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STUDY OF PRESSURE DROP ON CHEVRON PLATE HEAT EXCHANGER

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Abstract

A plate heat exchanger can be defined as a type of heat exchanger which provides a greater surface area for heat transfer between two fluids. Plate heat exchangers are widely used for heat transfer applications in the industries such as food processing, chemical reaction processes, heating and also cooling applications in sectors such as petroleum. However, the design of plate heat exchangers is complicated by the large number of variables and geometries that affect its performance. According to process designers, a better heat exchanger design is to achieve a high heat transfer rate at low pumping power with low cost. In this study, the focus is on the research and study of different values of chevron angles affecting the plate heat exchanger performance, especially rate of heat transfer and pressure drop. For this purpose, the simulation on MATLAB Simulink is used. The results show that the best performing heat exchanger that can be designed is with higher chevron angle values, that is around 60^0-65^0.

Keywords: Chevron Angle, Heat Transfer Rate, Plate Heat Exchanger, Pressure drop

1. Introduction

A heat exchanger is a system or a device where the enthalpy (heat) is transferred from one state to another state. The Plate heat exchanger (PHE) is a type of heat exchanger where heat is transferred through the separating wall. It consists of corrugated number plates with brazing on corner plates edges and corner portholes. The brazing plate is used for easy maintenance and advantages cleaning over its counterpart. With the counter flow in different plates, there is a fluid flow alternatively. Plates are assembled with the help of tie bolts between movable pressure plates and fixed frame plates. Due to overall high heat transfer coefficient which is 3 to 4 times compared to tube and shell types, compactness, cleaning and removing of plates would be easy which is used on different type of plants and industries like food and beverages, pharmaceutical, polymers, hydrocarbon processing, petrochemical, etc. for application in fields of cooling tower isolation, waste heat recovery, water heaters, thermal (ice) storage systems, heat pump isolation etc.

2. Layout Analysis

I] Parameters affecting Working of PHEs.

The efficiency of PHE is affected by several factors, such asfluid flow rate, specific heat of fluid, viscosity of fluid,overall heat transfer coefficient of fluid, and pressure drop in fluid from one end to other end of the plate. It is found that overall heat transfer coefficient and pressure drop, are the parameters that influence the efficiency of PHE the most. Hence, out of these factors, pressure drop is considered for further calculations.

II] Numerical Analysis

As discussed earlier, pressure drop is one critical factor affecting heat transfer in PHE. The Pressure drop refers to loss of pressure throughout the journey a fluid takes within the heat exchanger. Process engineers preferred to keep pressure drop as low as possible to reduce pumping cost and maintain the right suction pressure downstream of the heat exchanger. While heat exchanger designers aimed to provide a solution that minimizes future operating problems and heat transfer area and that is often only achievable with a relatively high pressure drop. Mathematically, the pressure drop is the sum total of three types of pressures acting on the PHE system, that is, Pressure drops across the channels of the corrugated plates, Pressure drop associated with the distribution ducts and Pressure drop due to the elevation change (due to gravity). Here, we have taken the different Theta values at various degrees i.e. at 45º, 50º, 60º, 65º , to check the pressure drop. While performing calculations, we have kept Reynold's number constant at 40. The value of pressure drop majorly depends on the friction factor of the fluid on the plate surface.

3. Results and Discussion

I] Calculations

The pressure drop is a crucial parameter that must be considered within the design and optimization of a plate device. In any process, it should be kept as close as possible to the look value, with a tolerance range established in line with the available pumping power. In a PHE, the pressure drop is that the sum of three contributions:

- Pressure drops across the channels of the corrugated plates.
- Pressure drops thanks to the elevation change (due to gravity).
- Pressure drops related to the distribution ducts.

