Volume-04
Issue-01
January -2019

ISSN: 2455-3085 (Online)
RESEARCH REVIEW International Journal of Multidisciplinary
www.rrjournals.com [UGC Listed Journal]

Applications of enhancement techniques and heat exchangers in heat transfer surface design

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ARTICLE DETAILS

Article History
Published Online: 20 January 2019

Keywords
enhancement techniques, heat exchangers, heat transfer.

ABSTRACT

The heat exchanger has the main role in the heat transfer techniques such as energy storage and recovery. To build the performance of the heat exchanger, the heat transfer improvement techniques are used in much modern application. The heat transfer techniques are for the most part utilized in regions, for example, warm power plants, cooling hardware car, and aviation. In this paper, the creator has talked about the use of improvement methods and heat exchangers in heat transfer surface plan.

1. Introduction

A heat exchanger is a complex device that provides the transfer of thermal energy between two or more fluids, which are at different temperatures and are in thermal contact with each other. Heat exchangers are utilized either separately or as parts of an enormous warm framework, in a wide assortment of business, mechanical and family unit applications, for example control age, refrigeration, ventilating and cooling frameworks, process, producing, aviation businesses, electronic chip cooling just as in natural designing. The upgrades in the presentation of the heat exchangers have pulled in numerous specialists for quite a while as they are of extraordinary specialized, prudent, and not the least, natural significance. Execution improvement winds up fundamental especially in heat exchangers with gases in light of the fact that the warm opposition of gases can be 10 to multiple times as huge as that of fluids which requires huge heat transfer surface territory per unit volume on gas side [1].

The conventional strategies for lessening the air-side warm obstruction are by expanding the surface zone of the heat exchanger, or by diminishing the warm limit layer thickness on the outside of the heat exchanger. Expanding the surface region is successful however it brings about the expansion in material expense and increment in mass of the heat exchanger. One of the techniques to diminish limit layer thickness is by the age of detached vortices. In this method the flow field is modified by a deterrent to produce a vortex situated toward the flow. The subsequent change in the flow because of a deterrent modifies the nearby warm limit layer. The net impact of this control is a normal increment in the heat transfer for the influenced territory. The present work is attempted to figure the heat improvement levels attainable in a plate-fin heat exchanger (with triangular blades between the plates) with inherent vortex generators mounted on these fins as rectangular winglets [2].

Compact Heat Exchangers

Compact heat exchangers are characterized by a large heat transfer surface area per unit volume of the exchanger. The compact heat exchangers have decreased space, less weight, bolster structure and impression, vitality prerequisites and cost just as procedure configuration, plant format and handling conditions, together with low liquid stock. The smaller heat exchangers can be of gas to gas, gas to fluid or fluid to fluid kind. They are utilized in vehicular heat exchangers, flying machine coolers, cooling, vehicle oil coolers, intercoolers of the blower, and airplane and space industry. They are likewise utilized in cryogenics forms, hardware, vitality recuperation, and different enterprises. A heat exchanger is alluded to as a reduced heat exchanger on the off chance that it fuses a heat transfer surface having a surface territory thickness more noteworthy than around 700 m2/m3 . The minimal heat exchangers of plate-blade and cylinder fin types, groups with little width, and regenerative sort are commonly utilized for application where the gas flows. Most basic smaller heat exchangers are plate-blade and cylinder fin heat exchangers which are clarified in a nutshell [3]:

Plate-Fin Heat Exchangers

These types of exchangers have corrugated fins or spacers sandwiched between parallel plates or parting sheets as shown in Fig.1. If liquid or phase change fluid flows on other side, the parting sheet is replaced by flat tube with or without inserts or webs.

