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A Review on Three-Dimensional Performance Analysis of Circular Fin Tube Heat Exchanger

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Abstract:-In recent years, thousands of numerical and experimental studies have been performed on heat exchangers with different configurations. Mainly heat transfer and frictional characteristics have been studied in detail with respect to different geometrical parameters in various ranges of Reynolds number. Further these studies have been cross verified with researches already performed in this field. With the advent of new tools like CFD for the study of thermo-hydraulic characteristics, it has becomes easier to understand flow phenomena around the tubes for different rows and also in rest of flow regions. These studies also bring about some correlations so as to easily find the values ofcolburn and friction factor for various different geometrical parameters so as to suit to the different industrial conditions and requirements. An overview of the work already done on plate fin heat exchangers is presented in this paper.

Key words- Plate-and-fin heat exchangers, circular fins, CFD

I.INTRODUCTION

The fin geometry has become as increasingly important factor in the design of a plate-and-fin heat exchanger. The high-performance offset strip, wavy and louver fins provide quite high heat transfer coefficients for gases and two-phase applications. It offers significant advantages like lower gas pressure drop than circular tube designs and the ability to have the fins normal to the gas flow over the full gas flow depth over the traditional fin-and-round tube geometry. Enhanced surface geometries are widely used with liquids for cooling electronic equipment. The typical extended surfaces used for the plate-and-fin heat exchangers are: plain fin, wavy fin, offset strip fin, louvered fin, perforated fin, etc. Based on the tube arrangement, these types of heat exchangers can further be divided in two different groups such as staggered and inclined arrangement. Fig. 1.3 shows some typical finned-tube heat exchanger designs especially for plain and wavy structure.

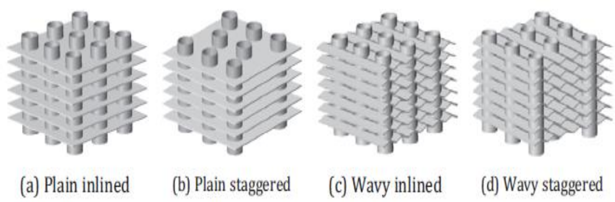

Fig. 1. Different fin and tube arrangement in plain and wavy finned-tube heat exchanger

Plate fin-and-tube heat exchangers of plain fin pattern are commonly used in the process and HVAC&R (Heating, Ventilating, air conditioning, and refrigeration) industries. The plain plate fin configuration is the most popular fin pattern, owing to its simplicity, durability and versatility in application. The plain fin-and-tube heat exchangers usually consist of mechanically or hydraulically expanded round tubes in a block of parallel continuous fins and, depending on the application, the heat exchangers can be produced with one or more rows. During the past few decades many efforts have been devoted to heat transfer and friction characteristics of plate fin-and tube heat exchangers. Among the entire extended fin surfaces, plain fin represents the simplest geometry.

Though lower heat transfer performance is observed for plain fins as compared to the specially configured fin surfaces, these fin types are still widely used where pressure drop characteristics low are desired. When the fins have periodic corrugations in their geometry in the form of a wave, then it is called a wavy fin. The wavy pattern may be smooth or of a herringbone pattern. These periodic corrugations having a definite angle of corrugation that helps in better mixing of flow, thereby providing higher heat transfer.

These corrugations in a wavy fin help in increasing the flow length in a limited space than that of the plain fin. This type of geometry is being widely studied and used these days due to its attractive heat transfer performance as demonstrated in their studies conducted by Nishimura et al. [8] and Wang et al. [9]. The important parameters in the study of wavy fin are the wavy angle and the wavy height, fin pitch, fin length, fin thickness, longitudinal pitch, transverse pitch, waviness amplitude, colburn factor, friction factor, andpressure drop which will be explored in detail in this study.

II. LITERATURE REVIEW

In recent years, thousands of numerical and experimental studies have been performed on heat exchangers with different configurations. Mainly heat transfer and frictional characteristics have been studied in detail with respect to different geometrical parameters in various ranges of Reynolds number. Further these studies have been cross verified with researches already performed in this field. With the advent of new tools like CFD for the study of thermo-hydraulic characteristics, it has becomes easier to understand flow phenomena around the tubes for different rows and also in rest of flow regions. These studies also bring about some correlations so as to easily find the values ofcolburn and friction factor for various different geometrical parameters so as to suit to the different industrial conditions and requirements. An overview of the work already done on plate fin heat exchangers is presented in this chapter.

Arafat A. Bhuiyan (2013) investigated heat transfer and fluid flow characteristicsof a four-row plain fin-and-tube heat exchanger using the Commercial Computational FluidDynamics Code ANSYS CFX 12.0. Heat transfer and pressure drop characteristics of the heat exchangerare investigated for Reynolds numbers ranging from 400 to 2000. Fluid flow and heat transfer aresimulated and results compared using both laminar and turbulent flow models (k-u) with steady andincompressible fluid flow. Model validation is carried out by comparing the simulated case friction factor(f) and Colburn factor (j) with the experimental data of Wang et al. [1].

Reasonable agreement is foundbetween the simulations and experimental data. In this study the effect of geometrical parameters suchas fin pitch, longitudinal pitch and transverse pitch of tube spacing are studied. Results are presented in the form of friction factor (f) and Colburn factor (j). For both laminar and transitional flow conditions heat transfer and friction factor decrease with the increase of longitudinal and transverse pitches of tube spacing whereas they increase with fin pitches for both in-line and staggered configurations. Efficiency index increases with the increase of longitudinal and transverse pitches of tube spacing but decreases with increase of fin pitches. For a particular Reynolds number, the efficiency index is higher in in-line arrangement than the staggered case.

