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Performance Analysis of Heat Exchanger with Different Types of Fin.

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ABSTRACT

The purpose of this study is firstly to give an overview of the Fins and description of recent improvement of fin geometries to increase the heat transfer rate. The objective of this investigation is to improve the performance of the fins using parabolic geometry of the fins without and with the holes. Through ANSYS simulations for fins in both conditions with and without holes, this study is trying to analyses the heat transfer rate in the fins. Current efforts focus on increasing their efficiency. In this project, focus on exploring the way to increasing the fin performance with and without holes by making the holes of 2mm, 4mm, and 6mm diameter.

Natural convection cooling with the help of finned surfaces often offers an economical and trouble free solution in many situation. Fin arrays on horizontal and vertical surface are used in variety of engineering application to dissipate heat to surrounding. The main controlling variables generally available to the designer are the orientation and the geometry of the fin arrays. For effective dissipation of heat, plain horizontal surfaces facing upward are preferred with aluminum or copper material to increase the heat transfer rate but we used vertical fin because in some application like thermal design for Light – Emitting Diodes (LEDs) is not possible to used the horizontal fin, so considering this point used vertical fins and instead of using copper used mild steel with aluminum, as mild steel have higher melting point than copper.

Fin performance is measured by using the effectiveness of fin, heat transfer rate, heat transfer coefficient and efficiency. Fins are extensively used in air cooled automobile engines, air craft engines, cooling of generators, motors, transformers, refrigerators, cooling of computer processors and other electronic devices etc. It has also applications in heat management in electrical appliances such as computer power supplied, IC engine cooling such in a car radiator. Thus heat transfer from fin arrays has been studied extensively, both computationally and experimentally.

Key Words: ANSYS TRANSIENT THERMAL 14.0, Fins (parabolic) with Holes and Without Holes, Natural Convection, Efficiency and Heat Transfer Rate.

CHAPTER 1

INTRODUCTION

In the study of heat transfer, 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, or 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 first two options are not feasible to enhancing for heat transfer rate. Adding a fin to an object, however, increases the surface area and can sometimes be an economical solution to heat transfer problems. Typically fin material is supposed to have high thermal conductivity and so they are made up of materials like copper, aluminum and iron. The fin is exposed to flowing fluid or atmosphere which cools with thermal conductivity allowing the heat being conducted from the wall through surface. Thus fins are used to enhance convective heat transfer in a wide range of engineering applications and offer a practical means for achieving a large heat transfer surface area without the use of an excessive amount of primary surface area. Fins are commonly applied for heat management in electrical appliances such as computer power supplies or substation transformers. Other applications include fins in a car radiator and compressors. Fins are also used in newer technology like hydrogen fuel cells. Fins improve heat transfer in two ways as: i. Creating turbulent flow through fin geometry which reduces thermal resistance (inverse of convective heat transfer co-efficient) through the nearly stagnant film that forms when a fluid flows parallel to a solid surface. ii. Increasing fin density which increases the heat transfer area that comes in contact with the fluid. Fins can be of shapes and sizes. Different types of fins available are cylindrical, parabolic, conical, trapezoidal, annular, step fin, rectangular etc.

CHAPTER 2

LITERATURE REVIEW

Bharti Sharma *et al* [1] Present work carried out by comparing various shapes of fins with holes and without holes. The four types of shapes are chosen for the comparison i.e. circular, rectangular, helical and trapezoidal. Analysis has been carried out in ANSYS 14.0 Transient Thermal by changing shape of fins with holes and without holes.The fins without holes are compared for different chosen shapes. Comparing this, it is found that helical fin gives better result because it has maximum surface area which provides maximum heat transfer. The same process is carried out for with holes condition. In this process also, helical fin provides better results among other fins. It is found that geometry of Helical Fins with hole have a better Heat transfer rate as compared to the fins without holes.

