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Review on CFD Analysis of Heat Transfer in a Pipe Having Finned Tube with Different Fin Profile

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ABSTRACT:

All electronic components generate heat during operation, which must be transmitted to the environment for correct and intended operation, as well as to avoid equipment damage. The primary goal of extended surfaces is to keep the maximum temperature in the metallic walls below a certain level. As a result, the option of employing the least refractory material while reducing material and processing costs is increased. The expanded surfaces (fins) are typically made of materials with high conductivity, such as aluminium.The heat transfer will depend on the geometry of the fin, such as length, thickness, cross sectional area, width, and fin spacing, as well as operating parameters such as heat supplied to the device, fin material, fin orientation, temperature difference between the fin and surrounding, number of fins, and fin array orientation. Heat generated by electronic gadgets and engines has increased in recent years, but the surface area of electronic equipment has decreased.

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

1. INTRODUCTION

Electronic components with extended surfaces or fins, such as power supply and transformers, are widespread. Electronic equipment design includes the dissipation and subsequent rejection of potentially damaging self-produced heat. Its proper operation necessitates the disposal of heat. The resistance that electric current encounters generates heat. The operating temperature will exceed the allowable limit unless suitable cooling arrangements are designed.As a result, the risks of failure increase. Some criteria such as a large heat transfer rate, a low pressure drop, a high heat transfer coefficient, the lowest maximum temperature attained, a high surface Nusselt number, low thermal resistance, easier manufacturing, a simpler structure, a reasonable cost, and so on should be considered when designing an effective heat sink, and the material of construction is taken as Aluminum has a thermal conductivity of 235 watts per Kelvin per meter (W/MK).The metal's ability to conduct heat is measured by its thermal conductivity number, which in this case is 235. Simply explained, the higher a metal's thermal conductivity number is, the more heat it can carry. Aluminium is very lightweight and inexpensive to make. When a heat sink is mounted, the weight of the heat sink places a certain amount of stress on the motherboard, which the motherboard is built to withstand. The lightweight nature of aluminium, on the other hand, is advantageous because it adds less weight and stress on the motherboard.

2. REVIEW OF PAST RESEARCH

S. B. Kute and B. K. Sonage (2018) present a study for the replacement of a fire tube boiler. The comparison is based on the flue gas side surface heat transfer coefficient. Experimentally, the heat transfer performance of helically ribbed tube (Rifled Tube) is compared to that of plain tube. This paper presents the experimental technique, experimental setup, and comparison results. This study evaluates and presents the gas side surface heat transfer coefficient for plain and rifled tubes. An experimental result revealed an increase of 80 percent in heat transfer coefficient. The temperature profile of plain tube and rifled tube is analysed using CFD.

ShaikHimamvalli (2017) used ANSYS WORKBENCH version 13.0 to investigate natural convection from a heated pipe with various fin designs. Aluminum is the material under discussion, and air is the free stream fluid. For various fin configurations, the heat transfer rate from the fins, outside wall, and overall heat transfer rate has been determined and compared. The surface nusselt number and total heat transfer coefficient of the surface have also been determined. The convection loops created around the heated pipe surface have been depicted using temperature contours for various fin configurations.The motion of heated fluid has been depicted using velocity contours for various fin designs. There are also plots for nusselt number and heat transfer coefficient. The assumptions used in the analysis were made with manufacturing, real applications, and working situations in mind. As a result, the acquired conclusions can be used to solve any such problems in the practical sector where only natural convection is taken into account.

B. Usha Rani (2017) investigated the primary characteristics that can have a substantial impact on the heat transfer performance of finned tubes. Different internal fin patterns, such as a single fin with large number of turns like a coiled shape and large number of fins with single turn, were compared with the reference tube on the basis of different parameters such as heat transfer rate, surface nusselt number, heat transfer coefficient, fin effectiveness, and so on. After obtaining the optimal fin configuration, it was compared against a rectangular cross-section fin profile.ANSYS 13.0 was used for all of the computer simulations. The fin material is aluminium, and the fluid moving inside the tube is assumed to be air, with a laminar flow. Because there is less flow resistance and a higher heat transfer rate, it was discovered that a large number of single-turn fins is more efficient than other fin patterns.

K. Ravi Kumar (2017) used computational fluid dynamics to simulate the 3D geometry of a cross flow smooth and finned tube heat exchanger with hot water within the tube and cooling air outside the tube (ANSYS-FLUENT 15). Heat transfer enhancement has been used in a variety of commercial and scientific applications. Solidworks software is used to create a symmetric image of the simplified geometry of the heat exchanger for simulation purposes.

