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STUDY ON THERMAL PERFORMANCE OF FINNED TUBE HEAT EXCHANGER

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Abstract: The Heat exchangers are used to transfer the heat from one fluid to another fluid (liquid or gas). In this heat transfer, fins (extended surface) plays a major role for the heat transfer. In the finned tube heat exchanger, the fins enhances better heat transfer between the fluids. So, in this study, a great deal of effort is spent on the design of the fins for the better temperature distribution. The fins of various designs, thickness, spacing between the fins are analyzed using ANSYS (Analysis of Systems) steady state thermal analysis. A secondary fin of rectangular shape is introduced for better heat transfer. The results of the steady state analysis shows that the secondary fin of 16mm length placed on the primary triangular fin at a distance of 16.75mm from base surface has better result compared to the others. The temperature at 16.75mm from the base, while placing the secondary fin of 16mm on the primary triangular fin is 323K which is the lowest temperature value compared to the other designs. Experimental analysis is also carried out to verify the analytical results. It is done by fabricating the one of the best result of the analysis. The result of the experimental is near to the result of the analytical analysis. From the results, it is concluded that the introduction of secondary fins, placement of secondary fins is proportional to the temperature distribution and secondary fin of 16mm length attached on the primary triangular fin base of 4mm at 16.75mm from base has better temperature distribution.

I. INTRODUCTION

A heat exchanger is a device that is used to transfer or exchange thermal energy between two or more fluids, between a solid surface and a fluid, or between solid particulates and a fluid, at different temperatures and in thermal contact. Heat exchangers are widely used in many industrial applications and energy recovery systems. There are several ongoing researches to improve the efficiency of heat exchanger. The most important approaches followed to improve the efficiency of heat exchanger are changing the heat exchanger material and redesigning. Increasing fin and tube heat exchanger performance usually means transferring more duty or operating the exchanger at a closer temperature approach.

Fins

Cooling fins rely on conduction to diffuse the heat away from what is being cooled. The fins are designed to increase the surface area with another liquid (air for example). Here the heat is transferred using convection, cooling the fins and warming the liquid.
In the study of heat transfer, fins are surfaces that extend from an object to increase the rate of heat transfer to or from the environment by increasing convection. The amount of conduction, convection, or radiation of an object determines the amount of heat it transfers. Increasing the temperature gradient between the object and the environment, increasing the convection heat transfer coefficient, or increasing the surface area of the object increases the heat transfer. Sometimes it is not feasible or economical to change the first two options. Thus, adding a fin to an object, increases the surface area and can sometimes be an economical solution to heat transfer problems.

Fins are most commonly used in heat exchanging devices such as radiators in cars, computer CPU heat sinks, and heat exchangers in power plants.

II. LITERATURE REVIEW

[1] P.J.Heggs, et.al. (2014) designed a mathematical model for a radial rectangular fin is presented. Design charts are presented and it allow us to evaluate the fin performance with respect to certain heat transfer process. The design charts have curves of the performance ratio plotted in terms of the fin aspect ratio against the maximum effectiveness.

[2] N.Nagarani, K et.al.,(2012) explained the Elliptical Annular Fin is considered to have optimization and the method uses the genetic algorithm to search, combine and optimize the structure of EAF. A generalized procedure has been developed to get the optimization by finding the maximum fin effectiveness and the value of SF at the maximum fin effectiveness.

[3] Tawat Samana, et.al.,(2014) explained the efficiency of solid wire fin in a wire –on-tube heat exchanger under forced convection was examined. The solid fin was re-placed with an oscillating heat pipe filled with R123 and it was tested .The result showed that the fin efficiency has increased than that of conventional fin around 5%.

[4] Pinar Mert Cuce et.al.,(2012) shows that a computational fluid dynamics analysis has been carried out for analysing heat transfer from a longitudinal fin with a step change .The amount of heat dissipation from the fin , fin efficiency and fin effectiveness has been calculated .

[5] Arjun Kumar Prasad (2019) Shell and Tube heat exchangers are having special importance in boilers, oil coolers, condensers, pre-heaters. They are also widely used in process applications as well as the refrigeration and air conditioning industry. The robustness and medium weighted shape of Shell and Tube heat exchangers make them well suited for high pressure operations. The basic configuration of shell and tube heat exchangers, the thermal analysis and design of such exchangers form an included part of the mechanical, thermal, chemical engineering scholars for their curriculum and research activity. This report presents the application of Differential Evolution (DE) for the optimal design of shell-and-tube heat exchangers. The main objective in any heat exchanger design is the estimation of the minimum heat transfer area required for a given heat duty, as it governs the overall cost of the heat exchanger. Many configurations are possible with various design variables such as outer diameter, pitch, and length of the tubes; tube passes; baffle spacing; baffle cut etc. Hence the design engineer needs an efficient strategy in searching for the global minimum.

[6] Gaurav Krishnayatra, et.al.,(2020) analysed the thermal performance of fins for a novel axial finned tube heat exchanger is investigated and predicted using machine learning regression technique. They varied heat transfer coefficient (h) along the fin geometry for two materials copper and steel and concluded that copper is obvious material for the finned-tube system.

[7] A. Shadlaghani, et.al.,(2015) explained a suitable pattern to allow for a better design of the fins used in heat sinks. They considered a fixed fin volume, the shape of fin cross section and its dimension were optimized to maximize the heat transfer rate. The result showed that an increased height/thickness ratio enhanced the heat transfer rate.

[8] Changzheng Sun, et.al.,(2011) performed the control of mixed convection (combined forced and natural convection) in a lid-driven square cavity is performed using a short triangular conductive fin. A numerical technique is used to simulate the flow and temperature fields. They observed that the triangular fin is a good control parameter for heat transfer, temperature distribution and flow field.

[9] M. Ahmadian-Elmi, et.al.,(2023) designed a highly conductive material ("insert") intruding a triangular fin is investigated to increase the heat transfer from the fin, and the optimum configuration of the insert is investigated. They found that triangular insert demonstrates higher heat extraction compared to a quadrilateral insert and resulted in a 47.7% increase in heat transferred compared to the quadrilateral insert.

[10] Doddamani Hithaish, et.al.,(2022) numerically investigated the various geometrical configuration of the triangular micro pin fin heat sink (TMPFHS) for the fluid and heat transfer. They considered three different configurations of triangular pin fin have been considered i) uniformly varying the fin height ranging 0.25mm-0.75mm. ii) Orientation of fin both in the clockwise and counter-clockwise direction (30°, 40°, 50o, and 60°) & iii) Change in the direction of fins facing upstream fluid from forward triangular to backward triangular between two successive rows and vice versa. The results reveal that the heat dissipation rate for all the configurations increases substantially with the rise in pressure drop.

[11] Mehdi Miansari, et.al.,(2022) numerically investigated the melting process of phase change material (PCM) in a storage by inserting innovative fins, which are combination of rectangular and triangular fins. The impacts of various efficient parameters on melting process are evaluated. Results shows that as the number of fins increments, melting time decreases and by the arrangement of triangular fins with different heights (ascending or descending) the melting can be further shortened.