Manikanand C. And Pachaiyappan [2] He conclude that perforated drop – shaped pin fin array is increase the heat transfer rate when compared to circular pin fin for same pressure drop characteristic the main reason are explain below- perforated drop – shaped pin fin have greater wetted surface area leading to higher heat flux. Perforated drop – shaped force the separation to delay. The drop shaped has a considerable in friction factor in comparison with the circular and rectangular shaped fin pin.

Hyeokin Kwon *et al* [3] Energy Conversion and Management 156 (2018)555-567: In this study, horizontally oriented radical plate- fin heat sinks in natural convection are optimized analytically and experimentally. The thermal resistance is selected as an objective function under the constraint of given base to ambient temperature difference. For thermal optimization, a new correlation of heat transfer coefficient for radical plate- fin heat sink is devolved using the asymptotic method and valuated experimentally. While the existing correlation has a limited applications range, the newly devolved correlation covers complete range of three design parameter for fin geometry: fin thickness (t), fin length (L), and number of fins (n_{fin}). Using this new correlation, the thermal performance of radial plate fin heat sink is optimized with respect to these three design parameter. Finally, optimum fin geometries for applications with various sizes are obtained, since the correlation is applicable to various physical sizes which are characterized by base diameter (D) and the fin height (H).

Ahmed F. Khudheyer and Mahmoud Sh. Mahmoud [4] Three-dimensional CFD simulations are carried out to investigate heat transfer and fluid flow characteristics of a two-row plain fin-and-tube heat exchanger using Open FOAM, an open-source CFD code. Heat transfer and pressure drop characteristics of the heat exchanger are investigated for Reynolds numbers ranging from 330 to 7000. Model geometry is created, meshed, calculated, and post-processed using open source software. Fluid flow and heat transfer are simulated and results compared using both laminar and turbulent flow models (k-epsilon, and Menter SST k-omega), with steady-state solvers to calculate pressure drop, flow, and temperature fields

In the literature review, the various investigations done on the topic of natural convection heat transfer from horizontal, vertical and inclined heated plate and its surface modifications along with various enhancement techniques for the heat transfer enhancement are seen. For maximum heat transfer coefficient optimum fin spacing is required. In the next part it is also seen that heat transfer coefficient depends upon orientation of base plate. It was also seen that by using electro hydro dynamic technique heat transfer coefficient can be increased. By using perforations on the fin, natural convection heat transfer coefficient can be increased. Perforations may be equilateral, triangular and rectangular. It was found that as the number of perforations increases heat transfer coefficient increases. Some researchers have used notch of different shape on fin and found that notched fin performs better than fin with without notch. It was also found that as the depth of notch increases heat transfer coefficient increases but up to a certain limit. Instead of aluminum, one of the researchers has used copper as a fin material and for the same he obtained better heat transfer coefficient. After this one of the researchers have used parabolic fins on base plate give more heat transfer coefficient as they are having drop shaped fin and having more heat transfer rate having 1.5mm hole So it is decided to work on parabolic fins by varying the hole diameter in fin by computational and experimental work.

CHAPTER 3

AIMS AND OBJECTIVES

Natural convection heat transfer in a fluid layer confined in a closed enclosure with partitions like fins is encountered in a wide variety of engineering applications. Such as in power and automotive sectors where heat exchangers, economizers used to heat the feed water to boiler and the activities like cooling of internal combustion engine, also removal of heat from integrated circuits in the electronic circuits or exchange of heat between two fluids as in nuclear power plants, passive cooling of electronic equipment such as compact power supplies, portable computers and telecommunications enclosures. In the design of electronic packages, there are strong incentives to mount as much electronic components as possible in a given enclosure.

Many researchers have mentioned through their literature, heat transfer rate is increased by increasing heat transfer coefficient or by heat transfer area. In case of natural convection there is only scope for increasing heat transfer area by providing finned surfaces. The enhancement ratio of heat transfer depends on the fins orientations and the geometric parameters of fin arrays. The most common configurations of using fin arrays in heat sinks involve horizontal or vertical surface plate to which fin arrays are attached.

