International Journal of Engineering Technology and Applied Science
(ISSN: 2395 3853), Vol. 7 Issue 7 July 2021

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

M.Tech. Scholar Sarfaraz Khan[1], Prof. Sujeet Kumar Singh[2]
Department of Mechanical Engineering,
PCST, Bhopal

Abstract- 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. The primary interest is to determine how the extended surface (i.e., the fin) will enhance the air-side heat transfer performance of this kind of heat exchanger. It is very important to consider the heat transfer rate (heating or cooling), which is normally limited by the thermal resistance on the air side of the heat exchanger. Improving the fin geometry or fin pattern is one way to augment the heat transfer rate of the fin-and-tube heat exchanger, but this method may require more fan power because of the loss associated with the pressure drop. In order to solve the aforementioned problems, finding the optimized fin configuration would be valuable in designing and creating the heat exchanger.

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

I. 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 primary interest is to determine how the extended surface (i.e., the fin) will enhance the air-side heat transfer performance of this kind of heat exchanger. It is very important to consider the heat transfer rate (heating or cooling), which is normally limited by the thermal resistance on the air side of the heat exchanger.

Improving the fin geometry or fin pattern is one way to augment the heat transfer rate of the fin-and-tube heat exchanger, but this method may require more fan power because of the loss associated with the pressure drop. In order to solve the aforementioned problems, finding the optimized fin configuration would be valuable in designing and creating the heat exchanger. In addition, we must realize that the effect of fin configurations, tube arrangements, and operating conditions has significance for the air-side heat transfer performance and flow characteristics of fin-and-tube heat exchangers.

Until now, many researchers have investigated those effects of plain fins, wavy fins, louver fins, slit fins, compounded fins, circular (or annular) fins, and several spiral fins on the air-side performance. Currently, the spiral fin-and-tube heat exchanger earns its popularity in waste heat recovery system applications.

The heat conducted through solids, walls or boundaries has to be continuously dissipated to the surroundings or environment to maintain the system in a steady state condition. In many engineering application large quantities of heat have to be dissipated from small areas. Heat transfer by convection between a surface and the fluid surroundings it can be increased by attaching to the surface thin strips of metals called fins. The fins increase the effective area of the surface there by increasing the heat transfer by convection. The fins are also referred to as ‗extended surface„. The fins may be of uniform or cross-section.

They have many different practical applications, viz. Economizers for steam power plants; Radiators of automobiles; Air-cooled engine cylinder heads; Cooling coils and condenser coils in refrigerators and air conditioners; cooling of electronic components; small capacity compressors; electric motors, transformer; high-efficiency boiler superheated conducting heat down their length to a cool disc.

II. REVIEW OF PAST RESEARCH

Naik, Hemant et al. (2020) presented fluid flow and heat transfer characteristics of different possible RWP locations concerning each tube are examined. Further, for higher performance, a search for an effective angle of attack ranging from 15° to 60° is also performed for optimized locations.

Taler, Dawid et al. (2020) examined a two-pass double-row plate-fin and tube heat exchanger (PFTHE) made of circular or oval pipes. A method for determining the air side Nusselt number on individual pipe row was developed, using the results of CFD (Computational Fluid Dynamics) modeling of the heat exchanger.

Taler, Dawid et al. (2020) presented a new method of modeling the transient operation of PFTHE, considering that the Nusselt numbers on the air side of individual tube rows are calculated from different empirical relationships.

Biçer, Nihat et al. (2020) presented a novel and innovative baffle design was offered in order to considerably reduce shell side pressure loss without compromising thermal performance. Computational fluid dynamics (CFD) was utilized to simulate and visualize 3-D turbulent flow field in the shell side so as to investigate various shapes of baffles for preliminary baffle design purposes.

Gupta, Sachin et al. (2020) investigated the effect of employing a rectangular winglet having a punched hole on heat transfer and flow resistance characteristics in a fin-tube heat exchanger with the help of numerical simulations.

Naik, Hemant et al. (2020) investigated the irreversibility‟s caused by fluid flowing under the effect of isothermal walls of fin-tube heat exchanger in the presence of longitudinal vortex generators.

Gupta, Arvind et al. (2020) performed Numerical simulations for investigating the effect of punching a rectangular winglet having hole from fin surface, on the heat transfer and flow resistance characteristics in a fin-tube heat exchanger.

Waser, Remo et al. (2020) presented a new modeling method which allows for the optimization of complex heat exchanger designs such as fin-tube concepts in latent storages units is proposed.

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.

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 aluminum and the free stream fluid is air. The heat transfer rate from the fins, 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 co-efficient has been found out.

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.

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 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 increase in heat transfer rate by 9% as compare 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 Multi physics 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 platefinned-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.

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 useful to predict the Thermo-hydraulic performance of solar air collector having roughened ducts.

III. SUMMARY OF LITERATURE SURVEY

The review of 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 few researchers focused 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.

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 of 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.

