“A REVIEW ON HEAT EXCHANGER”

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ABSTRACT

A Heat exchanger is a piece of equipment built for efficient heat transfer from one medium to another. The media may be separated by a solid wall, so that it never mix or may be in direct contact. The heat exchangers widely used in space heating, refrigeration, air conditioning, power plants, chemical plants, petrochemical plants, petroleum refineries, and natural gas processing and sewage treatment. One common example of a heat exchanger is the radiator in a car , in which the heat source , being a hot engine-cooling fluid, water transfer heat to air flowing through the radiator.

Keyword : - *Heat exchanger, heat, turbulent flow , efficiency, heat transfer*

1.INTRODUCTION

1.1 HEAT EXCHANGER

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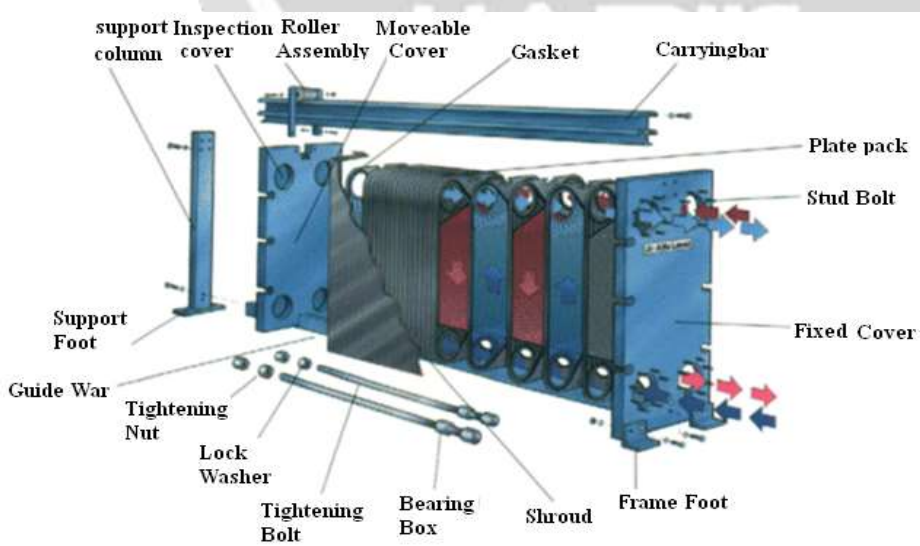


Figure 1.1 Plate Heat Exchanger

The plate heat exchanger is widely recognized today as the most economical and efficient type of heat exchanger on the market. With its low cost, flexibility, easy maintenance and high thermal efficiency, it is unmatched by any other type of heat exchanger. The corrugation patterns that induce turbulent flows, it not only achieves unmatched efficiency but also creates a self cleaning effect thereby reducing fouling. The most common surface pattern used is the chevron design.

1.2 CLASSIFICATION OF HEAT EXCHANGERS

Heat exchangers may be classified as:-

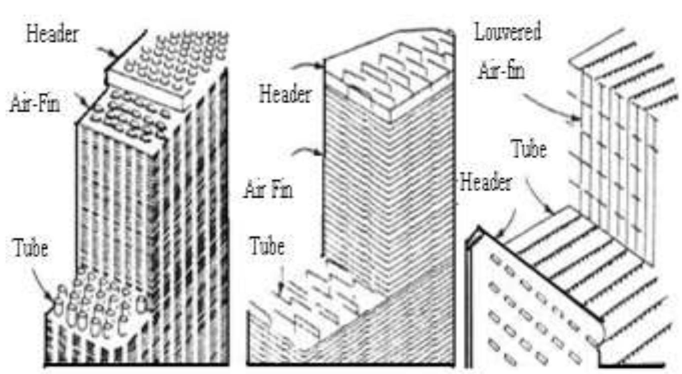
a) Recuperators or Regenerators
b) Transfer process (direct or indirect contact)
c) Type of construction (tube, plate and extended surfaces)
d) Heat transfer mechanism (single phase and two phase)
e) Flow arrangement (parallel flow and counter flow or cross flow)