[12] Vinous M. Hammed & Bashar Muslem Essa (2015) carried both experimental and numerical investigation to evaluate the performance of triangular finned tube heat exchanger by designing and manufacturing of triangular shaped fins from copper material. The inner tube is inserted inside the Perspex tube and cold air & hot water are used as working fluids in the shell side & tube side respectively. The experimental analysis is carried out at various mass flow rates (0.001875 to 0.003133) kg/sec through annuli and water at Reynold's numbers ranging from (10376.9 to 23348.03) flows through the inner tube. The result showed that the enhancement of heat dissipation for triangular finned tube is 3.252 to 4.502 times than that of smooth tube.

[13] Younes Menni and Ahmed Azzi (2017) were performed a two dimensional analysis of air (fluid with constant property) flowing into a rectangular cross section channel with staggered cascaded rectangular triangular shaped fins (CRTFs). The numerical results proved that both the Reynolds number and the CRTF separation distance had an effect on the dynamic and thermal behavior of air in the given computational domain.

[14] Pravin H. Yadav and Dillip Kumar Mohanty (2021) studied the effect offin geometry and the pitch ratio of the tube carried experimentally by subjecting water crossflow on a parallel triangular fin-tube array pattern. They have tested a five fully flexible tube arrays which are made up of steel and having a length of 320mm and an outer diameter of 19.05mm. The results showed that the critical velocity at which fluid-elastic instability occurs is greatly affected by density of fin pitch and fin height. The finned tube results fit within the scatter of the existing data for fluid-elastic instability, and the Karman vortex shedding occurred before the occurrence of instability in the tube array.

[15] Syed Saqib Shah, et.al.,(2021) analyzed the effects of thermal drift and force convection on water based single wall carbon nanotubes (SWCNTs) in a porous circular duct. Equilateral triangular fins are enclosed in a circular cavity and the thermal drift is determined by internal heat generation/absorption. The result showed there is significant impact of Q on temperature profile and Local Nusselt number as it decreases with increase of porosity parameter against the heated walls & increases in case of heat generation.

[16] R. Varun Kumar, et.al.,(2022) explained the transient thermal analysis of a triangular profiled longitudinal porous fin with the combined effect of magnetic and electric fields. A time-dependent nonlinear partial differential equation (PDE) was modeled for the heat transmission through the porous fin. The results of the analysis revealed that the emerging radiation, convective parameter, and dimensionless time parameter, faster the fin dissipate heat to the surrounding temperature. The presence of an electromagnetic field assists the triangular porous fin to distribute transient temperature effectively.

[17] V. Saravanan, et.al.,(2021) presented a numerical study of flow and heat transfer characteristics of three-dimensional heat sink with triangular pin fin using water and ethylene glycol as base fluid and later it mixed with diamond powder, aluminum oxide powder and copper powder nanoparticles with 2% and 4% volume concentration is considered. The result showed that pressure drop for water-based copper nanoparticles for 4% volume concentration is 9.4% greater compared to pure water and also heat dissipation rate enhances by 20.31% for ethylene glycol- based nanofluids and by 6.54% for water-based nanofluids.

[18] Abdul Rahim A. Khaled and Abdullatif A. Gari analyzed both experimentally and analytically, heat transfer through a wall containing triangular fins partially embedded in its volume. Finite volume method is used to solve the coupled heat diffusion equations. They found that the maximum reported heat transfer rate through the triangular rooted-finned wall is found to be at most 90% above that for the rootless case at wall Biot number of 1.54. At this Biot number, the maximum heat transfer rate through the combined system reaches 150% above that through the plain wall. So, they recommended to utilize the triangular rooted- fin as a heat transfer enhancer.

[19] Sandhya Mirapalli and Kishore P.S carried out heat transfer analysis by placing rectangular and triangular fins on an air cooled engine. They varied the temperature on the surface of the cylinder from 200 to 600 degree Celsius and varied the length from 6 cm to 14 cm. They found that at that length and 600 degree Celsius i) heat flow from triangular fin is increased by 33.14% compared to rectangular fin of 25.97% and the effectiveness of triangular fin is increased by 33.14% compared to rectangular fin of 25.8%.

[20] Hafiz Muhammad Ali, et.al.,(2018) experimentally investigated the optimization of heat transfer in electronic integrated circuits using close packed phase change materials (PCMs) filled pin-fin heat sinks. This experiment is based upon variation of pin-fin configurations in rectangular, round and triangular cross sections to find the most efficient pin-fin configuration. Each configuration is allowed a pin-fin volumetric percentage of 9%. They suggest that the triangular pin-fins are found to be the most effective pin-fin configuration for heat transfer both with and without PCM.

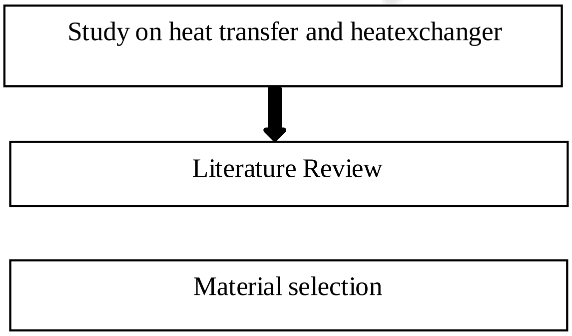
Objective:

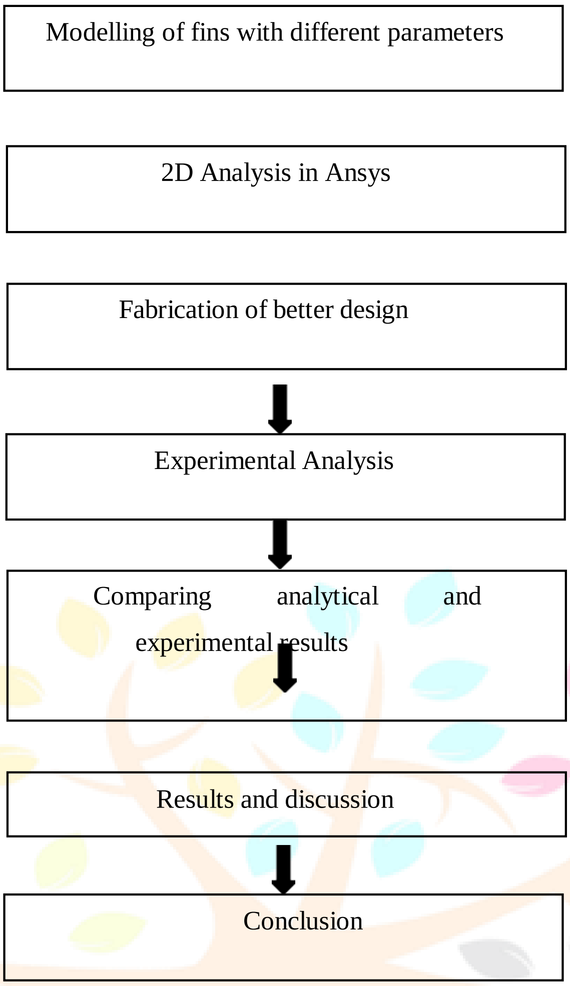
From the above literature reviews it is clear that, still there is need of better heat transfer in various fields such as mechanical, electrical, electronics etc. Hence we decided to work toward to satisfy the need of the better heat transfer in various fields.

The main objective of the project is to design the best fin for better temperature distribution by analyzing the triangular fins & introducing the secondary fins and to compare the results with various spacings of the secondary fins.

To also verify the analytical results with the experimental results by fabricating the one of the best design of the fins. The best design is considered by the Ansys result which has better temperature distribution.