OBJECTIVE:

1. Analyze the heat transfer rate through parabolic fin when it drills with 2mm, 4mm, and 6mm holes.

2. Determine the temperature distribution through the holes with finite length of fin.

3. Predict the heat transfer through a fin of finite length with different diameter holes.

4. Define and calculate heat transfer rate, heat transfer coefficient, fin efficiency and fin effectiveness.

CHAPTER 4

EXPERIMENTAL ANALYSIS

According to the objective the arrangement of block diagram is as shown Fig. 5.1

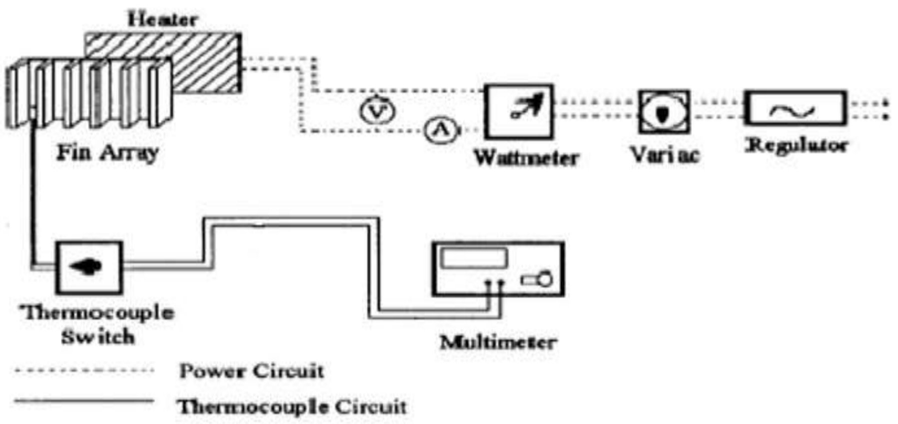

Fig. 5.1 Block diagram of required set up

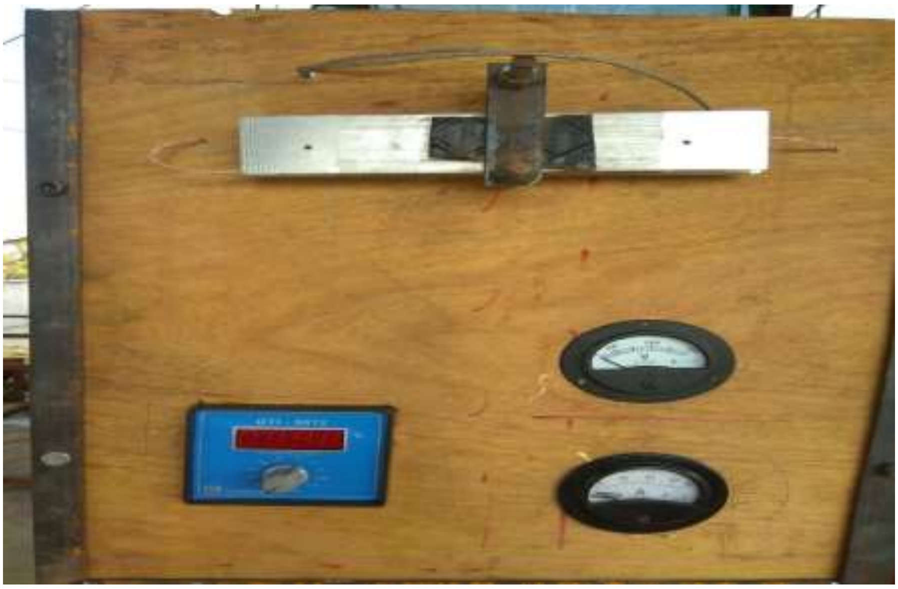

Fig.5.7: Experimental set up

The experimental set up is as shown in the fig.5.7. The base plates of ply used to hold all the experimental instruments, like thermocouples, digital temperature indicator, voltmeter, ammeter, parabolic fins etc for the experiment used aluminum fins having parabolic shape with dimensions length 100mm, thickness 10mm, width 50mm and drill with 2mm hole in between them, to increase the heat transfer rate. The rated power of 400 Watts, 5 Amp at 240 volts, is supplied to the plate. Mica claded, thin plate type, electrical heater wire was sandwiched between the symmetrical plates.