1.2.1 Compact Heat Exchanger

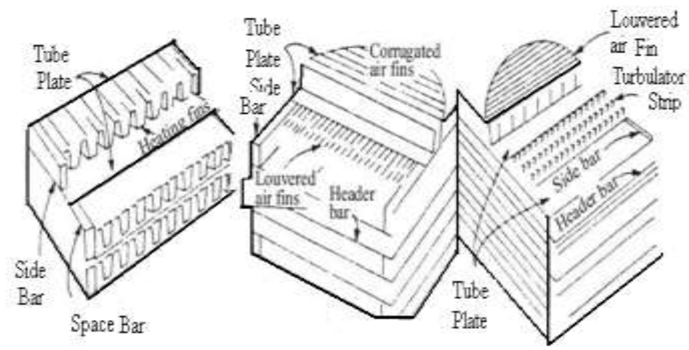
In forced-convection heat transfer between a gas and a liquid, the heat transfer coefficient of the gas may be 10 to 50 times smaller than that of the liquid. The use of specially-configured surfaces can be used to reduce the gas side thermal resistance. For heat transfer between two gases, the difficulty in inducing the desired heat exchange is even more pronounced. In this case especially, the use of enhanced surfaces can substantially reduce heat exchanger size. This is the motivation behind the design of a category of heat exchangers with reduced size and greatly enhanced gas side heat transfer, which are referred to as "compact"

Compact heat exchangers may be classified by the kinds of compact elements that they employ. The compact elements usually fall into five classes:

(1) Circular and flattened circular tubes. These are the simplest form of compact heat exchanger surface. The designation ST indicates flow inside straight tubes (example: ST-1), FT indicates flow inside straight flattened tubes (example: FT-1) and FTD indicates flow inside straight flattened dimpled tubes. Dimpling interrupts the boundary layer, which tends to increase the heat transfer coefficient without increasing the flow velocity.
(2) Tubular surfaces. These are arrays of tubes of small diameter, from 0.9535 cm down to 0.635 cm, used in service where the ruggedness and clean ability of the conventional shell-and-tube exchanger are not required. Usually, tube sheets are comparatively thin, and soldering or brazing a tube to a tube sheet provides an adequate seal against inter leakage and differential thermal expansion.

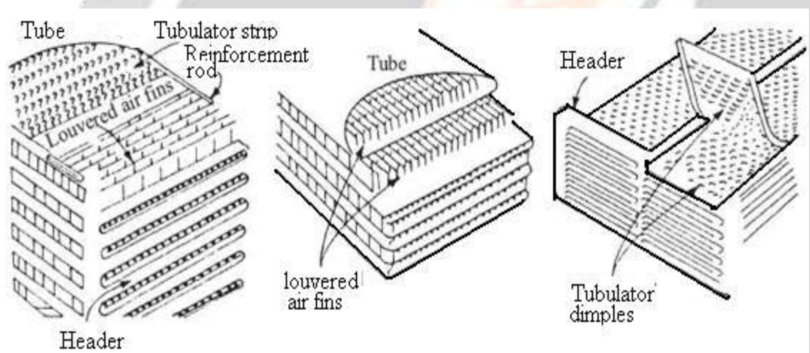


(a) Round tube and fin(b) Flat tube and fin(c)Tube and center



(d) Bar and plate (e) Bar and plate (f) Bar and plate

(3) Surfaces with flow normal to banks of smooth tubes. Unlike the radial low fin tubes, smooth round tubes are expanded into fins that can accept a number of tube rows, as shown in Fig. 12.a. Holes may be stamped in the fin with a drawn hub or foot to improve contact resistance or as a space between successive fins, as shown, or brazed directly to the fin with or without a hub. Other types reduce the flow resistance outside the tubes by using flattened tubes and brazing, as indicated in Fig b and c below. Flat tubing is made from strips similar to the manufacture of welded circular tubing but is much thinner and is joined by soldering or brazing rather than welding.