III. METHODOLOGY




Modelling of fins with different parameters
2D Analysis in Ansys
Fabrication of better design
Experimental Analysis
Comparing analytical and experimental results
Results and discussion
Conclusion

IV. MATERIAL AND DESIGN SELECTION

Usually the fins made up of special Aluminium alloy. For this project Aluminium fins was considered & designed.

Aluminium Alloy

Aluminium alloys (or aluminum alloys; see spelling differences) are alloys in which aluminium (Al) is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon, tin and zinc. There are two principal classifications, namely casting alloys and wrought alloys, both of which are further subdivided into the categories heat-treatable and non-heat-treatable. About 85% of aluminium is used for wrought products, for example rolled plate, foils and extrusions. Cast aluminium alloys yield cost-effective products due to the low melting point, although they generally have lower tensile strengths than wrought alloys. The most important cast aluminium alloy system is Al–Si, where the high levels of silicon (4.0– 13%) contribute to give good casting characteristics. Aluminium alloys are widely used in engineering structures and components where light weight or corrosion resistance is required.

Alloys composed mostly of aluminium have been very important in aerospace manufacturing since the introduction of metal-skinned aircraft. Aluminium-magnesium alloys are both lighter than other aluminium alloys and much less flammable than alloys that contain a very high percentage of magnesium.

Aluminium alloy surfaces will develop a white, protective layer of aluminium oxide if left unprotected by anodizing and/or correct painting procedures. In a wet environment, galvanic corrosion can occur when an aluminium alloy is placed in a electrical contact other metals with more positive corrosion potentials than aluminium, and an electrolyte is present that allows ion exchange. Referred to as dissimilar-metal corrosion, this process can occur as exfoliation or as inter-granular corrosion. Aluminium alloys can be improperly heat treated. This causes internal element separation, and the metal then corrodes from the inside out.

Aluminium alloy compositions are registered with The Aluminum Association. Many organizations publish more specific standards for the manufacture of aluminium alloy, including the Society of Automotive Engineers standards organization, specifically its aerospace standards subgroups, and ASTM International..

Fig. 4.1 Aluminium alloy

Properties of Aluminium Alloy

Table 4.1: Material properties of Aluminium alloy

S.No	Parameters	Value
1	Young's Modulus (Pa)	7.1e+10
2	Poisson's Ratio	0.33
3	Bulk Modulus (Pa)	6.9608e+10
4	Shear Modulus (Pa)	2.6692e+10
5	Compressive Ultimate Strength (Pa)	0
6	Compressive Yield Strength (Pa)	2.8e+08
7	Tensile Ultimate Strength (Pa)	3.1e+08
8	Tensile Yield Strength (Pa)	2.8e+08
9	Isotropic Relative Permeability	1
10	Co-efficient of linear expansion (l/k)	21.10e-6
11	Thermal conductivity (w/mk)	150
12	Density (kg/m3)	2770

V. HEAT EXCHANGER WITH VARIOUS DESIGNS OF FINS AND THEIR ANALYSED IMAGES

Design Parameters

The design consists of a tube with the inner diameter and the outer diameter of 12.5 & 16.5 mm respectively with the primary fin bottom thickness is 4mm and length of the fin from the origin is 35mm. Fin thickness is 2mm and the base thickness of the primary triangular fin is 4mm. The spacing between the fin is 50mm and 40mm. The material of the finned-tube system is chosen as Aluminium. The conjugated heat transfer is taking place from the inner isothermal wall (345K) to the ambient air (300 K).

- ☐ The temperature distribution were computed in the Ansys using with the following assumptions.
- ☐ The material is homogenous and isotropic.
- ☐ The fin tips are adiabatic.
- ☐ The convective heat transfer coefficient is uniform over the entire outer surface area
- ☐ The radiation phenomenon is neglected.

Case A:

Initially, we consider the rectangular fin as primary fin. The Case A is design of primary fin attached to a tube. The inner and outer diameter of the tube is 12.5mm and 16.5 mm respectively. The length of the primary fin from the origin is of 35mm.

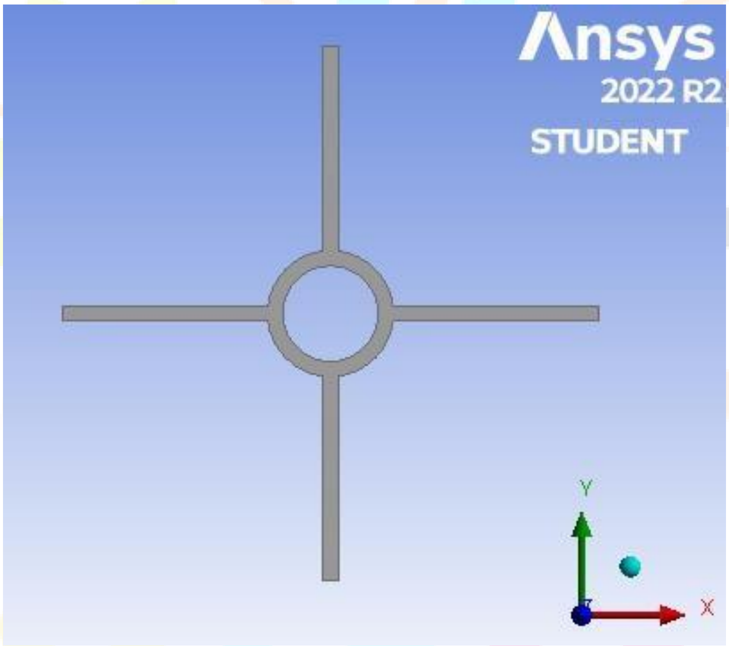


Fig. 5.1 Design of primary rectangular fins

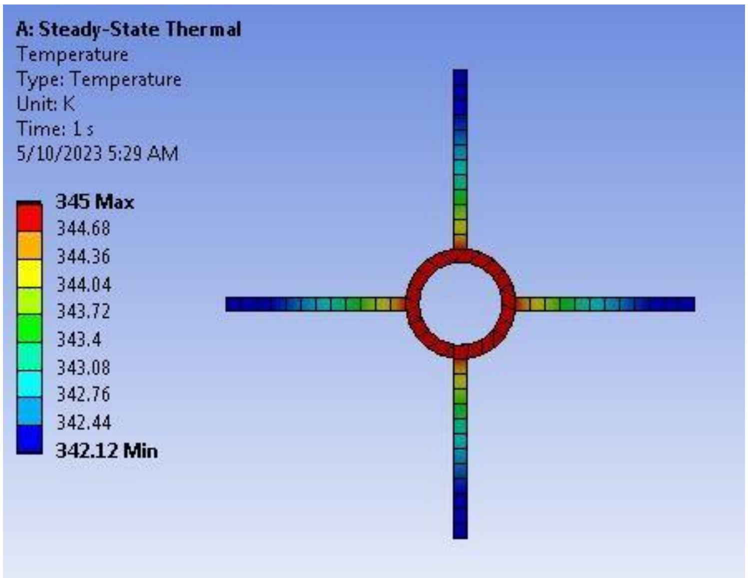


Fig. 5.2 Temperature Distribution in primary rectangular fin

From the analysis, it is found that the temperature throughout the primary fin is 342K. In order to reduce this temperature, a secondary fin is going to be attached.

Case B:

Let the secondary fin be a rectangular shaped fin. The primary fin attached to the tube and the secondary fin is attached to the primary fin. The secondary fins are placed between 50mm.