5.4 Computational Analysis for Parabolic Fin Ansys 16.0 Workbench

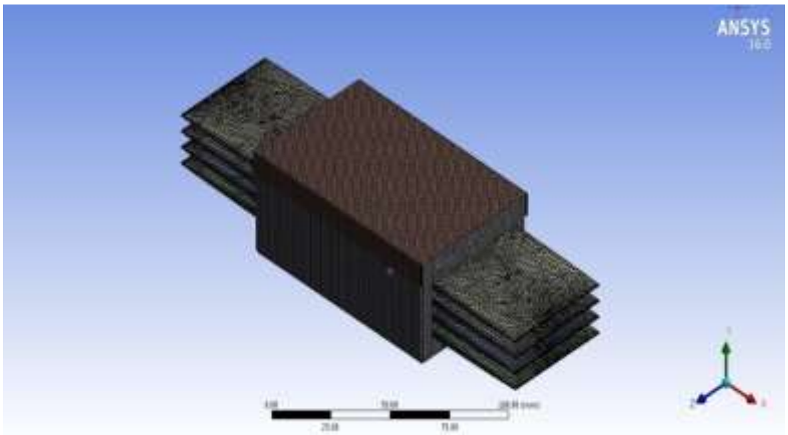

Fig 5.9: Meshing for 2mm hole parabolic fin

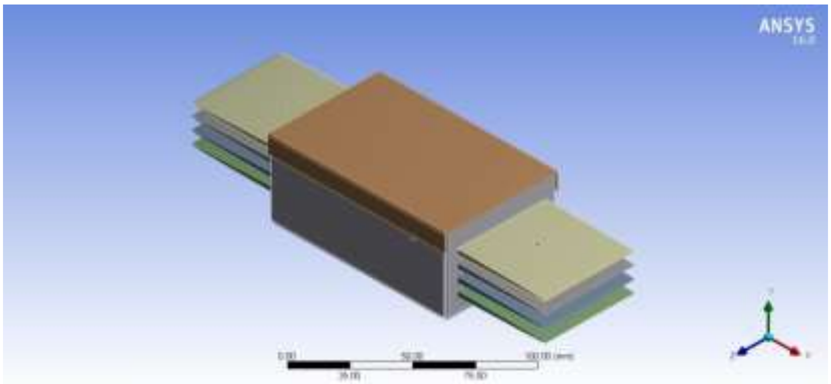

Fig 5.10: Model for 2mm hole parabolic fin

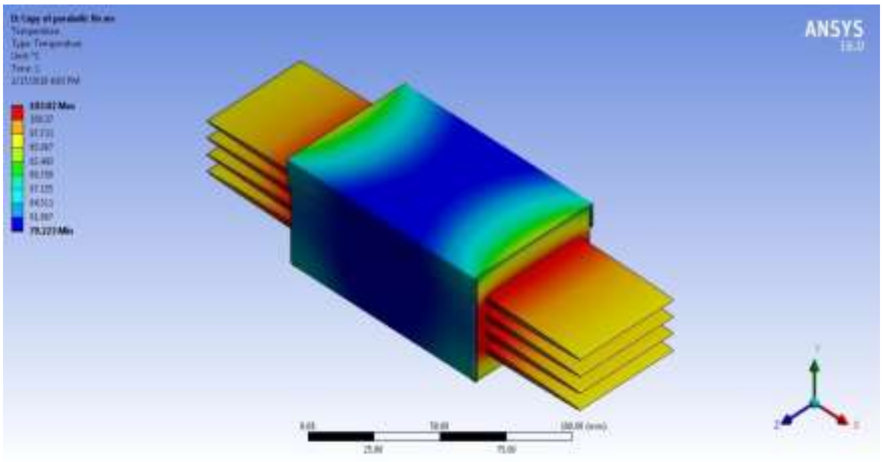

Fig. 5.11 Temperature change on parabolic fin (without hole)

