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PLATE FIN AND TUBE HEAT EXCHANGER

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ABSTRACT

The main objective of the present work is to investigation of optimum design of plate fin tube heat exchanger using Computational fluid dynamic approach and maximizing thermal performance. There are total five designs of plate fin and tube heat exchanger are used in present work and CFD analysis have been performed in it to get maximum heat transfer. It has been observed from CFD analysis that the maximum heat transfer can be achieved from plate fin and tube heat exchanger with elliptical tube arrangement inclined at 30º with 23.22% more heat transfer capacity as compared to circular tube plate pin heat exchanger. So that it is recommended that if the plate fins and tube heat exchanger with inclined elliptical tube used in place of circular tube arrangement, batter heat transfer can be achieved.

KEYWORDS: Plain fin; Turbulence; Friction factor; etc.

I.INTRODUCTION

The heat exchangers are found to have a wide range of applications ranging from the house-hold purposes to refineries and cryogenic operations. These heat exchangers had become the essential requirement of the current society as they do not cause any harmful effects to the environments. The cost involved in this energy extraction is also very less and economical. One of the concerns regarding these heat exchangers is to enhance the heat transfer and improve their efficiency. The survey and researches had been carried out in a large manner to improve the heat transfer enhancements. In this context, an objective is set to review the literature related to heat exchangers under the following categories: general study of heat exchangers, various configurations of heat exchangers, the compact heat exchangers and the effects of nanofluid in the heat transfer enhancements.

A. 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 fluids. It is often categorized as a compact heat exchanger to emphasis its relatively high heat transfer surface area to volume ratio. The plate-fin heat exchanger is widely used in many industries, including the aerospace industry for its compact size and lightweight properties, as well as in cryogenics where its ability to facilitate heat transfer with small temperature differences is utilized.

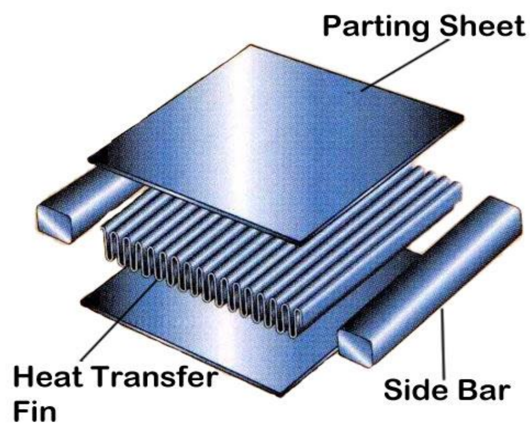

Fig. 1 Plate fin heat exchanger

Plate fin-and-tube heat exchangers are used extensively in heating, ventilating, and air conditioning (HVAC), process engineering, and refrigeration applications such as compressor intercoolers, fan coils, and air-coolers. The governing thermal resistance for heat exchangers is typically located on the air side, accounting for 85% or more of the total resistance in practical applications. Consequently, the use of finned surfaces on the air side facilitates improvements to the overall thermal performance of heat exchangers.

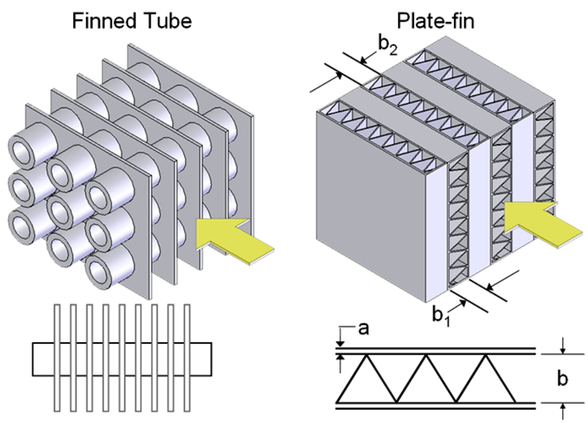

Fig. 2 design of fin plate heat exchanger

B. Heat transfer principle

Fourier's law of heat conduction states that if temperature gradient is present in a body, then the heat will transfer from a high-temperature region to allow- temperature region. And, this can be achieved in three different ways, such as convention, radiation and conduction.

Whenever two objects with different temperature come in contact with each other, conduction occurs causing the fast-moving molecules of the high-heat object to collide with the slow-moving molecules of the cooler objects, and thus, transfers thermal energy to the cooler object, and this is termed as thermal conductivity.