IV. CONCLUSION

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 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 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

REFERENCES

[1] Naik, Hemant, and Shaligram Tiwari. "Thermal performance analysis of fin-tube heat exchanger with staggered tube arrangement in presence of rectangular winglet pairs." International Journal of Thermal Sciences (2020): 106723.

[2] Taler, Dawid, Jan Taler, and Marcin Trojan. "Thermal calculations of plate–fin–and-tube heat exchangers with different heat transfer coefficients on each tube row." Energy 203 (2020): 117806.

[3] Taler, Dawid, Jan Taler, and Katarzyna Wrona. "Transient response of a plate-fin-and-tube heat exchanger considering different heat transfer coefficients in individual tube rows." Energy 195 (2020): 117023.

[4] Biçer, Nihat, Tahsin Engin, Halit Yaşar, Ekrem Büyükkaya, and Ahmet Aydın. "Design optimization of a shell-and-tube heat exchanger with novel three-zonal baffle by using CFD and taguchi method." International Journal of Thermal Sciences 155 (2020): 106417.

[5] Gupta, Sachin, Aditya Roy, and Arvind Gupta. "Computer-aided engineering analysis for the performance augmentation of a fin-tube heat exchanger using vortex generator." Concurrent Engineering 28, no. 1 (2020): 47-57.

[6] Naik, Hemant, and Shaligram Tiwari. "Thermodynamic performance analysis of an inline fin-tube heat exchanger in presence of rectangular winglet pairs." International Journal of Mechanical Sciences 193 (2020): 106148.

[7] Gupta, Arvind, Aditya Roy, Sachin Gupta, and Munish Gupta. "Numerical investigation towards implementation of punched winglet as vortex generator for performance improvement of a fin-and-tube heat exchanger." International Journal of Heat and Mass Transfer 149 (2020): 119171.

[8] Waser, Remo, Simon Maranda, Anastasia Stamatiou, Maurizio Zaglio, and Joerg Worlitschek. "Modeling of solidification including supercooling effects in a fin-tube heat exchanger based latent heat storage." Solar Energy 200 (2020): 10-21.

[9] Kute S. B., Sonage B. K (2018), "Comparison of Heat Transfer Performance of Plain Tube and Rifled Tube by Experimentation and CFD Analysis", International Journal of Engineering Technology Science and Research, 5(1), 75-84.

[10] Shaik Himamvalli (2017), "CFD Analysis on Tube with Different Internal Fin Profiles", International Journal of Research in Engineering and Applied Sciences, 2(3), 19-28.

[11] B. Usha Rani (2017), "Analysis of Heat Transfer through External Fins using CFD Tool", International Journal of Modern Trends in Engineering and Research, 5(3), 81-87.

[12] K. Ravi Kumar (2017), "CFD Analysis of a Cross-flow Heat Exchanger with Different fin thickness", International Journal of Dynamics of Fluids, 13(2), 345-362.

[13] Pankaj V. Baviskar, Kapil A. Saner, Nilesh P. Salunke, Vijay B. Jadhav (2016), "To Analyze the Effect of Varying Fin Shapes for Microprocessor Cooling", International Journal of Innovative Research in Science, Engineering and Technology, 5(4), 5613-5621.

[14] Shobhana Singh (2016), "Parametric CFD Analysis to Study the Influence of Fin Geometry on the Performance of a Fin and Tube Heat Exchanger", International Journal of Engineering Development and Research, 3(2), 393-399.

[15] Dibya Tripathi (2016), "Calculation of Effectiveness on the Fin Inside One Tube Plate Finned-Tube Heat Exchanger", International Journal for Research in Applied Science & Engineering Technology, 4(11), 107-112.

[16] Poorana Chandran Karthik (2015), "Experimental and Numerical Investigation of a Louvered Fin and Elliptical Tube Compact Heat Exchanger", Journal of Thermal Science, 19 (2), 679-692.

[17] Aditya Pratap Singh Jadaun (2015), "Thermal Analysis of Optimized Porous Fin on Various Profiles: A Review", International Journal of Engineering Development and Research, 3(2), 393-399.

[18] Shiva Kumar (2015), "Numerical study of heat transfer in a finned double pipe heat exchanger", World Journal of Modelling and Simulation, 11(3), 43-54.

[19] Abhishek Tripathi (2015), "A Review on Heat Transfer and Pressure Drop Correlations in Solid Circular Finned Tube Bundles Positioned at Inline and Staggered Arrangement in Cross Flow", Internal Journal of Engineering Research and Applications, 4(12), 61-67.

[20] K. Alawadhi (2014), "Computational Fluid Dynamics (CFD) Analysis of Natural Convection of Convergent-Divergent Fins in Marine Environments", Internal Journal of Engineering Research and Applications, 4(12), 32-36.

[21] Jignesh M. Chaudhari (2014), "Experimental Investigation of Finned Tube Heat Exchanger", International Journal of Innovative Research in Advanced Engineering, 1(5), 67-74.