The pressure called the manifolds and ports should be kept as low as possible, because it's a waste of energy, has no influence on the warmth transfer process, and might decrease the uniformity of the flow distribution within the channels. It's recommended to stay this loss less than 10% of the available pressure drop, although in some cases it can exceed 30%.

$$\Delta P = 2fLVPG^2/\rho D + 1.4G^2/2\rho + \rho gLV$$

where f is that the Fanning factor, given by Eq E1, P is that the number of passes and GP is that the fluid mass velocity within the port, given by the ratio of the mass flow, $\dot{M}$, and also the flow cross-sectional area, $\pi D^2/4$.

$$G_P = 4M/\pi D_p^2$$

$$f = K_p / [\![Re]\!]^m \qquad \text{Eq E1}$$

The values for Kp and m are constants, as a function of the Reynolds number for a few β values.

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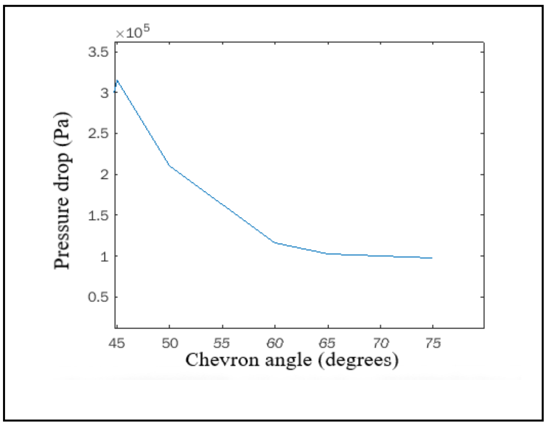
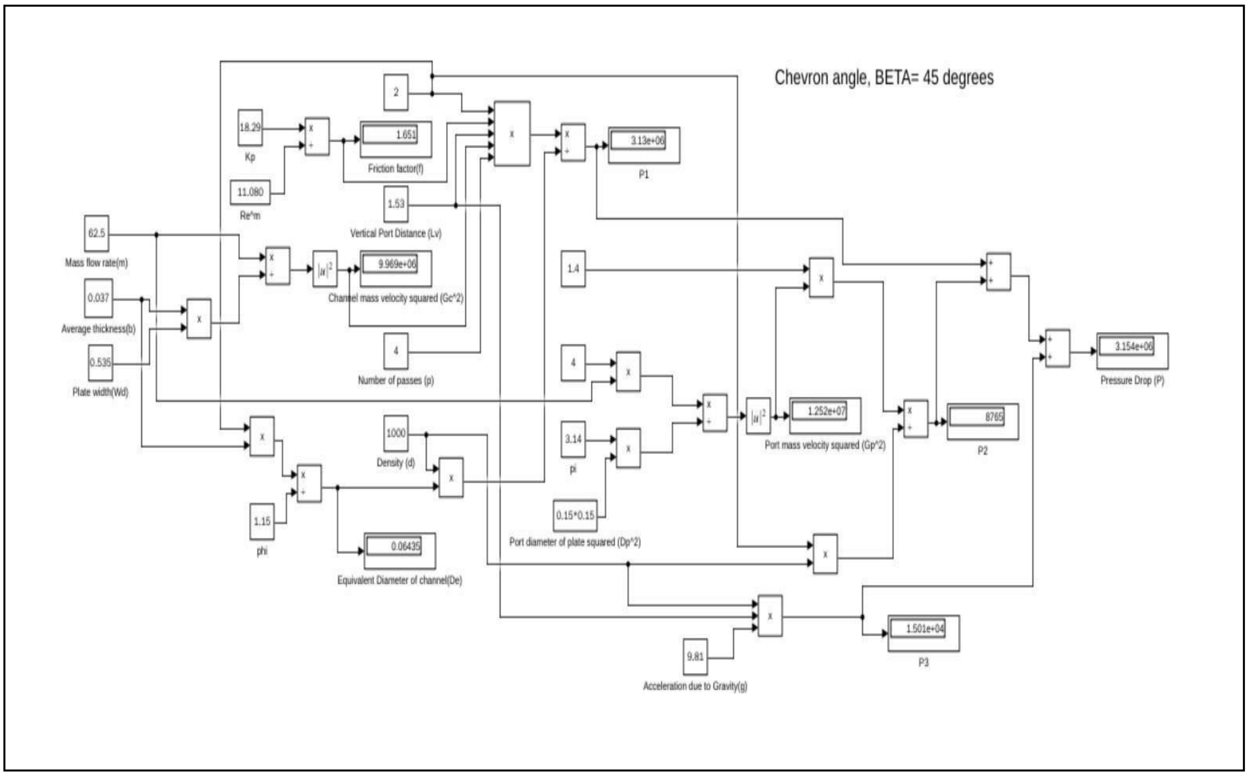