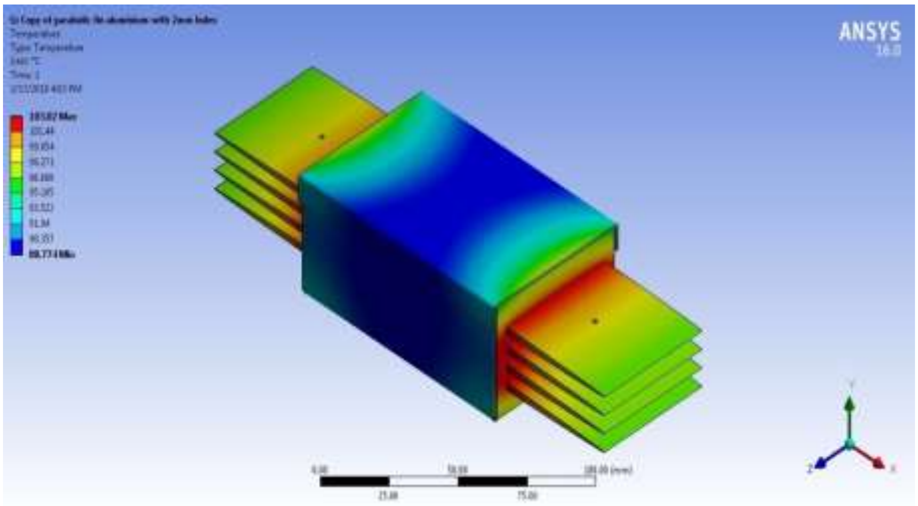

Fig 5.12: Temperature change on parabolic fin with 2mm hole

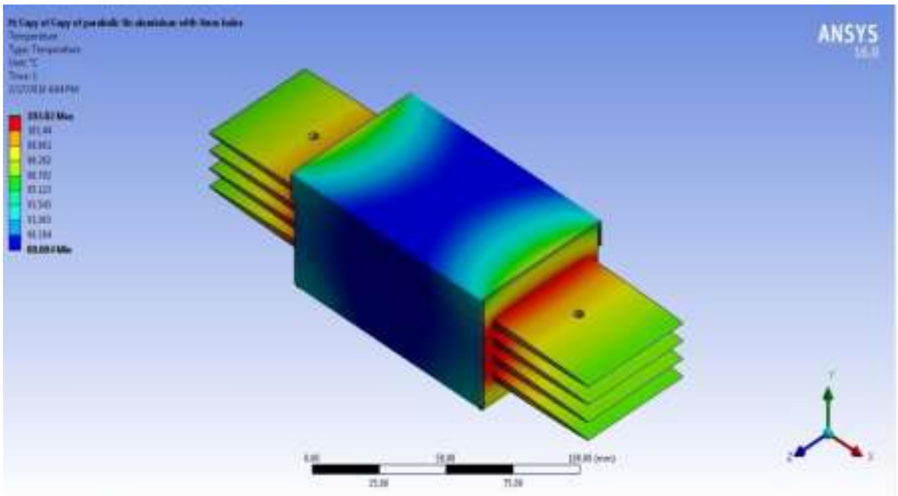

Fig 5.13: Temperature change on parabolic fin with 4mm hole

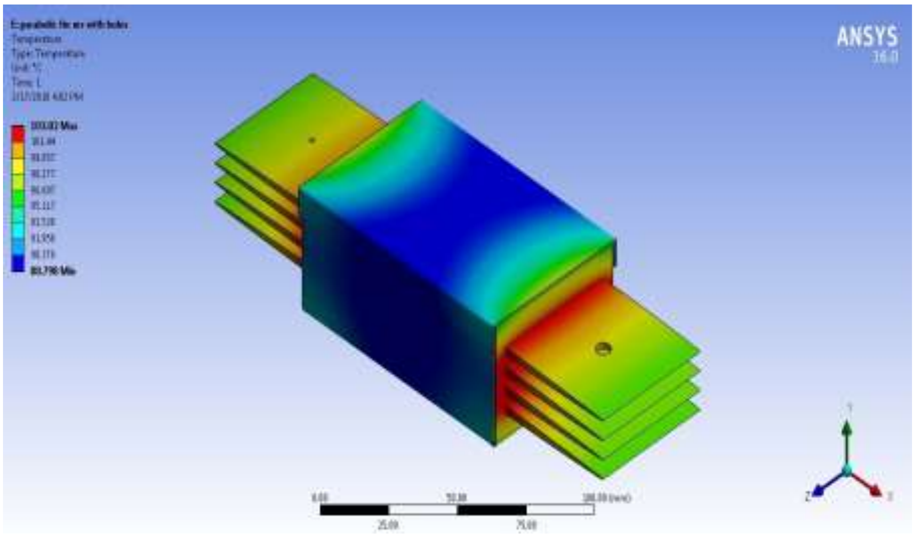

Fig 5.14: Temperature change on parabolic fin with 6mm hole

CHAPTER 5

RESULT AND DISCUSSION

6.1 Results and Discussion for parabolic fin:

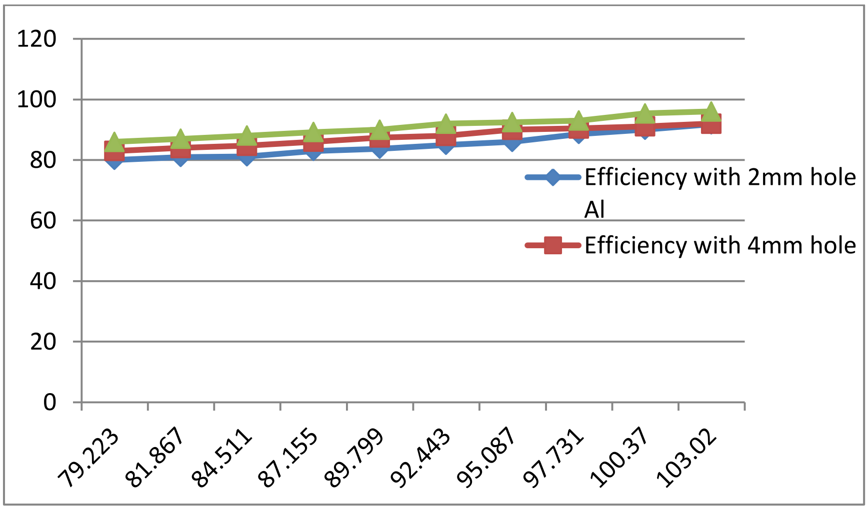

Fig -6.1 Temperature Vs Efficiency for Aluminum

The above graph of temperature vs efficiency shows that efficiency of 2mm hole is increasing as the temperature is increasing the same nature of graph is also observed for 4mm hole and 6mm hole. The curve in graph is shows the increasing nature as temperature increases when fin comes in contact with atmosphere. Hence efficiency increases and for 6mm hole we get maximum efficiency.

