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"Parametric Optimization And CFD Analyses Of Plate Heat Exchanger"-A Review

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***Abstract*— In this Work, published literature about CFD analysis of Plate Heat Exchanger (PHE) is referred and an attempt is made to find suitable method for CFD analysis. Conclusions derived from experimental work done on PHE are also reported. PHE has a three dimensional narrow channel with herringbone pattern. Its chevron angle, groove depth, and no. of channel are the variables for consideration in CFD analysis. The results, thus obtained will give optimum values of different parameters of PHE.**

Keywords: Plate Heat exchanger, CFD analysis of PHE, optimum parameters of PHE, Chevron angle

Nomenclature

Abbreviations

NTU : Number of transfer unit
CFD : Computational fluid dynamics
PHE : Plate heat exchanger
PHEs : plate heat exchangers

Symbols

p : Pitch of corrugated plate(mm)
H : Depth of corrugated plate (mm)
R : Heat capacity ratio
P : Temperature effectiveness

Greeks letters

β : inclination angle or chevron angle(degree)
ε : Effectiveness

I. INTRODUCTION

Heat exchanger is a device that provides the flow of thermal energy between two or more fluids at different temperatures. Heat exchangers are used in wide variety of applications. These include power production, process, chemical and food industries, electronics, environmental engineering, waste heat recovery, manufacturing industry, air-conditioning, refrigeration and space applications, as well as being key components of many industrial products.

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 type of heat exchanger. PHE is most commonly use in food industry due to several reasons such as suitability in hygienic applications, ease of cleaning and the thermal control requirement for sterilization and pasteurization.[1] PHEs have excellent heat transfer rate due to a very large surface area in small volume and easily modified by increasing or decreasing the number of plates whenever is needed. Plate heat exchangers can be fabricated in gasket, brazed or welded design depending on pressure of flow. Recently, a gasket sealing was replaced by brazed material. This improvement has increased the pressure, the temperature capabilities greatly and also leakage is prevented.

II. CONSTRUCTION OF PLATE HEAT EXCHANGER

The plate heat exchanger consists of a pack of corrugated metal plates with port holes for the passage of the two fluids between which heat transfer will take place. The plate pack is assembled between a fixed frame plate and a movable pressure plate and compressed by tightening bolts. The plates are fitted with a gasket or brazed which seals the inter plate channel and directs the fluids into alternate channels.

Channels are formed between the plates and the corner ports are arranged so that the two media flow through alternate channels. The heat is transferred through the plate between the channels, and complete counter-current flow is created for highest possible efficiency. The corrugation of the plates provides the passage between the plates supports each plate against the adjacent one and enhances the turbulence, resulting in efficient heat transfer.
The plates of these heat exchangers comprise some form of near-sinusoidal corrugations in a herringbone (or chevron) pattern, a design commonly used for PHEs as it is considered the most successful type. The angle, at which the corrugations are placed relative to the main flow direction, is a major parameter influencing performance. This angle is known as chevron angle. Heat transfer and Pressure drop are depends on this chevron angle.

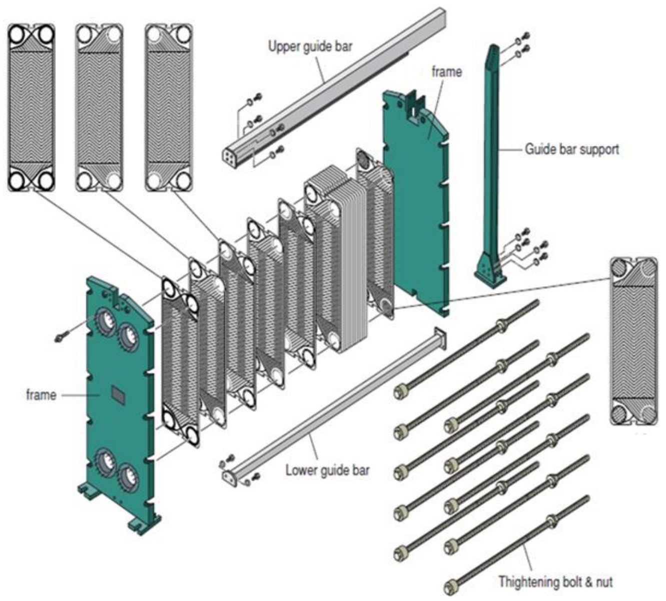

Fig.1 plate heat exchanger

III. WORKING PRINCIPLE OF PLATE HEAT EXCHANGER

Channels are formed between the plates and the corner ports are arranged so that the two media flow through alternate channels. The heat is transferred through the plate between the channels, and complete counter-current flow is created for highest possible efficiency. The corrugation of the plates provides the passage between the plates supports each plate against the adjacent one and enhances the turbulence, resulting in efficient heat transfer.

