Performance Analysis of Thermal Characteristics of Transient Heat Transfer through Finite Fins and Various Shapes of Notches : A Review

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Abstract— The present article investigates the analysis of transient heat conduction through fins. Fins are the extended surface used for enhancing the dissipation of heat transfer rate and different geometrical fins are used as per requirement its accessibility depends. Fins are extensively used in heat exchanging device in automobiles radiators, industrial sectors, power plants, newer technology like fuel cells. Earlier Work under steady state conduction had been carried out extensively. Transient heat conduction analysis for fins is being considered for simplifying heat transfer queries. Transient closed form solution had been derived earlier by various researchers. As proper heat dissipation results in saving of power and lesser chances of overheating problems, perforation are made on the fins. Perforated fin improves heat transfer rate collate to solid fin by varying the different parameter like shape of perforation, diameter of perforation and number of perforation. For the purpose of contrast and optimization, notches of different aspect ratio on single plate have also been analyzed. In a lengthwise short array where the single chimney flow pattern is present, the central portion of fin flat becomes futile due to the fact that, the heated air comes in its contact. In the present study, the fins of different geometries are modified by deposing the central fin portion by cutting a triangular, rectangular and un-notch fins. This article presents a performance analysis of thermal characteristics of Transient Heat Transfer for finite fins and various shapes of notches on single plate for that an experimental setup is developing and also shows a comparison between the experimental results and results obtained by using ANSYS software.

I. INTRODUCTION

Fins are the extended surfaces used for enhancing the dissipation of heat transfer rate. The transient response of fins is important in a wide range of engineering devices, automobiles and industrial sectors. Work under steady state conduction had been carried out extensively. Transient heat conduction analysis for the fins is being considered for simplifying heat transfer queries. Transient Closed form solutions had been derived earlier by various researchers.

Extended surface is used specially to enhance the heat transfer rate between a solid and an adjoining fluid. Such an extended surface is termed a fin. In a conventional heat exchanger heat is transferred from one fluid to another through a metallic wall. The rate of heat transfer is directly proportional to the extent of the wall surface, the heat transfer coefficient and to the temperature difference between one fluid and the adjacent surface. If thin strips (fins) of metals are attached to the basic surface, extending into one fluid, the total surface for heat transfer is thereby increased. The use of fins in one side of a wall separating two heat-exchanging fluids is exploited most if the fins are attached to or made an integral part of that face on which the thermal resistivity is greatest. In such a case the fin serve the purpose of artificially increasing the surface transmittance. Thus, fins find numerous applications in electrical apparatus in which generated heat must be efficiently dissipated, in specialized installations of single and double-pipe heat exchangers, on cylinders of air cooled internal-combustion engines. Recently, finned surfaces are widely used in compact heat exchangers that are used in many applications such as air conditioners, aircrafts, chemical processing plants, etc… Finned surfaces are also used in cooling electronic components. .Generally in transient heat transfer on horizontal fin array single chimney flow pattern is used for analysis. In this flow pattern the air enters from sideways and gets heated as it moves inwards(towards center of the fin channel).As the temperature of the air increases air rises up due to decreases in density. Hence, no air comes in contact with the central bottom portion of fin channel. This creates a stagnation zone near the central bottom portion of fin channel. To overcome this difficulty some portion of fin is removed near the stagnation zone, to increase the HTC. The notches are provided in various size and shapes on single plate and are added at the place where fresh air comes in contact with fin surface.

The general disposition of fins on the base surface is usually either longitudinal (straight fins) or circumferential (radial fins). Fins may also be disposed in the form of continuous spiral on the base surface or in the form of individual rods known as pin-fins or spines.

The cross section shape of the extended surface in a plane normal to the base surface is to be referred to as the profile of the fin or spine. Different fin profiles considered in the present study are shown in Figure.