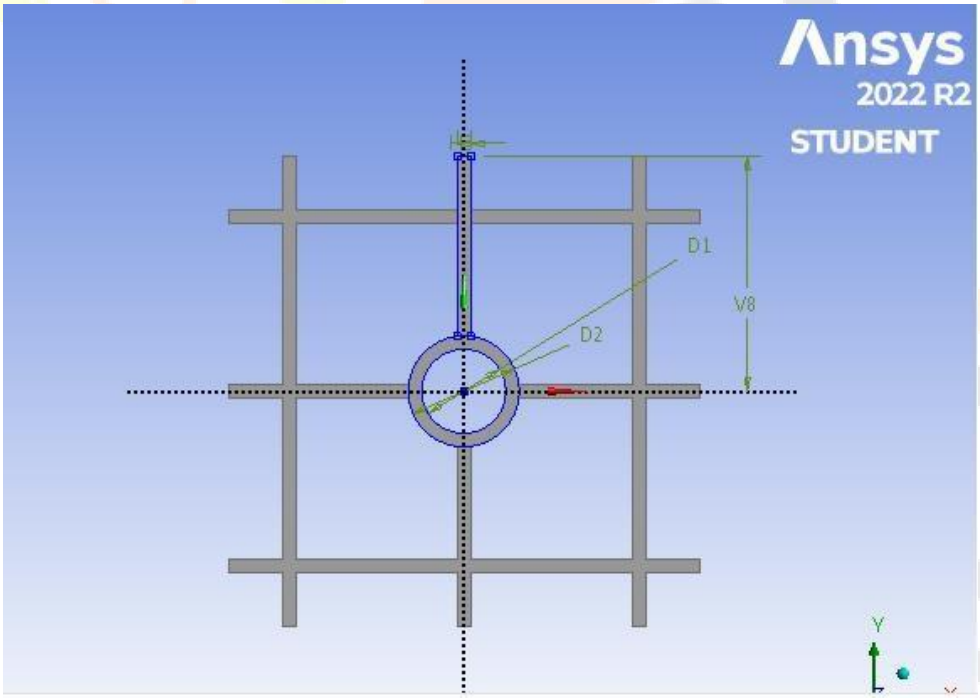


Fig 5.3 Design of primary and secondary rectangular fin

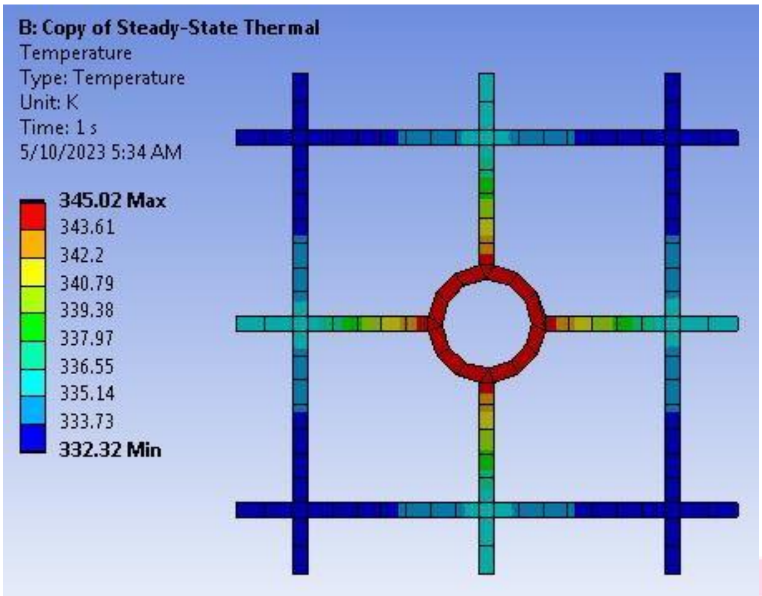


Fig. 5.4 Temperature Distribution in primary & secondary rectangular fin

Case 3A:

In order to reduce the area and increase the temperature distribution let us consider the primary fin as triangular fins and the secondary fins as rectangular fins. The primary fin is attached to the tube and the secondary were attached to the primary fins. In Case 3A, the length of the primary fin is 35mm from the center and the secondary fin is considered with the extra projection & placed between 40mm.

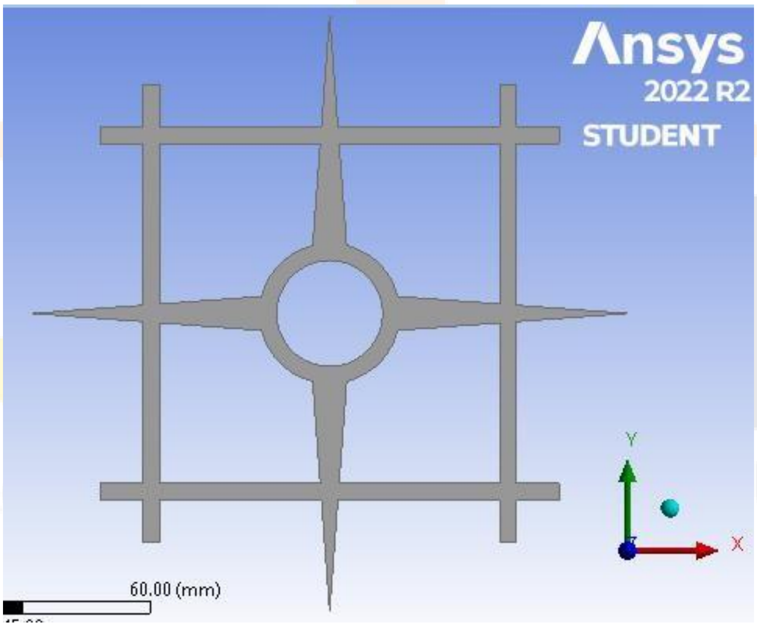


Fig. 5.5 Design of primary triangular with secondary fins (40mm)

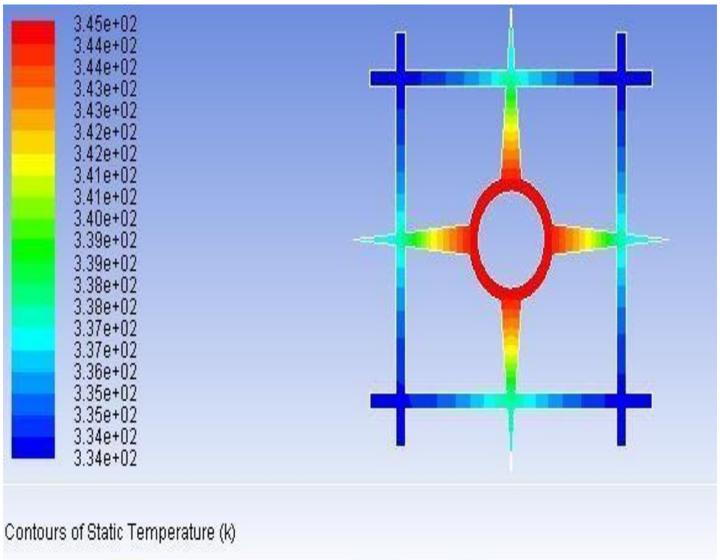


Fig. 5.6 Temperature Distribution in primary triangular with secondary fins (40mm)

Case 3B:

In Case 3B, the length of the primary fin is 35mm from the center and the secondary fin is considered with extra projection & placed between 50mm.