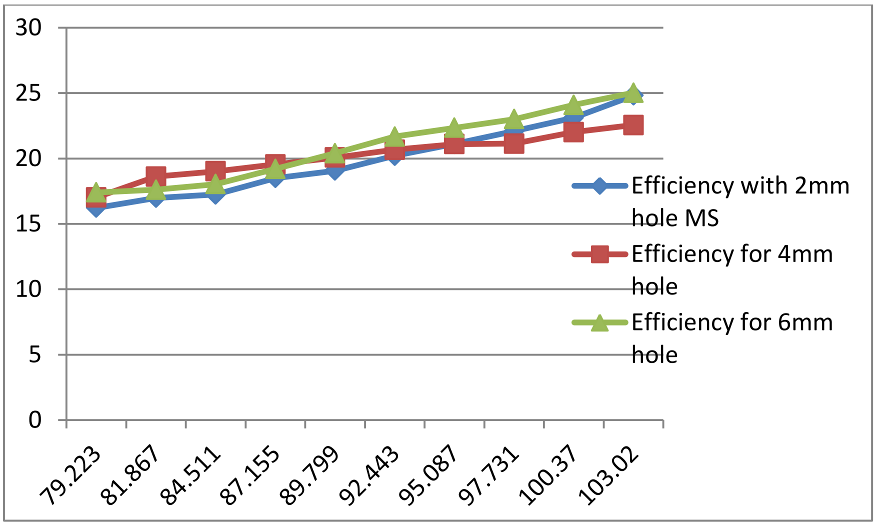

Fig 6.2 Temperature vs Efficiency for Mild Steel

The above graph of temperature vs efficiency for mild steel material shows that efficiency of 2mm hole is increasing as the temperature is increasing the same nature of graph is also for 4mm hole and 6mm hole. The curve in graph is shows the increasing nature it means it indicates as the temperature increases the efficiency of parabolic fin also increases and it is highest for 6mm hole as the maximum surface area comes in contact with atmosphere but the main difference in efficiency for aluminum and mild steel material is, the efficiency curve for aluminum is increase as compared to mild steel it indicates the heat transfer rate is maximum for aluminum material for same hole sizes.

In above graphs we see how the heat transfer rate, heat transfer coefficient, efficiency and effectiveness of parabolic fin are varying with the temperature. And with the help of all graphs we can conclude that aluminum material gives maximum heat transfer rate, heat transfer coefficient, efficiency and effectiveness as compared to mild steel. Also when we compared the curve for 2mm, 4mm, and 6mm holes, it is noticed that 6mm holes has heat transfer rate, heat transfer coefficient, efficiency and effectiveness because of maximum area which is available for cooling and it helps to reduces the heat temperature .

For more clarifications, here show the comparison of computational and experimental results for 2mm hole parabolic fin of aluminum and mild steel materials.

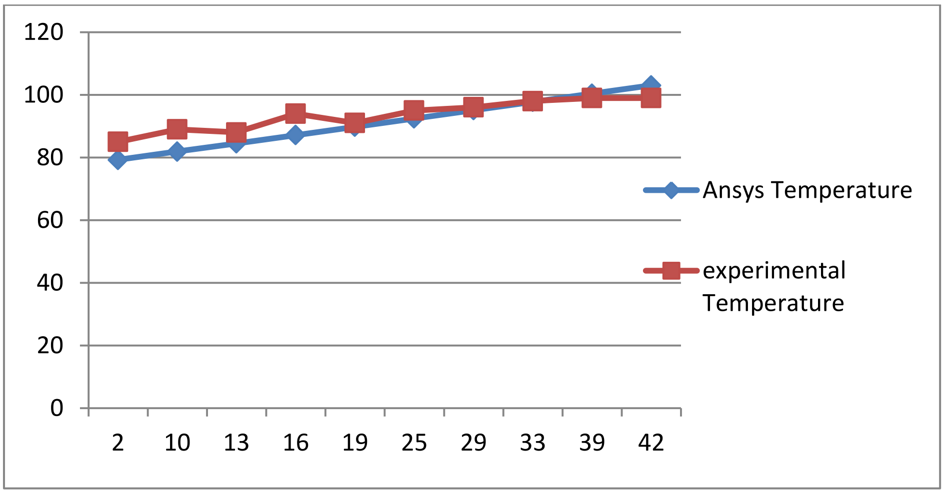

Fig 6.9: Temperatures vs Time

The above graph we compared the ansys temperature and experimental temperature with time, in the graphs we compared the ansys temperature with experimental temperature which shows the same curve after some time of interval which means, the experimental and ansys result are same, and can used the ansys result for further results.

