PERFORMANCE ANALYSIS AND OPTIMAL DESIGN OF A GASKETED PLATE HEAT EXCHANGER

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ABSTRACT

Heat exchanger is an essential component in complex engineering systems related to energy transformation industrial scenarios. Gasketed plated heat exchanger is an important part of a condensing or evaporating system, food processing industries. The purpose of this study is to investigate heat transfer rate and pressure drop in a gasketed plated heat exchanger. The use of gasketed plate heat exchanger increases the overall heat transfer coefficient of the exchanger. With the equations of the gasketed plated heat exchanger , mathematical modeling is done and the heat transfer coefficient, friction factor and pressure drop calculations are found . After validating the methodology of ANSYS analysis of a heat exchanger, transfer characteristics and pressure drop are established.

Keywords—**Gasketed-plate heat exchanger, performance, chevron angle , heat transfer, correlation.**

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I.INTRODUCTION

Plate heat exchangers (PHEs) were introduced in the 1930s and were exclusively used in the food industries because of their ease of cleaning. They are used for space heating, air conditioning, waste heat recovery, power production, chemical processes and general heating and cooling processes [1]. Over the years, the development of the PHE has generally continued towards larger capacity, as well as higher working temperature and pressure. Recently, a gasket sealing was replaced by a brazed material, and each thermal plate was formed with a series of corrugations (herringbone or chevron). These greatly increased the pressure and the temperature capabilities. The corrugated pattern on the thermal plate induces a highly turbulent fluid flow .The high turbulence in the PHE

leads to an enhanced heat transfer, to a low fouling rate, and to a reduced heat transfer area. Recently, plate heat exchangers are commonly used when compared to other types of heat exchangers such as shell and tube type in heat transfer processes because of their compactness, ease of production, sensitivity, easy care after set-up and efficiency [2, 3, 4].

II.CONSTRUCTION

The plate heat exchanger (PHE) consists of a pack of gasketed corrugated metal plates, pressed together in a frame. The fluids flow through a series of parallel flow channels and exchange heat through

the thin corrugated metal plates. The gasket design and the closed ports of the plates determine the fluid flow arrangement, which can be parallel, in series or one of several possible combinations of the two. The flow distribution, number of plates, type of gaskets and feed locations characterize the exchanger configuration. To the author’s knowledge there is no rigorous design method for PHEs in the literature. Shah and Focke (1988) have developed a detailed step-by-step design procedure for rating and sizing a PHE, which is however restricted to parallel flow arrangements.

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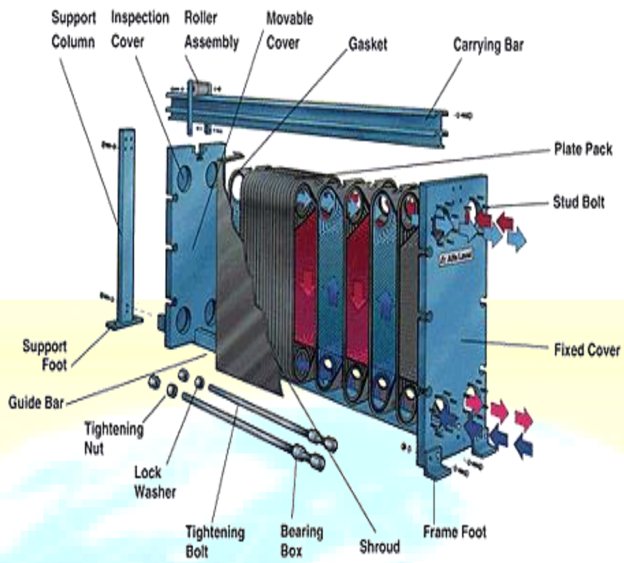
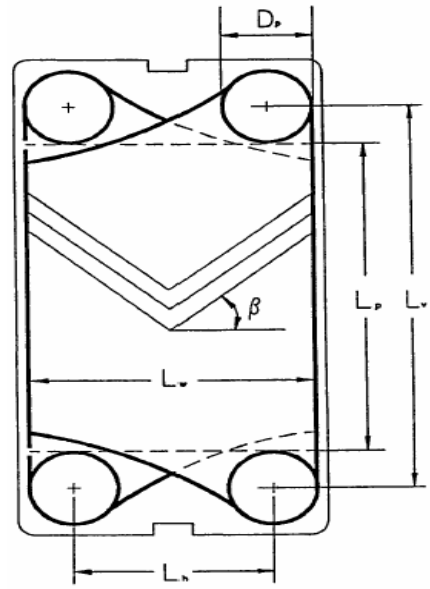


Fig 1:Gasketed plate heat exchanger assembly.

