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A Review on CFD analysis of heat transfer in a pipe having different External fin profile

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ABSTRACT

All the electronic components release heat during their operation which must be transferred to the surrounding and its proper and intended operation and to avoid the damage of the equipment. The main aim of extended surfaces is to limit the maximum temperature in the metallic walls. Hence increase the possibility of using the least refractory material and minimizing the material and processing cost. Generally, the extended surfaces (fins) are made up of the materials having high conductivity like aluminum. The heat transfer will depend on the geometry of the fin-like length, thickness, cross-sectional area, width, spacing between the fins and the operating parameters such as heat supplied to the device, material of the fin, orientation of the fins, temperature difference between the fin and surrounding, number of fins, fin array orientation etc.as the electronic devices and engines developed, heat generated from them increases and while the surface area of the electronic equipment decreases continuously.

Keywords: *Triangular fins, Rectangular fins, turbulent flow, heat transfer and pressure drop*

1. INTRODUCTION

Extended surfaces or fins are commonly found on electronic components ranging from power supplies to transformers. The dissipation and subsequent rejection of potentially destructive self-produced heat is an important aspect of electronic equipment design. The dissipation of heat is necessary for its proper function. The heat is generated by the resistance encountered by electric current. Unless a proper cooling arrangement is designed, the operating temperature exceeds permissible limit. As a consequence, chances of failure get increased. In order to design an effective heat sink, some criterions such as a large heat transfer rate, a low pressure drop, high heat transfer coefficient, lowest maximum temperature attained, high surface Nusselt number, low thermal resistance, an easier manufacturing a simpler structure, a reasonable cost and so on should be considered and the material of the construction is taken as Aluminium has a thermal conductivity of 235 watts per Kelvin per meter (W/MK). (The thermal conductivity number, in this case, 235, refers to the metal's ability to conduct heat. Simply put, the higher the thermal conductivity number of a metal, the more heat that metal it can conduct. Aluminum is also cheap to produce and is lightweight. When a heat sink is attached, its weight puts a certain level of stress on the motherboard, which the motherboard is designed to accommodate. Yet the lightweight makes up of aluminum is beneficial because it adds little weight and stress to the motherboard.

2. REVIEW OF PAST RESEARCH

Kute S. B. and Sonage B. K (2018) present study for consideration of replacement in fire tube boiler. Flue gas side surface heat transfer coefficient is the criteria used for the comparison. Heat transfer performance of helically ribbed tube (Rifled Tube) is compared with that of plain tube experimentally. The experimental methodology, experimental setup and the comparison results are presented in this paper. Gas side surface heat transfer coefficient for the plain and rifled tube is evaluated and presented in this study. An experimental result proved that 80% enhancement in heat transfer coefficient is observed. CFD Analysis is done for temperature profile of plain tube and rifled tube.

Shaik Himamvalli (2017) studied natural convection from a heated pipe having fins of various configurations using ANSYS WORKBENCH version 13.0. The material under consideration is aluminium and the free stream fluid is air. The heat transfer rate from the fins, an outer wall, and the overall heat transfer rate has been calculated and compared for various fin configurations. Also, the surface nusselt number and surface overall heat transfer coefficient has been found out. Temperature contours for various fin configuration have been plotted showing the convection loops formed around the heated pipe surface. Velocity contours for various fin configurations have been plotted and the motion of the heated fluid is shown. Plots for nusselt number and heat transfer coefficient are also shown. The assumptions during the analysis have been taken considering the manufacturing and practical applications and working conditions. Hence the results obtained can be referred to while solving any such kind of problems in the practical field where only natural convection is under consideration.

B. Usha Rani (2017) studied the main parameters which can significantly influence the heat transfer performance of finned tube has been analyzed. Natural convection in a vertical tube without fins was taken as the reference tube and different internal fin patterns such as a single fin with large no. of turns like coiled shape and large no. of fins with single turn is compared with reference tube on the basis of different parameters such as heat transfer rate, surface nusselt number, heat transfer coefficient, fin effectiveness etc. After getting best fin configuration compared it with a fin profile of rectangular cross-section. All the computer simulation has been done on the ANSYS 13.0. Aluminum is used for the fin material and the air is taken as the fluid flowing inside the tube and the flow is taken as laminar. It was found that a large number of fins with a single turn is more efficient than other fin patterns, as there is less flow resistance, high heat transfer rate.

K. Ravi Kumar (2017) simulated the 3D geometry for cross-flow smooth and finned tube heat exchanger with using hot water inside the tube and cooling air outside the tube by using computational fluid dynamic (ANSYS-FLUENT 15). The enhancement of heat transfer has been introduced in many fields of industrial and scientific applications. For the simulation, purpose a symmetric view of the simplified geometry of the heat exchanger is made using solid works software.

Pankaj V. Baviskar et al (2016) performed a numerical study of different fin profile heat sinks which are rectangular, circular, trapezoidal and triangular using ANSYS. The numerical results were validated with experimental test setup for rectangular fin shape heat sink. Validated numerical result signifies that the more heat transfer rate for the triangular fin. So the modified triangular fin heat sink was fabricated and can be checked experimentally to get better results. The modified triangular heat sink shows that there was an increase in heat transfer rate by 9% as compared to rectangular fin heat sink.