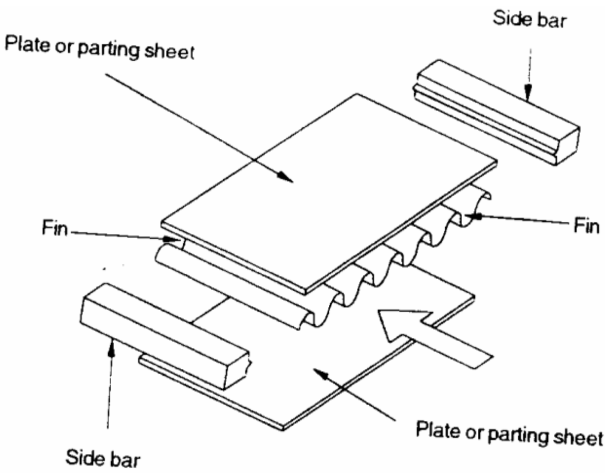


Fig.1: Basic components of plate-fin heat exchanger

The plates or level cylinders separate the two liquid flows, and the blades structure the individual flow sections. Interchange liquid sections are associated in parallel by reasonable headers to frame the at least two liquid sides of the exchanger. The plates and fins are made of assortment of materials, for example, metals, papers and earthenware production. Fins are pass on or roll shaped and are connected to the plates by brazing, fastening, cement holding, welding, mechanical fit, or expulsion. Fins might be utilized on the two sides in gas-to-gas heat exchangers. In gas-to-fluid applications, fins are by and large utilized uniquely on the gas side, whenever utilized on the fluid side, they are utilized principally for basic quality and flowmixing purposes. The blades utilized in a plate-fin heat exchanger are plain or straight fins, plain yet wavy fins, or intruded on fins, for example, strip, louver and punctured fins. Figure 2 shows distinctive blade geometries utilized in plate-fin heat exchangers [4].

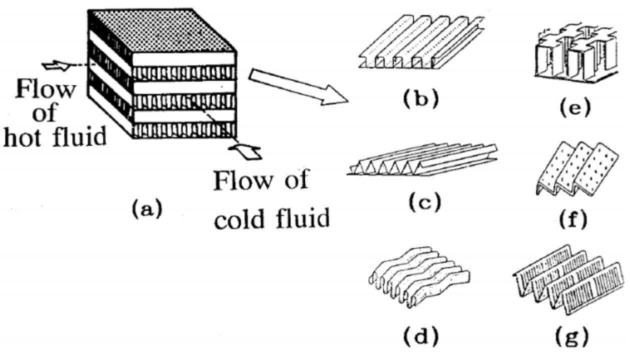


Fig.2: (a) Plate-fin heat exchanger and its surface geometries (b) Plane rectangular fins (c) Plane traingular fins (d) Wavy fins (e) Offset strip fins (f) Perforated fins (g) Louvered fins; after Webb(1987)

2. Literature Review

There has been a considerable amount of research in the area of heat transfer enhancement available both in the form of experimental results and as predictions of the numerical investigation. In this section, a synopsis of these discoveries is introduced so as to place the present issue in the correct viewpoint. The writing is explored from three unique perspectives [5].

- An outline of the field of heat transfer upgrade is introduced in the primary segment.
- The second segment centers around those examinations which have been performed to assess the utility of the vortex generators in increase of heat transfer in the smaller heat exchangers.
- The third segment centers on the improvement of the numerical strategies for tackling the Navier-Stokes conditions.

Heat Transfer Augmentation

The subject of heat transfer upgrade is of genuine enthusiasm for the plan of conservative heat exchangers. The accentuation is given on limiting the space involved by the hardware for the ideal pace of heat transfer. An enormous number of expansion methods have been created over the most recent couple of decades and these are relevant to assorted territories, for example, single stage flows, two stage flows and convective mass exchange. Various audit articles and handbooks by Bergles (1978, 1983 and 1985) manages the upgrade of heat transfer for various applications.

Classification of Heat Transfer Augmentation Techniques

A detailed account of the different techniques of heat transfer growth is given by Bergeles (1985) and Webb (1987). Expansion systems can be characterized either as detached techniques, which require no immediate use of outside power, or as dynamic strategies, which require the outer power. The viability of both dynamic and inactive sorts depends unequivocally on the method of heat transfer, which may run from single-stage free convection to scattered flow film bubbling. A portion of the aloof strategies are:

Compact surfaces: This sort of strategy includes metallic or non metallic covering superficially. These are utilized to improve the heat transfer in single stage convection or bubbling and buildup. Non wetting covering, for example, teflon is utilized to advance drop shrewd buildup. Figure 3 demonstrates the cross-area of a sintered permeable metal covering utilized for nucleate bubbling [6].