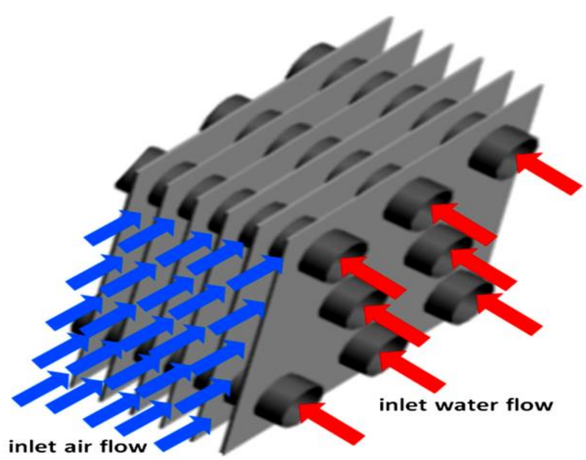

Fig 3 design of fin plate inlet air flow

Heat exchangers have been widely used in the fields of refrigeration, air conditioning, space heating and chemical engineering. Fin-tube heat exchanger with two rows of round tubes is widely used in air-conditioning and refrigeration systems to meet such demands as fan power saving and quietness. Traditional heat exchanger devices such as plate type, plate fin type and tubular type operate on the principle of temperature difference between two mediums and can realize efficient sensible heat transfer from one fluid to another. With the development of design of heat exchanger and making some changes without affecting the cost much the heat transfer enhancement can be achieved. One such novel approach is using punched winglet-type vortex generator in fin tube heat exchanger which is proved numerically that it enhance the heat transfer.

C. Heat Exchangers

A heat exchanger is a device, which is used to transfer thermal energy between two or more fluids, between a solid surface and a fluid, or between solid particulates and a fluid, at different temperatures and in thermal contact. Not only are heat exchangers often used in the process, power, petroleum, air-conditioning, refrigeration, cryogenic, heat recovery, alternative fuel, and manufacturing industries, they also serve as key components of many industrial products available in the market. The heat exchangers can be classified in several ways such as, according to the transfer process, number of fluids and heat transfer mechanism. Conventional heat exchangers are classified on the basis of construction type and flow arrangement. The other criteria used for the classification of heat exchangers are the type of process functions and fluids involved (gas-gas, gas-liquid, liquid-liquid, two phase gas etc.). The classification according to the surface compactness deals with one of the important class of heat exchangers named as compact heat exchangers.

D. Extended surface heat exchangers

Heat exchangers, based on constructional details, can be classified into tubular, plate type, extended surface and regenerative type heat exchangers. The tubular and plate–type exchangers are the primarily used surface heat exchangers with effectiveness below 60% in most of the cases. The surface area density of these heat exchangers is usually less than 700 m2 /m3 In this regard, an important fact is that the thermal conductance 'h .A' on both sides of the heat exchanger should approximately be the same. Hence, the heat transfer surface on the gas side needs to have a much larger surface area as it is well known that the heat transfer coefficient 'h' for gases is much lower than that for liquids. One of the most common methods to increase the surface area and compactness is to have extended surface (fins) with an appropriate fin density (fin frequency, fins/m) as per the requirement. This addition of fins can increase the surface area by 5 to 12 times the primary surface area. These types of exchangers are termed as extended surface heat exchangers. The heat transfer coefficient 'h' on extended surfaces may be higher or lower than that of un-finned surfaces. The louvered fins increase both the surface area and the heat transfer coefficient, while the internal fins in a tube increase the tube surface area but may result in a slight reduction in heat transfer coefficient depending on the fin spacing. However, the overall thermal conductance increases due to the presence of extended surfaces.

II.LITERATURE REVIEW

Y Peng (2017) Air-cooled heat exchanger plays an important role in the field of industry like for example in thermal power plants. On the other hand, it can be used to remove core decay heat out of containment passively in case of a severe accident circumstance. Thus, research on the performance of fins in air-cooled heat exchangers can benefit the optimal design and operation of cooling systems in nuclear power plants.

Artur Rubcov (2017) Results of experimental tests of a wavy fin and tube heat exchanger used to heat (cool) air in a ventilation system when the wavy fin of the heat exchanger is dry and wet. The experimental tests, performed in the range of 1000<Re<4500 of the Reynolds number, determined the dependency of the heat transfer coefficient on the amount of supplied air with the varying geometry of the heat exchanger (the number of tube rows, the distance between fins, the thickness of the fin and the diameter of the tube). The experimental tests were performed on 9 heat exchangers in heating mode (dry fin) and 6 heat exchangers in cooling mode (wet fin).