Disposition of fins on the base surface results in increase of the total surface area of heat transfer. It might be expected that the rate of heat transfer per unit of the base surface area would increase in direct proportion. However, the average surface temperature of this strips (fins), by virtue of temperature gradient through them, tends to decrease approaching the temperature of the surrounding fluid. So, the effective temperature difference is decreased and the net increase of heat transfer would not be in direct proportion to the increase of the surface area and may be considerably less than that would be anticipated on the basis of the increase of surface area alone. The ratio of the actual heat transfer from the fin surface to that would transfer if the whole fin surface were at the same temperature as the base is commonly called as the fin efficiency.

II. LITERATURE REVIEW

Arun kumar Sao, Dr. Yamuna Prasad Banjare [1], they work on the analysis of transient heat conduction through long fins and comparisons with the theory based on it termed as "exact fin theory" & "quasi steady theory" at different locations of fins at different parameters. The dimensionless temperature distribution is presented for both quasi steady theory and exact fin theory and compared with their results. This work has been done with dimensionless positions of Fin and dimensionless temperatures in different segments for premium solutions. The graphical results are incorporated in the work for the generalized thermal characters of composite fins, mostly emphasizing on Heat Exchanger. The effect on thermal performance for different conditions is analyzed in the work. Raseelo Moitsheki, Charis Harley[2], they work on Transient heat transfer in longitudinal fins of various profiles with temperature-dependent thermal conductivity and heat transfer coefficient Dr. Rahul Salhotra and Harbans singh ber [3] , they work emphasizes on the analysis of transient heat conduction through fins. the exact local and mean temperature distribution had been generated by numerical technique methods. Majtaba Mokhtari, M. Barzegar Gerdroodbary Rezvan Yeganesh, k Fallah [4], they work on Numerical study of mixed convection heat transfer of various fin arrangements in horizontal channel. Esmail M.A.Mokheimer [5] presented article investigates the effect of lacally variable heat transfer coefficient on the performance of extended surface (Fins) subject to natural convection. M.Shaukat Ali and M. Altamush Siddiqui [6] discussed Effect of variable Heat Transfer coefficient on the performance of the Different Profile Fins. A.Moradi, H.Ahmadikia [7] discussed Analytical solution for Different Profiles of Fin with temperature Dependent Thermal Conductivity. Raseelo Moitsheki and Atish Rowjee[8], they work on Steady Heat transfer transfer through a Two dimensional Rectangular straight fin. Exact solution for models describing heat transfer in a two-dimensional rectangular fin are constructed. here they apply kirchoff transformation on the governing equation.