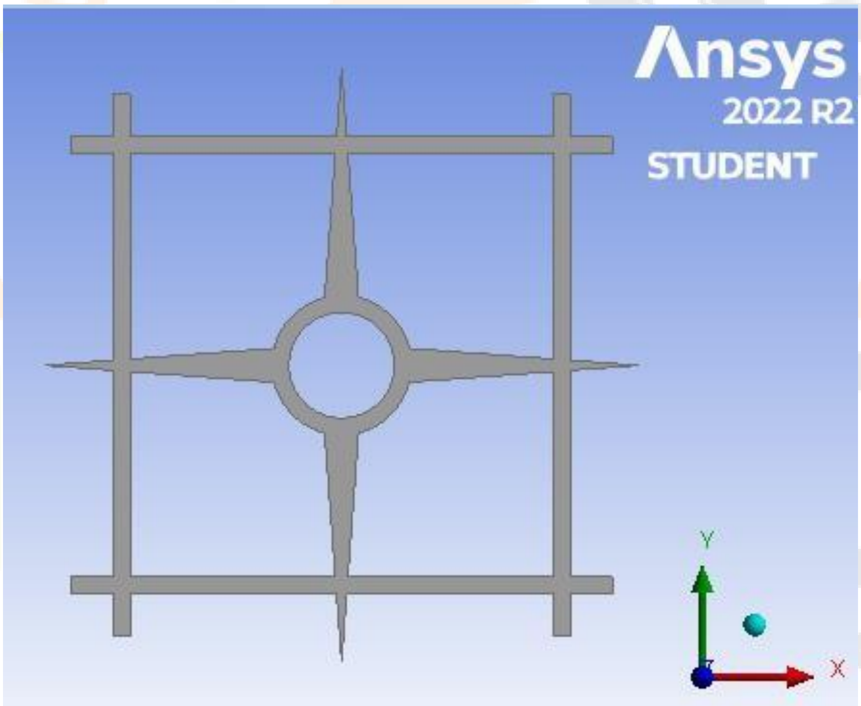


Fig. 5.7 Design of primary triangular with secondary fins(50mm)

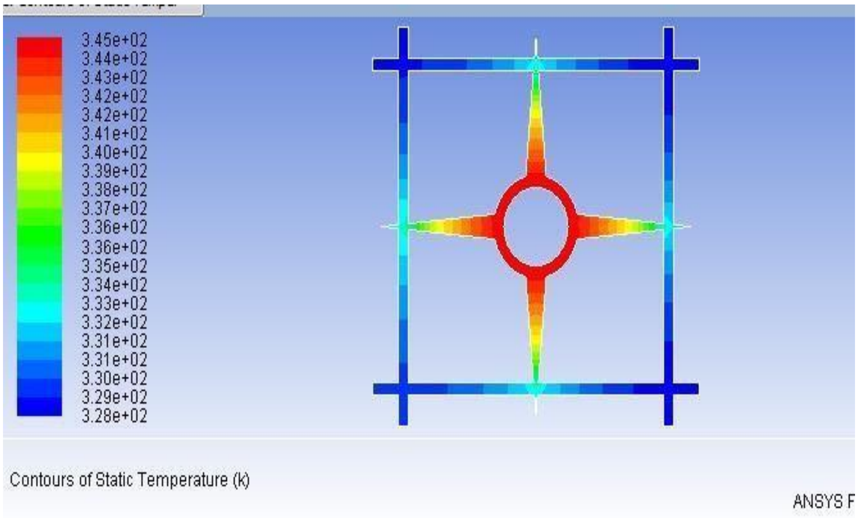


Fig. 5.8 Temperature Distribution in primary triangular with secondary fins (50mm)

Case 4A:

Since the temperature becomes constant after certain distance from the primary fin, the length of the secondary fin is decreased. The length of the primary fin is 35mm from the center and the secondary fin is of 16mm & placed between 40mm on both sides of the primary fin.

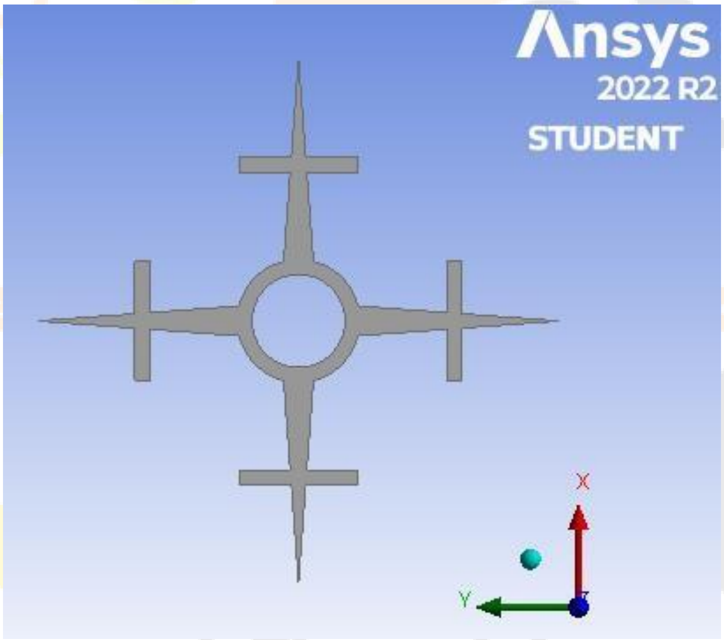


Fig. 5.9 Design of primary triangular and small projection of secondary fins (40mm)

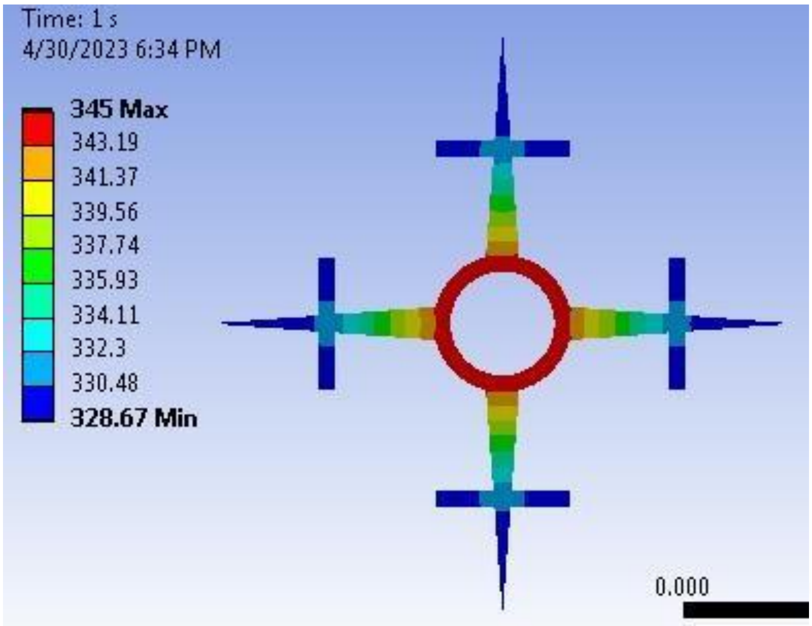


Fig. 5.10 Temperature Distribution in primary triangular and small projection of secondary (40mm)

Case 4B:

The length of the primary fin is 35mm from the center and the secondary fin is of 16mm & placed between 50mm on the both sides of the primary fin.

