

IJEAST

INTERNATIONAL JOURNAL
OF ENGINEERING APPLIED SCIENCE
AND TECHNOLOGY

VOLUME : 2 ISSUE : 4 Print / Issue Publication Date: 31-Mar-2017

ISSN : 2455-2143

Indexed In

Google SCHOLAR OPEN ACCESS doi Crossref

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International Journal of Engineering Applied Sciences and Technology, 2017
Vol. 2, Issue 4, ISSN No. 2455-2143, Pages 105-109
Published Online February-March 2017 in IJEAST (http://www.ijeast.com)



A REVIEW ON ENHANCEMENT IN COMPACT HEAT EXCHANGERS

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Abstract: Various methods are used to increase rate of heat transfer without affecting much the overall performance of the system. Heat exchangers are used in various applications in day to day life. Some of the applications of heat exchangers are-in process industries, thermal Power plants, air conditioning equipments, refrigerators, radiators for space vehicles, automobiles etc. The present paper is a review of the various methods used to increase the heat transfer performance by using different types of fins. The performance of different fin types (Plate, wavy & compounded fin) is evaluated at different Reynolds number, fin pitch, number of tube rows etc.

Keywords: Heat exchanger, Pressure drop, Heat transfer enhancement, Fin tube heat exchanger.

I. INTRODUCTION**:**

Heat exchanger is a basic component in industrial system involving the process of heat transfer Improved design fins are used as a effective way to improve the performance of heat exchanger. Heat exchangers are widely used in air-conditioning, refrigeration, processing industry. Compact heat exchangers are also used in automobile industries, radiators, evaporators, condensers, and charge air coolers. In these applications, the heat transfer performance is normally limited by the thermal resistance on the air side of the heat exchangers(1-3). Fins are also used in cooling of electronic components and gas turbine blades. In these applications, fins are used in simple designs such as rectangular, triangular, parabolic, annular, and pin rod fins or complicated designs such as spiral fins(4-5).

So what exactly heat exchanger is? Heat exchanger is a device that is used to transfer thermal energy between two or more fluids, between a solid surface and a fluid at different temperatures and in thermal contact. There are usually no external heat and work interactions. In most heat exchangers, heat transfer between fluids takes place through a separating wall or into and out of a wall in a transient manner(6).

II. TYPE OF HEAT EXCHANGERS

In industries, there are lots of heat exchanger that can be seen. The types of heat exchanger can be classified in three major constructions which are tubular type, plate type and extended surface type.

- **Tubular Heat Exchangers**

The tubular types are consists of circular tubes. One fluid flows inside the tubes and the other flows on the outside of the tubes. The parameters of the heat exchanger can be changed like the tube diameter, the number of pitch, tube arrangement, number of tubes and length of the tube can be manipulate. The common type of heat exchangers lie under this categories are double-pipe type, shell-and-tube type and spiral tube type. The tubular heat exchangers can be designed for high pressure relative to the environment and high pressure difference between the fluids. These exchangers are used for liquid-to-liquid and liquid-to-vapor phase. But when the operating temperature or pressure is very high or fouling on one fluid side, it will used gas-to-liquid and gas-togas heat transfer applications.

- **Double-Pipe Heat Exchanger**

According to Sadic Kakac, a double-pipe heat exchanger consists of smaller and larger diameter pipe where the smaller pipe fitted concentrically into the larger one in purpose to give direction to the flow from one section to another. One set of these tubes includes the fluid that has to be cooled or heated. The second fluid runs over the tubes being cooled or heated in order to provide heat or absorb the heat. A set of tubes is the tube bundle and it can be made up of several types of tubes such as longitudinally plain, longitudinally finned, and more. If the application

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requires an almost constant wall temperature, the fluids may flow in a parallel direction. It's easy to clean and convenient to disassemble and assemble. The double-pipe heat exchanger is one of the simplest. Usually, it is used for small capacity applications because it is so expensive on a cost Per unit area basis.



Figure 1. Double-pipe heat exchanger

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- **Shell-and-Tube Heat Exchanger**(10)

This exchanger is built of a bundle of round tubes mounted in a large cylindrical shell with the tube axis parallel to the shell to transfer the heat between the two fluids. The fluid flows inside the tubes and other fluid flows across and along the tubes. But for baffled shell-and-tube heat exchanger the shell side stream flows across between pairs of baffles and then flows parallel to the tubes as it flows from one baffle compartment to the next. This kind of exchanger consists of tubes, shells, front-end head, rear-end head, baffles and tube sheets. The different type of shell-and-tube heat exchangers depends on different application. Usually in chemical industry and process application, it is used as oil-coolers, power condensers, and preheaters in power plants and also steam generators in nuclear power plants.



Figure 2. U-tube shell-and-tube heat exchanger

III. LITERATURE REVIEW

- **S.M. Pesteei et al.**(11-12)

Proposes a novel technique that can augment heat transfer but nevertheless can reduce pressure loss in a fin-tube heat exchanger with circular tubes in a relatively low Reynolds number flow, by deploying delta winglet-type vortex generators. Following the same arrangement as discussed in many papers above, "common flow up" configuration as well as the "common flow down" configuration.

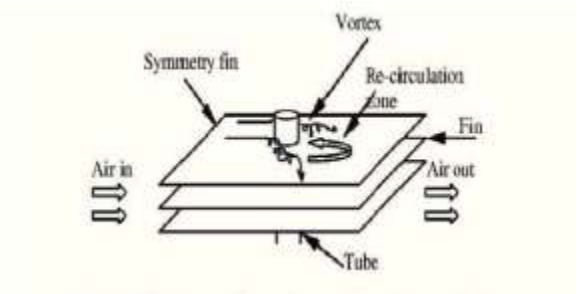


Figure 3. Fin tube configuration and flow characteristics

- **C.B. Allison et al.**(13-14)

Numerical and experimental analyses were carried out to study the heat transfer and flow in the plate-fin and tube heat exchangers with inclined block shape vortex generators mounted behind the tubes. The effects of different span angles are investigated in detail for the Reynolds number ranging from 400 to 3000.

