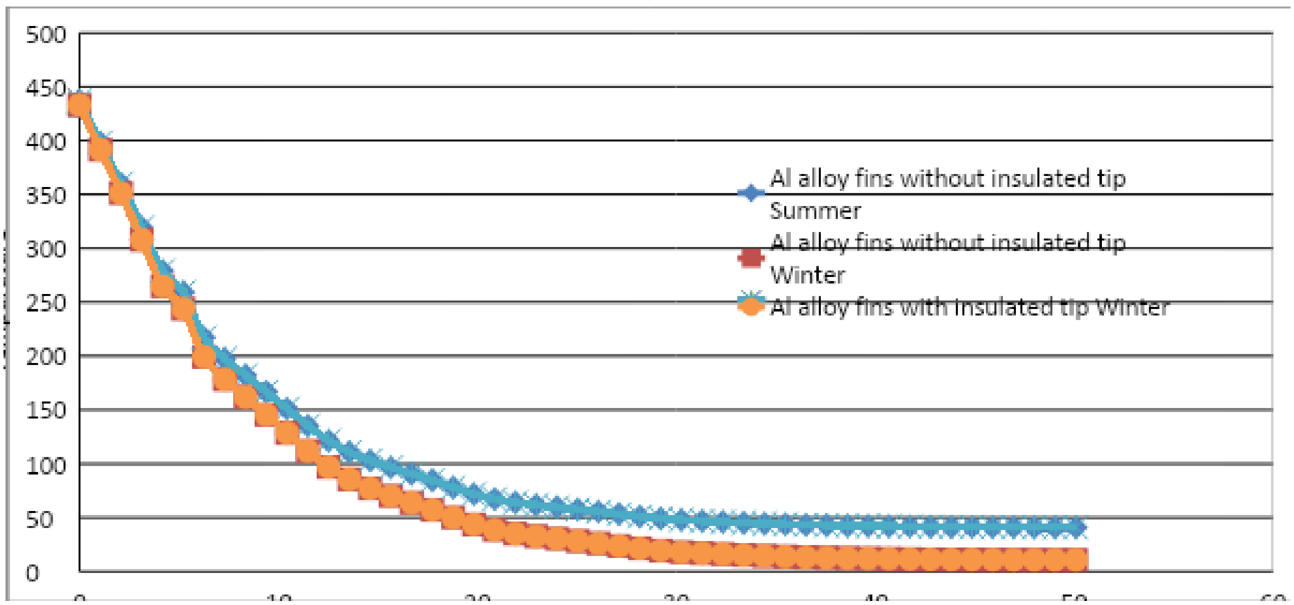


Fig 30: Temp vs. Length curve of Al cylindrical fins

In the above graph is a temp. vs. length curve of Al cylindrical fins, here the base temperature of Cylindrical fins is 500℃ & the min temp in summer for insulated tip & non-insulated tip is 40.806℃ & 40.64℃ respectively whereas in winter it is 10.776℃ & 10.613℃ respectively. The graph plotting depends mostly on Fourier's law of conduction equation which is given by: $Q = -KA\frac{dt}{dx}$

Where, 'Q' is the heat transfer rate

'K' is the thermal conductivity of the fin material

'A' is the area of cross section of the fin profile

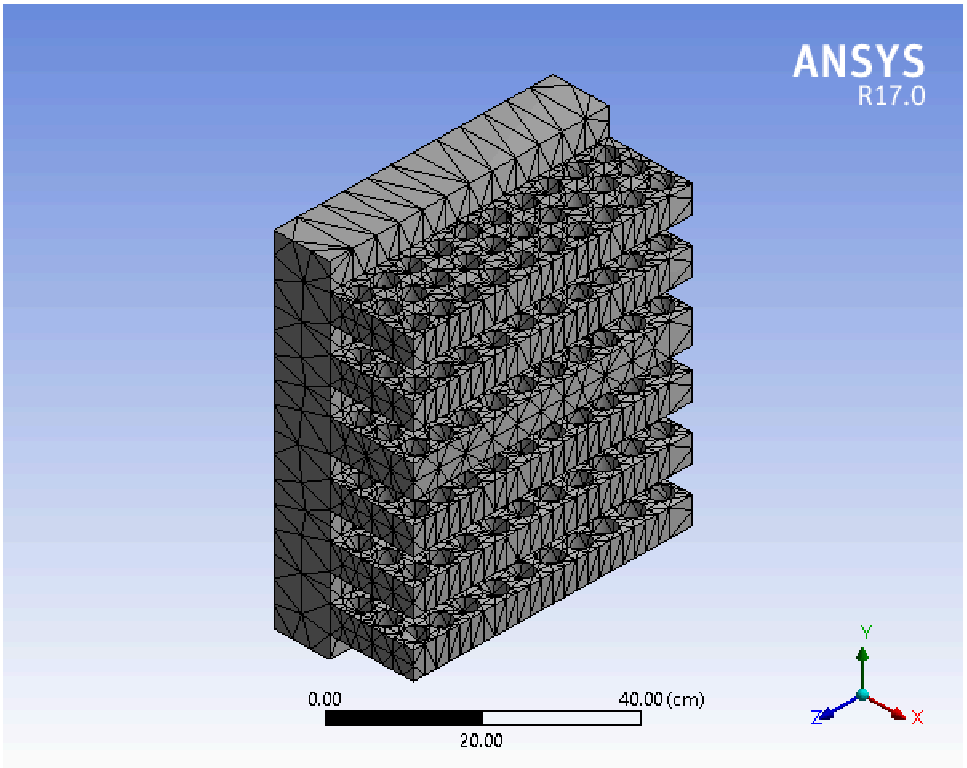
$\frac{dt}{dx}$ is the rate of change of temperature w.r.t change in length

RESULTS FOR CYLINDRICAL FINS:

Fin profile	Material used	Boundary condition	Atmospheric condition	Max. Base temp.	Fin tip temp.	Effectiveness	Efficiency
cylindrical fins	Copper alloy	Insulated tip	40℃ (Summer)	500℃	50.496°C	0.87	13.05%
		Non-insulated tip			49.15°C	2.51	37.65%
	Aluminium alloy	Insulated tip			40.806°C	0.95	14.25%
		Non-insulated tip			40.64°C	2.97	44.55%
	Copper alloy	Insulated tip	10℃ (Winter)		21.18°C	0.76	11.4%
		Non-insulated tip			19.699°C	1.51	22.65%
	Aluminium alloy	Insulated tip			10.776°C	0.89	13.35%
		Non-insulated tip			10.613°C	3.02	45.30%

Table 2: Results for cylindrical fins

6. ANALYSIS OF PERFORATED RECTANGULAR FINS:



In thermal engineering, an rectangular fins is a specific type of fin used in heat transfer that varies, Perpendicular in cross-sectional area. Adding an rectangular fin to an object increases the amount of surface area in contact with the surrounding fluid, which increases the convective heat transfer between the object and surrounding fluid. Because surface area increases as length from the object increases, an annular fin transfers more heat than a similar pin fin at any given length. Rectangular fins are often used to increase the heat exchange in liquid–gas heat exchanger systems.