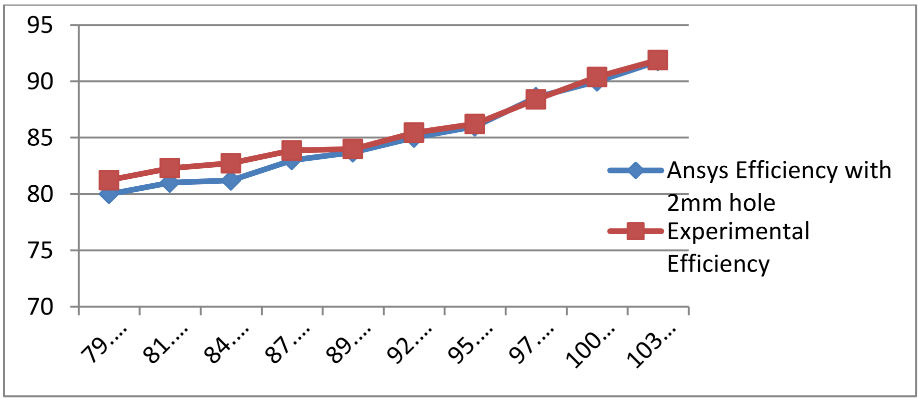

Fig 6.10: Temperatures Vs Efficiency for 2mm Hole Aluminum Material

The above graph we compared the ansys efficiency and experimental efficiency with temperature, the curve shows upward nature while increasing the temperature, it means efficiency is increasing because of good heat transfer from fin material.

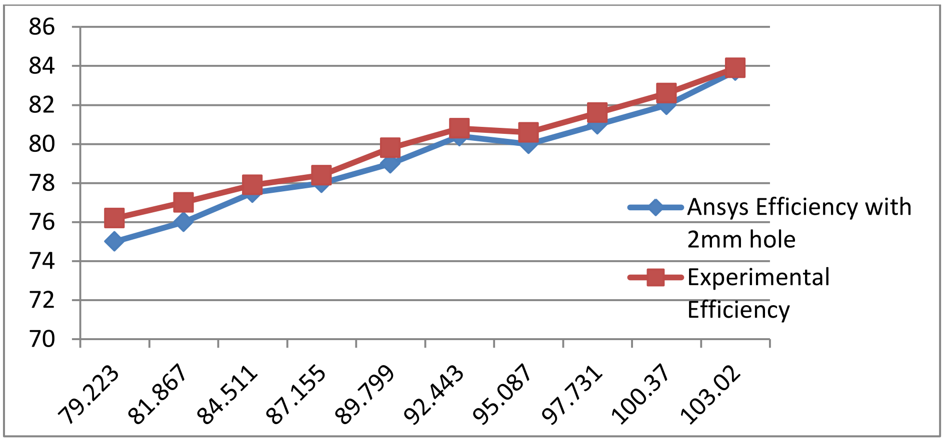

Fig 6.11: Temperatures vs Efficiency for 2mm Hole Mild Steel Material

The above graph we compared the ansys efficiency and experimental efficiency with temperature, the curve shows upward nature while increasing the temperature, because of good heat transfer of rate, the experimental and ansys readings gives the almost same result.

CHAPTER 6

CONCLUSIONS AND SUMMARY

In this investigation work parabolic fin with holes is used to increase the rate of natural convection heat transfer. Parabolic fin with holes gives the better surface area we get better fin effectiveness, heat transfer rate, heat transfer coefficient and effectiveness. It is thus anticipated that a low pressure suction region is created in the nose region on the downstream side of each parabolic fin which eventually admits the low temperature ambient fluid from surrounding. This immensely helps to allow the inflow of the low temperature fluid into the separation region and increases the heat transfer rate.

It is concluded that the maximum convective average heat transfer coefficient is obtained for parabolic fin. The flow of air from the fins is laminar as observed and calculated using nusselt number formula. Ansys 16.0 workbench and experimental setup showed the similar trend. On the basis of design and Ansys computational results gives the almost same results for fin effectiveness, heat transfer rate, heat transfer coefficient and effectiveness. Due to the low pressure region generated in the nose region of each parabolic fin, it increases the heat transfer rate. It was also concluded that as the heat flux increases, heat transfer coefficient increases along with increase in temperature difference, it is also notes that from experimental and computational results 6mm hole parabolic fin gives better heat transfer than 4mm and 2mm hole in parabolic fin due to increasing in surface area.

Following points are worth noting from the present investigation work.

- Computational analysis and subsequent experimental investigations have revealed fins can be used effectively to enhance threat of heat transfer.