Sanjeev D. Suryawanshi, Narayan K. Sane [9], they work on Natural Convection Heat Transfer From Horizontal Rectangular Inverted Notched Fin Arrays. The variables for natural convection cooling designed according to the need surfaces orientation and geometry. In lengthwise short array L/H 5, where single chimney of pattern is present, a stagnant zone is created at the central bottom portion of n array channel and hence it does not contribute much in heat dissipation. Hence for enhancement of heat transfer it is removed in the form of inverted notch at the central bottom portion of n to modify its geometry. The investigation on normal and inverted notched n arrays, an experimental setup is developed for studying and taking results. Fin spacing, heater input, and percentage of area removed in the form of inverted notch. For few spacing, it is verified by computational fluid dynamics and the results are well matching. It is found that the average heat transfer coefficient for inverted notches is nearly 35 to 45 percent higher as compared with normal array. D. Merwin rajesh, K. Suresh kumar[10], Effect of heat transfer in cylindrical fin body by varying geometry and material. The principal implemented in this article is to increase the heat dissipation rate by usinf invisible working fluid is air. We know that, by increasing the surface area we can increase the heat dissipiation rate, so desiging such a large complex engine is very difficult. the main purpose of using these cooling fins is to cool the engine cylinder by any air. A parametric model of piston bore fins has been developed to predict the transient thermal behavior. S. M. Ramnani, S.Y. Bhosale [11] they work on Optimization of Heat Transfer Rate by Forced Convection Process on Perforated Fin. In Natural convection heat transfer with the help of fin arrays, parameter are spacing and orientation of geometry and ratio of height to fin length. In the longitudinally short fin array, heat transfer coefficient is high, where single chimney flow pattern was presented. In long rectangular fin arrays, air is converges at central zone hence it is not so much contributed in heat dissipation. In present study experimental setup was fabricated for studying the effect of natural convection on rectangular fin array. During the experimentation spacing in fins, height and heater input the parameters are studied. For black fin surface lampblack coating is used. Used smoke flow visualization techniques flow patterns for various spacing investigation. B.N.Niroop kumar gowd, Ramatulasi [12] they calculate heat transfer rate of cylinder fin body by varying geometry and material. here they use aluminum alloy 7075 instead of aluminum alloy 204 because of high thermal conductivity. “Thermal Analysis of Square and Circular Perforated Fin Arrays by Forced Convection”, Kavita H. Dhanawade1, Vivek K. Sunnapwar2 and Hanamant S. Dhanawade3 [13]: Heat dissipation is a drastic issue to tackle due to continued integration, miniaturization, compacting and lightening of equipment. Heat dissipaters are not only chosen for their thermal performance; but also for other design parameters that includes weight, cost and reliability, depending on application. The present paper reports an experimental study to investigate the heat transfer enhancement over horizontal flat surface with rectangular fin arrays with lateral square and circular perforation by forced convection. The cross sectional area of the rectangular duct was 200 mm x 80 mm. The data used in performance analysis were obtained experimentally for fin arrays of material aluminum, by varying geometry and size of perforation as well as by varying Reynolds number from 21 104to 8.7 104. It is observed that the Reynolds number and size perforation have a larger impact on Nusselt number for the both type of perforation. Computational Analysis of Inverted Notched Fin Arrays Dissipating Heat by Natural Convection", S M.Wange1, R.M.Metkar2[14]: The extended surfaces known as fins are used for the heat transfer purpose in various instruments like heating and cooling equipments. Fins offer an economical and trouble free solution in many situations demanding natural convection heat transfer. Heat sinks in the form of fin arrays on horizontal and vertical surfaces used in variety of engineering applications, studies of heat transfer and fluid flow associated with such arrays are of considerable engineering significance. The main controlling variable generally available to designer is geometry of fin arrays. In a lengthwise short array, where the single chimney flow pattern is present, the central portion of fin flat becomes ineffective due to the fact that, already heated air comes in its contact. A stagnant zone is created at the central bottom portion of fin array channel and hence it does not contribute much in heat dissipation. Hence it is removed in the form of inverted notch at the central bottom portion of fin to modify its geometry for enhancement of heat transfer. The comparison of experimental and computational analysis is done and results are well matching. It is found that the average heat transfer coefficient for inverted notch fin arrays is higher than normal fin array. Heat Transfer Analysis through Fin Array by Using Natural Convection", Shivdas S. Kharche1, Hemant S. Farkade [15]: The main purpose of extended surfaces called fins to increase the heat transfer rate. Fins offer an economical and trouble free solution in many situations demanding natural convection heat transfer. Heat sinks in the form of fin arrays on horizontal and vertical surfaces used in variety of engineering applications, studies of heat transfer and fluid flow associated with such arrays are of considerable engineering significance. The main controlling variable generally available to designer is geometry of fin arrays. Considering the above fact, natural convection heat transfer from vertical rectangular fin arrays with and without notch at the center have been investigated experimentally and theoretically. Moreover notches of different geometrical shapes have also been analyzed for the purpose of comparison and optimization. In a lengthwise short array where the single chimney flow pattern is present, the central portion of fin flat becomes ineffective due to the fact that, already heated air comes in its contact. Many researchers have been studied the heat transfer rate through without notch and notched fins by using aluminium as a material. Verities of researchers were carried out, this paper focuses on heat transfer rate of copper fin for greater heat transfer rate which is need of increased rate of modernization thus extent of copper is tested.