ANALYSIS OF COPPER RECTANGULAR FINS WITH INSULATED TIP:

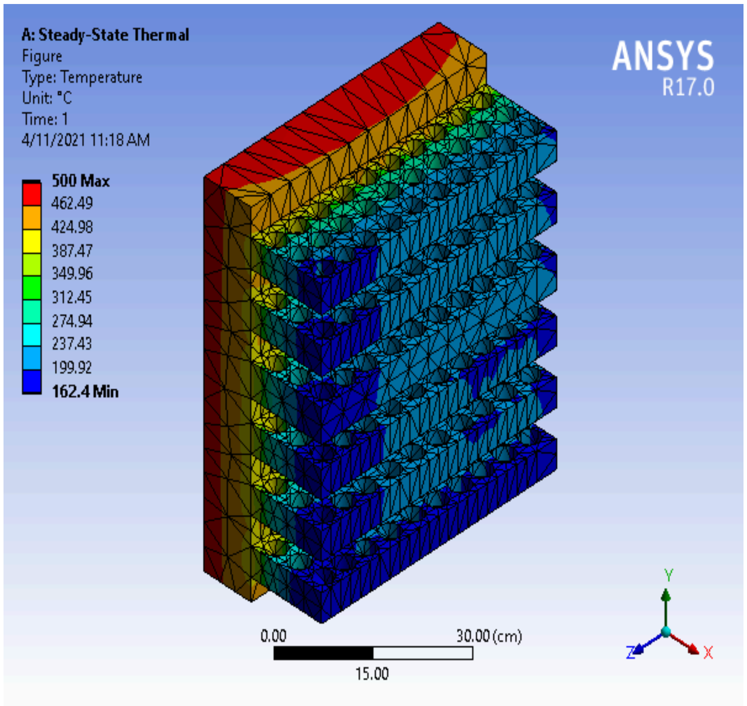


Fig 30:Rectangular fin with insulated tip in summer

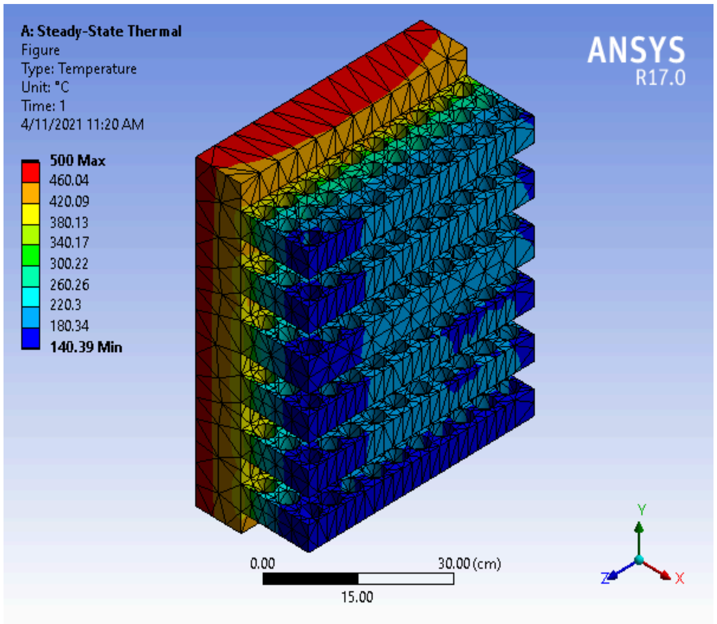


Fig 31: Rectangular fin with insulated tip in winter

ANALYSIS OF COPPER RECTANGULAR FINS WITHOUT INSULATED TIP:

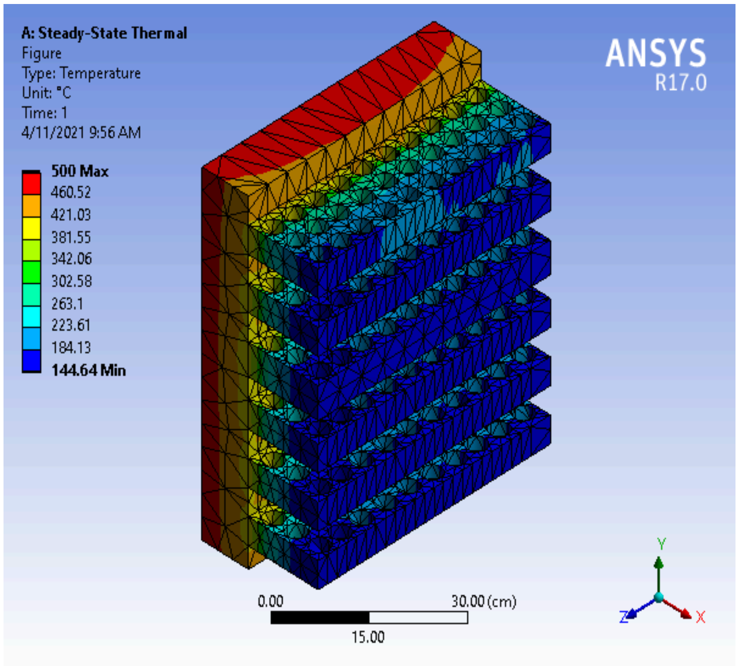


Fig 32: Rectangular fin without insulated tip in summer

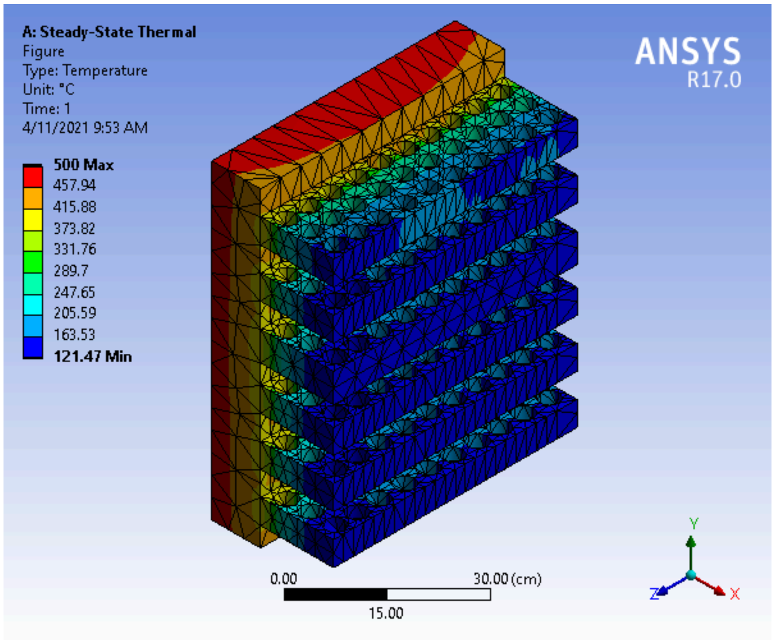


Fig 33: Rectangular fin without insulated tip in winter

TEMPERATURE vs. LENGTH CURVE OF COPPER RECTANGULAR FINS:

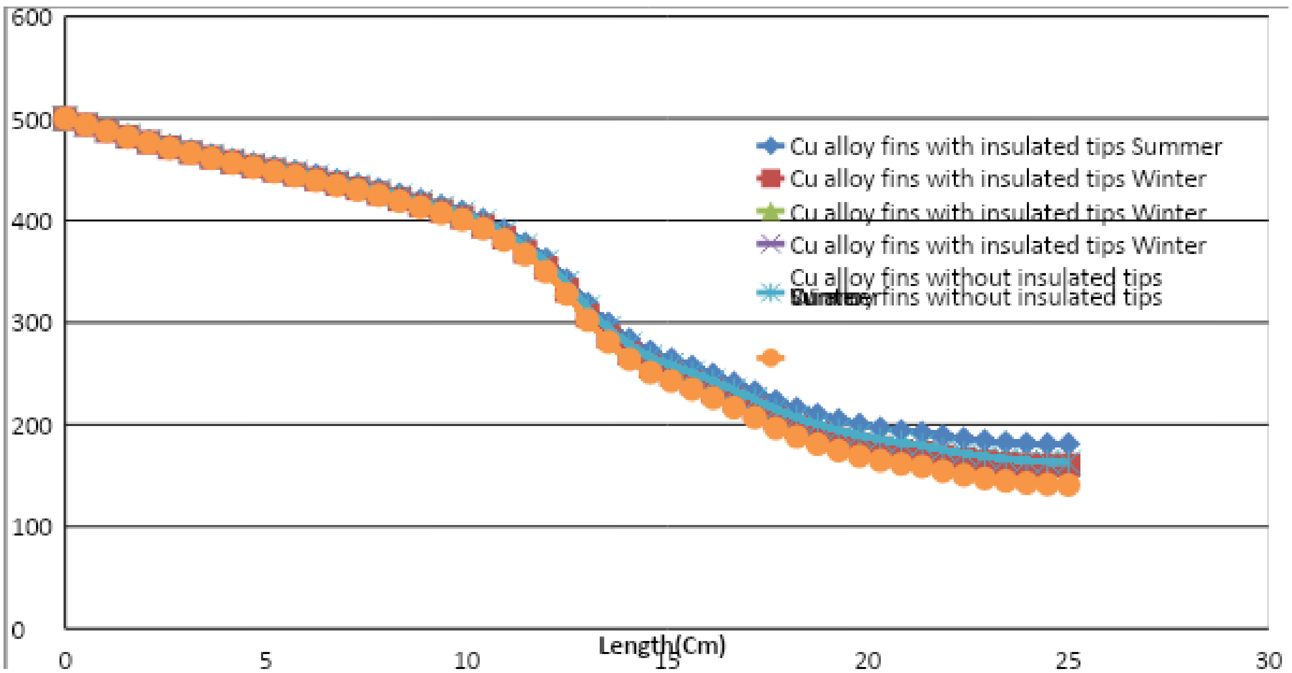


Fig 34: temp. vs. Length curve of Cu rectangular fins

In the above graph is a temp. vs. length curve of Cu rectangular finsl, here the base temperature of rectangular fins is 500℃ & the min temp in summer for insulated tip & non-insulated tip is 162.4℃ & 144.6℃ respectively whereas in winter it is 140.39℃ & 121.47℃ respectively. The graph plotting depends mostly on Fourier's law of conduction equation which is given by: $Q =- KA\frac{dt}{dx}$

Where, 'Q' is the heat transfer rate

'K' is the thermal conductivity of the fin material

'A' is the area of cross section of the fin profile

$\frac{dt}{dx}$ is the rate of change of temperature w.r.t change in length

ANALYSIS OF ALUMINUM RECTANGULAR FINS WITH INSULATED TIP:

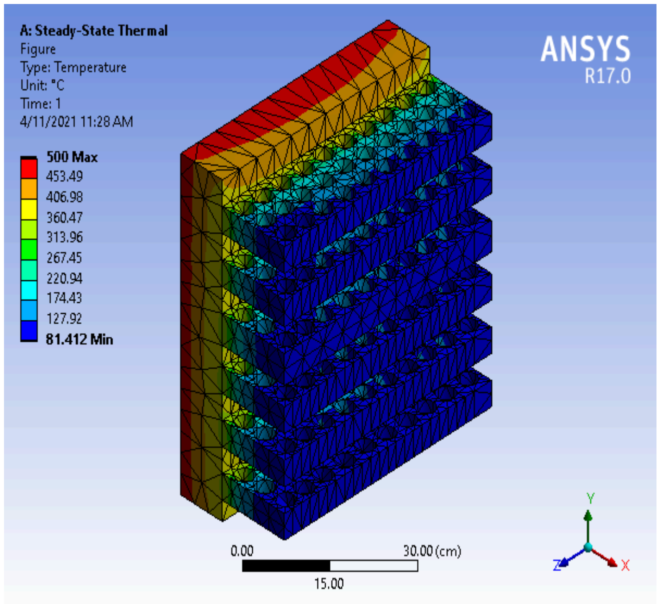


Fig 35: Rectangular fin with insulated tip in summer

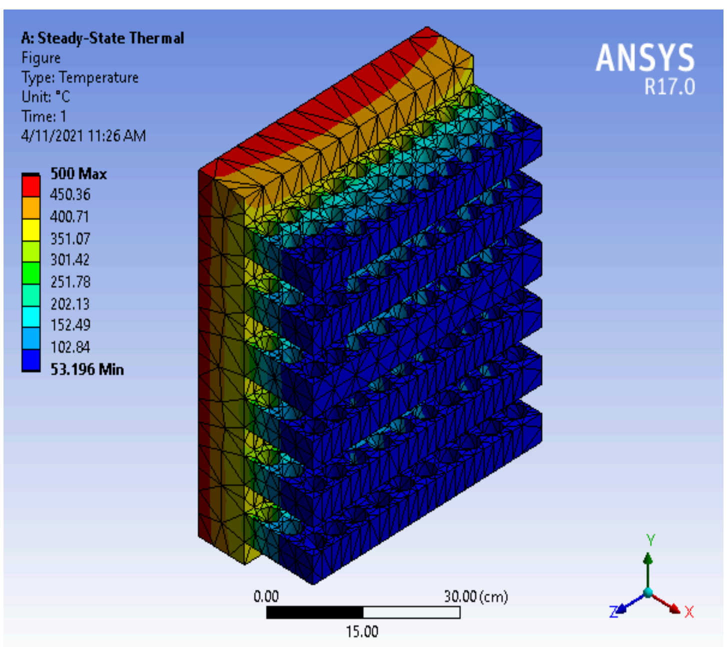


Fig 36:Rectangular fin with insulated tip in winter

ANALYSIS OF ALUMINUM RECTANGULAR FINS WITHOUT INSULATED TIP:

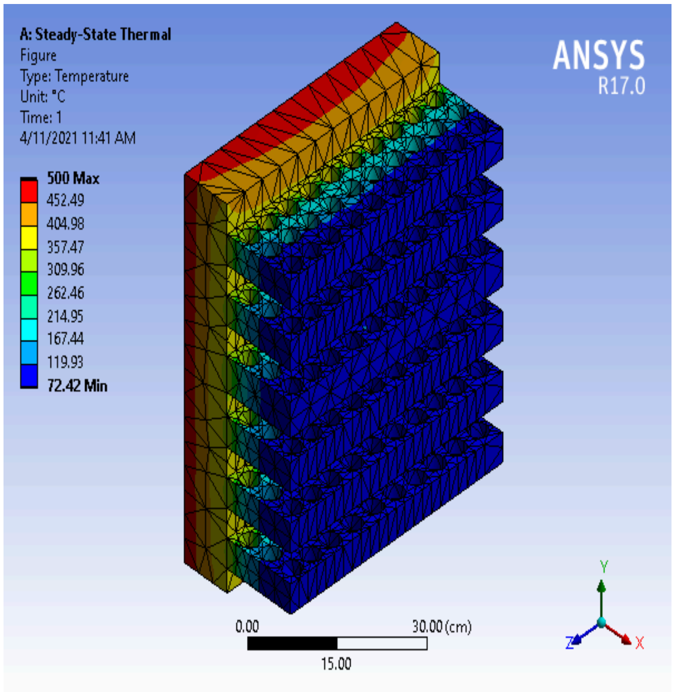


Fig 37: Rectangular fin without insulated tip in summer

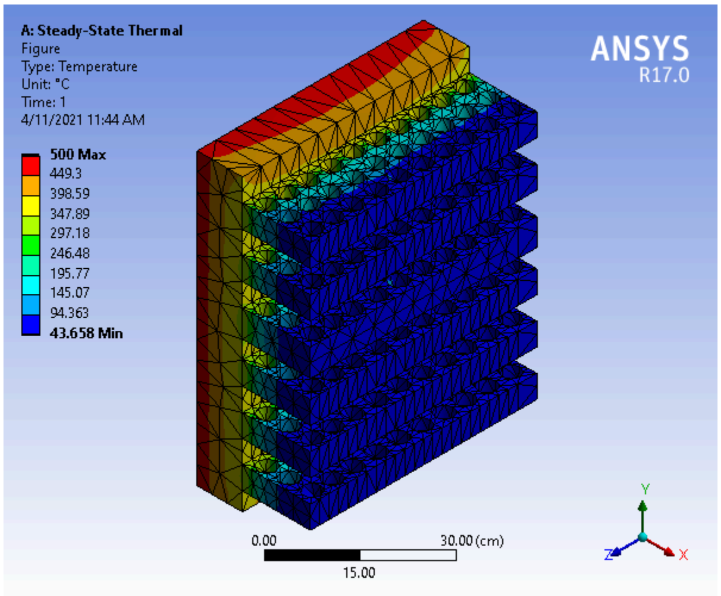


Fig 38: Rectangular fin without insulated tip in winter

TEMPERATURE vs. LENGTH CURVE OF ALUMINUM RECTANGULAR FINS:

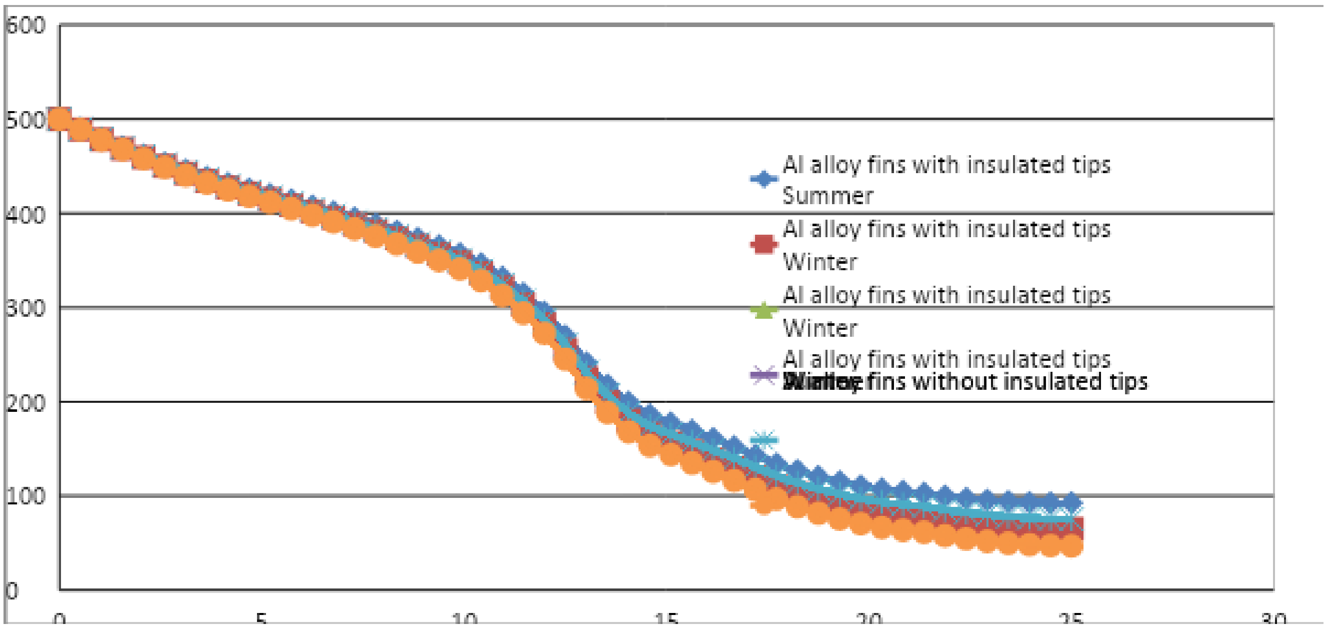


Fig 39: Temp. vs length curve of Al rectangular fins

In the above graph is a temp. vs. length curve of Al rectangular finsl, here the base temperature of rectangular fins is 500℃ & the min temp in summer for insulated tip & non-insulated tip is 81.412℃ & 72.47℃ respectively whereas in winter it is 53.196℃ & 43.658℃ respectively. The graph plotting depends mostly on Fourier's law of conduction equation which is given by: $Q =- KA\frac{dt}{dx}$

Where, 'Q' is the heat transfer rate

'K' is the thermal conductivity of the fin material

'A' is the area of cross section of the fin profile

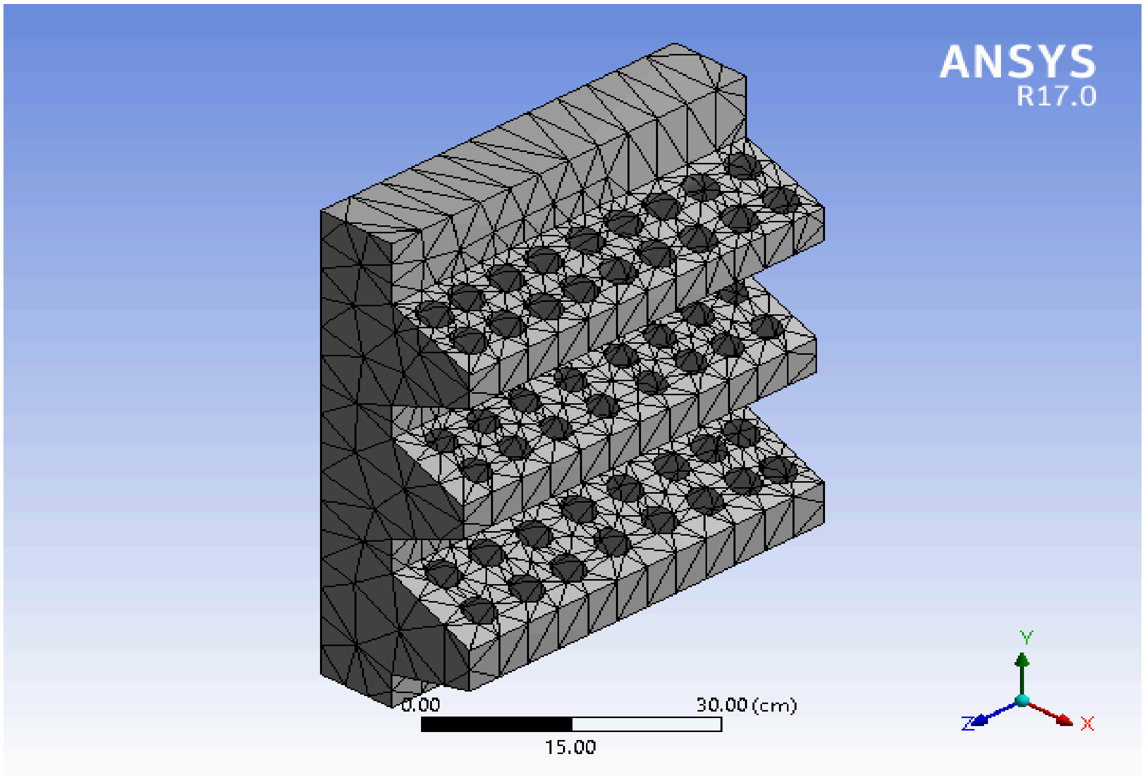
$\frac{dt}{dx}$ is the rate of change of temperature w.r.t change in length

RESULTS FOR RECTANGULAR FINS:

Fin Profile	Material used	Boundary Condition	Atmospheric Temp.	Max base temp.	Fin tip temp.	Effectiveness	Efficiency
Rectangular fins	Copper alloy	Insulated tip	40℃ (Summer)	500 ℃	162.4℃	0.77	25.65%
		Non-insulated tip			144.6℃	1.89	60.3%
	Aluminum alloy	Insulated tip			81.42℃	0.85	28.33%
		Non-insulated tip			72.47℃	2.04	60.8%
	Copper alloy	Insulated tip	10℃ (winter)		140.4 ℃	0.94	31.33%
		Non-insulated tip			121.5 ℃	2.57	85.6%
	Aluminum alloy	Insulated tip			53.19℃	0.71	23.66%
		Non-insulated tip			43.66 ℃	1.33	44.34%

Table 3: Result for rectangular fins

7. ANALYSIS OF PERFORATED TRIANGULAR FINS:



In thermal engineering, triangular fins is a specific type of fin used in heat transfer that varies, Perpendicular in cross-sectional area. Adding a rectangular fin to an object increases the amount of surface area in contact with the surrounding fluid, which increases the convective heat transfer between the object and surrounding fluid. Because surface area increases as length from the object increases, a rectangular fin transfers more heat than a similar pin fin at any given length. Triangular fins are often used to increase the heat exchange in liquid–gas heat exchanger systems.