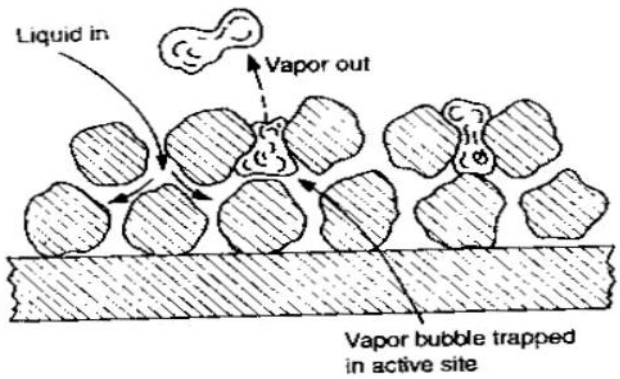


Fig. 3: Porous metal coating

Rough Surfaces: These are either integral (formed by machining) to the base surfaces or are made by placing a roughness surface. The roughness of sand grain type to discrete protruberance configuration is chosen in such a way that it promotes the mixing in boundary layer near the surface rather than to increase the heat surface area. The rough surfaces are used in mainly single phase flow. Figure 4 shows the rough surfaces.

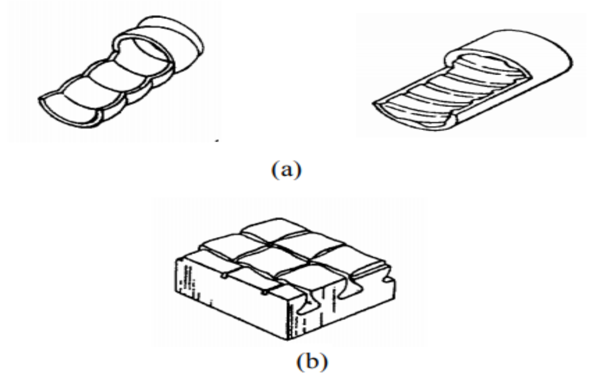


Fig.4: (a) Tube side roughness (b) Rough surface for nucleate boiling

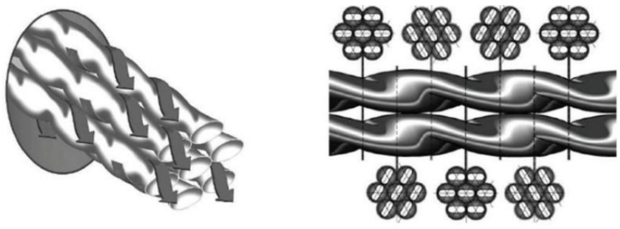
Longitudinal Vortex System

Longitudinal vortex generators generate vortices having their axes in the flowwise or flow direction and always imply three-dimensional flow. The trailing vortices behind the wingtips of wings, and the main edge vortices of delta wings are old style longitudinal vortices. Numerous hypothetical and test examinations on the flow past a delta wing have been accounted for by various specialists. Among them Winter (1956), Fink (1956), Marsden et al. (1958) and Lawford (1964) are essential early works [7]. Lanchester (1915) expressed that vorticity can't diffuse in the flow and it tends to be created uniquely at strong surfaces. In this way, the longitudinal vortices may keep going for some vortex generator lengths downflow. The vortices are produced by partition along their driving edges of delta wings at moderate approaches, which result in isolates shear layers, which are temperamental and transfer up to longitudinal vortices. Delery et al. (1984) found that the initiated circumferential and flowwise speeds of these longitudinal vortices are of a similar size as the free-flow speed. The extraordinary and enduring twirl incited the utilization of longitudinal vortex generators as winglets and connected geometries for limit layer control with a plan to defer limit layer by blending high energy liquid outside into the limit layer [8].

Jacobi and Shah (1995) and Fiebig (1995 a) [9] noticed that the longitudinal vortices show better heat transfer attributes and less flow misfortune than the transverse vortices. Along these lines, for heat transfer applications the occasional courses of action of longitudinal vortex generators are of incredible intrigue. The vortex is able to do emphatically annoying the limit layer and impacting the heat transfer rates. Also, these longitudinal vortices ordinarily keep up their rationality over a long flow insightful separation. Subsequently the heat transfer rates behind a vortex generator are noteworthy. There have been various investigations on the utilization of longitudinal vortex generators in heat transfer improvement. The writing survey introduced here will concentrate on the business related to the present investigation. It is sorted out in three areas i.e., the utilization of LVG in level plate, tube-fin and channel flow upgrade [10].