A literature survey has been performed to examine the method for developing the Nusselt number (Nu) and friction factor (*f)* correlations by using the experimental data. Muley and Manglik [11] used a single pass, U-type, counter flow plate heat exchangers with three different plates having different chevron angles in their study. As a result of these experiments, it was seen that as the chevron angle increases the amount of heat transfer is multiplied by 2-5 of that of flat plates. Moreover the pressure drop of the plate heat exchanger is 13 to 44 times higher than the pressure drop of the flat plate. As a result of this study, correlations for Nusselt number and friction coefficients were developed.

III. PLATE GEOMETRY

Chevron or Herringbone is a most common type Configuration. Corrugations are pressed to same depth as plate spacing.It operate at High pressure. Corrugation depth 3mm to 5mm.Operating Velocity is 0.1 to 1 m/s. Chevron Angle, usually termed , β is shown in Figure, the usual range of being 25- 65°. The pattern used is Chevron or herringbone corrugations To express the increase of the developed length, in relation to the projected length, an enlargement factor *f* is used.The enlargement factor varies between 1.11 and 1.25.



.**Fig 2 : Plate Geometry of the gasketed plate**

IV.Mathematical Modelling of Gasketed plate heat exchanger

By knowing entering temperature and leaving temperature of the hot fluid and cold fluid, Log-mean temperature is calculated as:

$$\Delta T_{LM}=\frac{(Th,in-Tc,out)-(Th,out-Tc,in)}{\ln\left(\frac{Th,in-Tc,out}{Th,out-Tc,in}\right)}$$

Overall heat transfer coefficient can be calculated from heat rate ,area of the plates and log mean temperature by

$$Q=UA\Delta T_{LM}$$

Channel Reynolds number can be considered to characterize the flow dominantly which is found by channel mass velocity, equivalent diameter and dynamic viscosity.

For Re≤ 400

$$Nu=0.44\left(\frac{\beta}{30}\right)^{0.38}Re^{0.5}Pr^{0.33}\left(\frac{\mu b}{\mu w}\right)^{0.14}$$

$$f=\left(\frac{\beta}{30}\right)^{0.83}\left[\left(\frac{30.2}{Re}\right)^{5}+\frac{6.28}{Re\hat{}0.5}\right]^{0.2}$$

For Re≥800

$$Nu=[0.2668-0.006967\beta+7.244*10^{-5}\beta^2]Re^{0.728}+0.0543\sin[(2\pi\beta/90)+3.7]Pr^{0.33}\frac{\mu b}{\mu w}^{0.14}$$

$$f=[2.917-0.1277\beta+2.016*10^{-3}\beta^2]Re^{-[0.2+0.0577\sin((2\pi\beta/90)+2.1)}$$

Nusselt number is obtained by applying a coefficient pilot method. While overall heat transfer coefficient is related with heat transfer coefficient as:

$$\frac{1}{U}=\frac{1}{hh}+\frac{1}{hc}+\frac{t}{Kw}$$

Hydraulic diameter defined can be calculated from enlargement factor and breadth of the plates by

$$D_h=\frac{2b}{\Phi}$$

Heat transfer coefficient can be calculated by knowing Reynolds number, Prandtl number,hydraulic diameter and dynamic viscosities of water and dowtherm by

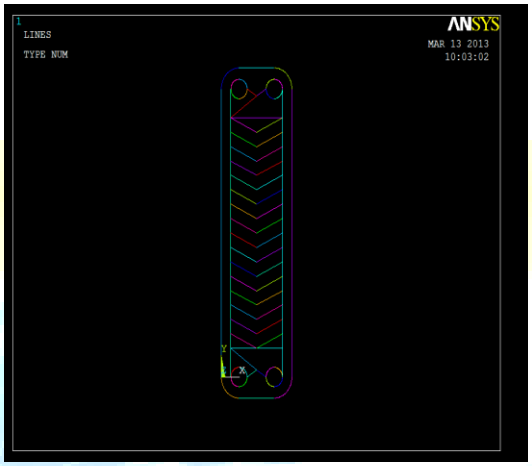
$$h=\frac{Kf}{Dh}CRe^aPr^b\frac{\mu}{\mu w}$$

Pressure drop can calculated by knowing gasketed constant,density ,hydraulic diameter and dynamic viscosity by

$$\Delta P=4f\frac{LeffNp}{Dh}\frac{Gc2}{2\rho}(\frac{\mu b}{\mu w})^{-0.17}$$

SOFTWARE MODELLING:

The modeling of the gasketed plate heat exchanger with chevron angle is modelled by using ANSYS.The design of the plates are done by the length=74cm and the width of the plate The effective plate length, width of the stainless steel plates are 74cm and 23.6cm.The average thickness of the channel is 27cm.Port diameter of the plate is 5.9cm.Chevron angle is 45 ° The modeling of the gasketed pate heat exchanger using ANSYS is shown in the figure .