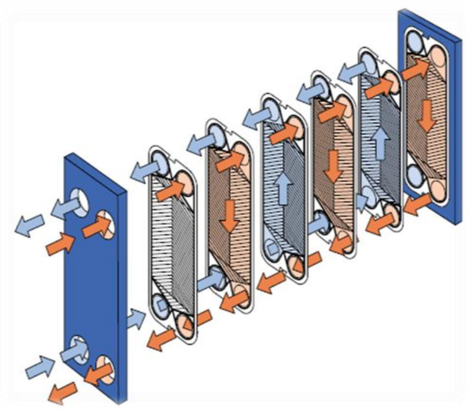

Fig.2 Flow principle of plate heat exchanger (parallel - flow)

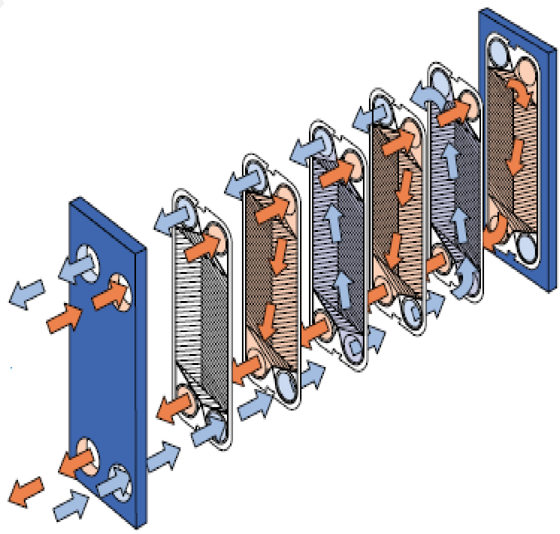

Fig.3 Flow principle of plate heat exchanger (counter - flow)

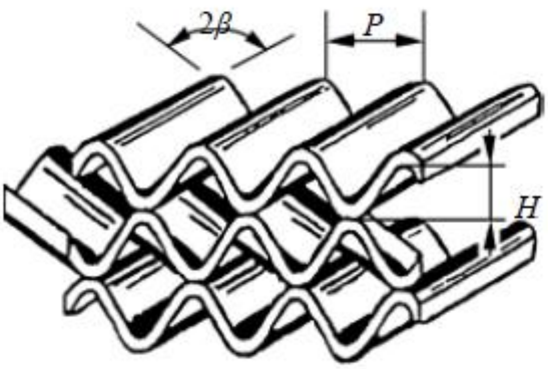

Fig.4 The geometry of the corrugated channels

IV. LITERATURE REVIEW

In the Literature review following research work study and conclude. This literature review is based on performs of plate heat exchanger and effect of different parameter.

In 2011,S Muthuraman [2] develop Three Brazed Plate heat exchanger (BPHEs) with chevron angles of 20°,35°, and 45° were used as the test sections. The angles of corrugation were measured from the horizontal axis. In this work, two working fluid, R410A and R22 are use. The heat transfer coefficients and pressure drops of R410A and R22 were measured in three BHPEs with chevron angles of 20°, 35°, and 45° by varying the mass flux, the vapour quality and the condensing temperature. The results give that Both the heat transfer coefficient and the pressure drop increased proportionally with the mass flux and the vapour quality and inversely with the condensation temperature and the chevron angle.

In 2008, ZhenHua Jin, GiTae Park, YongHun Lee et al.[3] Reported to optimize the heat transfer area, subjected constraints on the number of channels, pressure drop, flow velocity and thermal effectiveness. CFD tool is use to determine temperature and velocity distribution inside of channel. CFD tool is able to analysis of velocity and temperature distribution inside the PHE. It is very difficult to obtain experimental results of temperature and velocity distribution inside PHE. So CFD tool is use to compare experimental results with simulated results. CFD tool is save the experimental time.

In 1985, W.W Focke, J.Zachariades And I. Olivier[4] investigated the effect of inclination angle β of plate heat exchanger is a major parameter in the thermo hydraulic performance. At constant Reynolds number, the effect of corrugation inclination angle on heat transfer and pressure drops is shown below.

1. Increase with β at an increasing rate up to $\beta \sim 60^0$
2. Increase at a decreasing rate for $\beta \sim 60^0$ to $\beta \sim 80^0$
3. Maximun at $\beta \sim 80^0$
4. Local minimum at $\beta = 90^0$ and also change the angle β affects the basic flow structure which is primary factor influencing pressure drop and heat transfer.

In 2009, Aydın Durmus, Huseyin Benli et al.[5] found that the effects of surface geometries of three different type heat exchangers called as PHE flat (Flat plate heat exchanger), PHE corrugated (Corrugated plate heat exchanger) and PHE asterisk (Asterisk plate heat exchanger) on heat transfer, friction factor and energy loss were investigated experimentally. and results obtained from three different heat exchanger types, it is that heat gained from corrugated type heat exchanger is higher than that of other two. but pressure drop increases too. These pressure drop greatly increases the capital cost.

In 2011, Harika Sammeta, Kalaichelvi Ponnusamy et al.[6]. To investigate a 9-plate counter flow corrugated plate heat exchanger is modelled and simulated using computational fluid dynamics (CFD). The performance of the PHE is analysed using the obtained simulated data in the form of charts such as effectiveness, ε versus number of transfer units, NTU at constant capacity ratio, R; Temperature effectiveness, P versus NTU at constant R and non-dimensional mean temperature difference, h versus temperature effectiveness, P at constant NTU and R.

In 2010, Harika Sammeta, Kalaichelvi Ponnusamy, M.A. Majid et al.[7]. The effectiveness charts for 9-channel parallel flow plate heat exchanger from the simulated data using CFD. A validated model was simulated at different operating conditions using CFD. The performance of this PHE is analysed using these effectiveness charts.

V. CONCLUSION

Here published work about effect of different parameters on heat transfer rate and pressure drop in PHE is studied. Performance of PHEs (i.e. Heat transfer rate, pressure drops) depends on their geometry i.e. number of channels, chevron angle, plate thickness, groove dimensions, pattern of plates, etc. Works of different investigators clearly indicate that geometric design parameters of PHE, strongly affect its performance. Hence it is necessary to establish relationship between them and work should be carried out to obtain optimum design. In PHE, pressure drop is higher compared to shell and tube heat exchanger. Hence we can optimize the pressure drop and heat transfer rate using the design of experiments.

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