3. Applications in heat transfer surface design

For a similar mass liquid speed, the surface geometry turns into an elective structure alternative for improving the thermohydraulic execution of a heat exchanger. Instances of altered surfaces utilized in rounded heat exchangers are the curved cylinder exchanger (Figure 5). The whirl flow transferment makes a consistent evacuation of the laminar layer, along these lines expanding the heat transfer coefficient with negligible increment of the weight drop. This geometry includes both the interior and the outer liquid. In activity, the shell side of customary heat exchangers speaks to a significant region of chance for development. Heat transfer hosing because of the production of dormant zones and high weight drop because of sudden alters of course can be abstained from utilizing helical bewilders [11]. Helical confound heat exchangers display an increasingly uniform flow circulation on the shell side contrasted with ordinary shell and cylinder exchangers for a similar weight drop. They can likewise diminish tube vibrations and fouling. Their assembling expenses are higher, yet they require less upkeep and their working expenses are lower which so in the long haul the speculation satisfies. The geometrical highlights (Figure 6) that characterize this sort of innovation are: helical pitch, Phel (separation between two back to back bewilders); the helical point, β (the edge framed between the helix and the vertical); and the shell measurement, Di. In [5], it has been shown that the most noteworthy warm execution in this kind of geometry is accomplished when the bewilder edge is 40° [12].



(a) (b)

Figure 5: (a) Twisted tube heat exchanger technology; and (b) twisted tube construction

Numerical studies in 3D [13] indicate that the heat transfer rates in helical baffle exchangers are higher than in conventional segmental baffle exchangers from 9 to 23%. Other structure options incorporate the utilization of numerous shell passes. The improved exhibition of these sorts of units has additionally been shown tentatively. There is little data about articulations to gauge the thermohydraulic execution of helical exchangers and the couple of articulations accessible are accounted for perfect flow conditions and for configuration purposes revision factor must be applied. In late work, heat transfer and grinding factor articulations got from trial information have been accounted for various helix points. Helical-astound heat exchangers show better execution thought about than customary segmental bewilder exchangers. In [14], an alternate route configuration approach for helical bewilder heat exchangers dependent on the idea of full utilization of accessible weight drop was created. The utilization of this structure strategy demonstrates that improved plans are conceivable with helical puzzle exchangers. For a similar heat obligation and weight drop utilization, a decrease of practically 30% in surface territory is gotten. In the quest for improved warm surface execution, heat exchangers have developed to what are called smaller heat exchangers. A large variety of new surface structures are accessible. The primary element of these innovations is that for a similar weight drop, they make higher heat transfer coefficients [15].

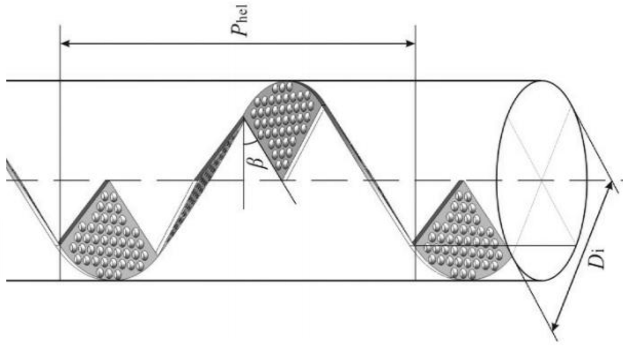


Figure 6: Main geometrical features of a helical heat exchanger

Some of the most common types of compact heat exchangers are described below:

- Plate and fin heat exchangers
- Plate and frame heat exchangers
- Spiral heat exchangers

4. Conclusion

The performance of the heat exchangers can be improved by mounting protrusions on the surfaces. The surface geometries, which are popular in different industrial applications, are wavy fins, off-strip fins, perforated and louvered fins. To some degree distinctive idea for the decrease of warm opposition and upgrade in heat transfer is the utilization of longitudinal vortex generators as winglet. The geometrical design considered in this theory is illustrative of single component of a plate-blade heat exchanger, having triangular fins between the plates. The capability of the longitudinal vortex generators as a winglet and winglet pair put on the triangular blades have been assessed in detail.

The rectangular winglet mounted on the triangular fins of the plate-fin heat exchanger irritates the flow structure and makes longitudinal vortices. Because of the presence of complex flowwise vortices framework in the flow section, the heat transfer between the liquid and its neighboring surfaces is essentially upgraded with a moderate pressure drop.

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