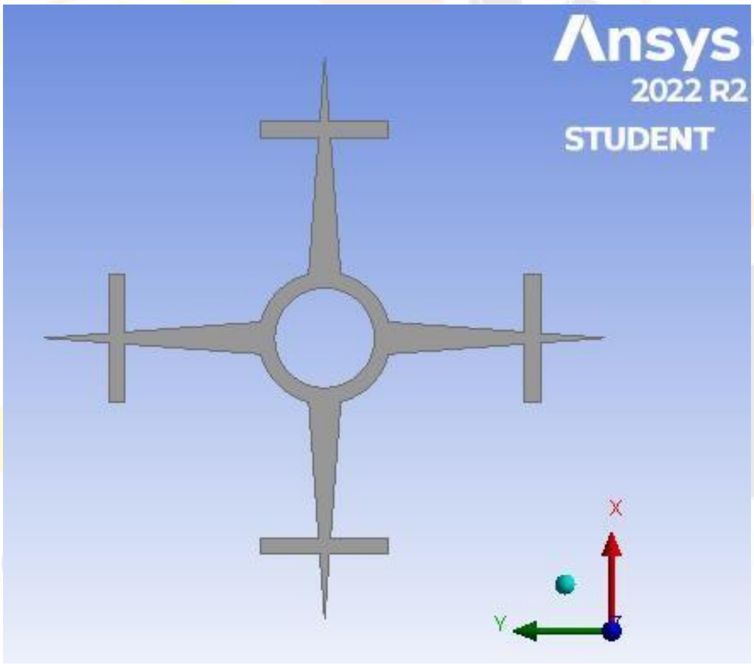


Fig. 5.11 Design of primary triangular and small projection of secondary fins (50mm)

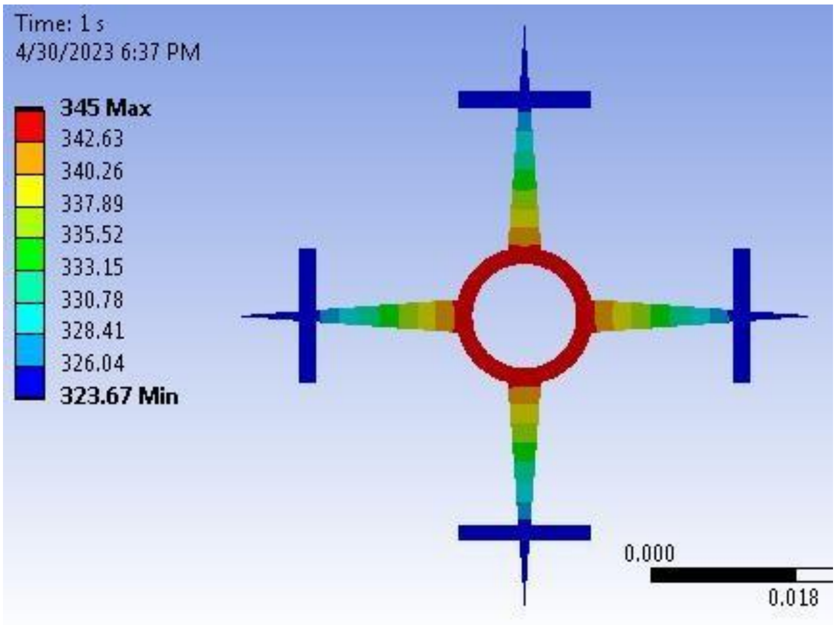


Fig. 5.12 Temperature Distribution in primary triangular and small projection of secondary (50mm)

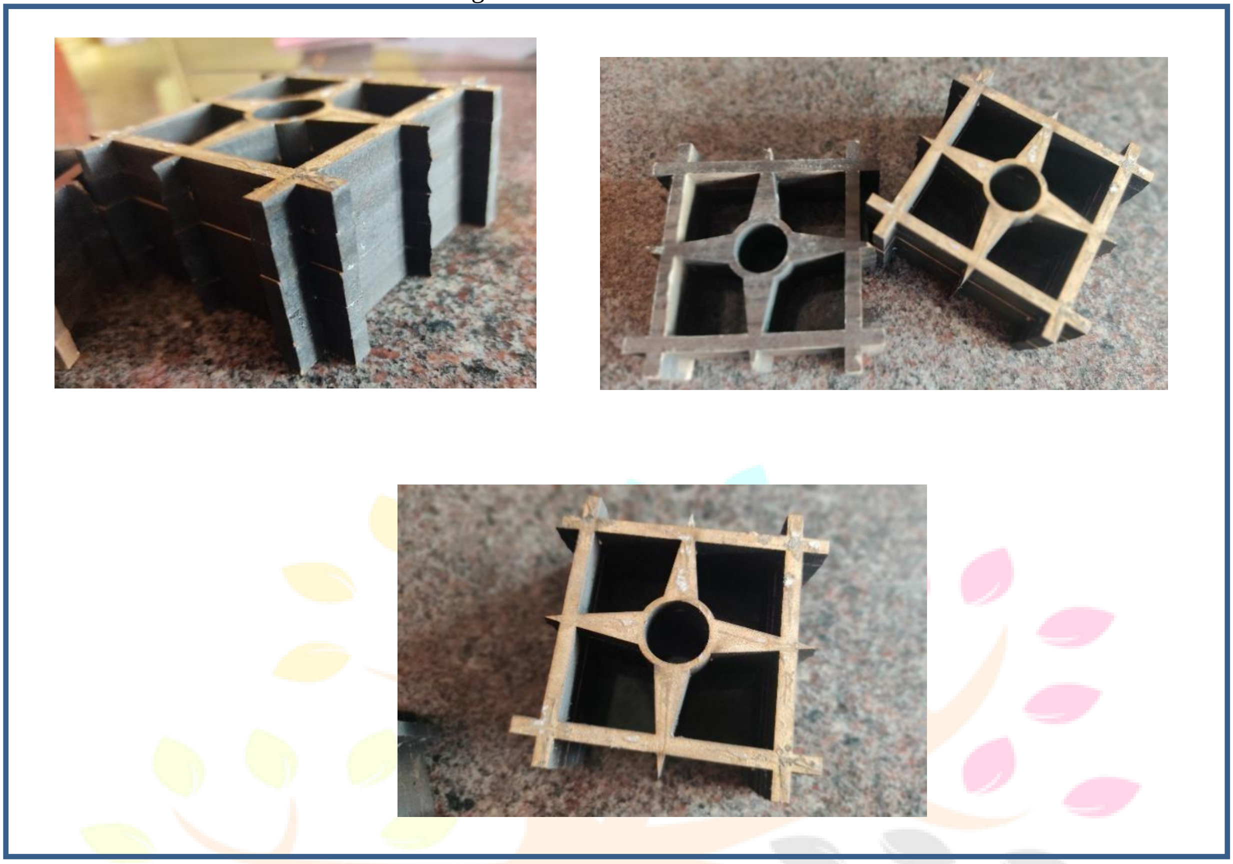
VI. EXPERIMENTATION

Parameters for Fabrication

- ☐ Inner diameter of the tube - 17.5 mm
- ☐ Outer diameter of the tube - 22.5mm
- ☐ Primary fin bottom thickness - 5mm
- ☐ Length of primary fin from the origin - 40mm
- ☐ Length of primary fin Secondary fin - 80mm
- ☐ Fin thickness - 5mm
- ☐ Fin spacing - 55 mm
- ☐ Material used - Aluminium

Pattern of primary triangular and secondary with extra projection

Fig. 6.1 Pattern for fabrication



The pattern for the casting is made by cardboard. The cardboard is cutted accurately with the help of laser cutting.