II] Observations

So, from these observations, it can be concluded that, as the chevron angle i.e. theta increases, the pressure drops in the plate decreases, as shown in graph 1, as obtained from calculations. We want the pressure drop as low as possible to reduce the pumping cost and to maintain the right suction pressure downstream of the heat exchanger. Because if the pressure drop goes high, then we should have to find ways to limit the flow rate of fluids which we don't want. High pressure drop will lead to high velocity at the exit of the heatexchanger, possibly causing erosion problems. pressure drop, such that it gives maximum efficiency with minimum wear of the plate surface. Fig1, fig.2, and fig.3 show the calculations of pressure dropfor chevron angles 45°, 60°, and 65° respectively.



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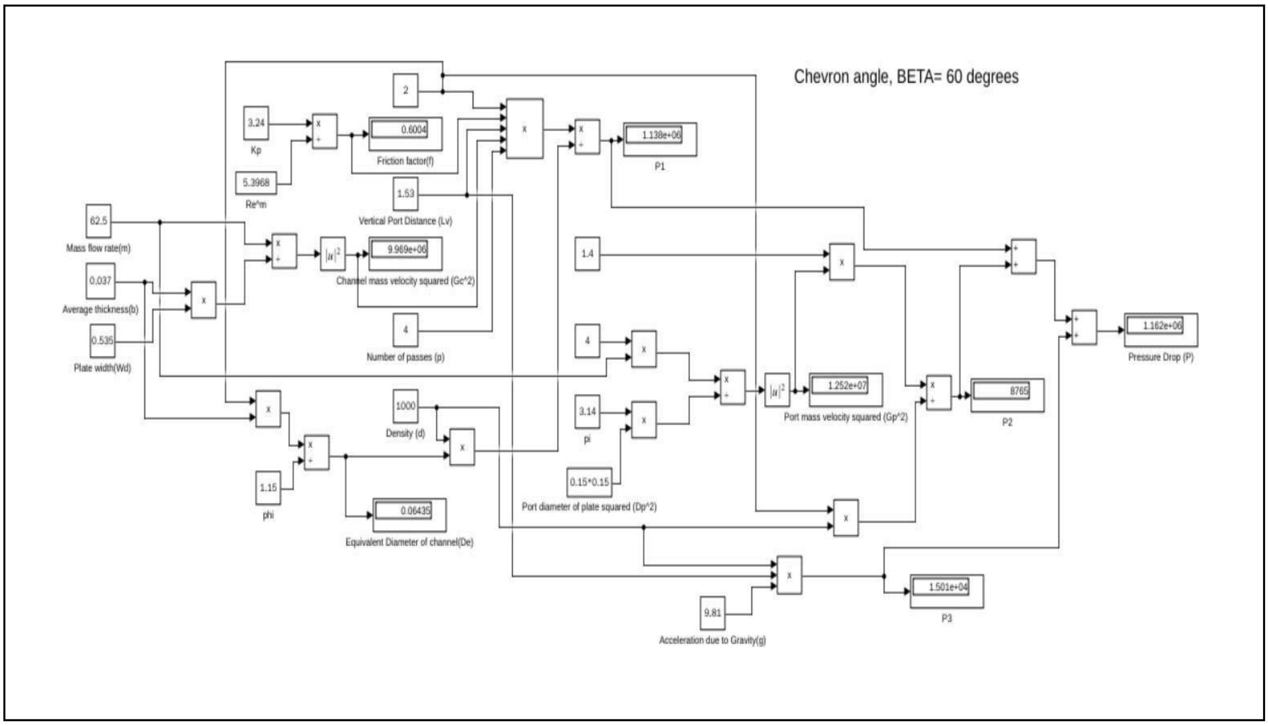