(g) Formed plate fin (h) Formed plate fin (i) Dimpled strut tube

Figure 1.2 various types of compact heat exchanger.

(4) Finned-tube surfaces. Circular tubes with spiral radial fins are designated by the letters CF followed by one or two numerals. The first numeral designates the number of fins per inch, and the second (if one is used) refers to the nominal tube size. With circular tubes with continuous fins, no letter prefix is employed and the two numerals have the same Plate fin surfaces. A plate fin heat exchanger is a type of heat exchanger that uses metal plates to transfer heat between two fluids. This has a major advantage over a conventional heat exchanger in that the fluids are exposed to a much larger surface area because the fluids spread out over the plates. This facilitates the transfer of heat, and greatly increases the speed of the temperature change. Meaning as those used for circular tubes with spiral radial fins. For finned flat tubes, no letter prefix is used; the first numeral indicates the fins per inch and the second numeral indicates the largest tube dimension. When CF does not appear in the designation of the circular tube with spiral radial fins, the surface may be presumed to have continuous fins.

(5) Matrix surfaces. These are surfaces that are used in rotating, regenerative equipment such as combustion flue gas–air preheaters for conventional fossil furnaces. In this application, metal is deployed for its ability to absorb heat with minimal fluid friction while exposed to hot flue gas and to give up this heat to incoming cold combustion air when it is rotated into the incoming cold airstream. Some typical examples of compact heat exchanger surfaces

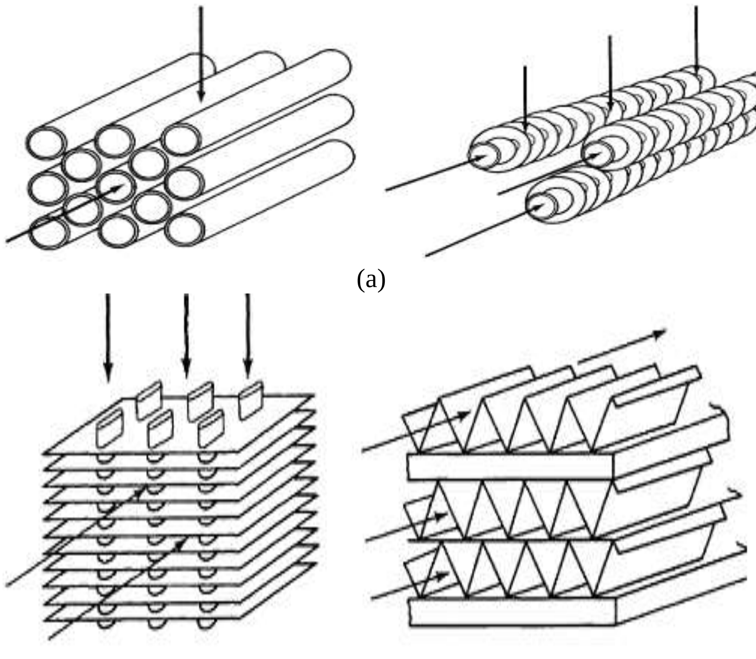


Figure 1.3 Examples of compact Heat exchanger (a) cylindrical tube; (b) cylindrical tube with radial fins; (c) flat tube with continuous fins; (d) plate fin

1.2.2 Plate Fin Heat Exchanger

Plate heat exchangers are usually designed to achieve turbulence across the entire heat transfer area in order to get the highest possible heat transfer coefficient with the lowest possible pressure drop and allow for close temperature approach. Consequently this means smaller heat exchangers and sometimes even less heat exchanger.

1.2.3 Tube Fin Heat Exchangers

In a tube fin heat exchanger, round, rectangular, and oval tubes are used and fins are employed either on he outside, inside or on the both sides depending upon the application. The liquid flows through the tube and the gas flows in cross flow direction along the fins. No fins are required on the liquid side.