Fabrication and Analysis of Heat Exchange

Fabrication of primary triangular with secondary fin

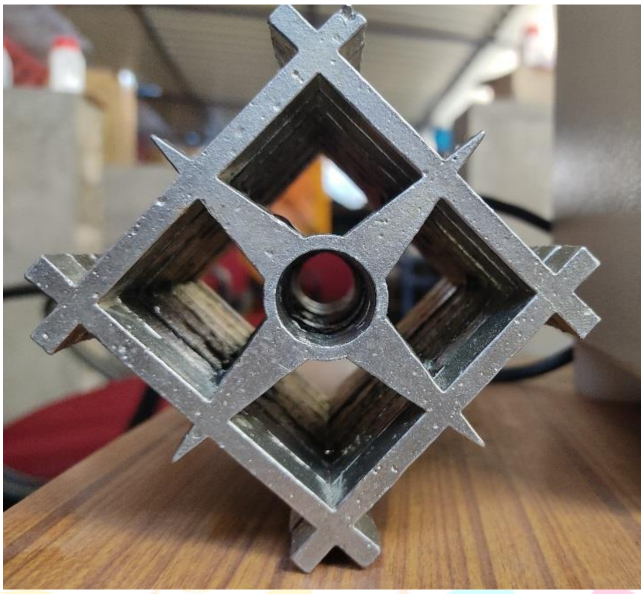


Fig. 6.2 Fabricated product

Analysis of the fabricated model

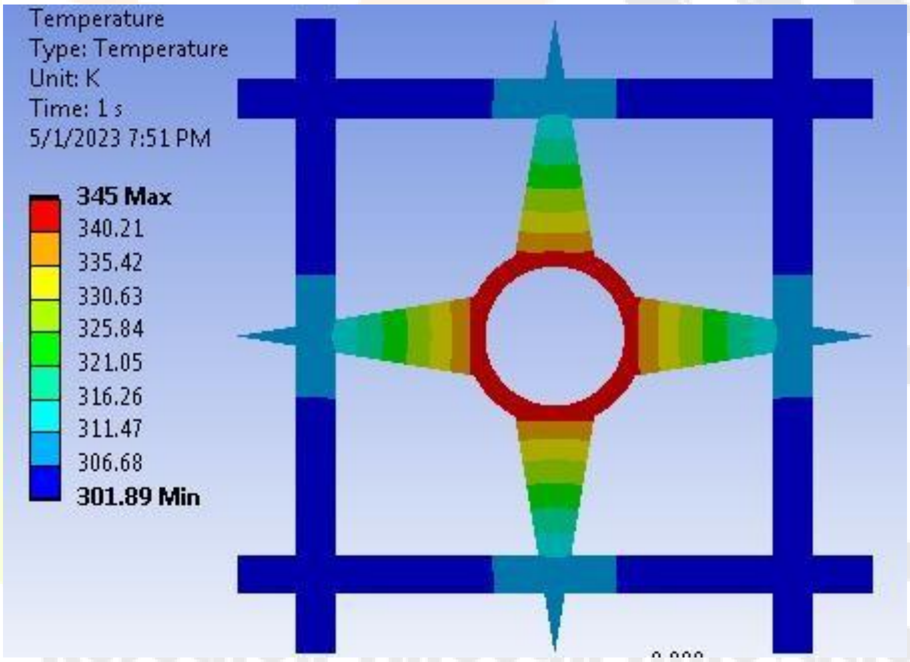


Fig. 6.3 Temperature distribution of the analyzed model

Experimental Setup

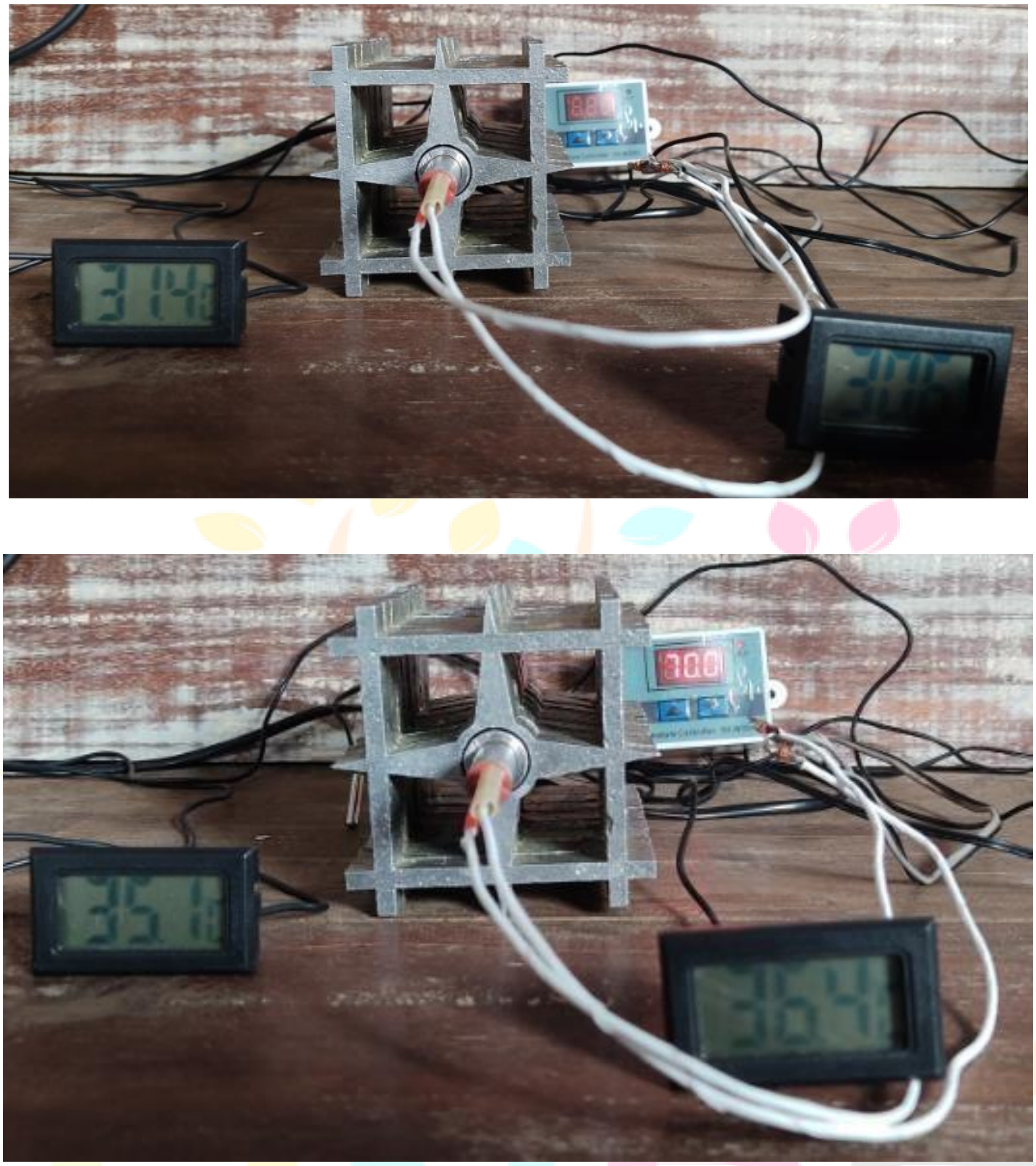


Fig. 6.4 Experimental setup for temperature test

Temperature Test

Table 6.1: Experimental Readings

Trial number	**Temperature at center (K)**	**Temperature at a distance of 12.5 mmfrom the center (K)**	**Temperature at a distance of 18mm from the center (K)**	**Temperature at a distance of 24mm from the center (K)**	**Temperatureat a distance of 30 mm from the center (Intersectionof primary and secondary fins) (K)**	**Temperature at the intersection of the two secondary fins (K)**	**Temperature at the tip of the secondary fintip (K)**
1.	345	344	336.2	335	326	318.4	307.4
2.	345	343.7	336	336.2	325	318.1	307
3.	345	344.3	336.1	335.7	325.5	317 .6	307.9
Average	345	344	336.1	335.6	325.5	318	307.4

Experimental value vs Analytical value

Table 6.2: Experimental vs Analytical Values

Method	**Temperature at center (K)**	**Temperature at a distance of 12.5 mm from the center (K)**	**Temperature at a distance of 18mm from the center (K)**	**Temperature at a distance of 24mm from the center (K)**	**Temperature at a distance of 30 mm from the center (Intersection of primary and secondary fins) (K)**	**Temperature at the intersection of the two secondary fins (K)**	**Temperature at the tip of the secondary fintip (K)**
Experimental	345	344	336.1	335.6	325.5	318	307.4
Analytical	345	340	328	322	307	302	302

VII. RESULTS AND DISCUSSION

Case: 1

Initially, the rectangular fin is considered as primary fins and attached to the tube. The Fig. 5.2 depicts the analysis of temperature distribution of primary rectangular fins. The analysis shows that the temperature throughout the primary fin is between 344.68 K and 342.12 K. The temperature at a distance of 25mm from the origin is 342.2 K.

Case: 2

In order to increase the temperature distribution and maximize the heat transfer, the secondary fins which is also in rectangular shape is attached to the primary fin. The secondary fins are placed between 50mm. The temperature at a distance of 25mm from the origin i.e. at the intersection of the primary and secondary fin is 336K. It is observed that by introducing the secondary fins, the temperature at that point is decreased by 1.81% compared to case 1 and hence we have better heat transfer.

Case: 3A & 3B

The Fig. 5.8 depicts the analysis of temperature distribution of primary triangular fin attached to the secondary fin. The secondary fin is placed between 50mm. It is observed that the temperature at a distance of 25mm i.e. the intersection of the primary and secondary fin is 332K. So, the temperature at that point is reduced by 1.19% compared to case 2. The Fig. 5.5 depicts that the secondary fins are placed at 40mm. It is found from the analysis Fig.5.6 that the temperature at a distance of 25mm is 337K. Hence we can say that the secondary fins placed between 50mm distance has better result compared to the case 2.

Case: 4A & 4B