From the early literature on the experimental analysis of thermal–hydraulic performance of Copper–water nano-fluid flow in different plate-fin channels presented by M. KhoshvaghtAliabad(2014)et al., fabricated and tested seven plate-fin channels, including plain, perforated, offset strip, louvered, wavy, vortex generator, and pin. The fluid used for testing was copper–water nano-fluids. Experimental study on thermal hydraulic performance of a wavy fin-and-flat tube aluminium heat exchanger presented by Junqi Dong (2013) et al., in this experimental investigation a 16 samples with different geometry parameters were tested and the effects of fin height, fin pitch, fin length, wavy amplitude, and wavy length on the heat transfer and pressure drop were studied.

Experimental and numerical investigation of thermal - hydraulic performance in wavy fin-and-flat tube heat exchangers presented by Junqi Dong (2016) et al., experimentally investigated the air flow and heat transfer characteristics over the wavy fin heat exchangers and the results of friction factor and heat transfer performance test data are for fully developed turbulent region of air flow in the wavy fin.

Jose Fernandez-Seara (2013) et al., investigated on the pressure drop and heat transfer characteristics of a titanium brazed plate-fin heat exchanger with offset strip fins by using firstly water on both sides of the heat exchanger and secondly 10-30 wt% ethylene glycol aqueous solutions as working fluids and both the results were compared. Giovanni lozza (2005) et al., showed the performance of v*9arious fin configurations in air cooled condenser and liquid coolers to enhance the heat transfer capabilities of the devices the results showed louvered fin geometry had the best heat transfer rate but the pressure drop was high.

S.M. Pesteei (2005) et al., investigated experimentally study of the effect of winglet location on heat transfer enhancement and pressure drop in fin-tube heat exchangers the results showed a reasonable amount of increase in the heat transfer with addition of winglet type vortex generators. Ting Ma (2011) et al., conducted an experimental study on investigation of a novel bayonet tube high temperature heat exchanger with inner and outer fins where the numerical results showed that the inner fins and inner tube both should not be welded together and the mass flow rate and the inlet temperature on the fuel gas side have a reasonable effect on the heat transfer rate and effectiveness, and the pressure drop ratios are mainly affected by the mass flow rate rather than the inlet temperature.

Design and experimental analysis of spiral tube heat exchanger by **Jay.J. Bhavsar (2013) et al.,** a spiral tube heat exchanger was fabricated and experimental analysed and was compared with a shell and tube heat exchanger and the results showed the spiral tube heat exchanger had a better heat transfer rate with an increase in pressure drop compared to shell and tube heat exchanger. Performance analysis of cross flow plate fin heat exchanger for Immiscible system using ANN by M.Thirumarimurugan(2010) et al., the results such effectiveness and overall heat transfer were obtained experimentally and simulation results were also obtained by using ANN general regression it showed the predicted results obtained by the ANN approach are close to the experimental results. Experimental determination of correlations for mean heat transfer coefficients in plate fin and tube heat exchangers by Dawin taler (2012) experimental determined the heat transfer coefficient for a cross flow plate fin and tube heat exchanger and correlation were developed for the this type of heat exchanger the result show increase in heat transfer and as well as increase in pressure drop.

Vaisi (2011) et al., carried out an experimental investigation of geometry effects on the performance of a compact louvered heat exchanger in which the results indicated that the configuration of the louvered fins has the dominant influence on the heat transfer and pressure drop from that louver fin. Heat-transfer enhancement in fin-and-tube heat exchanger with improved fin design by

Mao-Yu Wena (2009) et al., showed the study of use of the compounded fin constructed for heat exchanger. Results of the compounded fin had an increase in heat transfer and pressure drop, f factor and j factor compared to the flat fin heat transfer coefficient. Role of channel shape on performance of plate-fin heat exchangers. Experimental assessment by M. Khoshvaght-Aliabadi(2014) et al., carried out a comparison study on seven common configurations of channels used in plate-fin heat exchangers .All the channels, including plain, perforated, offset strip, louvered, wavy, vortex-generator, and pin, were fabricated and tested experimentally. The working fluid was water. The results showed that the vortex generator channel has a significant enhancement in the heat transfer coefficient and a proper reduction in the heat exchanger surface area.

An experimental investigation of heat transfer and friction losses of interrupted and wavy fins for fin and tube for fin and tube heat exchanger by Giovanni lozza(2001) et al., conducted an experimental study on a pin fin heat exchanger used in air cooled and liquid cooler condensers with different fin configuration like flat, wavy and louvered fins. All the fins geometries were compared by experimental data and the results showed a better heat transfer and pressure drop enhancement when louvered fins compared to flat and wavy fins.

III.CONCLUSION

1. Several previous studies have been performed on plate and tube fin heat exchangers, the geometrical parameters have been varied for different range of Reynolds number which brought us some important conclusions. Heat transfer increases whereas pressure drop decreases with increased fin pitches and vice versa.
2. Heat transfer is directly proportional to fin thickness.
3. The louver fin has higher values of f and j factor compared to wavy and plate fin configurations.
4. The number of tube rows has negligible effect on fictional and heat transfer characteristics.
5. The effect of number of tube rows on heat transfer is prominent at low Reynolds number values.
6. Heat transfer is always higher in staggered tube arrangement than that of in-line arrangement. Heat transfer is higher for highly conductive material at high Reynolds number values.
7. The pressure drop for staggered arrangement is always higher than that of in-line arrangement.
8. Plate and flat tube-fin heat exchanger have higher heat transfer with wing type vortex generator than that of plate and round tube-fin configuration with VGs.
9. VGs embedded fins helps in reduction of fin area by 25% as compared to plain fin heat transfer area.

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