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Study on Thermal Behavior of Flat Plate Heat Exchanger

Nitesh Kumar Singh
M. Tech. Scholar
Millennium Institute of Technology
Bhopal, M.P, India
niteshsingh141@gmail.com

N. V. Saxena
Professor
Millennium Institute of Technology
Bhopal, M.P, India
nishant.mgi@gmail.com

Abstract: **The plate Fin-and-tube heat exchangers are one of the most common types of heat exchangers used in various industrial applications such as heating, cooling, air conditioning, power plants, chemical plants, petrochemical plants, oil refineries, natural gas processing, industry aerospace, and wastewater treatment. It is very important to reduce the size and weight and improve the heat transfer rate of the heat exchanger. Finned and tubular heat exchangers with different geometries and orientations are used to improve thermal performance. This paper presents the Plate fin heat exchanger and types of Plate Fin Heat Exchanger Surfaces.**

Keywords: fin, heat exchanger, heat transfer, CFD.

I. INTRODUCTION

A plate-fin heat exchanger is a type of heat exchanger design where plates and finned chambers are used to transfer heat between fluids. It is often categorized as a compact heat exchanger because of its high heat transfer surface area to volume ratio. The plate-fin heat exchanger are mainly used in many industries, like aerospace industry for its properties like compact size and lightweight, and also in cryogenics where heat transfer takes place with a small temperature differences. In a plate-fin heat exchanger, the fins can easily be rearranged. Flows like cross flow, counter flow, parallel flow are possible in different application if the fins are designed well, the plate-fin heat exchanger works in a perfect condition in a counter cross arrangement.[1]-[3]

II. LITERATURE REVIEW

Basim Freegah et al. [4] The study showed that finned heat sinks with corrugated vertical semicircular pins exposed to parallel flow and finned heat sinks with symmetrical hollow semicircular pins in a vertical arrangement that are exposed to vertical flow the impact has superior thermal performance compared to other configurations. The old design offers a base temperature and thermal resistance reduction of approximately 25.1% and 29%, respectively, and an increase in the Nusselt number of approximately 34.48% instead of the ribs of the conventional profile plate threaded. For the latter project, the base temperature and thermal resistance were reduced by approximately 22.6% and 25.7% respectively, while the Nusselt number shows values increasing by approximately 31.6%. Therefore, these designs have promising potential for cooling electronic devices.

hang-Hyo Son et al. [5] in this paper presented re the very few studies have been done on heat transfer analysis of finned plate heat exchangers. Therefore, the single-phase convection heat transfer coefficients were calculated in this work using the modified Wilson diagram method and the pressure drop relative to other correlations. The main results are summarized as follows. The pressure drop corresponds well to the previous correlation, but the convection heat transfer coefficients differ from the others. Based on the experimental results, a new correlation of the single-phase heat transfer for the plate fin heat exchanger is presented.

Máté PETRIK et al. [6] The aim of this work is to perform parametric analysis of the thermal power of a compact car cooler using computer-assisted fluid dynamics. The analysis was performed at different air speeds, with different fins modeled as real fins and as porous media. SC-Tetra computerized fluid dynamics software was used for this study. Liquids are incompressible; the flow was three-dimensional and turbulent. The results show that the relationship between the pitch of the slats, the thickness of the walls of the slats, the number of slats, the depth of flow and the geometry of the tube are the main factors of heat transfer.

Abhishek Tiwari et al. [7] In the field of cryogenics, heat exchangers with a maximum efficiency of the order of 0.96 or more are used to maintain the low temperature effect generated. The compact heat exchanger (CHE) is modified by cross-flow channels between a small volume and a high rate of energy exchange between two liquids. The thermo-hydraulic performance of the compact heat exchangers (CHE) strongly depends on the Colburn fins 'j' and Fanning factor 'f', the triangular and rectangular perforated fins.