It is found that in cases 2, 3A, 3B after certain distance from the primary fin, the temperature in the secondary fin becomes constant. Hence it is considered as an extra area which does not help for heat transfer. So the secondary fin is modified as a small projection. The Fig.5.10 & 5.12 depicts the temperature distribution in the small projection of the secondary fin. After modifying the secondary fin, the temperature at a distance of 25mm from the origin i.e. the intersection of the primary & the secondary fin is 323.67 K. The temperature at 25mm from the origin while the secondary fins are placed between 40mm is 328.67 K. So, the temperature at a distance of 25mm is reduced by 2.60% and 3.1% compared to case 2 and case 3 respectively while placing the small projection of secondary fin between 50mm on both sides. Since the secondary fin size is reduced, the area of the secondary fin is reduced, cost of the material & manufacturing is reduced and the air flow is increased.

To verify the Analytical results, we have experimentally noted down the temperature distribution by fabricating the case 3B with aluminium material. The readings of the experimental and analytical values were tabulated. The electrical heater (500W, AC supply) is used to give heat at the tube. A temperature controller (XH W- 3001) is used to cutoff the power supply of the heater to maintain the constant temperature of 345k. The thermocouples were used to note the temperature distribution at various places of the fin. The reading of the thermocouple were tabulated and average at that point was calculated.

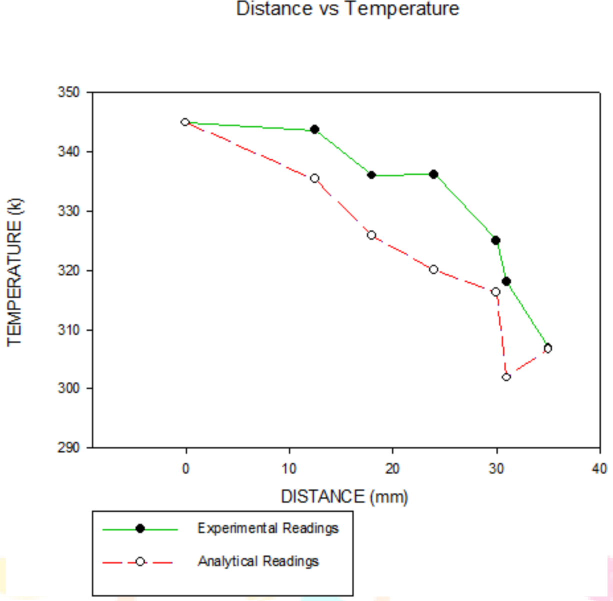


Fig.7.1 Distance vs Temperature

To easily compare the results of the analytical and experimental values a graph has been plotted. From the graph, it is clear that the analytical and experimental values are near to each other. The difference between the values of the temperature at that point may be due to environmental losses.

Table No: 7.1 Results

S.No	**Condition**	**Maximum Temperature (K)**	**Temperature at 25mm from the origin (K)**
1	Primary rectangular fins	345	342.12
2	Primary and secondary rectangular fins		332.32
3	Primary triangular with secondary fins (40mm)		334
4	Primary triangular with secondary fins (50mm)		328
5	Primary triangular and small projectionof secondary fins (40mm)		328.67

6	Primary triangular and small projectionof secondary fins (50mm)		323.67

VIII. CONCLUSION

The 2D simulation analysis is carried out for primary triangular fins, secondary fins with corner projection, and small projection of the secondary fins. The temperature at a distance of 25mm from the origin for the above mentioned designs are compared. From the above results, it is concluded that the small projection of secondary fin attached to the primary triangular fin at 25mm from origin is the best design for the better heat transfer compared to the others, since it has better air flow region for convection, reduced area of fin and the cost of material & manufacturing is also low.

The experimental analysis is also carried out to verify the analytical results. The result of the experimental and analytical were tabulated and compared with a graph. The graph shows that the temperature of analytical and experimental lies near to each other and the difference between the values are due to environmental losses. From the results, it is concluded that the introduction of secondary fin, spacing between the secondary fins are proportional to the temperature distribution.

On comparison of all the results, finally it is concluded as the secondary fins of small projection, spacing of 25mm from the origin placed on the primary triangular fin of base 4mm and height 35mm from the origin has better temperature distribution.

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