Pankaj V. Baviskar et al. (2016) used ANSYS to simulate various fin profile heat sinks, including rectangular, circular, trapezoidal, and triangular. The computational results for a rectangular fin form heat sink were verified using an experimental test setup. The greater heat transfer rate for triangular fin, according to the validated numerical result. As a result, the redesigned triangular fin heat sink was created, and it can now be tested experimentally to see if it produces better results. When compared to a rectangular fin heat sink, the modified triangle heat sink demonstrates a 9 percent increase in heat transfer rate.

Shobhana Singh (2016) cross-flow type heat exchanger with circular tubes and rectangular fin profile is selected as a reference design. To forecast the impact on overall heat exchanger performance, the fin geometry is modified using a design aspect ratio as a variable parameter in the range of 0.1-1.0. Geometric profiles with a constant thickness of fin base are investigated in this article. COMSOL v5.2, a commercially available Multiphysics software, is used to create a three-dimensional, steady-state CFD model. The numerical results for Reynolds numbers ranging from 5000 to 13000 are derived and confirmed using experimentally determined correlations. Dimensionless performance parameters such as Nusselt number, Euler number, efficiency index, and area-goodness factor are determined.Based on higher heat transfer and lower pressure loss, the best performing geometric fin profile is projected. The study will provide an insight light on the effect of fin geometry on heat transfer performance, allowing for a better knowledge of heat exchanger design and production at a low cost.

DibyaTripathi (2016) proposed to calculate fin effectiveness, on the fin inside one-tube plate finned-tube heat exchangers for various air speeds 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.

The heat transfer characteristics of a louvred fin and elliptical tube compact heat exchanger used as a radiator in an internal combustion engine were investigated by Poorana Chandran Karthik et al (2015). The radiator is placed in an open-loop wind tunnel to conduct the tests. The temperature reductions of air and water were measured for a total of 24 sets of air and water flow rate combinations. For three selected data from the tests, a numerical analysis was performed using Fluent software (a general purpose computational fluid dynamics simulation tool). The experimental values are compared to the numerical air-side temperature decline.

Aditya Pratap Singh Jadaun (2015) found a solution to high-performance computer systems' heat problems. The Power Heat Sink is an effective thermal solution to the issues presented by designers of high-performance computer systems, with a weight per volume less than half that of a standard solution and a reduced base surface area. Thermo-hydraulic performance of solar air collectors with roughened ducts may be predicted using correlations discovered by several studies using experimental results for heat transfer and friction factor for solar air collectors using varied roughness geometries.

3. SUMMARY OF LITERATURE SURVEY

The review of literature revealed the following,

A modern heat exchanger with fin systems is currently being developed, with great thermal performance and low environmental effect.

The difficulty for thermal designers is to increase power density while keeping the volume, envelope shape, and cost in mind. Elliptical fins, as opposed to annular circular and eccentric fins, will be a preferable choice since they increase the surface area of the fins in one direction while space is limited in another.

The primary goals of improving thermal system performance are to improve heat transfer between hot and cold surfaces, as well as the flow of fluid. This task is expected to be accomplished in a variety of ways. The focus of this project is on certain traditional fin techniques.

This is particularly essential in modern electronic systems with high circuit package density. Thermal solutions with effective emitters like fins are desirable to alleviate this challenge.

Only a few researchers have concentrated on nanocoating extended surfaces.

The inverse approach and commercial software FLUENT are used in conjunction with experimental temperature data to compute the average heat transfer coefficient h, heat transfer coefficient depending on fin base temperature, and fin efficiency for various fin spacings.

These were simplified by assuming periodically developed two-dimensional flow and isothermal heat transfer surfaces. Fin shapes with rounded geometries outperform those with sharp edges in general. In every case, staggered geometries outperform inline geometries. Elliptical fins perform best when pressure drop and pumping force are moderate. Round pin fins provide the best performance at higher values.

Some of the results established here have been shown by the small number of earlier investigations of these fin shapes, which usually compared only two at a single operating point. The current work quantifies these impacts and compares several designs with equal values of fin/base area ratio and lengthwise span wise 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's worth noting that there are just a few outcomes with a single tube and a few rows, therefore more research with four and more tube row bundles is needed. On the other side, some research has been done to address this issue by generating row correcting factors.

. A substantial amount of related data on local and average heat transfer, pressure drop, and qualitative judgments on circular finned tube geometries has been established. Despite these previous improvements, this research found that further attention to existing challenges in designing optimal fin geometry and tube configurations is still required. The following are some last thoughts:

• 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 to a single tube.

• Temperature distributions over the fin surface and the flow structures between fins are of complex pattern. When the need arises to measure such effects accurately, it is an experimentally difficult task to do without disturbing the heat transfer behaviour on a fin surface. Therefore, more precise data on the local behaviour are necessary.

• Different results came out of the relevant information regarding the tube spacing adjustments and number of rows.

• Since most correlations were based on their own data, authors gave 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 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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