Mohd Zeeshan et al. [8] in the present numerical study, the thermo-hydraulic performance of the finned and tubular heat exchangers (FTHE) was assessed and compared. The results show that the two improved cases have a heat output higher than that of the base case. Furthermore, on the basis of the surface quality factor, it can be concluded that with a low Reynolds number heat exchanger (Re) (400-600) with circular tubes with RVG, a lower front surface is needed, while with a range Higher (700-900) oval tube heat exchangers require less frontal area.

S. Lowrey et al. [9] Air-to-air plate heat exchangers are often used for domestic and industrial HVAC applications. The widespread use of plate heat exchangers makes their control and optimization essential to improve the overall system performance. The experimental data obtained in this work have been used to extend the validity of a numerical model recently developed for a wet air-air plate heat exchanger which extends its working range for the conditions of entry of moist air on the hot side. Heat and cold air flow conditions and duct configurations and duct proportions.

Ahmed Y Taha Al-Zubaydi et al. [10] The indirect evaporation cooling system and the heat recovery system use the return air to condition the fresh air by exchanging air-air heat between the two flows. In this document, we present a theoretical analysis of several designs of aluminum plate counter-flow heat exchangers and the results of the CFD analysis of pressure drop, flow and thermal efficiency. In order to improve the heat transfer between the plates and minimize energy losses, the analysis is useful in the optimization method for selecting the parameters of the plate heat exchangers.

III. Plate fin heat exchanger

A plate fin heat exchanger is a type of heat exchanger design that uses plates and finned chambers to transfer heat between liquids. It is often classified as a compact heat exchanger to emphasize the relatively high ratio between the heat transfer surface and the volume. The plate fin heat exchanger is widely used in many sectors, including the aerospace one, due to its compact size and light properties, as well as cryotechnics, where its ability to facilitate the transfer of heat is used with small differences in temperature [1].

Plate heat exchangers in finned aluminum alloy, often called welded aluminum heat exchangers, have been used in the aviation industry for over 60 years and have been adopted in the cryogenic separation sector. Air in chemical plants such as the processing of natural gas during the Second World War and immediately afterwards. They are also used in railway engines and motor vehicles. The stainless steel fins have been used in aircraft for 30 years and are currently being established in chemical plants.

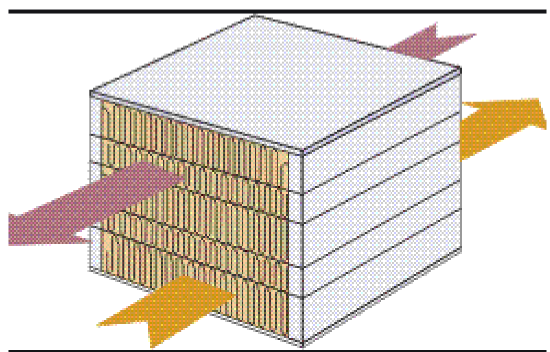

Fig. 1 plate fin heat exchanger

IV. Types of Plate Fin Heat Exchanger Surfaces

Due to their low gas-side heat transfer coefficient, large surfaces are generally used in plate heat exchangers with fins. Therefore, the large areas are configured to increase the heat transfer coefficient. For this purpose, special slat geometries have been developed which offer very high heat transfer coefficients compared to the extended flat surface. At the same time, they sometimes cause a drop in pressure. So far, variants of large areas have been developed, namely H. A simple trapezoid, a simple rectangle, a wavy offset, a grid, etc. We are interested in the offset geometry of the ribs for numerical and experimental work.

A. *Plain Fins*

Smooth fins are straight and continuous fins. The smooth ribs are generally triangular and rectangular in section. Compared to other models of slats, it is also easy to produce triangular slats. The limitations of simple lamination, however, are lower heat transfer rates during laminar flow and structural weakness. Flat ribs are often used for critical pressure drops.

Fig. 2 Plain fins

B. Wavy Fins

The wavy fins have transverse shapes similar to those of the individual fins, but curved shapes in the normal direction of the direction of the fluid. The waveforms that lead to the wavy fins provide effective interference and induce a complex flow field that causes a vortex to form when the liquid flows over the concave and rough surface. These anti-rotation swirls create a corkscrew motif. The pressure drop and heat transfer properties of these types of fins are proportional to the increase in the Reynolds number between the flat plate and the fins. Unlike stepped ribs, the thickness of the rib is not limited to high density. For this reason, corrugated fins are often used in high pressure flows, especially in cases where a low heat transfer coefficient can be tolerated.