ANALYSIS OF COPPER TRIANGULAR FINS WITH INSULATED TIP:

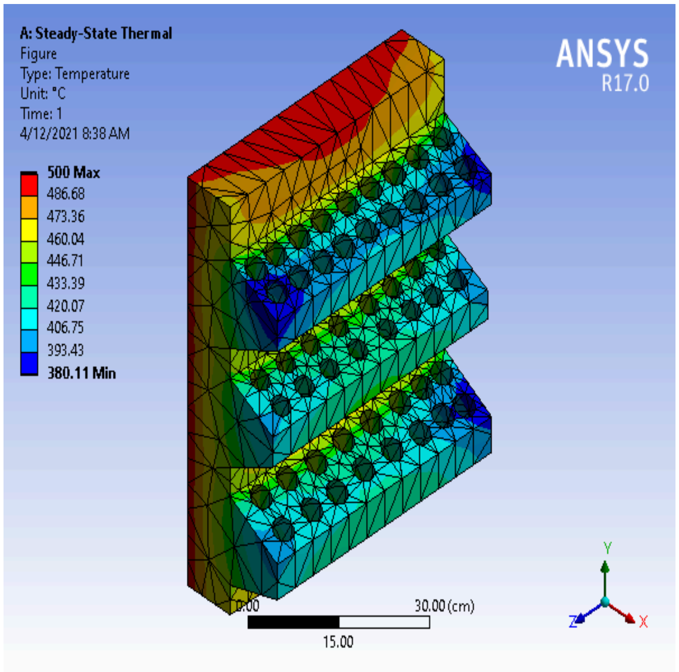


Fig 40: Tringular fin with insulated tip in summer

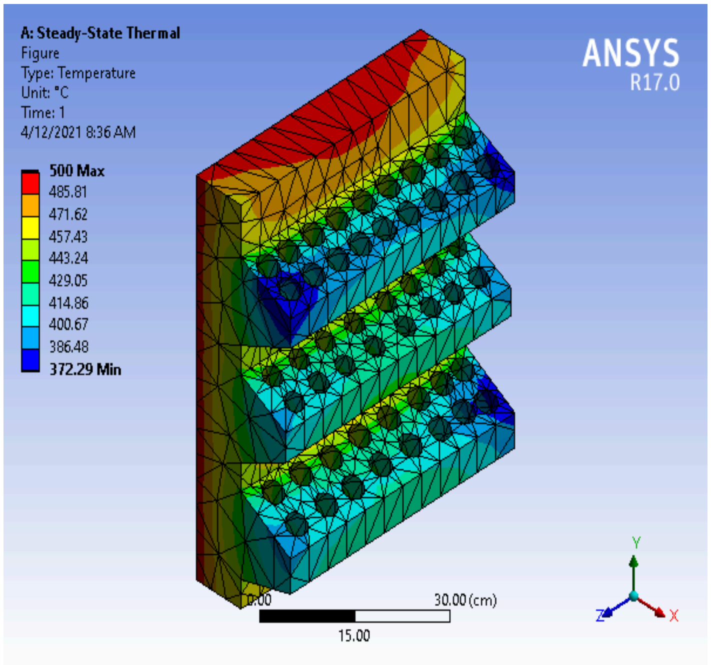


Fig 41: Tringular fin with insulated tip in winter

ANALYSIS OF COPPER TRIANGULAR FINS WITHOUT INSULATED TIP:

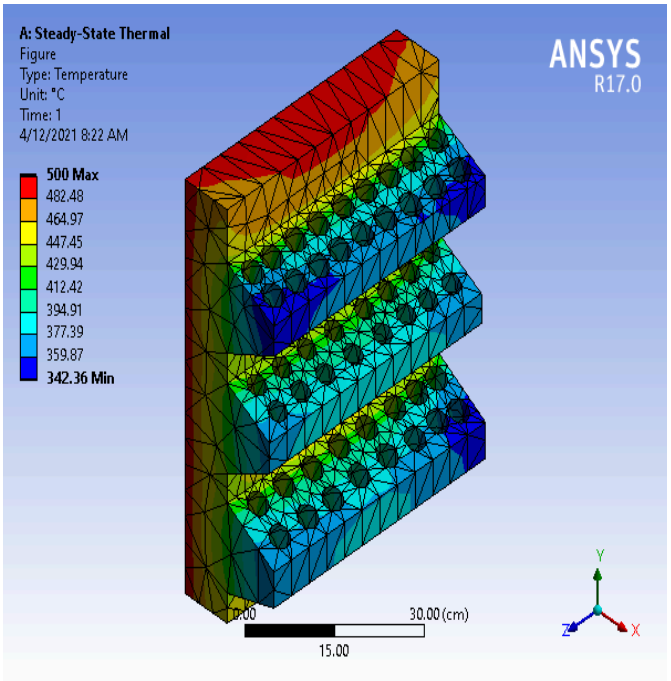


Fig 42: Tringular fin without insulated tip in summer

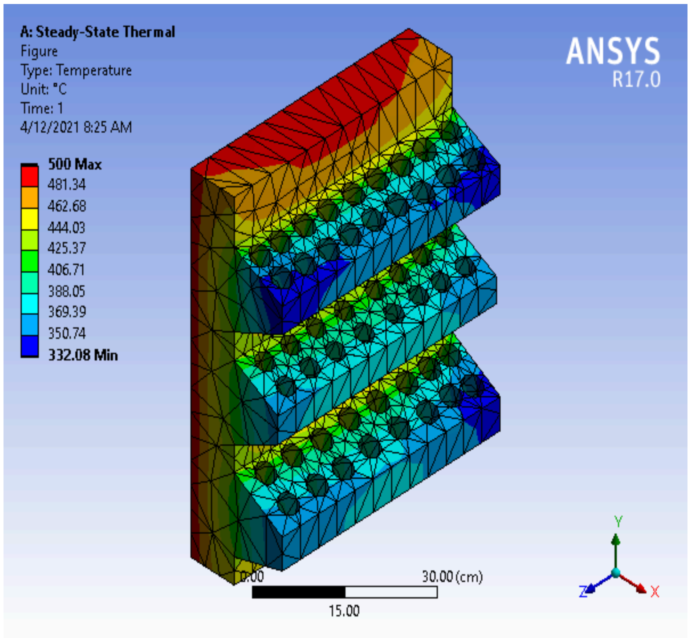


Fig 43: Tringular fin without insulated tip in winter

TEMPERATURE vs. LENGTH CURVE OF COPPER TRINGULAR FINS:

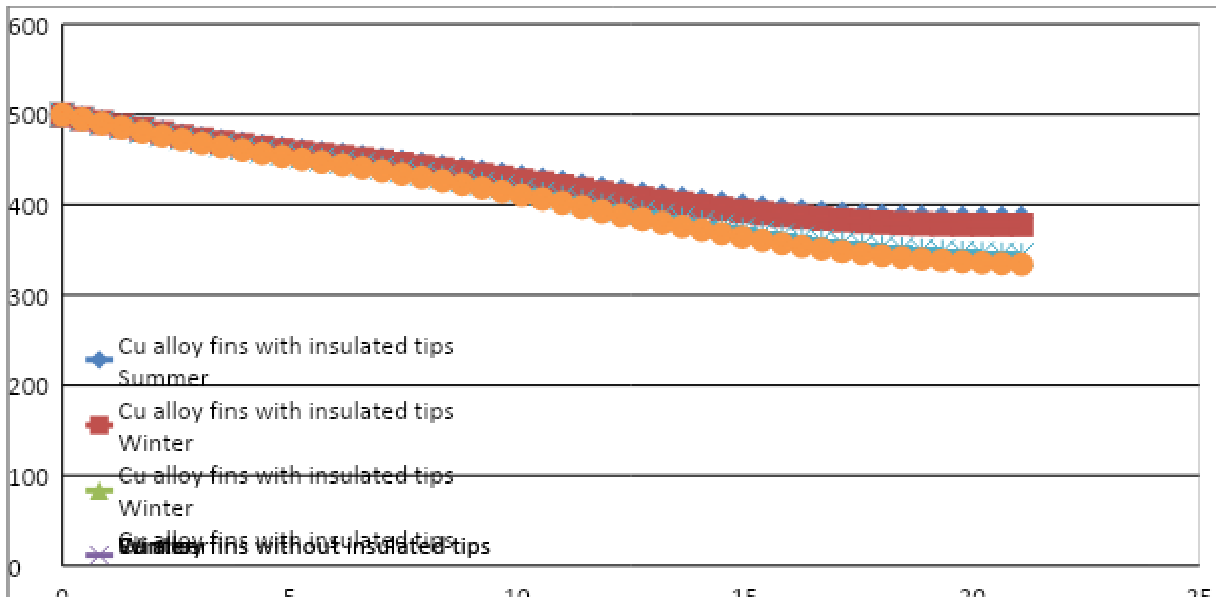


Fig 44: Temp. vs length curve of Cu triangular fins

In the above graph is a temp. vs. length curve of Cu triangular fins, here the base temperature of triangular fins is 500℃ & the min temp in summer for insulated tip & non-insulated tip is 380.11℃ & 342.36℃ respectively whereas in winter it is 372.27℃ & 332.08℃ respectively. The graph plotting depends mostly on Fourier's law of conduction equation which is given by: $Q =- KA\frac{dt}{dx}$

Where, 'Q' is the heat transfer rate

'K' is the thermal conductivity of the fin material

'A' is the area of cross section of the fin profile

$\frac{dt}{dx}$ is the rate of change of temperature w.r.t change in length

<u>ANALYSIS OF ALUMINUM TRIANGULAR FINS WITH INSULATED TIP:</u>

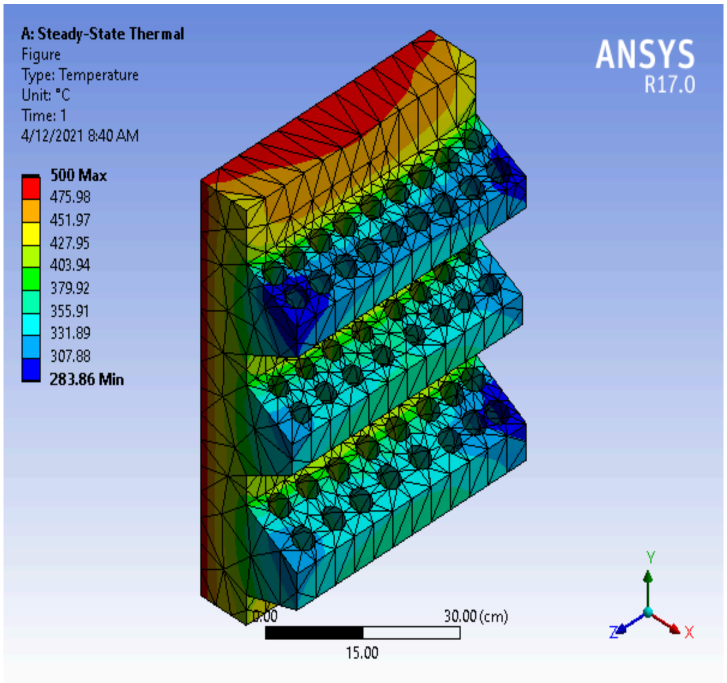


Fig 44: Tringular fin with insulated tip in summer

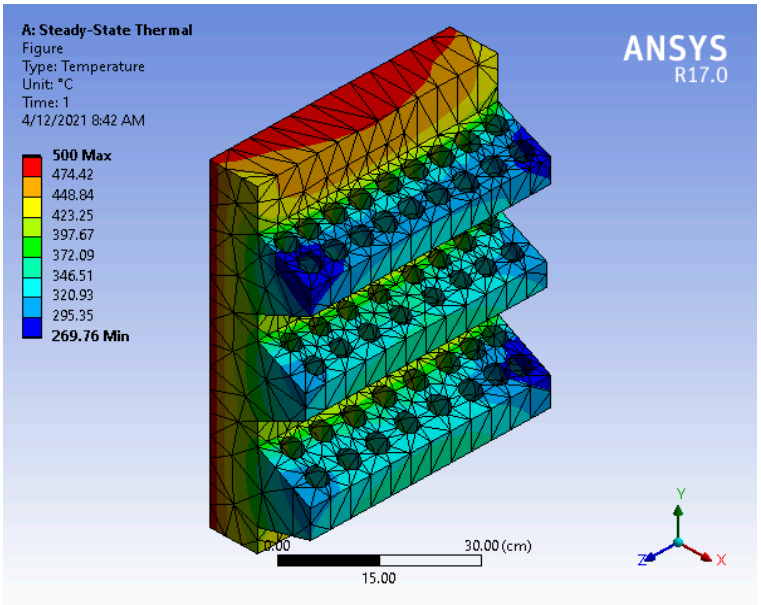


Fig 45: Tringular fin with insulated tip in winter

ANALYSIS OF ALUMINUM TRIANGULAR FINS WITHOUT INSULATED TIP:

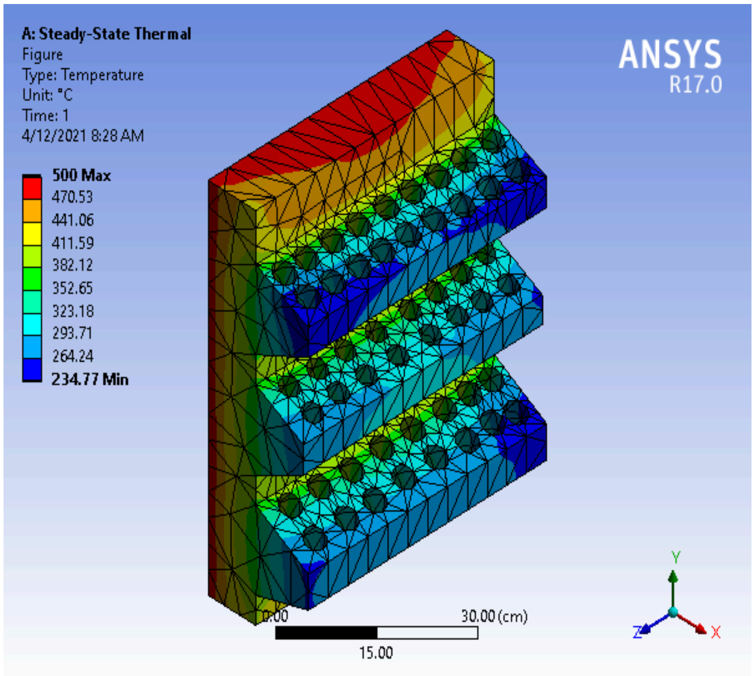


Fig 46: Tringular fin without insulated tip in summer

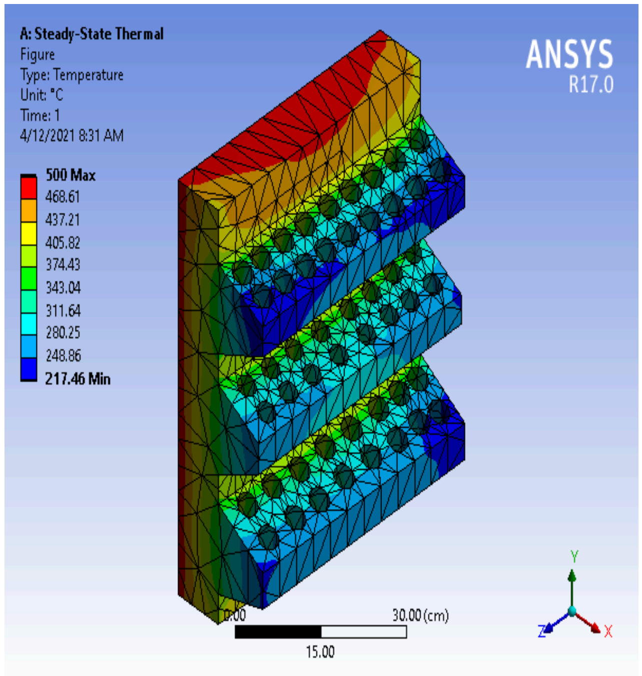


Fig 47: Tringular fin without insulated tip in winter

TEMPERATURE vs. LENGTH CURVE OF ALUMINUM TRINGULAR FINS:

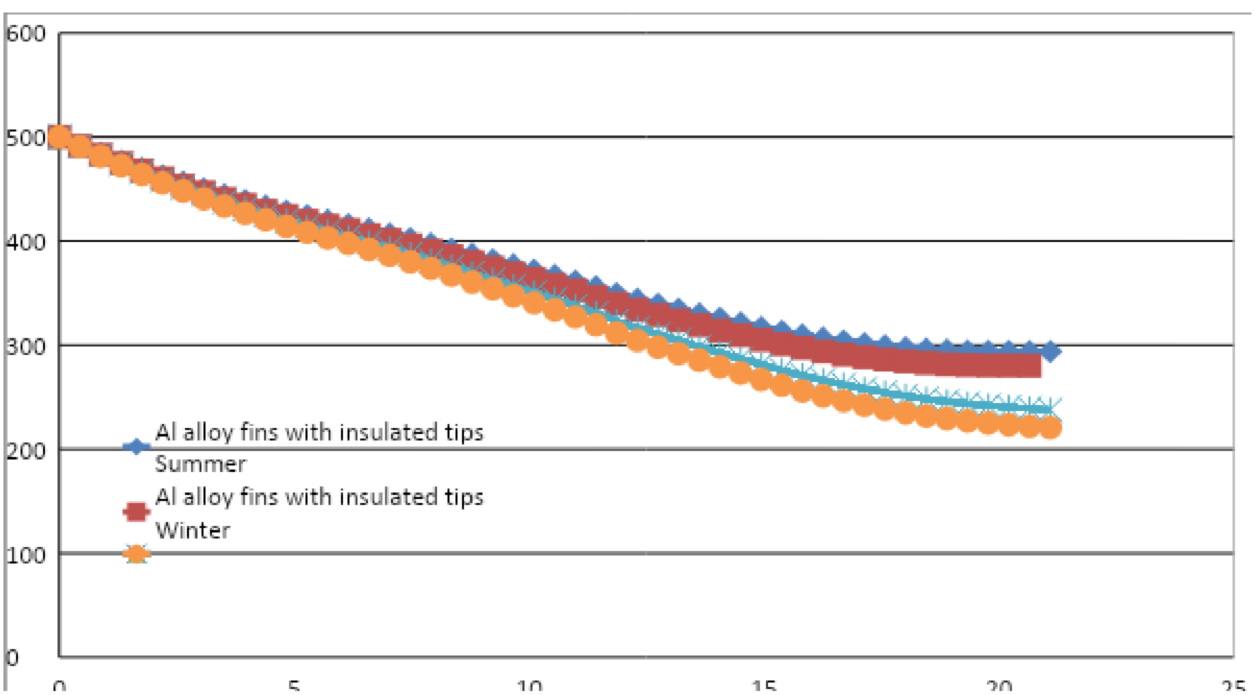


Fig 48: Temp. vs. length curve of Al triangular fins

In the above graph is a temp. vs. length curve of Cu triangular fins, here the base temperature of triangular fins is 500℃ & the min temp in summer for insulated tip & non-insulated tip is 283.86.11℃ & 234.77℃ respectively whereas in winter it is 269.46℃ & 217.76℃ respectively. The graph plotting depends mostly on Fourier's law of conduction equation which is given by: $Q = -\ KA\frac{dt}{dx}$

Where, 'Q' is the heat transfer rate

'K' is the thermal conductivity of the fin material

'A' is the area of cross section of the fin profile

$\frac{dt}{dx}$ is the rate of change of temperature w.r.t change in length

ANALYSIS OF COPPER RECTANGULAR & TRINGULAR FIN BASE WITHOUT FINS:

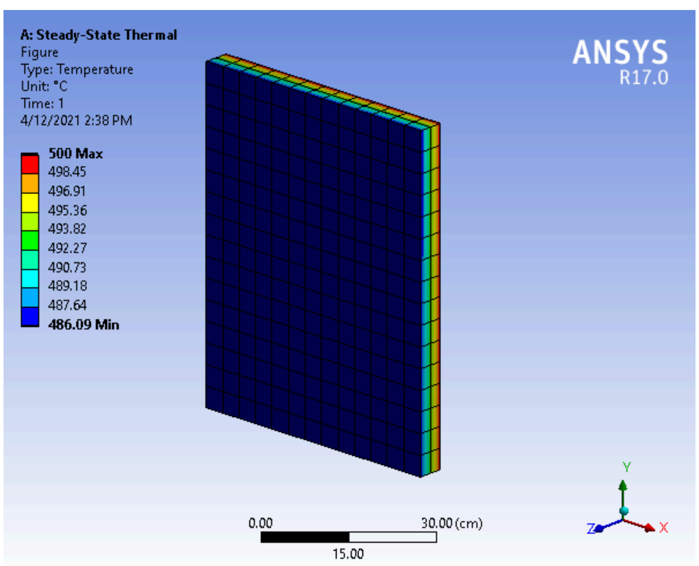


Fig 49: Copper fin base for rectangular & triangular fins in summer

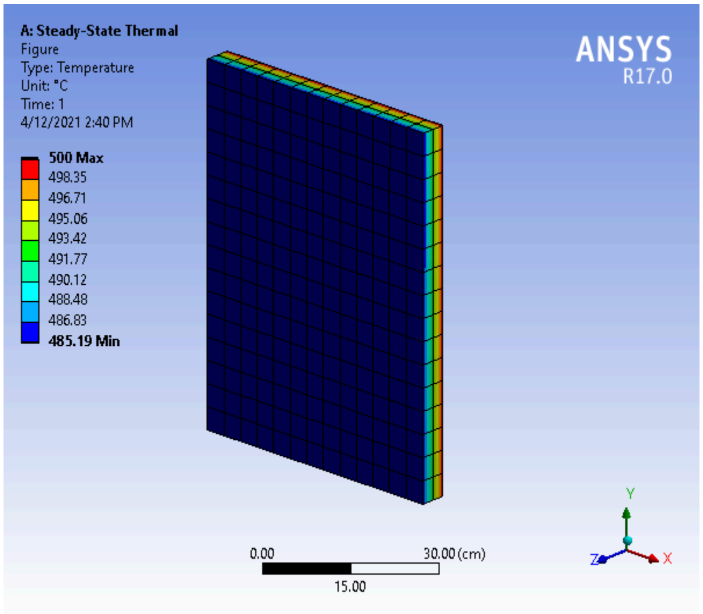


Fig 50: Copper fin base for rectangular & triangular fins in winter

ANALYSIS OF ALUMINUM RECTANGULAR & TRINGULAR FIN BASE WITHOUT FINS:

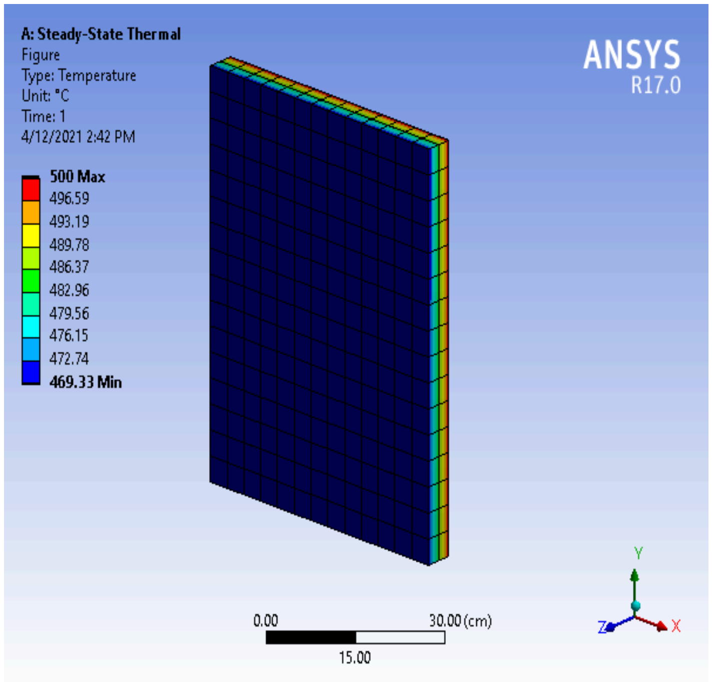


Fig 51: Aluminum fin base for rectangular & triangular fins in summer

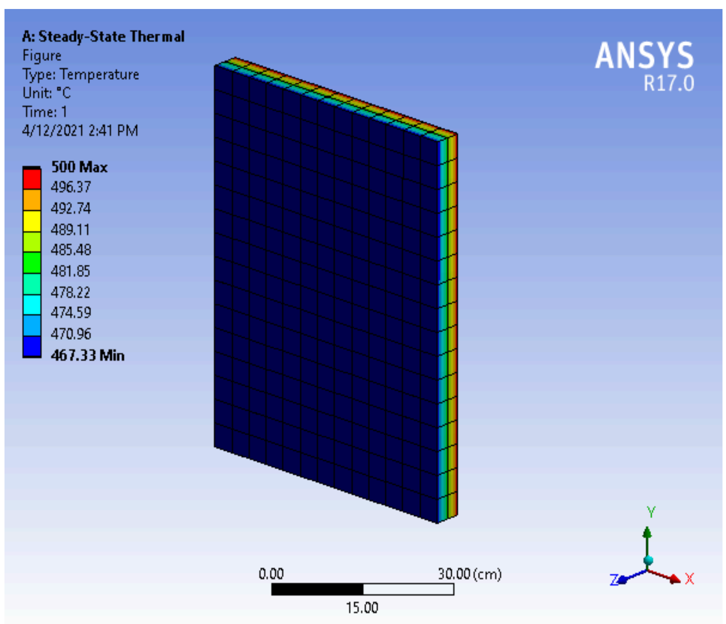


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Fig 52: Aluminum fin base for rectangular & triangular fins in winter

TEMP vs. LENGTH CURVE OF RECTANGULAR & TRINGULAR FIN BASE WITHOUT FINS:

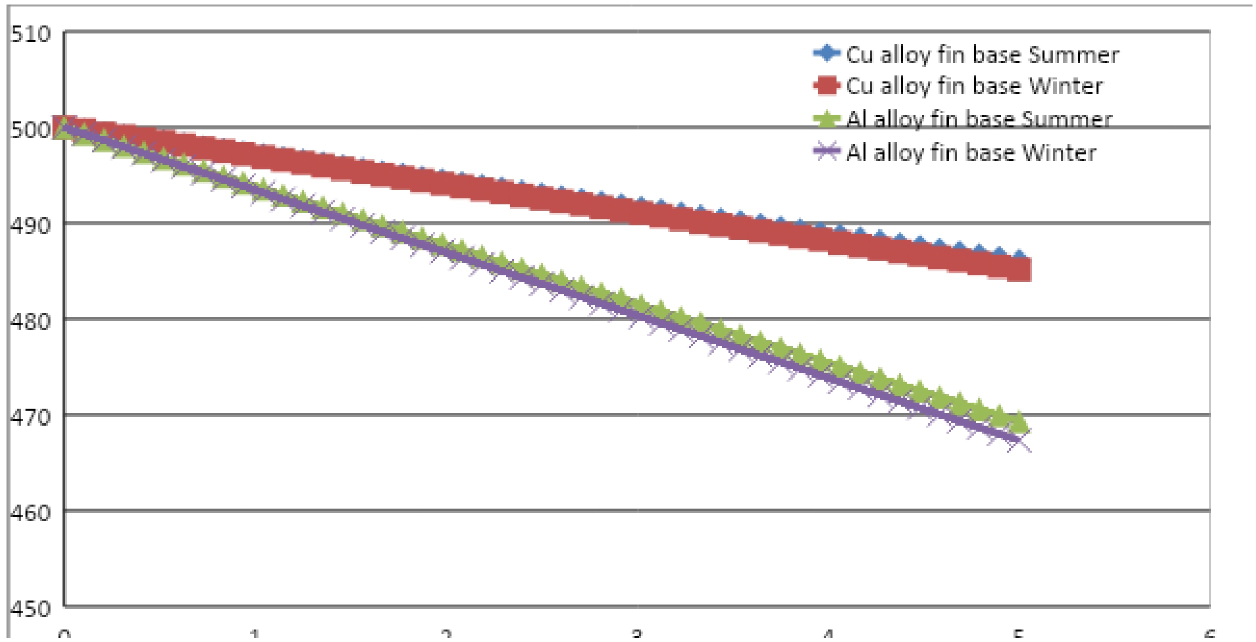

Fig 53: Temp. vs Length curve of rectangular & triangular fin base without fins

In the above graph is a temp. vs. length curve of rectangular & triangular fin base without fins, Here the temp. Here the max temp is 500℃ in both the cases but the slope of base made of Cu is less as compared to that of Al material which is more. The graph plotting depends mostly on Fourier's law of conduction equation which is given by: $Q =- KA\frac{dt}{dx}$

Where, 'Q' is the heat transfer rate

'K' is the thermal conductivity of the fin material

'A' is the area of cross section of the fin profile

$\frac{dt}{dx}$ is the rate of change of temperature w.r.t change in length

RESULTS FOR TRIANGULAR FINS:

Fin Profile	Material used	Boundary Condition	Atmospheric Temp.	Max base temp.	Fin tip temp.	Effectiveness	Efficiency
triangular fins	Copper alloy	Insulated tip	40℃ (Summer)	500 ℃	380.11℃	0.33	29.7%
		Non-insulated tip			342.36 ℃	1.04	39.6%
	Aluminium alloy	Insulated tip			283.86 ℃	0.45	40.5%
		Non-insulated tip			234.77 ℃	1.59	41.31%
	Copper alloy	Insulated tip	10℃ (Winter)		372.29 ℃	0.67	25.02%
		Non-insulated tip			332.08 ℃	2.78	60.3%
	Aluminium alloy	Insulated tip			269.76 ℃	0.81	17.64%
		Non-insulated tip			217.46 ℃	1.96	27.9%

Table 4: Result for triangular fins

8. CONCLUSION:

✔ From the above study we have concluded that when the effectiveness of the fin is less than 1, i.e .(Ɛ<1) the fin acts as an insulation, slowing the heat transfer rate from the surface to the surroundings and thus the efficiency decreases.

- ✔ On the other hand when the effectiveness of the fin is greater than 1, i.e.(ε>1) then it indicates that the fins enhancing the heat transfer rate from the surface to the surroundings and thus the efficiency increases.
- ✔ Hence we conclude that thermal conductivity of copper is better than aluminum and the specific heat of copper is less than that of aluminum. So fins made of Copper alloy will transfer more heat.

9. <u>REFERENCES:</u>

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[2] Ehteshum, Mehedi, et al. Thermal and Hydraulic Performance Analysis of Rectangular Fin Arrays with Perforation Size and Number, Procedia Engineering 105,2015, 184-191.

[3] Jassem RR (2013) Effect the form of perforation on the heat transfer in perforated fins J Nat Apply Science: 4(3):198–207.

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[5] Ibrahim TK, Basrawi F, Mohammed MN, Ibrahim H (2016) Effect of perforation area on temperature distribution of the rectangular fins under natural convection :11(10):637-640.