Shobhana Singh (2016) cross-flow type heat exchanger with circular tubes and rectangular fin profile is selected as a reference design. The fin geometry is varied using a design aspect ratio as a variable parameter in a range of 0.1-1.0 to predict the impact on overall performance of the heat exchanger. In this paper, geometric profiles with a constant thickness of fin base are studied. Three dimensional, steady-state CFD model is developed using commercially available Multiphysics software COMSOL v5.2. The numerical results are obtained for Reynolds number in a range from 5000 to 13000 and verified with the experimentally developed correlations. Dimensionless performance parameters such as Nusselt number, Euler number, efficiency index, and area-goodness factor are determined. The best performed geometric fin profile based on the higher heat transfer and lower pressure loss is predicted. The study provides insights into the impact of fin geometry on the heat transfer performance which help escalate the understanding of heat exchanger designing and manufacturing at a minimum cost.

Dibya Tripathi (2016) proposed to calculate fin effectiveness, on the fin inside one-tube plate finned-tube heat exchangers for various airspeeds and the temperature difference between the ambient temperature and the tube temperature. Previous work has been done to predict fin efficiency. Fin effectiveness is also a measure significant in fin study.

Poorana Chandran Karthik et al (2015) analyzed the heat transfer characteristics of a louvered fin and elliptical tube compact heat exchanger used as a radiator in an internal combustion engine. Experiments are conducted by positioning the radiator in an open-loop wind tunnel. A total of 24 sets of air, water flow rate combinations are tested, and the temperature drops of air and water were acquired. A numerical analysis has been carried out using fluent software (a general purpose computational fluid dynamics simulation tool) for three chosen data from the experiments. The numerical air-side temperature drop is compared with those of the experimental values. A good agreement between the experimental and numerical results validates the present computational methodology.

Aditya Pratap Singh Jadaun (2015) solved the heat problems of high-performance computer systems. With a weight per volume less than half that of a traditional solution, and with its smaller base surface area, the Power Heat Sink is a powerful thermal solution to the problems faced by designers of high-performance computer systems. Correlations developed by various researchers with the help of experimental results for heat transfer & friction factor for solar air collector by taking different roughness geometries are given & these correlations are used to predict the Thermo-hydraulic performance of solar air collector having roughened ducts.

3. SUMMARY OF LITERATURE SURVEY

The review of the literature revealed the following,

Modern heat exchanger with fin systems has high thermal performance and low environmental impact is presently in development.

Thermal designers face a challenge of increasing power density within the volume, envelope shape, and cost. Elliptical fins will be a better choice compared to annular circular and eccentric fins by increasing the surface area of the fins in one particular direction when space is restricted in another direction.

The main objectives in raising the performance of thermal systems are to reinforce the heat transfer between hot and cold surfaces and also the flowing fluid. Numerous ways are projected to attain this task. Some classical techniques on fins are the main interest of this work.

This is especially important in modern electronic systems, in which the packaging density of circuits is high. In order to overcome this problem, thermal systems with effective emitters as fins are desirable.

Only a few researchers focussed on nano coating of extended surfaces.

The present study proposes the inverse method and the commercial software of FLUENT in conjunction with the experimental temperature data to determine the average heat transfer coefficient h, heat transfer coefficient based on the fin base temperature and fin efficiency for various fin spacing‘s.

These were simplified by assuming periodically developed two-dimensional flow and isothermal heat transfer surfaces. In general, it is found that rounded geometries outperform similar sharp-edged fin shapes. In all cases, staggered geometries perform better than inline. At lower values of pressure drop and pumping power, elliptical fins work best. At higher values, round pin fins offer the highest performance.

The small number of previous studies of these fin geometries, usually comparing only two at a single operating point, has demonstrated some of the conclusions reached here. These conclusions are qualitatively known, but the current study quantifies these effects and compares various geometries with equal values of fin/base area ratio and lengthwise spanwise pitch ratio.

All studies verified that the heat transfer coefficient around the fin, and from row-to-row vary in accordance with the bundle depth. It is useful to note that only limited results with a single tube and very few rows are found, and further studies applying four and more tube row bundles should follow. On the other hand, some studies have done to resolve this situation by developing the row correction factors. A considerable amount of related data on the local and average heat transfer and the pressure drop were established and qualitative judgments on circular finned tube configurations are rendered. Despite these earlier developments, this review indicated that further concentration on the existing problems in designing of optimum fin geometry and tube arrangements are still necessary. Some conclusion points are:

• Considerably more information on numerical simulation has been published for plate fins than circular fin tubes.
• The heat transfer coefficient and flow distribution over a tube in the bundle is different from a single tube.
• Temperature distributions over the fin surface and the flow structures between fins are of a complex pattern. When the need arises to measure such effects accurately, it is an experimentally difficult task to do without disturbing the heat transfer behavior on a fin surface. Therefore, more precise data on the local behavior are necessary.
• Different results came out of the relevant information regarding the tube spacing adjustments and a number of rows.
• Since most correlations were based on their own data, authors gave a different formula for the heat transfer and pressure drop correlations. In addition, the characteristic dimension to define Reynolds number was dissimilar. Thus, it is fairly anticipated that to compare directly to experimental correlations is found to be difficult.
• Finally, all related works for the circular finned-tubes have been correlated with experimental ones and respective correlations have not been verified yet under numerical simulations. Therefore, additional numerical data are needed in order to establish improved correlations

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