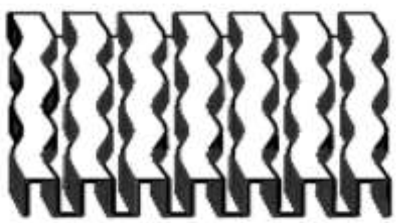

Fig. 3 Wavy Fins

C. Offset Strip

The offset fin is similar to the simple rectangular fin, except that the length of the fin flow (Lf) is discontinuous on one side of the heat exchanger. This length of the flow of the ribs is equal to the sum of all the lengths of the strips (Ls). An interruption of the surface is due to these displacements. These fins thus improve the heat transfer by continuously interrupting the growth of the thermal boundary layer. This creates thin boundary layers, responsible for the low resistance to thermal conduction. This leads to a higher heat transfer rate. The heat transfer rate is better, but the pressure drop is greater with the offset arrangements.

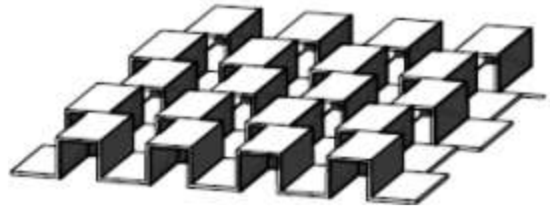

Fig. 4 offset type fin

D. Louver fins

In the case of the lamellar lamellas, the lamellar sections are parallel and marked by the base of the lamella at its center along the thermal conduction path. In order to maintain the required structural length of the fin, the flaps are not extended to the base of the fin. Ideally, the heat transfer through the individual air intakes corresponds to that of the simple triangular fins. With a low Reynolds number, the current flow is parallel to the axial direction (channel flow), while with high Reynolds numerical values, the liquid flow occurs along the direction of the slots air (boundary layer flow).

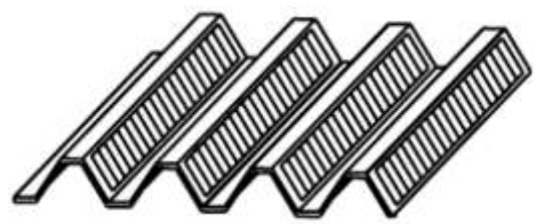

Fig. 5 Louver Fins

E. Perforated Fin

A pattern of spaced holes is perforated in the rib material to create the perforated ribs. Then, the fin material is folded to form the flow channels. The channels can be rectangular or triangular with rectangular or round perforations. Although these fins improve the surface for heat transfer, they are still wasted because the removed material is thrown away as waste.

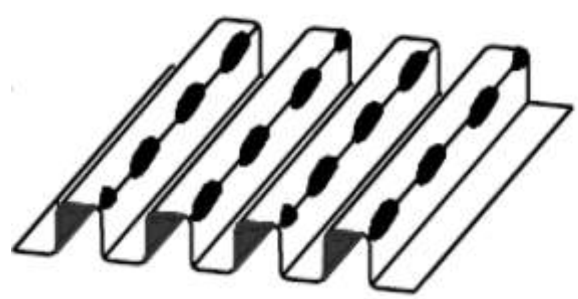

Fig. 6 Perforated Fin

V. Conclusion

This review paper presents the plate-fin heat exchangers. A considerable amount of experimental as well as numerical and computational research by various authors has been studied on the enhancement of heat transfer and pressure drop characteristics and other parameters. In this paper presented the Plate fin heat exchanger and types of Plate Fin Heat Exchanger Surfaces. In this review study, a brief survey of the relevant literature is presented to indicate the extent of work already reported in open literature pertaining to the enhancement of heat transfer by introducing protrusions mounted on the heat transfer surfaces.

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