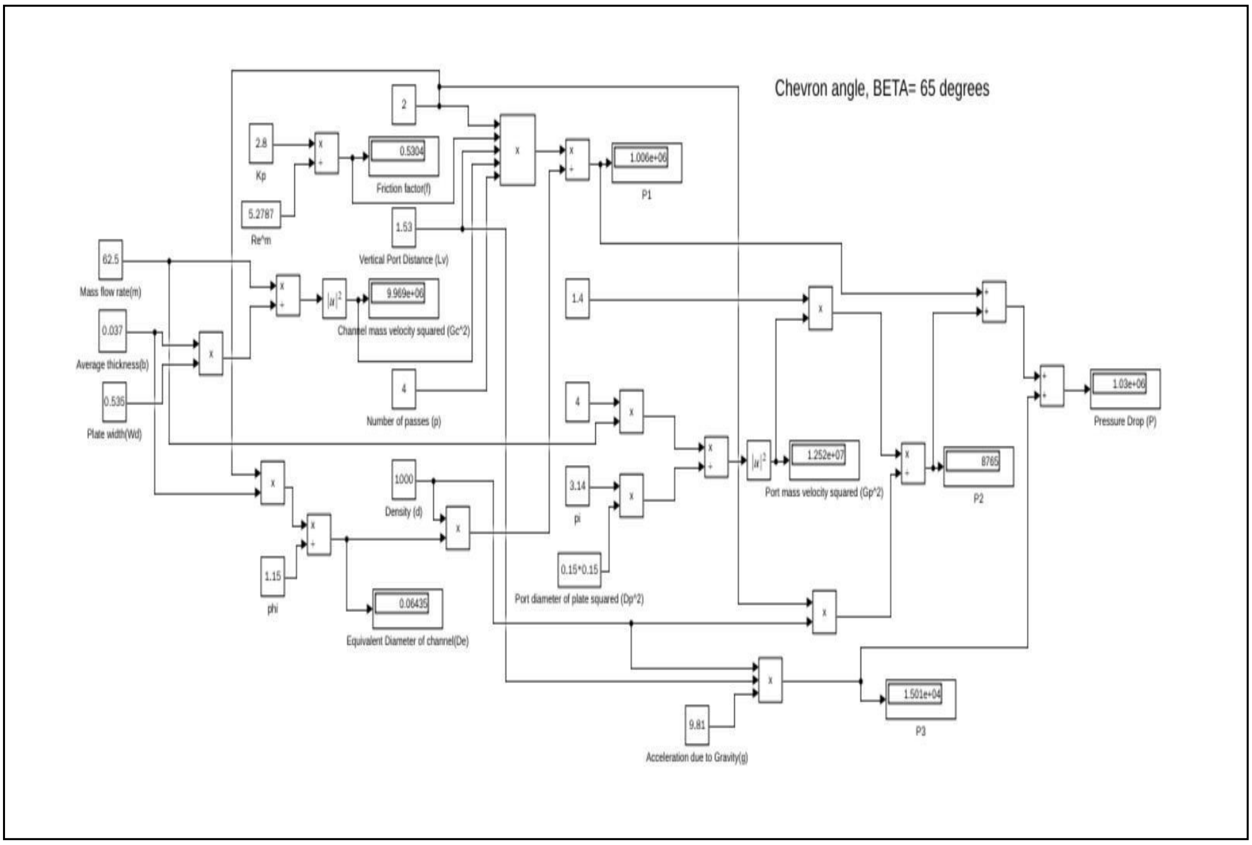

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4. Conclusions

In this paper, the effect of different parameters on the surface of plate, 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. From the study it can be clearly concluded that the Pressure drop depends on the friction factor, which inturn depends on the values of Reynolds number and kP, which varies depending on the chevron angle. Hence pressure drop is reduced as the chevron angle is increased.

Future Scope

Works of different investigators clearly indicate that geometric design parameters of PHE strongly affect its performance. Hence it is necessary to establish a relationship between them and work should be carried out to obtain optimum design.

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