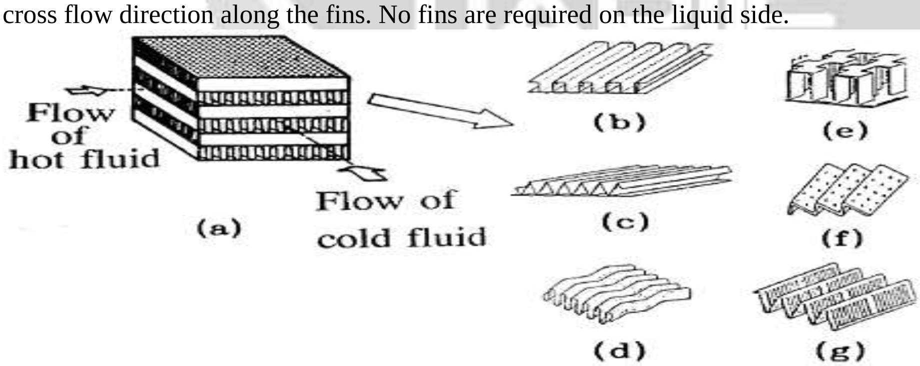


Figure 1.5 (a) Plate fin heat exchanger and its surface geometries (b) Plan rectangular fin (c) Plane triangular fin (d) Wavy fin (e) Offset strip fin (f) perforated fin (g) Louvered fin

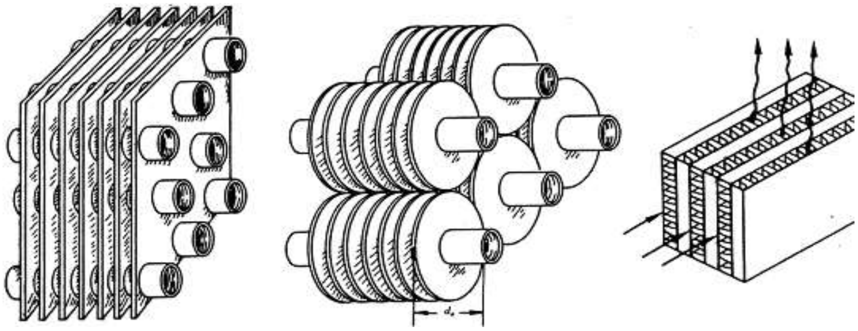


Figure 1.6 Different types of tube fin heat exchangers

LITERATURE REVIEW

An extensive review of the recent progress in heat transfer enhancement using longitudinal vortex generation has been done by Jacobi and Shah [3]. The review given below is focused on articles that are particularly relevant to the current research.

As described by Fiebig [4], when the attack angle is small, the generated vortices are mainly longitudinal, when the attack angle is 90°, transverse vortices are generated. Jacobi and Shah [3] and Fiebig [4] noted that longitudinal vortices show less flow losses and better heat transfer characteristics than transverse vortices. In recent years, the third generation of the enhanced surface designed with longitudinal vortex generators (LVGs) is receiving more attention.

The first report on longitudinal vortices in boundary layer control was presented in 1960 by Schubauer and Spangenberg [5]. Jonhnson and Joubert [6] early reported the impact of vortex generators on the heat transfer performance in 1969. Since then, the use of LVGs in channel flow application has received considerable attention.

Lee et al. [7] numerically simulated heat transfer characteristics and turbulent structure in a three-dimensional turbulent boundary layer with delta wing type longitudinal vortices. The study found that longitudinal vortices are capable of disturbing the turbulent and thermal boundary layer, which caused anisotropy of turbulent intensity and augmentation of heat transfer. Gentry and Jacobi [8], [9] experimentally studied the heat transfer enhancement performance of delta wings in a flat plate flow by a naphthalene sublimation technique. The results indicated that the average heat and mass transfer could be increased by 50–60% at low Reynolds number conditions in comparison with the original configuration. Effects of an external delta wing on the flow and heat transfer characteristics in fan flows and uniform flows were experimentally investigated and compared by Chen and Shu [10].and Lau et al. [11] measured instantaneous velocity vector and temperature of the turbulent channel flow with rectangular winglets using quadruple hot-wire probes.