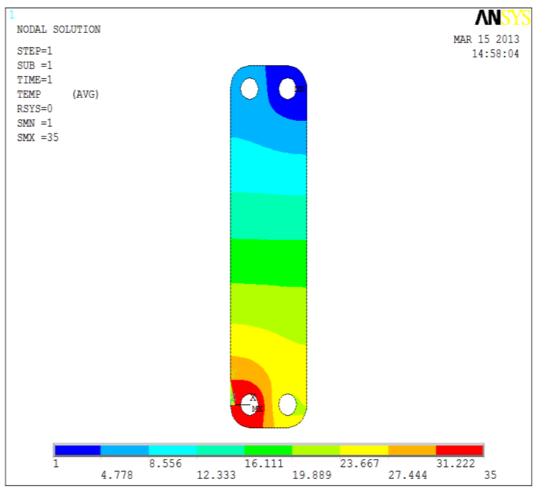
After modeling is done, the plate is meshed by using the size edge element as 10.The meshed diagram is shown in the figure. Boundary conditions are applied to the inlet of the hot fluid and the inlet of the cold fluid. Inlet temperature of the hot fluid =35 °C .Outlet temperature of the cold fluid= 1 °C .Pressure at the outlet walls =1 atm .Velocity of the fluids = 0.5m/sec

Results:

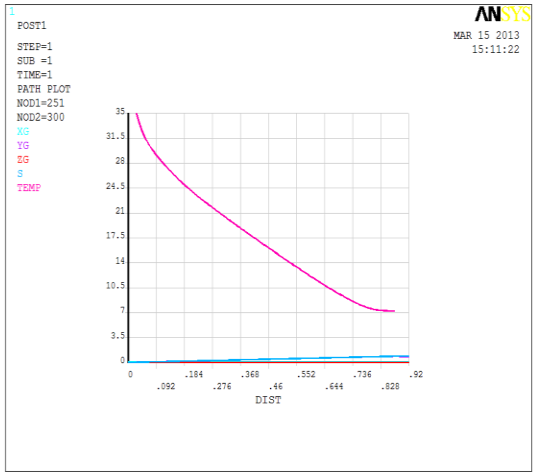
TEMPERTURE DISTRIBUTION

The temperature distribnution of the gasketed plate heat exchanger is obtained when the inlet temperature of the hot fluid and the inlet temperature of the cold fluid is 35°C and 1°C .The temperature distribution is shown in the figure .The temperature of the outlet of the hot fluid is 7.2 °C

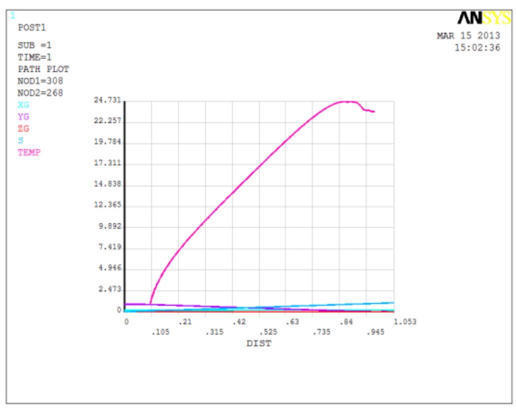
The temperature of the outlet of the coldfluid is 23.6 °C.The temperature is plotted between the temperature and time ,for the temperature being varying from the inlet temperature of the hot fluid and the outlet temperature of the hot fluid.



As the heat transfer area increases with the distance, the temperature decreases in the hot region.The temperature of the hot region decreases form 35°C to 7.2 °C .The temperature plot of the hot region is shown in figure. The temperature is plotted between the temperature and time ,for the temperature being varying from the inlet temperature of the cold fluid and the outlet temperature of the cold fluid.

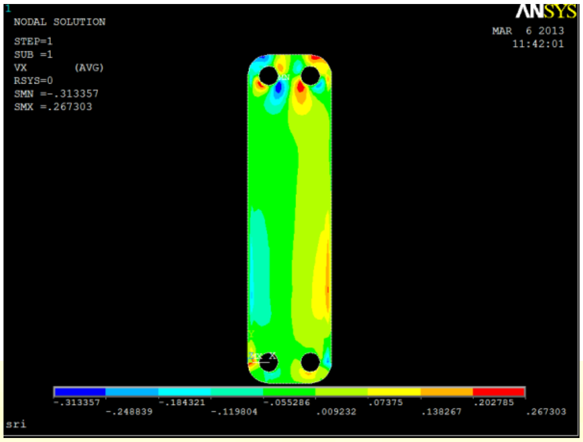


As the heat transfer area increases with the distance, the temperature increases in the cold region The temperature at the outlet of the cold region increases from 1°C to 23.6 °C. The temperature plot of the hot region is shown in figure



Pressure Distribution:

After modeling is done, the boundary conditions for the pressure should be applied art the out side of the walls to be 1 atm. The pressure plot of the distribution is shown in the figure.



Pressure distribution in the hot region is 0.05atm pressure. Pressure distribution in the cold region is 0.075 atm pressure

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