III. NEED OF SIMULATION

Need of simulation is required for the following parameters analysis,

1) To determine dimensions of the notch for optimum Transient heat transfer rate.
2) To study influence of height of rectangular and triangular notch on transient heat transfer.
3) To calculate minimum material for maximum heat transfer.
4) To analyze the effect for different materials.
5) To study spacing of the fins.

IV. SIMULATION SOFTWARE

The invention of high speed digital computers, combined with the development of accurate numerical methods for solving physical problems, has revolutionized the way we study and practice fluid dynamics and heat transfer. This approach is called Computational Fluid Dynamics or CFD in short, and it has made it possible to analyze complex flow geometries with the same ease as that faced while solving idealized problems using conventional methods. CFD may thus be regarded as a zone of study combining fluid dynamics and numerical analysis. Historically, the earlier development of CFD in the 1960s and 1970s was driven by the need of the aerospace industries. Modern CFD, however, has applications across all disciplines – civil, mechanical, electrical, electronics, chemical, aerospace, ocean, and biomedical engineering being a few of them. CFD substitutes testing and experimentation, and reduces the total time of testing and designing. Fig. gives the overview of the CFD modeling process. CFD is a sophisticated computationally based design and analysis technique. CFD software gives you the power to simulate flows of gases and liquids, heat and mass transfer, moving bodies, multiphase physics, chemical reaction, fluid-structure interaction and acoustics through computer modelling. This software can also build a virtual prototype of the system or device before can be apply to real-world physics and chemistry to the model, and the software will provide with images and data, which predict the performance of that design. Computational fluid dynamics (CFD) is useful in a wide variety of applications and use in industry. CFD is one of the branches of fluid mechanics that uses numerical methods and algorithm can be used to solve and analyses problems that involve fluid flows and also simulate the flow over a piping, vehicle or machinery. Computers are used to perform the millions of calculations required to simulate the interaction of fluids and gases with the complex surfaces used in engineering. More accurate codes that can accurately and quickly simulate even complex scenarios such as supersonic and turbulent flows are ongoing research. Onwards the aerospace industry has integrated CFD techniques into the design, R D and manufacture of aircraft and jet engines. More recently the methods have been applied to the design of internal combustion engine, combustion chambers of gas turbine and furnaces. Furthermore, motor vehicle manufactures now routinely predict drag forces, under bonnet 20 air flows and surrounding car environment with CFD. Increasingly CFD is becoming a vital component in the design of industrial products and processes.

A. CFD Programs

The development of affordable high performance computing hardware and the availability of user friendly interfaces have led to the development of commercial CFD packages. Before these CFD packages came into the ordinary use, one had to write his own code to carry out a CFD analysis. The programs were usually different for different problems, although some part of the code of one program could be used in another. The programs were inadequately tested and reliability of the results was often questioned. Today, well tested commercial CFD packages not only have made CFD analysis a routine design tool in industry, but are also helping the research engineer in focusing on the physical system more effectively.

V. CONCLUSION

Fins are used to increase heat transfer rate. It is also revealed that heat transfer coefficient and in turn the rate of heat transfer can further be increased by increasing the surrounding fluid velocity i.e. by forced convection. The performance of heat transfer fins can be analyzed effectively by commercially available CFD software, Ansys in specific. The rate of transient heat transfer in the triangular and parabolic fins are higher than rectangular. The heat transfer coefficient is highest for the set of fins and Larger value of M increases the transient response of fin. where M is the dimensionless parameter. here unsteady fin equations were considered time term is also invoved in this with respect to time we can obtain the temperature at different locations. this equation is made dimensionless so that it will be applicable in all geometry of fins. This has been reviewed from the experimental analysis done in various papers. Friction factor slightly increases with increase in the size of perforation. The perforated fin is light in weight, saves material and extracts heat quickly from heated surface compared to solid fin. Heat transfer enhancement depends on number of perforation, size and shape of perforation, thickness of perforated fin and thermal conductivity of fin material. The same methodology of experimental investigation and computational analysis can be used further for different types of fins and notches.

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