Zhu et al. [12] computed the turbulent flow and heat transfer in a rectangular channel with rectangular winglets on one wall and rib-roughness elements on the other wall. The results showed that the combined effect of rib-roughness and vortex generators could enhance the average Nusselt number by nearly 450%.

Sohankar [13] simulated three-dimensional unsteady flow and heat transfer using Direct Numerical Simulation (DNS) and Large Eddy Simulation (LES) for a rectangular channel with considering finite thickness of rectangular winglets at Reynolds numbers of range from 200 to 2000. Deb et al. [14] numerically simulated heat transfer characteristics and flow structure in laminar and turbulent flows through a rectangular channel containing built-in delta winglets.

Biswas et al. [15] carried out numerical and experimental studies of flow structure and heat transfer effects of longitudinal vortices behind a delta winglet placed in a fully developed laminar channel flow. They found that the delta winglet produce a main vortex, a corner vortex and an induced vortex.

Objective of Research Work

The objectives of this work are following:

To visualize the cross-stream velocity vectors along and beyond the winglet vortex generator.

1. Utilize the technique to evaluate the heat transfer enhancement of rectangular winglet pair vortex generator placed at the different location inside a triangular fin.

2. To find the heat transfer characteristics in term of combined span wise average Nusselt number and Bulk temperature. Nusselt number is a measure of the efficacy of heat transfer and the bulk temperature is a direct measure of thermal energy.

3. To reduce the length of the heat exchanger

This work represents a first phase of ongoing work in the area of the heat transfer enhancement using longitudinal vortex generation.

METHODOLOGY

3.1 INTRODUCTION

The work which is undertaken for the thesis is to evaluate the performance of longitudinal vortex generator (LVG), which is used to enhance the transfer rate in a plate fin-heat exchanger. These vortex generators are mounted inside the triangular fins which are used as inserts between the plates. For detailed investigation a rectangular winglet pair is considered.

3.2 STATEMENT OF THE PROBLEM

Computation has been done for cross-flow, plate fin-heat exchanger having triangular fins, which are placed between the plates. For this purpose a triangular duct is taken in which a rectangular winglet pair of zero thickness is introduced. Rectangular winglet makes an angle of attack (β) with the direction of flow. Air is taken as working fluid and laminar flow is considered.

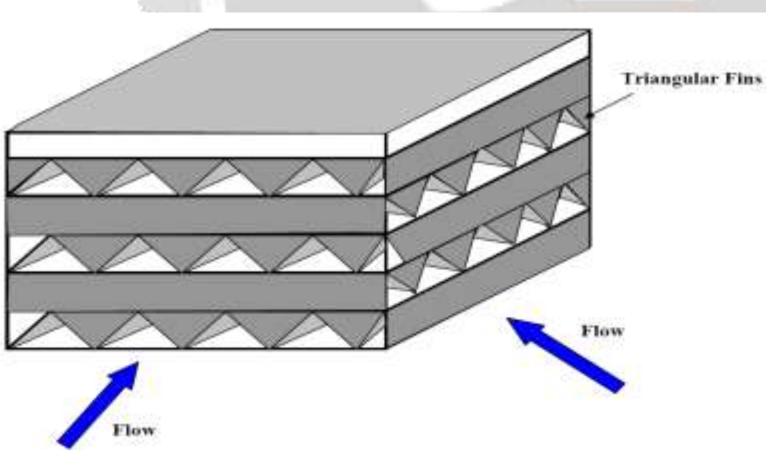
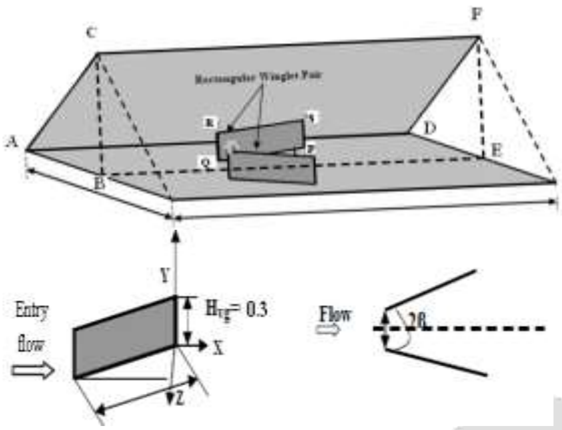