R.Anbarasan (2017) The CFD simulations of the working fluid flow distribution in individual tubes of fin-andtube heat exchanger. For this purpose, the CFD simulations have been conducted for the design of the inlet and outlet manifolds of the heat exchanger tube elliptical, and the results compared with the values determined empirically, by measuring the mass flow flowmeter installed in the lower part of the heat exchanger tube. A comparison of the results of numerical calculations with the measurement results is presented. The turbulence model k-ε, k-ω and Shear Stress Transport model SST was considered in the computations.

III.PLATE FIN HEAT EXCHANGERS

A plate fin heat exchanger is a form of compact heat exchanger consisting of a block of alternating layers of corrugated fins and flat separators known as parting sheets. A schematic view of such an exchanger. The corrugations serve both as secondary heat transfer surface and as mechanical support against the internal pressure between layers.

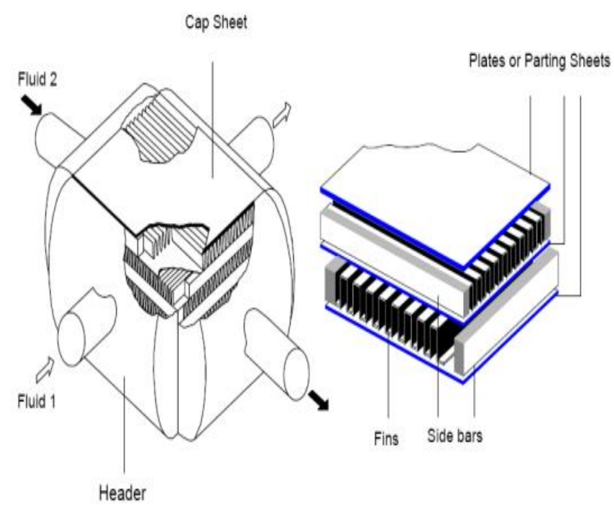

Fig 4: Plate fin heat exchanger assembly and details Side bars Plates or Parting Sheets Fins Fluid 1 Fluid 2 Cap Sheet Header

Steam exchanges heat by flowing along the passage corrugations between the parting sheets. The edges of the corrugated layers are sealed by side-bars. Corrugations and side-bars are brazed to the parting sheets on both sides to form rigid pressure-containing voids. The first and the last sheets, called cap sheets, are usually of thicker material than the parting sheets to support the excess pressure over the ambient and to give protection against physical damage. Each stream enters the block from its own header via ports in the side-bars of appropriate layers and leaves in a similar fashion. The header tanks are welded to the side-bars and parting sheets across the full stack of layers.

IV.MERITS AND DRAWBACKS

Plate fin heat exchangers offer several advantages over competing designs.

1) High thermal effectiveness and close temperature approach. (Temperature approach as low as 3K between single phase fluid streams and 1K between boiling and condensing fluids is fairly common.),
2) Large heat transfer surface area per unit volume (Typically 1000 m2/m3),
3) Low weight,
4) Multi-stream operation (Up to ten process streams can exchange heat in a single heat exchanger.), and
5) True counter-flow operation (Unlike the shell and tube heat exchanger, where the shell side flow is usually a mixture of cross and counter flow.).

The principal disadvantages of the plate fin geometry are:

1) Limited range of temperature and pressure,
2) Difficulty in cleaning of passages, which limits its application to clean and relatively non-corrosive fluids, and
3) Difficulty of repair in case of failure or leakage between passages

V.APPLICATIONS

Plate-fin and tube-fin heat exchangers have found application in a wide variety of industries. Among them are air separation (production of oxygen, nitrogen and argon by low temperature distillation of air), petrochemical and syn-gas production, helium and hydrogen liquefiers, oil and gas processing, automobile radiators and air conditioners, and environment control and secondary power systems of aircrafts. These applications cover a wide variety of heat exchange scenarios, such as:

1) Exchange of heat between gases, liquids or both,
2) Condensation, including partial and reflux condensation,
3) Boiling,
4) Sublimation, and
5) Heat or cold storage

VI.CONCLUSION

The easy manufacturing and designing process as compared to other fin and tube heat exchanger motivates various researchers to study this fin. Various performance parameters such as fin pitch, fin length, fin thickness, longitudinal pitch, transverse pitch, waviness amplitude, Coburn factor, friction factor, and pressure drop were studied in the literature review. Following were the major finding from the literature review.

1. The wavy surface lengthen the air flow path and cause better air flow mixing thus increasing the heat transfer rate.
2. Increase in longitudinal and transverse pitch decreases the heat transfer and pressure drop performance.

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