They found that the heat transfer mechanisms of the two fin surfaces differ dramatically. The louver fin surface facilitates boundary layer renewal and has numerous leading

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edges. The delta-winglet fin has fewer leading edges and relies predominantly on increasing convection through vortex generation. According to the results, the louver fin is superior to the delta winglet fin. Although coherent vortices were generated from the first row of winglets, we doubt whether the downstream winglets produce the same level of vortices. This implies that only the first row of winglets may be effective in producing vortices which can improve heat transfer.

- **K. Torii et al.**(15-16)

This paper present local heat transfer coefficients were measured on fin-tube heat exchanger with winglets using a single heater of 2 inch diameter and five different positions of winglet type vortex generators. The measurements were made at Reynolds number about 2250. Flow losses were determined by measuring the static pressure drop in the system. Results showed a substantial increase in the heat transfer with winglet type vortex generators. It has been observed that average Nusselt number increases by about 46% while the local heat transfer coefficient improves by several times as compared to plain fin-tube heat exchanger. The maximum improvement is observed in the re-circulation zone. The best location of the winglets was with DX = 0.5D and DY = 0.5D. The increase in pressure drop for the existing situation was of the order of 18%.

- **Jin-Sheng Leu et al.**(17-18)

Investigated the experimental analysis of the effects of delta-winglet vortex generators on the performance of a fin and tube radiator is presented. The winglets were arranged in flow-up configuration, and placed directly upstream of the tube. This is a hitherto untested configuration, but is thought to have certain advantages. In addition to vortex generation the flow is guided onto the tube surface increasing the localised velocity gradients and Nusselt numbers in this region. The study includes dye visualization and full scale heat transfer performance measurements. The results are compared to a standard louver fin surface. It was found that the winglet surface had 87% of the heat transfer capacity but only 53% of the pressure drop of the lower fin surface.

- **Guobing Zhou et al.**(19-20)

Heat transfer enhancement and lower pressure loss penalty, even reduction in pressure loss; two novel fin-tube surfaces with two rows of tubes in different diameters are presented in this paper. Numerical simulation results show that the fin-tube surface with first row tube in smaller size and second row tube in larger size can lead to an increase of heat transfer and decrease of pressure drop in comparison with the traditional fin-tube surface with two rows of tubes in the same size.

- **J.M. Wua et al.**(21-22)

The Result of a pair of new vortex generators e curved trapezoidal winglet (CTW) has been experimentally investigated and compared with traditional vortex generators e rectangular winglet, trapezoidal winglet and delta winglet using dimensionless factors e j/j0, f/f0 and R ¼ (j/j0)/(f/f0). The results showed that delta winglet pair is the best in laminar and transitional flow region, while curved trapezoidal winglet pair (CTWP) has the best thermo hydraulic performance in fully turbulent region due to the streamlined configuration and then the low pressure drop, which indicates the advantages of using this kind of vortex generators for heat transfer enhancement. Parametric study on CTWP showed that smaller attack angle (b ¼ 0_ ¼ and 15_), larger curvature (b/a ¼ 1/2) and larger angle of inclination (a ¼ 20_) gives better thermo hydraulic performance under the present conditions. An appropriate spacing between the leading edges of a pair of CTW VG should be considered for different flow regions. In addition, double rows of CTWP do not show better thermo hydraulic performance due to the larger pressure drop and the spacing between the two rows of CTWP should also be optimized.

- **Y.L. He et al.**(23)

Investigated the effect of punched longitudinal vortex generator in form of winglets staggered arrangements to enhance the heat transfer in high performance finned oval tube heat exchanger. Winglets in staggered arrangement bring larger heat transfer enhancement than in inline arrangement. K. Torii *et al*., propose a novel technique that can augment heat transfer but nevertheless can reduce pressure-loss in a fin tube heat exchanger with circular tubes.

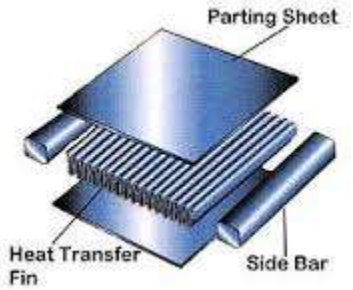


Figure 4. Plate Fin



IV. FUTURE SCOPE

For this dissertation work the scope can be recorded as below:

1) Identifying the parameters of critical importance influencing the rate of heat transfer

2) Determining the geometry of the evaporator for achieving the best performance (high rate of heat transfer)

3) Developing alternatives as variants with different material and geometry

4) Using alternatives for working media

5) Evaluating performance for the variants using CFD software

6) Tuning the variants to the application of heating milk (with the perspective of food product that calls for a high degree of resistance to contamination through working media)

7) Trials and Testing through physical experimentation at the host company's premises for the best option selected.

8) Documenting and proposing the best alternative for the given application.

V. CONCLUSIONS

Various type of possible and cost effective technique of the heat transfer enhancement were presented in this literature review. It is clear the vortex generator technique is one of the promising approaches of heat transfer enhancement. Lot of work been carried out on various designs and use of simulation software made it easier.

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INTERNATIONAL JOURNAL OF ENGINEERING APPLIED SCIENCE AND TECHNOLOGY

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