Figure 3.1 Plate-fin heat exchanger having triangular fins



ADFC No-Slip Plane, ABED No-Slip Plane
BCFE Plane of Symmetry, ABC Inflow ,DEF Outflow

Figure 3.2 (a) Triangular fins with a rectangular winglet pair on the fin surface (b) rectangular winglet geometry

4. Expected Result

The performance of the heat exchanger will be improved by mounting Protrusion on the surface. The surface geometries, which are popular in different industrial applications, are wavy fins, off strip fins, perforated fins and louvered fins. This work will be for the enhancement of heat transfer by the use of longitudinal vortex generators in the form of winglet.

1. The vortex generator with the attack angle of 45° it will provide the better effectiveness of the heat transfer enhancement.
2. It will be increase in the angle of attack of the winglet, there is increase in both combined Spanwise Nusselt number and the average temperature.
3. The pressure drop in channel with the longitudinal vortex generator increases rapidly with the increase of attack angle of the winglet.
4. The winglet when located near to the inlet it will be provides good results.

REFERENCES

[1] Admiraal, D.M. and C.W. Bullard, 1993, "Heat Transfer in Refrigerator Condensers and Evaporators," Air Conditioning and Refrigeration Center TR-48, 'The University of Illinois, Urbana, ll.

[2] Webb, R. L., 1987, "Enhancement of Single-Phase Heat Transfer," in Handbook of Single- Phase Convective Heat Transfer, edited by Kakac, et al., Wiley Interscience, New York, NY.

[3] A.M. Jacobi, R.K. Shah, Heat transfer surface enhancement through the use of longitudinal vortices: a review of recent progress, Experimental Thermal and Fluid Science 11 (1995) 295–309.

[4] M. Fiebig, Embedded vortices in internal flow: heat transfer and pressure loss enhancement, International Journal of Heat and Fluid Flow 16 (1995) 376–388.

[5] G.B. Schubauer, W.G. Spangenberg, Forced mixing in boundary layers, Journal of Fluid Mechanics 8 (1960) 10–31.

[6] T.R. Johnson, P.N. Joubert, the influence of vortex generators on drag and heat transfer from a circular cylinder normal to an airstream, ASME Journal of Heat Transfer 91 (1969) 91–99.

[7] S.H. Lee, H.S. Ryou, Y.K. Choi, Heat transfer in a three-dimensional turbulent boundary layer with longitudinal vortices, International Journal of Heat and Mass Transfer 42 (1999) 1521–1534.

[8] M.C. Gentry, A.M. Jacobi, Heat transfer enhancement by delta-wing vortex generators on a flat plate: vortex interactions with the boundary layer, Experimental Thermal and Fluid Science 14 (1997) 231–242.

[9] M.C. Gentry, A.M. Jacobi, Heat transfer enhancement by delta-wing-generated tip vortices in flat-plate and developing channel flows, ASME Journal of Heat Transfer 124 (2002) 1158–1168.

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Author Photo-2 	My self Prof. Parmeshwar Dubey have completed my BE in Mechanical Engineerin from Bhabha Engineering College Bhopal M.P,(2008-12); completed M.Tech. in Thermal Engineering from SEC college Bhopal M.P.(2013-15); having two years industry experience and two years teaching experience right now working as a Training Officer in *Anjali Foundation Gurgaon, Haryana.*